The Quantification of Facial Expression Using a Mathematical Model of the Face: Validation and Extension of a Microcomputer-Based Technique.

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ERRATA

Page 5 Line 20 should read "Duchenne.......sole reason for the existence......."
Page 13 Line 16 should read "aggression (comprising anger and frustration)....."
Page 13 Line 24 should read "Aggression.......has also been studied."
Page 14 Line 13 should read "equated with.......led to the action."
Page 30 Line 21 should read "A group of subjects was......."
Page 38 Line 11 should read "display rules.......explains......."
Page 39 Line 19 should read "Bilateral, tightening......."
Page 51 Line 28 should read "arousal may be independent."
Page 54 Line 3 should read "In this study, a group of subjects was......."
Page 56 Line 1 should read "show that.......act independently......."
Page 58 Line 12 should read "maintained.......not dependent on......."
Page 71 Line 11 should read "the dimensions.......generally integrated......."
Page 76 Line 16 should read "i.e. the Pleasure and Activity dimensions."
Page 79 Line 16 should read "phylogenetic.......are by far the......."
Page 94 Line 16 should read "work done.......supports......."
Page 101 Line 1 should read "the emotions of happiness......."
Page 112 Line 9 should read "which comprised such terms as......."
Page 114 Footnote 1 Line 1 should read "A study which......."
Page 114 Footnote 1 Line 3 should read "They examined......."
Page 119 Line 25 should read "agreement regarding......."
Page 122 Line 27 should read "benefited from.......identification."
Page 125 Line 1 should read "group was also shown......."
Page 125 Line 3 should read "excerpts.......were presented......."
Page 128 Line 11 should read "listened to the tape recorded messages......."
Page 133 Line 19 should read "Another group of subjects was......."
Page 138 Line 24 should read "In addition.......was well accepted......."
Page 156 last line should read "one emotion from the other......."
Page 171 Line 11 should read "visual scoring.......in the training of......."
Page 174 line 24 should read "independently......."
Page 184 Line 3 should read "detailed.......data points is......."
Page 195 Line 6 should read "Each scaled.......by one of two......."
Page 197 Line 20 should read "The entire set of faces was......."
Page 205 line 20 should read "emphasis on.......dependent upon......."

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Abstract

This thesis describes the use of a new measurement technique for the study of the facial expression of emotion. Based on a mathematical model of the face, a microcomputer-based approach is utilised to quantify facial movement. Sixty-two points are digitised from a still image of a face and twelve facial measures are generated which represent distance scores between facial landmarks. Furthermore, the digitised points can be connected to form a smooth curved line drawing representation of the facial expression.

This thesis has three parts. An extensive literature review focussing on the theories of emotion and the methodological and measurement techniques used to describe and capture facial expressions is presented in Part 1.

Part 2 of this thesis concerns the validation of the computer model as a measurement tool. Two experiments were conducted to examine the relationship between the ratings made by a set of smiling and neutral expressions and the facial features which influence these ratings. In the first study, judges were shown forty real face photographs of smile and neutral expressions and forty line drawings derived from the photographs. In Study Two, subjects were shown eighty line drawing representations only of smile and neutral expressions. They were asked to rate the degree of smiling behaviour of each expression. Significant differences were found between the ratings of smile and neutral expressions. Furthermore, there were several facial measures which were found to discriminate significantly between the ratings made on smile and neutral expressions. The second study was further designed to assess differences in expression development. The findings revealed that there was a greater variation in ratings for the development of the smile than there was for the neutral expression. Encoder differences emerged and gender differences in the decoding abilities of the raters were also found.

In Part 3 of the thesis, the utility of the model is extended to firstly incorporate the quantification of other expressions and secondly to extend its utility into the clinical arena. To address the first issue, twenty-three actors posed the six fundamental emotions of happiness, surprise, fear, disgust, anger, sadness and a neutral expression. These expressions were digitised and the resulting facial measures were subjected to a numerical taxonomy analysis, which yielded five main classes. The most prominent of these were three classes comprising of a majority of the happiness expressions, surprise expressions and a total absence of happiness expressions respectively. Two further experiments were conducted to assess the ability of human subjects to classify these emotions. A Multidimensional Scaling Procedure was applied to the judgements of two separate groups of volunteers. The results from both experiments revealed a two-dimensional structure consisting of a Pleasant-Unpleasant and Facial Activity dimension.

Secondly, this method was used to measure the smiling behaviour of a group of Parkinson's disease (PD) sufferers, a group of patients with Major Depression and a Control group, of comparable age. Subjects were asked to view a series of amusing slides and the most animated smile for each subject was chosen for analysis. The Depressed group differed significantly from the other groups on several of the facial measures. Both the Depressed group and the PD group were found to smile significantly less often during the slide session when compared to the Control group.

Conclusions focus on the primacy of happiness and the utility of the model as a measurement tool.

Author's Statement

This thesis contains no material which has been accepted for the award of any other degree or diploma at any University. To the best of my knowledge and belief it contains no material previously published or written by any other person except where due reference is made in the text. If accepted for the award of the degree I consent to the thesis being made available for photocopying and loan.

Signed:

Mary Katsikitis

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Overview

The study of facial expression has been approached from a variety of perspectives, both theoretical and methodological. The strong foundations laid by the early pioneers have attracted researchers from a number of disciplines, such as psychology, physiology and ethology, to name a few. The study of facial expression has generally been embraced under the more common quest for a theory of emotion and is considered to be the most immediate and informative component of the emotional experience. Methods designed to capture and measure this dynamic phenomenon have greatly improved our understanding of discrete muscle action associated with the varied facial displays.

This thesis presents a methodological contribution to the study of facial expression of emotion. It describes a new technique developed to quantify facial expressions and proceeds to test its validity as a measurement tool. Furthermore, it extends the functional utility of this new technology, insofar as its applicability both clinically and empirically is concerned. This thesis builds on previous work resulting initially in the construction of a mathematical model of the face (from which all measurements were taken), and secondly, a computer programme which automated the process. The history of the development of a microcomputer-based model for the quantification of facial expression is presented in Chapter 5.

Chapter 1 reviews the theories of emotion beginning with the pioneering works of Duchenne and Darwin in the nineteenth century, to the contemporary theories of Tomkins, Izard and Ekman. The review is approached from two perspectives. Firstly, the categorical or typological approach to emotion is presented, emphasising the existence of a fixed set of discrete, innately programmed emotion categories. Each category is further characterised by its unique facial display. In direct opposition to this view is the dimensional approach to the study of facial expressions of emotion. The proponents of this view stress that the structure of emotion is composed of two or three pivotal dimensions, along which the various emotion categories are placed. It is evident that the causal relationship between emotion, expression and either the categorical or dimensional approach is yet to be resolved.

Chapter 2 explores the controversial issue of the social and biological influences on the facial expression of emotion. To further elucidate the contribution of nature versus nurture in the origin of facial expressions, psychologists have relied on (1) comparative research undertaken mainly by ethologists, (2) the ontogeny of expression , and (3) cross-cultural research. The evidence pertinent to these issues is presented.

Chapters 3 and 4 review the methodological and measurement techniques associated with facial research. Chapter 3 specifically focusses on the judgement approach to the measurement of facial expression. This method involves the presentation of a series of photographs or slides of facial expressions to a group of observers, who are asked to judge the expression or emotion portrayed. It is generally a holistic approach to facial measurement. The accuracy of the judgement approach is discussed in the light of the many methodological techniques which have been employed to address this issue.

Chapter 4 describes an alternative approach to facial measurement, namely the component approach. Researchers utilising this method concentrate on the features of the face and their actions in the display of the various emotions. This chapter highlights the systems which are designed to measure facial expression from the face directly such as the various facial action coding systems, facial electromyography and the computer-assisted techniques which are gaining in popularity in this field.

Chapter 5 outlines the development of the mathematical model of the face and the microcomputer-based approach to the quantification of facial expression.

The central objective of this thesis is to contribute to the further validation of the microcomputer-based model (FAC.E.M.) and its role in the measurement of facial expression. The model produces facial measures which represent distances between key facial landmarks, thus defining the excursion of the various facial features on the face during an emotional display. Secondly, the model produces line drawing representations of photographs or any still image of a face, thus rendering the facial stimulus anonymous.

Two studies are presented in Chapter 6. The first study examines the relationship between ratings made of a set of smiling and neutral expressions and the facial features which influence these ratings. The second study explores the possibility of substituting photographs of facial expressions with line drawing representations of faces.

Chapter 7 examines the ability of the model to differentiate between the six fundamental emotions of happiness, surprise, fear, disgust, anger and sadness (Ekman and Friesen, 1975). Three experiments are conducted to investigate this issue. In the first study, a numerical taxonomic procedure is applied to the facial measures generated by the model from a series of posed facial expressions. In the second study, the photographs of the posed expressions and a list of emotion words are presented to a number of observers, who are asked to match the photographs with the emotion categories provided. Study 3 is a replication of the second study with one variation, namely, line drawing representations of the facial expressions are presented to the judges.

Chapter 8 extends the application of the FAC.E.M. model into the clinical arena, examining the facial actions of a group of patients with Parkinson's disease and Depression, with matched Controls. Facial measures associated with the smile are targeted as is the frequency of smiling between the three groups.

The conclusions focus on an integration of the findings and accordingly, implications for the utility of the model are discussed. It is clear that this method has considerable potential for use in a number of contexts and this chapter lists a few of the possibilities.

PART 1

CHAPTER 1

THEORIES OF THE FACIAL EXPRESSION OF EMOTION

1.1. Introduction

Although still unresolved scientifically, the structure of emotion has been a subject for debate for many years. The nature and phenomenology of emotion and its expression through facial action has attracted considerable interest for over one hundred years. This chapter presents an historical overview of the theories of emotion which have shaped current thinking and research, specifically related to the use of the face in the judgement or assessment of emotional intent and experience.

Psychologists have been interested in the structure of emotion since the publication of "*The Expression of Emotions in Man and Animals*" (Darwin, 1872). In fact, Goldstein's (1983) review reports just how influential Darwin and his book were in attracting many behavioural scientists into face-related research. Although some of these investigators will be well known for their work in this field, many published an isolated report and consequently diverted their research interests into other areas. Goldstein (1983) concluded that early investigators may have been overwhelmed with the time and difficulties involved in face research, especially as Darwin's propositions were firmly embedded in, and incorporated the much larger nature-nurture controversy. Nevertheless, much of this early work laid the foundations for the scientific scrutiny of emotion and facial expression. Although many researchers were discouraged and pursued interests in other fields, for the contemporary writers in this area, the importance of the methodologies and emphasis of these early papers cannot be overlooked.

This chapter will review the research findings concerned with the structure of emotion from two perspectives, namely that of the categorical and the dimensional approaches. The categorical approach espouses the delineation of emotion and its accompanying facial expression into fixed independent and discrete categories, while the dimensionalists on the other hand, produce evidence for more global dimensions which may encompass several emotions. Secondly, this chapter will show the development of the various theories of emotion and expression beginning with the earliest theories which were narrowly focussed on particular bodily functions such as the actions of the muscles (Spencer, 1890), the nervous system (Darwin, 1872), visceral-glandular activities (James, 1884) or brain function (Gellhorn, 1964). Following this, the most influential theories of the current time will be reviewed, with an emphasis on the physiological and psychological (psychoanalytic, behavioural and cognitive/affective) approaches towards the delineation of the emotions and facial expressions.

1.2. The Early Theories

From a scientific point of view, the earliest interest in the face came chiefly from Sir Charles Bell (1806) and Duchenne (1862). Bell introduced the topic as amenable to further analysis with some graphic displays of the muscles in the face. Following Bell's (1806) focus on the muscles of the face, Spencer (1890) argued that the result of neural impulses were reflected in those muscles overcoming the least resistance, namely, the facial muscles. It was in the face that emotional excitation was most visible. The major criticism of this work was that Spencer offered no explanation as to why a neural impulse would produce a certain facial expression such as a smile, rather than result in another facial response, e.g. a frown. He maintained that emotions were discrete and the result of unique neural discharges. This "mechanical" approach to the study of emotion was later reviewed and extended by Dumas (1948), who maintained that the expressions were distinguishable by the amount of muscle resistance shown to the nervous impulse. For example, sadness was characterised by a suppression of muscle tone, and joy by an increase in muscle tone.

1.2.1. Duchenne and "*The Mechanism of Human Facial Expression*"

> "*The study of facial expression is that part of psychology dealing with the different ways man manifests his emotions by the movements of the face*"
> (p.29, 1990).

Acknowledging the importance of Bell's interest in the facial muscles, Duchenne combined the art of photography with his own discovery of using electricity to manipulate the muscles of the face, thus capturing the expression of emotion on film for the first time in history. Attributing the expressive abilities of man to the soul, Duchenne proposed that the perception and display of emotion was an innate and universal phenomemon. Thus;

> "*man has the gift of revealing his passions by his transfiguration of the soul...To express and to monitor the signs of facial expression seem to me to be inseparable abilities that man must possess at birth. Education and civilisation only develop or modify them*" (p.29, 1990).

Furthermore, he proposed that;

> "*it is always a single muscle that executes the fundamental movement, representing a movement dictated by the soul*" (p.30, 1990).

With the use of electricity on the face, Duchenne was able to locate facial muscle stimulation sites which resulted in the activity of specific muscles or muscle regions. In this way, he grouped the facial musculature into those which were "*completely expressive, incompletely expressive, expressive in a complementary way, or inexpressive*" (p.12, 1990). Using a subject who suffered from facial anaesthesia, Duchenne was able to show the muscles involved in the emotions of joy, sadness, surprise, scorn and fear, and in the expressions of pain, aggression, crying, snivelling, reflection, kindness, and lasciviousness. Duchenne used his own judgement as his only criterion for the inclusion of a muscle or a group of muscles involved in the display of any emotion.

Duchenne also asked one of his subjects to deliberately pose some of the facial expressions in order to investigate which movements were purely involuntary. He found that many expressions were easily posed, except for those involving the eyebrows, where some difficulty was experienced. In his conclusion, Duchenne noted that;

> "*the creator placed expression under the control of instinctive or reflex muscular contractions*" (p.30, 1990)

and that;

> "*the muscles that move the eyebrows...are least under the control of the will; in general, only the emotions of the soul can move them in an isolated fashion*" (p.43, 1990).

1.2.2. Darwin and "*The Expression of the Emotions in Man and Animals*"

No-one was more influential in attracting attention to the scientific study of expression and emotion than Charles Darwin (1872) with the publication of his book "*The Expression of the Emotions in Man and Animals*". He expanded on the earlier work of Bell and Duchenne and looked for the answer to the origin and evolution of facial expressions with empirical techniques and methods similar to those used by his contemporaries. For example, he was the first to conduct what is commonly known at the present time as a "judgement" study. He presented a series of photographs displaying a number of facial expressions (which he obtained from "*Mecanisme de la Physionomie Humaine:ou analyse electrophysiologique de l'expression des passionns*" by Duchenne, 1862) to individuals of various ages and asked for an identification of the emotion portrayed. Furthermore, he observed and recorded the spontaneous expression of infants and the insane, making detailed lists of their behaviour (resembling the contemporary ethological approach). In contrast to Bell and Duchenne, who believed that the sole existence of facial muscles was their role in expression, Darwin maintained that facial muscles also had other uses. His comparative studies of animal expressions paved the way for generalisations to be made about the evolutionary origins of facial expression in humans. Furthermore, from reports received from missionaries around the world, he was also the first author to speculate about the universality of certain expressions based on information obtained concerning groups such as the Australian Aborigines, Maoris, Dyaks, Chinese, Indians and Malays.

The accumulation of information and recorded observations from these sources led Darwin to formulate three "general principles" of emotional expression.

According to the *principle of serviceable associated habits*, certain actions, when associated consistently with a unique state of mind, became habitual, almost reflex-like. These acquired acts, after repeated sensory-motor association, became innate and even if of no use, will be performed when the triggered stimulus arises. Darwin conceded that some actions did not seem to be fixed by habit, but were indeed innate, existing from generation to generation through the process of natural selection. He emphasised however, that all actions were amenable to change and if imperative for the survival of the species, the modified action was inherited and passed on to the next generation.

Strongly related to the first, the *principle of antithesis*, proposed that just as there are serviceable associated habits which have been or still are of use, there also existed actions of a directly opposite kind, inducing an opposite state of mind, also fixed by habit, but for which no use can be found. These actions, like those accounted for by the previous principle, may be highly expressive. Their origin appeared to have been the result of muscles acting in a directly opposite way when an opposite movement to an already fixed action occurred.

Thirdly, the *principle of direct action of the nervous system* on the body referred to those actions which arose as a direct result of an excited nervous system, and were involuntary and independent of habit. Examples given were trembling of muscles, perspiration, and the secretions of various organs affected by emotion. Darwin regarded this principle as the most obscure and concluded that it was usually the combination of nervous system and actions following on from one or other of the other principles, that constituted all emotional and expressive behaviour.

According to Darwin, fixed action patterns acquired through habit and the activity of the nervous system during the different states of mind evoked by the emotions, explained the varied expressions displayed by humans. The formulation of these three principles, following from an evolutionary perspective on the origin of expression, lead to the proposition of a categorical structure of emotion, defined by discrete bodily and facial actions. Nine emotions were delineated:

1. Suffering, which may involve crying intended to alleviate pain. The facial focus of this expression is the eyes which close as the muscles around them contract to prevent a rush of blood to the eyeballs. This action results in the movement of muscles around the lip, causing the mouth to open (and release screams of agony).
2. Grief, which is characterised by the upward movement of the inner eyebrows and the downward movement of the corners of the mouth.
3. Joy, characterised by the act of smiling or laughing due to the contraction of the zygomatic muscles which pull the corners of the mouth outward and upward. The upper lip is raised and wrinkles form under the eyes.
4. Reflection, especially if prolonged and accompanied by deep complicated thoughts, results in a frowning action across the forehead produced by the contraction of the corrugator muscle. The eyes remain open or may be downcast. Meditation, which involves deep reflection however, is not associated with frowning but with relaxed "vacant" eyes.
5. Anger, characterised by stiffness of the body and a flushed face. The mouth is closed and widened almost into a grinning position and the eyes are open and staring.
6. Contempt/Disgust, is closely related to disdain and sneering. Common facial movements include open mouth, slightly more on one side than the other, contraction of muscles around the eyes, raising of upper lip and wrinkling of the nose.
7. Surprise, or astonishment involves a sudden attention resulting in the raising of the eyebrows and the opening of the mouth and the eyes.
8. Fear, very closely resembles the expression of surprise which usually precedes it. The eyes and mouth open widely and the

eyebrows are raised. The face loses colour rapidly, the body remains motionless and hair stands on end.

9. Shame/Shyness/Modesty, is characterised by blushing of the face, associated with the opinion of others to our appearance, especially of the face. The main facial feature of these expressions is the downward movement or the turning away of the eyes.

In summary, Darwin's pioneering work (1872) promoted the scientific study of emotion and emotional expression. His detailed description of the various emotions, through facial and bodily action, laid the foundations for the study of:

1. The structure of emotion.
2. The innate versus the learned origins of facial expression.
3. Facial expression in infants.
4. The universality of facial expression.
5. The use of scientific and methodological techniques including hypothesis testing for the study of expression.
6. Emotional expression in animals.
7. The influence of cardiovascular and physiological processes in the development and formation of an expression.

Unknown to Darwin at the time of publishing "*The Expression of the Emotions in Man and Animals*", his book was instrumental for the future development of one of the major theories concerning the structure of emotion. He was espousing, in however embryonic a form, a categorical, unique taxonomy of emotional actions. The fundamental emotions he proposed, and gave evidence for through the application of his three principles, were amenable to scientific research and replication. Much of the recent work in this area had its foundation in the work of a few such early theorists. Indeed, some would say that the modern theories were mere extensions of these classical works, aided by the use of updated methodological and measurement techniques (Izard, 1971).

1.3. The Structure of Emotion: The Categorical Approach.

1.3.1. Psychological Theories of Emotion

Apart from James (1884) whose work will be discussed in the next section, scholars of psychology did not pursue the earlier work on expression and emotion further. The beginning of the twentieth century was devoid of the use of the terms emotion and expression almost solely due to the influence of two emerging psychological theories, namely that of Freud's Psychoanalytic Theory and the Stimulus-Response (S-R) paradigm introduced by the behaviourists. Indeed, as will become evident in the following section, the term emotion was at times overlooked and replaced with notions of arousal (activation), drive, instinct and stimulation. The two theories will be briefly discussed in turn.

1.3.1.1. The Psychoanalytic Theory

Of the psychological theories to have made a negative impact on the study of emotion, one must begin with Freud and his psychoanalytic theory. Freud (1949) proposed that humans, like other animals, endeavoured to satisfy their innate needs. In "*Instincts and their Vicissitudes*", Freud distinguished between instincts and stimuli. He asserted that instincts were the principal motivators of behaviour. An instinct, or instinctual drive, could be characterised by its impetus, its aim, its object and its source.

> "*An instinct may be described as having a source, an object and an aim. The source is a state of excitation within the body and its aim is to remove that excitation. In the course of its path from its source to the attainment of its aim the instinct becomes operative mentally*".
>
> (Freud, 1933, p.133).

Freud defined two fundamental groups of instincts, i.e. the life (Eros) and death (Thanatos) instincts. The life instincts included those forces which maintained life. The death instincts, on the other hand, had a destructive purpose. The interaction of these instincts produced all possible combinations of effects.

Underlying the psychoanalytic theory was the hypothesis that motivation resulted from the arousal of tensions and the organisation of behaviour around tension reduction. In "*Instincts and their Vicissitudes*", Freud held that the main function of the nervous system was to abolish stimuli or to reduce excitation to the lowest possible level (Peters, 1958). All human behaviour was reducible to energy, and the goal of all behaviour was pleasure, equated with the reduction of tension or the release of energy. This was what Freud referred to as the "pleasure principle". In sum then, instinctual drives were characterised by their energy. The fulfillment of certain goals resulted in the discharge of this energy. Instinctual drives operated in the pursuit of pleasure (tension reduction).

Instincts function through the mind and according to Freud, three divisions were seen, namely the id, ego, and superego. These were the structural units of the mind. The id contained everything that was inherited. It was the "*reservoir of instinctual energy*" (Cofer & Appley, 1964, p. 606). The primary process, the means by which the id operated, consisted in discharging instinctual energy. Such energy was discharged in the forms of impulses or wishes. In addition, the id was completely unconscious. The ego mediated between the demands of the id and the external world. It was seen both at a conscious and unconscious level. The superego, on the other hand, pursued perfection. It represented the moralistic side of the personality and opposed the instinctual aims of the pleasure-seeking id.

In Freud's early theorising, there was the striking absence of a clear formulation of the role of emotion and its expression. In fact, Freud (1933) only realised the importance of emotion in his attempts to unravel the phenomenon of personality. Indeed in his writings he refers to Darwin's (1872) conclusion that the emotions represented meaningful and purposeful actions, and also to the James-Lange theory which he dismissed as irrelevant to the concept of emotion for psychoanalysts (Freud, 1973, 1979).

His psychoanalytic view raised a very important issue with regard to cognition and emotion. Freud asked the question of whether emotion could be unconscious. This caused a dilemma in his theorising, as emotion was seen as an active response to mounting tension. However, once the role of evaluation of environmental stimuli was assigned to the ego, the dilemma was resolved.

The psychoanalytic theory of intrapsychic conflict provided an emphasis on cognitive functions in emotion by its reference to anxiety. Freud concluded that the evaluation of an emotion, such as free-floating anxiety, could be unconscious and still have an observable response. Affect was regarded as a "*repetition of some particular significant experience*" (Freud, 1973, p.444). Anxiety was considered to be a very powerful emotional experience, representing a threat or danger to the individual. It also represented the repetition of an earlier traumatic experience, i.e. birth. Freud hypothesised that as the earlier trauma was not available to consciousness, the anxiety had a free-floating quality. Anxiety, in psychoanalytic terms, was said to be the response of the ego to stimulation it was unable to control. Individuals learned or developed defense mechanisms against anxiety. Unconsciously, the individual (ego) distorted reality, so as to minimise anxiety. The major defense mechanisms used by the ego included projection, denial, repression and regression.

Freud (1979) attributed most emotional difficulties to the sexual drive which he considered instinctual and the constant motivating force for many actions. The libido's aim was to achieve pleasure (and every kind of sensory fulfillment was libidinal in nature), leading to a cessation of excitation. On the other hand, increased excitation resulted in displeasure, e.g. pain or anger. The defense mechanism against internal or external excitatory forces was the superego. Freud was not primarily interested in the phenomenon of emotion or the events leading to its display. However, he came to regard it as a discharge of excitatory impulses brought about by stirrings in the unconscious. The resulting emotion acted to release high tension, when direct action was not possible. Thus, the expression of emotion resulted when drive tension increased, with no action alternative available (Freud, 1973).

1.3.1.2. A Behaviouristic Approach to Emotion

While the personality theory of Freud equated emotion with drive states and not as a separate phenomenon, the specific emotions known to humans have been virtually ignored by the behaviouristic drive-reduction theory or Stimulus-Response

(S-R) theory, in which the emphasis is on reinforcement, conditioning and drive reduction. The originator of "Behaviourism", J.B. Watson (1924), considered emotion to be "*a hereditary 'pattern reaction' involving profound changes of the bodily mechanism as a whole, but particularly of the visceral and glandular systems*" (p. 195). Three such emotional "pattern reactions" were identified, namely anger, fear and love. Similarly, Skinner (1938) associated emotion with changes in reflex actions. However, he did not speculate about the stimulus-response associations in emotion. The Hullian viewpoint, which will serve as a behaviourist example in this thesis, equated emotion with increasing or decreasing drive strength.

Clark Hull (1943) produced a unified theory of behaviour, which accommodated many of the behaviouristic concepts of the time. The superiority of his formulation over previous ones was reflected by the fact that it stimulated a great deal of research. Hull developed three partially overlapping theories of motivation. First, there was the associative or conditioning theory, which was an attempt to show that learning could be explained by S-R associations. Secondly, the drive theory stressed the importance of reinforcement in learning. The drive theory indicated a transition from a contiguity account to a reinforcement account of learning, and for the first time, drive was credited with having more than simply associative properties. In fact, drives were implicated in determining what constituted reinforcement. Thus, the drive theory incorporated distinct motivational and learning mechanisms, the latter being dependent on reinforcement. Finally, the need theory emphasised the survival of the organism and so consequently, certain motivational states were accorded special significance. These were the states of hunger, thirst, sex and pain avoidance. Hull, not unlike Freud, proposed that the needs of the body were the "*ultimate basis of motivation*" (Cofer and Appley, 1964, p. 470). Need preceded actions, therefore they motivated or provided the drive for behaviour. Needs produced primary drives and in Hull's view, all drives were traceable to primary tissue needs. Drives provided the motivating force which urged the organism into action, aimed at satisfying internal needs.

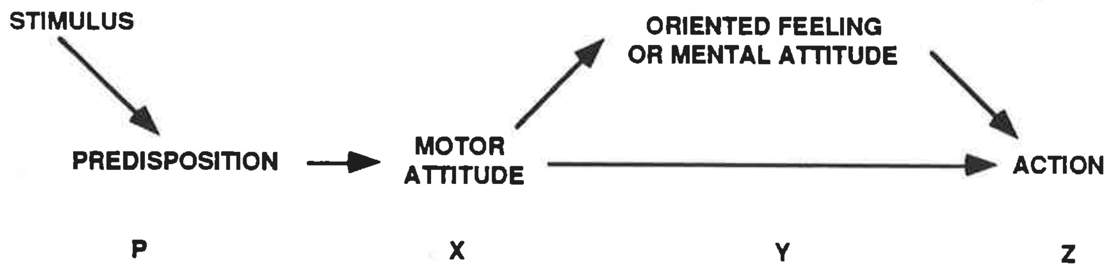
In summary, the organism's (biological) need state produced a state of motivation called a drive. Drive energised or activated behaviour. Drive stimuli directed this behaviour toward the reduction of bodily need. Reduction of a need served as reinforcement and produced learning of the response, i.e. the particular behaviour. Thus, three functional properties of drives were identified. Firstly, drives energised behaviour. Secondly, drive stimuli which directed behaviour were associated with them, and finally, drive reduction was reinforcing.

With the Hullian schema in mind, Dollard and Miller (1950) attempted to relate the psychodynamic concepts inherent in Freud's personality theory to the learning experiences of the individual. Working on the premise that Freudian principles, referring to specifically unconscious content, could be tested in the laboratory, these authors explained the learning process, with respect to need reduction and drive states associated with psychopathology. The neglect of emotion or emotion concepts was clearly evident since the integration of these two theories, with an emphasis on the learning process associated with the neuroses, considered fear and aggression (comprising of anger and frustration) as drive states which were strengthened by reinforcement. Laboratory research focussed on animals and clinical cases were analysed in terms of early childhood experiences and parental influence.

With a focus on mainly observable behaviour, it was the case that the specific emotions of human experience were virtually ignored by the behaviourists. Instead, they were considered as global entities, generally associated with changes in drive strength. Most investigators in this tradition have concentrated their efforts on the behaviour of animals in avoidance conditions, where fear and anxiety were inferred as the motivating variables. Aggression, inferring anger or frustration as the intervening emotion, have also been studied (Dollard, Miller, Doob, Mowrer & Sears, 1939). However, by relying on observable behaviour, mainly in animals, the experiential aspect of emotion in humans was overlooked. Indeed, the emphasis on simple behaviours or isolated responses lending themselves to experimental manipulation was unable to cope with the number and complexity of interactions associated with the display of emotion. However there were exceptions; Nina Bull

(1951) to be discussed shortly, and Floyd Allport, (1924) whose theory will be presented in section 1.3.2.

Although couched in behaviouristic terms, (stimulus awareness leads to action), Nina Bull's "*Attitude Theory of Emotion*" (Bull, 1951) strongly emphasises the role of the face in the perception of emotion. In fact, the expression of emotion was divided accordingly, where the perception of a stimulus referred to as "the attitude" was the first part, and motor activity the second part of the expressive process. The attitudinal step, named the motor attitude because of its mediatory role between stimulus and motor activity, also preceded and influenced the subjective experience of emotion. Thus, it was the momentary awareness of the motor attitude which resulted in the experiential feeling of the emotion. Hence, a sad feeling of wanting to cry was preceded by an attitude of readiness to cry. The motor attitude was equated with facial or postural activity producing the feeling which in turn lead to the action. The idea of postural activity determining action was congruent with the work of James (1884). James proposed that the action precipitated the feeling, e.g. crying resulted in the feeling of sadness. Nina Bull modified this sequence by suggesting that the feeling (e.g. of being sad and wanting to cry) precedes the action (e.g. of actually crying). The process of emotion is shown in the following diagram (Bull, 1951, p.9);



As mentioned above, the expression of emotion begins with the motor attitude (X) and is viewed as a separate stage to the expression of emotion through action (Y and Z). The motor attitude represents the postural preparations which activate the reflex or involuntary responses of the body. Once the individual becomes aware of this motor attitude, that is to say, once the organic sensations precipitated by the motor attitude reach consciousness, the emotion is felt as a readiness to action. It is at this point that the intention to act is realised, i.e. approach-avoidance or fight-flight. This sequence of events is irreversible and set in motion by an affective stimulus impinging on a predisposing neural network. In other words, each step in the sequence depends on the preceding step, if the active process of emotional expression is to be fulfilled. The interpersonal communicative aspects of expression seen through bodily and facial movements, are also organised at stage X (the motor attitude) and activated by stage Y (feeling) and Z (action). Not all stimuli, impinging on the neural set, result in motor activity however. Conflicting motor attitudes, seen mainly in the unpleasant emotions, interrupt the flow of the sequence by confusing the feelings experienced, hence delaying motor activity or suppressing it altogether. For example, some psychiatric disorders are considered to begin in this way.

1.3.2. Neurophysiological Theories and their Contribution to the Discrete Emotions

Thus, with the exception of Nina Bull and Floyd Allport, there appeared to be no awareness in mainstream psychology in the first half of this century, as to the complex and unique nature of emotional processes. The gradual appearance of neurophysiological evidence, suggesting the existence of neural and sensory pathways which functioned to transmit experiential information, inspired other psychologists to explore further the structure of emotion.

James (1884) was the first psychologist to differentiate between what he termed the "standard" emotions using a neurophysiological approach. He theorised that following the perception of a stimulus, the bodily responses activated were expressed as the emotion. According to James, perception was instigated by afferent impulses from the sensory organs, passing through the cortex and resulting in reflex impulses transmitting messages to the muscles and the viscera. The feedback from the muscles and viscera in turn reach the cortex and the emotion is experienced. In other words, it is the conscious awareness of this feedback at the cortical level which produces the emotion rather than the cortical activity produced by the impulses sent from the muscles. The latter process was seen to produce the "feeling" which James disassociated from the emotion proper. If these neural impulses on the cortex (i.e. feeling) did not achieve consciousness, then the emotion was not felt.

James' theory centred on the role of the glandular and visceral activities in the expression of emotion. However, he conceded that the face and postural responses also had a major function in the emotion process. He noted that each emotion had a unique bodily expression eventuating in a discrete emotional reaction, expressed by facial and postural responses. These were seen in two broad categories, namely, the coarse expressions and the subtle expressions. Grief, fear, rage and love fell into the former category and feelings generated by such stimuli as colours and music or intellectual interest and excitement (seen to exist independently of emotion) were associated with the latter category.

James' organic theory influenced the physiological approach to the study of emotion for sixty years and played a role in some of the contemporary formulations of Izard (1971) and Tomkins (1962, 1963). Cannon (1927), however, refuted James' hypotheses on 5 grounds;

1. <u>Total separation of the viscera from the central nervous system does not alter emotional behaviour (Cannon, 1927, p.108)</u>.

One of James' assertions was that the emotion felt was dependent on the preceding organic sensations. Cannon's evidence opposing this view was taken from an experiment conducted by Sherrington (1900) on dogs, where all neural connections to the glandular-visceral organs were severed. The findings showed that a lack of response from the viscera did not alter the emotional behaviour of these animals. Similarly, Cannon, Lewis and Britton (1927), experimenting on cats, found that their emotional behaviour was unaffected after the removal of the entire sympathetic nervous system.

2. <u>The same visceral changes occur in very different emotional states and in non-emotional states (Cannon, 1927, p.109)</u>.

According to Cannon, the viscera were not equipped with the variety of responses to account for the number of diverse emotional reactions. For example, bodily sensations influenced by visceral changes such as quickening of the heartbeat, perspiration and erection of body hair, readily occur during such different emotional states as fear and anger and similarly during non-emotional states such as fever and asphyxia.

3. The viscera are relatively insensitive structures (Cannon, 1927, p.111).

According to Cannon, emotions were felt not by forces impinging on the viscera, but by the sensations produced due to the effects of the cardiovascular system.

4. Visceral changes are too slow to be a source of emotional feeling (Cannon, 1927, p.112).

Cannon acknowledged the speed with which skeletal muscles acted, but he noted that this was not the case for the smooth muscles associated with the viscera. The long latent responses of these muscles ruled out their involvement in emotional production (Wells, 1925; Wells and Forbes, 1911).

5. Artificial induction of the visceral changes typical of strong emotions does not produce them (Cannon, 1927, p.113).

Cannon indicated that the injection of adrenalin into the body functioned in such a way so as to mimic the sensation of the presence of a strong emotion (but he did not specify which one). Thus, mimicking the function of the visceral organs in this way, if true to James' theory , should lead to the awareness and experience of an emotional episode. However, Maranon (1924) found no evidence to support the above statement, although he noted that some knowledge of one's state was achieved by his subjects, but it was not accompanied by the appropriate emotional feeling. For example, after the injection some subjects reported feeling as if they were about to cry without knowing the reason for this feeling.

The five criticisms presented above attack James' theory which proposed that the direct action of the visceral-glandular organs detemined the emotion. Furthermore, Cannon refuted James' view that the facial and postural feedback to the cortex influenced the expression of emotion. According to Cannon, this function was subserved by the activity of subcortical centres, in particular the thalamus which generated the physiological impulses necessary for emotional expression. He described a sequence in which a stimulus impinging on receptors directed neural activity towards the cortex. Conditioned cortical neurones then sent messages to the thalamus, where special combinations of neural impulses resulted in certain emotional responses. The information sent out by the thalamus affected muscles and viscera, but there was also feedback to the cortex via afferent pathways. Thus, the emotion was felt and expressed simultaneously with the neural discharge from the thalamus. Whereas James postulated that the feedback from the peripheral organs determined the emotion, Cannon regarded these structures as lacking the quantity of patterns needed to produce the discrete emotions. The thalamic neurones, on the other hand, combined in a variety of ways, so as to contribute to the unique character of each emotion.

Allport (1924) extended James' organic theory of emotion and incorporated a modification of Darwin's three principles into his theory of facial expression. He anticipated Cannon's concern in attributing the expression of emotion to what he also considered was the slow reaction of the glandular-visceral organs. Instead, he proposed that discrete facial expressions and the associated body movements were achieved by the rapid feedback from facial and postural activity to the cortex. Allport considered there were two broad categories of facial expression: pleasant and unpleasant. These were considered as the affective element of the emotions. However, this classification did not differentiate between the discrete expressions associated with the different emotions within the same affective category. According to Allport, the underlying physiological process evoking the relay of sensory information (impinging on facial, postural and visceral organs) to the cortex was the emotion. The emotion was registered as either pleasant or unpleasant, depending on the activation of the parasympathetic or sympathetic nervous systems respectively. At this stage, the unique feeling of fear or anger for example (both unpleasant), had not yet been differentiated. Hence thus far, Allport's theory resembled the original theory put forth by James (1884). Allport's theory progressed however, to include the feedback from facial-postural activity, as the differentiating factor in the experience of a discrete emotion.

The facial features associated with the two affective categories (and a neutral category) were as follows:

1. Pleasant

This category included the smiling, laughing, joy and love expressions. Typical facial movements were widening of the mouth, open or closed mouth, corners of lips raised, relaxed forehead, open eyes.

Neutral

2. Unpleasant

The unpleasant emotions were separated into 4 major groups:

Pain-Grief;

Pain, characterised by a wrinkled forehead, raised inner eyebrows, narrow eyes, mouth slightly open and stretched.

Grief, characterised by the drooping of the corners of the mouth raised inner eyebrows, narrow eyes.

Surprise-Fear;

Surprise, characterised by eyes widened, eyebrows arched, open mouth.

Fear, characterised by oblique eyebrows, wide mouth, dilated nostrils.

Anger, characterised by inner eyebrows downward and close together, open staring eyes, lower lip extended downwards with teeth exposed, dilated nostrils.

Disgust , characterised by protruding lower lip, narrowing of mouth and nose upwards, open eyes, upper lip may open on one side to reveal teeth.

These groups represented the fundamental emotion types, but they also included a variety of related facial expressions under their headings. For example, the pain-grief group incorporated the expressions of despair and sorrow. The surprise-fear group included amazement, dismay and disillusionment and the anger group involved annoyance and irritation. Under the heading of disgust, such similar expressions as contempt, sneering and scorn were grouped. Thus, by limiting the discrete emotions to these six groups, a classification of emotions was made possible, but many between group and within group combinations were also recognised.

Allport's theory was interpreted within the general framework of Darwin's three principles. Beginning with the third principle, i.e. activity of the nervous system, he concluded that emotional expression was achieved by the activation of the autonomic nervous system. Secondly, the principle of antithesis was reinterpreted as the antagonistic activity between the sympathetic and parasympathetic divisions of the autonomic nervous system. The result of these physiological responses manifested itself as the discrete facial expression. The principle of serviceable habits was also modified slightly. Allport accepted the genetic transfer of reflexes important for the survival of the species. The facial movements in disgust or rage were passed on as significantly important reflex actions, but he did not accept that the expressive function was inherited. Instead, the direct relationship between the reflexes and expression was seen as developing ontogenetically, as the individual interacted with his continuously changing environment.

Finally, Gellhorn (1964) also addressed the problem of the structure of emotion within a neurophysiological framework. According to Gellhorn, the role of the hypothalamus, in particular the reciprocal balance between posterior hypothalamic activity and anterior hypothalamic activity, was the focus of emotional processing. Gellhorn proposed that an increase of proprioceptive impulses stimulating the posterior hypothalamus leads to increased cortical excitation, and in turn, to increased sympathetic activity. Activation of the anterior hypothalamus on the other hand, decreased cortical involvement and activated parasympathetic responses. The balance of activity at this site, affected by direct or indirect excitation, influenced the cortex, which in turn resulted in changes to somatic structures, thereby manipulating the process of emotional expression.

According to Gellhorn, the face played a vital role in the communication of emotion. Just as the proprioceptive discharge from the hypothalamus was directed upwards to the cortex, it may have also been directed downward to the facial muscles. The sheer number of proprioceptive and cutaneous discharges in the facial region and the resulting varied elicitation of hypothalamic-cortical excitation, accounted for the diverse range of expressions seen in the discrete emotions. Gellhorn concluded that perception of emotion and expression were the direct result of the contraction of facial muscles, producing proprioceptive and cutaneous impulses which facilitated the interaction between the hypothalamus and the cortex. A variety of cortical patterns emerge which lead to the different expressions of the discrete emotions.

To summarise, Darwin's (1872) third principle acknowledged the role of neural activity in the expression of the emotions, however, his focus on the evolutionary precursors of expression, mainly following on from the first and second principle, contributed to his lack of theorising on the neural antecedents of expression. The neurophysiological approach to emotion emphasised the nervous system, in the main, the sensory pathways to the brain and brain activity, localised and/or general, resulting in the experiential and motor qualities of the discrete emotions.

James (1884) was the first scientist to hypothesise about the relationship of the nervous system to the subjective quality of emotion (Izard, 1971). He advocated the existence of a feedback loop between the muscles, viscera and cortex which activated the emotional experience.

Cannon's (1927) critique of James' hypothesis questioned the role of the visceral-glandular organs in the production of the emotions on five grounds. Firstly, Cannon provided evidence to suggest that the experience of the emotion was unaffected even when neural connections to these organs were severed and that artificial induction of visceral activity did not result in the expected emotional pattern. Further criticisms attacked the specificity (or lack of it), sensitivity and the speed of visceral reaction. The thalamus was presented as the chief site of emotion differentiation.

Allport extended James' view by including the face, specifically emphasising facial-postural activity, as the important factor in the experience of a discrete emotion. Gellhorn's (1964) approach nominated hypothalamic activity in cortical excitation leading to the expressive display of emotion. It was the assimilation of the neurophysiological and psychological disciplines which reaffirmed the importance of emotion as a pheneomenon worthy of further study. More importantly, this association drew attention to the face as the key site for the experiential display of emotion and paved the way for a new branch of evidence emphasising the role of the face in emotion processing. This is the topic to be considered in the next section.

1.3.3. The Facial Feedback (FFH) Hypothesis

Darwin had earlier hypothesisised that;

"*the free expression by outward signs of an emotion intensifies it. On the other hand, the repression, as far as possible, of all outward signs softens our emotions*" (1872, p.22).

James (1890) considered the importance of muscular feedback in the experience of emotion. However, Cannon's (1927) scathing critique of this peripheral theory of emotional experience, largely discredited the James theory of emotion in general, and the feedback theory in particular. A revival of the feedback hypothesis began with Tomkins (1962) and Izard (1971), with the realisation that facial muscular feedback was not subject to the same criticisms as Cannon had proposed for the visceral responses of the body (Tourangeau & Ellsworth, 1979).

1.3.3.1. Tomkins' Theory of Emotion

A considerable body of work and one which has influenced the theoretical framework of subsequent researchers in the field of emotion, arose from the influence of Tomkins' two volumes of "*Affect, Imagery and Consciousness*" (1962, 1963). Tomkins reattributed humans' primary motivational function to the emotions, which he noted were grossly ignored with the advent of Behaviourism, or if mentioned, were relegated as a function of the drive system. Although Spencer (1890) had previously alluded to a difference between the drive system and emotion, it was Tomkins who emphasised this distinction and based his theory of affect on the interaction and separate functions of the two systems.

Tomkins argued that our primary motivational system was comprised of affects. The drive system had a secondary role and indeed, to reach a certain motivational level, relied on the activation of the emotions, which in turn amplified the drive system. The basic differences were seen to be in the affect system's ability to control a drive signal either by acting as a catalyst or an inhibitor and in its motivational power in the absence of a drive signal. The notion of the drive system acting as the primary motivating force has been popular due to its biological and reproductive significance. Through the sex drive for example, humans reproduced over time and the hunger drive motivated the quest for food. According to Tomkins, the motivating information provided by the drive system was vital to one's well being. However, the affect-drive interaction and the controlling function the former has over the latter assured one's survival over time. The human organism, in short, was governed by the interaction between the affects and drives and also by their joint interaction with other biological and neurological mechanisms. This distinction and interrelationship represented the most fundamental premise of Tomkins' theory.

His second contribution to the study of emotion was his view that the face acted as the primary site for the expression and identification of the emotions. When a facial response was consciously received, via a feedback mechanism to the brain, only then was awareness of that emotion complete. According to Tomkins, each affect had a specific activation network which was innate and when aroused at inherited subcortical sites, influenced facial and bodily responses. In other words, pain and distress responses, such as the cry for example, were not learned, but were the result of the intensity or activity of neural firing, which was caused by internal or external forces. The density of neural firing was graded, therefore reinforcing or punishing depending on the "*product of the intensity x the number of neural firings per unit time*" (Tomkins, 1962). Increased neural stimulation led to both positive and negative emotions such as interest (slight gradient), or fear, startle (steep gradient), whilst a low level of neural firing resulted in a positive affect, usually resulting in a smile (slight gradient). A relentlessly high level of stimulation activated the negative affects such as distress or anger (constant steep gradient). It is this increase, constancy, or decrease in the density of neural firing which sensitised the individual to (a) new messages, (b) those which continue for a period of time, and (c) those which no longer exist.

Tomkins identified eight primary emotions; two were positive, five were negative and one was a resetting or neutral affect. All were delineated by the facial expression evoked during facial and postural activation. The eight emotions were:

1. Interest-Excitement, positive, eyebrows turned downward, eyes fixed or tracking an object.
2. Enjoyment-Joy, positive, smiling with outer ends of lips raised.
3. Surprise-Startle, resetting, raised eyebrows and an eyeblink.
4. Distress-Anguish, negative, corners of mouth turned downwards and eyebrows arched.
5. Fear-Terror, negative, marked eye opening and fixed stare.
6. Shame-Humiliation, negative, eyes and head lowered.
7. Contempt-Disgust, negative, upper lip raised slightly. (In a later paper (Tomkins, 1982) contempt and disgust were treated as separate affects, i.e. contempt, as above and disgust, as protrusion and lowering of bottom lip).
8. Anger-Rage, negative, frowning, tightening of jaw.

A subsequent revision of the theory led Tomkins (1978) to modify 4 important points. Firstly, the amplifying function of the affect system has been reformulated and specified in terms of its analogous role in simulating the effect on bodily responses caused by the triggering stimulus. In other words, affect, in acting as an analog amplifier, magnified and prolonged the duration of the body's reaction to the activating stimulus. Secondly, Tomkins (1978), acknowledging the importance of the face as the central site of emotion release, emphasised the role of the skin, over and above the previously noted muscles, as the major contributor to affect production. The third modification of Tomkins' earlier theory is peripheral to this thesis and pertained to the role of breathing and vocalisation in the experience of emotion. Finally, Tomkins' original theory that the affect system and resultant behavioural outcome were mutually exclusive occurrences has been reconsidered and modified to result in the exact opposite assertion, i.e. that affect not only amplified its activator but also amplified the response as well. Support for Tomkins' theory is evident in the subsequent works of Izard and Ekman, who provide experimental evidence for the existence of a certain number of emotions and expressions considered to be innate and which can be delineated by separate and unique facial actions.

1.3.3.2. Izard's Theory of Emotion

Izard (1971), in his attempt to formulate a truly comprehensive theory of emotion, maintained that it was not enough to emphasise any one psychological construct or bodily process. Instead, he advocated an integration of all the mechanisms involved which, although leading to a very complicated and intensive model, would facilitate the clarification and definition of emotion as well as lending itself to consistent psychological review.

Izard's classification of emotion was embedded in his much broader theory of personality, and was seen to influence personality through its relationship with four other subsystems, viz, the homeostatic, drive, cognitive and motor components of the individual. The first two systems, i.e. homeostatic and drive were not believed to influence personality to a great extent unless their functioning was impaired. Emotion was considered to be the primary motivational system, influenced by cognitive and motor processes which were dependent upon an efficient nervous system, ultimately leading to personality and behavioural states and traits.

According to Izard (1971), emotions were activated in the nervous system by neurochemical substances which acted on the facial and postural muscles. It was the transformation of these activities into conscious meaning that resulted in individual emotions, which were innate and phenomenologically unique to the individual. Nine such fundamental emotions were differentiated; joy, contempt, distress, disgust, anger, fear, surprise, interest and shame. Interestingly, these categories were not very different from the ones proposed by Darwin (1872) late last century. The existence and interrelationship of these nine emotions provided the principal thrust of Izard's "Differential Emotions" theory. Another major focus of this theory was the role played by the face in differentiating between the emotions. The importance of facial patterning was two-fold. Firstly, the feedback from the face to the brain resulted in the discrete emotions and secondly, in an evolutionary sense, the face has become the major source of emotion communication, proceeding phylogenetically up to humans. Each of the fundamental emotions has its own characteristic facial expression which provided information to others of the emotional state of an individual. The facial activity associated with each of Izard's nine emotions was as follows;

1. Joy, bright eyes, mouth usually open to reveal teeth, outer corners raised.
2. Contempt, one eyebrow raised, narrow eyes, protrusion of lower lip and one side of upper lip raised.
3. Distress, eyebrows together, narrow eyes, mouth corners down.
4. Disgust, nose wrinkled, eyes narrow and raising of the upper lip
5. Anger , eyes open and staring, teeth clenched, nostrils flared, mouth tightly pulled back.
6. Fear, raised eyebrows, open eyes, open mouth.
7. Surprise, eyes open, mouth open, raised eyebrows usually.
8. Interest, eyebrows lowered or elevated, lips may separate, open staring eyes.
9. Shame, inner eyebrows lowered, eyes looking down, protrusion of lower lip and lowering of the head.

In sum, Tomkins (1962) proposed that emotional experience was determined primarily by the expression of the facial muscles and similarly, Izard (1971) and Gellhorn (1964) postulated, in simple terms, that the action of the face activated the nervous system leading to the subjective experiential quality of affect. Although the causal mechanisms involved in the expression of emotion were largely theoretical and subject to debate, the central common tenet held by the above authors was the role played by the face in the production of the "felt" emotion and behaviour. The facial feedback hypothesis, borne out of the quite different approaches of Tomkins, Izard and Gellhorn, assumed that the emotional expression in the face affected the emotional response of the body. Moreover, the facial expression acted as a predictor for the experiential quality of the stimulus.

1.3.3.3. The Facial Feedback Hypothesis: The Evidence

The strongest empirical evidence in support of the facial feedback hypothesis came from a study conducted by Lanzetta, Cartwright-Smith and Kleck (1976). In a series of experiments, subjects were asked to (1) inhibit their anticipatory responses to a number of shock intensities, while a second group of subjects observed and rated the perceived intensity of the shock presented (2) exaggerate the level of pain induced by the shocks, similarly, before a group of onlookers judging pain intensity (3) pose an anticipatory pain response which was immediately followed by either intense shock or no shock. This latter condition primed the subject to pose the appropriate response by presenting two lights prior to the stimulus, i.e. a red light indicated an intense pose for no shock while a green light indicated an inhibitory response followed by a moderately painful shock. In all of the above trials, it was found that the facial expressions contributed to the emotional response of the subject, in terms of self-report and physiological measures. The authors regard their results as offering support to the facial feedback hypothesis.

Kleck, Vaughan, Cartwright-Smith, Vaughan, Colby and Lanzetta (1976), introduced the presence of a second person and observed the expressive displays of subjects as they were subjected to painful shock stimuli. Assuming that an onlooker's presence would inhibit facial expressions of pain in an individual (Izard, 1971), the authors found that physiological indices of arousal varied if the facial expression of pain was inhibited, as opposed to it being freely displayed by the subjects. The authors found concordant responses from the self-report measures and skin conductance responses, thus supporting the facial feedback hypothesis.

Interestingly, while not testing the facial feedback hypothesis directly, Schwartz, Fair, Salt, Mandel and Klerman (1976a, 1976b) provided evidence for the existence of covert expressions during an emotive imagery condition, whilst assessing the differing muscle actions in the face of depressed people versus a group who were not depressed.

At a time when it seemed that the facial feedback hypothesis advanced by Tomkins and Izard was gaining some acceptance from the empirical evidence appearing in the literature, Tourangeau and Ellsworth (1979) published a paper reporting no relationship between facial expression and subjective experience. The experiment was designed to test and clarify three important issues raised by the facial feedback hypothesis. Firstly, the issue of necessity, which as an extreme implication of the theory, claimed that emotional experience was not possible without the appropriate facial expression. Secondly, the sufficiency hypothesis which predicted that facial activity alone was sufficient to cause an emotion, implying that posed expressions with no emotional intent, may equally lead to an emotional experience. Finally, Tourangeau and Ellsworth examined whether the degree of facial expression and emotion reported were correlated positively, in a monotonic relationship.

An experiment was conducted in which subjects were exposed to sad, fearful, or neutral films while asked to manipulate their facial actions, so that they unwittingly posed an expression of sadness, fear or a neutral grimace respectively. The results showed that facial expressions were not necessary or sufficient for the experience of emotion and moreover, a correlation of zero was obtained between the facial expressions exhibited and the emotion experienced.

The disconfirming results of the Tourangeau and Ellsworth study resulted in a defensive response from the major exponents of the facial feedback hypothesis. Tomkins (1981) was the first to comment on the findings of the previous authors by disclaiming the hypothesis tested by Tourangeau and Ellsworth, on the grounds that his own theory of emotional expression was based on spontaneous expressions and not the manipulated facial actions used by Tourangeau and Ellsworth. Similarly, Izard (1981) claimed that the version of the facial feedback theory examined in the Tourangeau and Ellsworth study was discordant with the feedback theory which he espoused as part of the larger Differential Emotions Theory. Hager and Ekman (1981) commented on several methodological flaws inherent in Tourangeau and Ellsworth's experimental design and emphasised the techniques which should be used to measure facial expression. With these replies, Tomkins, Izard, Hager and Ekman believed they had discredited the findings of Tourangeau and Ellsworth.

The debate regarding the role of facial feedback in the elicitation of emotional feeling came full circle with the reply of Ellsworth and Tourangeau (1981), who reacted with some amusement at the attention that their original paper received, although commenting on the lack of empirical evidence produced by their critics to justify their negative responses.

Leventhal and Tomarken (1986) considered the difficulties involved in testing the facial feedback hypothesis, and discussed the possibilities associated with the inconsistent findings obtained by Tourangeau and Ellsworth. It was suggested that the major difficulty was with the ambiguity surrounding causal mechanism and feedback pathways. Leventhal and Tomarken claimed that these two issues were not adequately addressed by the facial feedback hypothesis. Secondly, there was the possibility of the operation of demand characteristics, i.e. at any time during the experiment, subjects may have identified the purpose of the study, which in turn affected their spontaneous emotional responses (cf also Buck, 1980). Thirdly, the subjects in the Tourangeau and Ellsworth study were asked to maintain their expressive display for two minutes, a period of time considered too long to maintain an effective spontaneous bodily response. Finally, Leventhal and Tomarken questioned whether the intensity of the expression was concordant with the intensity of the emotion, pointing out that if this was not the case, then the feedback process might be disrupted.

Kraut (1982) tested the difference between spontaneous and posed expressions and their relationship to the facial feedback hypothesis. Subjects were videotaped while reacting to a variety of olfactory stimuli. Spontaneous and posed expressions were obtained from each subject. Each participant rated the odour on a 7 point scale, with pleasant scent and unpleasant scent at the extremes. The videotaped facial expressions were rated for degree of pleasantness by a separate group of judges. The results supported the facial feedback hypothesis, as subjects rated pleasant odours as more pleasant while expressing a pleasant expression, than they did when displaying an unpleasant expression. Furthermore, spontaneous facial expressions were more frequently associated with concordant ratings of the odour, than were the posed facial expressions.

Buck (1980) suggested that one reason for the inconsistent findings in the analysis of the facial feedback paradigm was that the experimenters failed clearly to identify the version of the feedback hypothesis which they were testing. For example, Buck stated that there were two versions of the facial feedback hypothesis, namely, the "between-subjects" version and the "within-subjects" version. The former compared the responses of several subjects in varying conditions, taking individual differences into account, while the latter examined the behavioural and physiological responses made by one subject. The between-subjects theory implied that an expressive subject would be more responsive on facial, physiological and self-report measures, as compared to a non-expressive subject (i.e. a trait response). The within-subjects hypothesis predicted an expressive subject would have stronger emotional responses across all indices when they were being expressive rather than when they were non-expressive (i.e. a state response). Buck concluded from his review of the literature that many of the studies examining the facial feedback hypothesis have used the within-subjects design, with very few designed to test the between-subjects version (see Adelmann and Zajonc (1989) for a comprehensive review of these studies).

Kleinke and Walton (1982) conducted an experiment designed to investigate the "between-subjects" version of the facial feedback hypothesis. A group of subjects were randomly allocated to one of four groups: smile reinforced, smile-instructed, smile simulation and control. The subjects were told that they were participating in a biofeedback procedure. Members of the first group were reinforced for every smile produced during the course of an interview, but were led to believe that the green feedback light represented their ability to adapt to an interview situation. They were encouraged to achieve "green light" status, as the number of times it appeared and its duration were indicative of the coping skills of the subject during the interview. The other groups were given noncontingent reinforcement and told to smile whenever a blue light was flashed. At regular intervals, the subjects were asked to indicate how they were feeling by pressing one of the five buttons representing very positive feelings, somewhat positive feelings, neutral feelings, somewhat negative feelings and negative feelings. The results indicated that the smile reinforced group had more smiling responses than the other groups and also registered a significantly greater number of positive feelings as indicated by the button presses. These findings were interpreted as providing positive support for the "between-subjects" version of the facial feedback hypothesis.

It is important to note here that while Tourangeau and Ellsworth found no relationship between facial activity and emotional experience, there had been an early study which did find a negative relationship between expression and emotion. Jones (1935) labelled individuals who were capable of marked facial expressivity while simultaneously registering a low autonomic reaction, as "externalisers". Likewise, those persons who had low overt expressive responses matched with high autonomic activity were called "internalisers". Buck (1979) reconciles the facial feedback approach and the externaliser-internaliser dimension by referring back to the methodologically different between-subjects versus within subjects approaches to the relationship between facial expressiveness and autonomic arousal. He suggested that the facial feedback theory uses the within subjects or state approach, emphasising the positive relationship between expression and emotional response for a particular individual. The externaliser-internaliser theory on the other hand, is a between-subjects or trait approach which according to Buck (1979) is more likely (than the former) to yield a negative relationship between facial action and physiological response as it measures activity across a number of subjects.

Zuckerman, Klorman, Larrance and Spiegel (1981) conducted an experiment which was designed to simultaneously test the validity of the facial feedback hypothesis and the externaliser-internaliser dimension. Subjects were asked to inhibit (group 1) or exaggerate (group 2) their facial expressions while viewing a series of pleasant, unpleasant and neutral films. A third group was given no instruction about their facial display, in an effort to record their spontaneous facial behaviour. Physiological measurements were recorded and self-report questionnaires were administered. The results confirmed the facial feedback tenet that facial expressions, self-report and autonomic responses corresponded concordantly. There were no significant findings in support of the externaliser-internaliser dimension however.

Laird (1984) argued that the number of studies attempting to clarify the issues raised by the facial feedback hypothesis resulted in a majority of confirming results, at the rate of ten to one. He differentiated between the two approaches in the assessment of the facial feedback paradigm. Firstly, there was the "muscle by muscle" procedure, which required the subject to pose an expression by moving the facial muscles according to the experimenter's instructions. Secondly, the "exaggerate/minimise" approach, where the subject was asked to over-emphasise or inhibit their facial expressions, usually to mask their true emotion from an observer. A confounding factor in experimental designs of this type, was the use of the between-subjects paradigm versus the within-subjects paradigm.

Laird (1984) concluded that the majority of experiments conducted in this area have supported the claim that the feedback from the face determined the experiential quality of the emotion. Winton (1986), in a critique of Laird's (1984) work, declared that Laird failed to make a clear distinction between the categorical and dimensional versions of the facial feedback hypothesis. According to Winton, Laird's conclusion that "*the facial feedback effect had been demonstrated with a wide variety of emotions, including anger, happiness, sadness, fear, pain, and humour*" (p.914), implied empirical support for the categorical version of the facial feedback hypothesis, a claim which he felt was unwarranted. In fact, in reviewing the studies quoted by Laird, Winton found that six of the seven studies actually examined and supported the dimensional version of the facial feedback hypothesis.

Matsumoto (1987) questioned Laird's conclusions in the light of what he considered to be methodological problems associated with the 18 published articles reviewed by Laird. Two major issues which were highlighted included firstly, the validity of the expressive displays in terms of distinctiveness, intensity and duration of expression, degree to which expressions may change during a display and methodology chosen to induce the facial expression, across all subjects. Secondly, Matsumoto raised the question of whether only the emotion intended to be induced actually was. Using a meta-analytic technique on the same 18 studies, Matsumoto concluded that only 11.76% of the variance associated with the subjective experience of emotion, examined by self-report measures, was attributed to the facial movement.

Similarly, Manstead (1988) also concluded that Laird's (1984) review may have overemphasised the support shown for the facial feedback theory. According to Manstead, Laird did not clarify the differences amongst the cited studies with regard to the hypotheses presented and tested. In his review of the facial feedback literature, Manstead discriminated between studies using the three hypotheses tested by Tourangeau and Ellsworth (1979) as reference points. Using this approach to reassess the facial feedback studies, Manstead reported almost no empirical support for the necessity hypothesis and partial support for the sufficiency hypothesis (see above for definitions of these hypotheses). Indeed, Manstead found that the majority of studies which supported the facial feedback theory were actually testing the monotonicity hypothesis, suggesting that there was a relationship between the emotional expression and the intensity of the emotional response.

Other explanations for the inconsistent findings of various studies in this area included (1) posed expressions versus spontaneous expressions (Tomkins, 1981); (2) methodological difficulties (Hager & Ekman, 1981); (3) operation of demand characteristics (Leventhal & Tomarken, 1986); (4) within-subjects design versus between-subjects design (Buck, 1980); (5) categorical version of the facial feedback hypothesis versus the dimensional approach (Winton, 1986), and (6) muscle by muscle display of expression versus exaggerate-minimise expressive display (Manstead, 1988). Briefly, in further reference to the last point regarding facial manipulation, McCaul, Holmes, and Solomon (1982) suggested that changes in facial expression causing concurrent changes in autonomic activity may in fact be due to the effort involved in orchestrating facial movement rather than facial feedback directly. Their work showed that autonomic activity resulted from posed facial expressions but was not accompanied with any associated affect.

More recently, Strack, Martin and Stepper (1988) used a novel approach in a test of the facial feedback hypothesis. Their methodological design was such that subjects were able to manipulate their facial muscles so as to inhibit or express a smiling response without awareness at the cognitive level. The mediating effect of cognitive mechanisms in the expression of emotion has been accepted by some researchers (Laird, 1974, 1984) and rejected by others (Ekman, Levenson & Friesen, 1983; Izard, 1977; Tomkins, 1962), while some are unsure of the cognitive input in subjective experience (Zuckerman, Klorman, Larrance & Spiegel, 1981).

Strack, Martin and Stepper (1988) attempted to minimise the confounding effects of demand characteristics associated with the smiling response by distracting the subject with a task involving the use of certain psychomotor skills, designed to manipulate the facial muscles into expressions without the subjects' direct awareness. The purpose of the study was explained as an investigation of the subject's ability to use parts of the body, not usually employed while performing certain tasks. The experiment was couched in terms of evaluating a disabled bodied person's ability to continue functioning adequately when certain parts of the body have been impaired. The task emphasised in this study was their pen holding ability. Three conditions were examined; (1) holding the pen with the lips only, (2) with the teeth only, and (3) with their non-dominant hand. In each condition, the subject was provided with instructions of how to hold the pen. The instructions were written in such a way so as to obstruct the smiling response in the "lips pen-holding condition" and enhance it in the "teeth pen-holding condition". They were asked to rate a number of cartoons for the degree of humour they conveyed on a ten-point rating scale, using their limited co-ordinative movements. The authors interpreted their results as supportive of the facial feedback hypothesis as "*affective reaction toward an emotional stimulus was intensified when the facial expression was facilitated and softened when this expression was inhibited by an irrelevant task*" (p. 775). Furthermore, the findings implied the absence of cognitive awareness of facial feature positioning for the subjective experience of emotion.

Following this, Zajonc, Murphy and Inglehart (1989) conducted a series of experiments designed to measure the association between facial action and hedonic tone in the absence of subject awareness of facial "efference" (a term coined by the authors meaning emotional facial action). During a tedious process of reading stories and repeating certain specially picked phonemes (chosen as their pronunciation resembles facial actions (involving mouth and corrugators) made in some emotional expressions), subjects reported experiencing more negative feelings towards some words (those containing the phoneme ü) as opposed to others (non ü words). Similarly, positive affect was generated in the repetition of sounds like "e" and "ah" designed to stretch and open the mouth. The authors concluded in support of the facial feedback hypothesis that facial movement alone was enough to induce positive and negative tone.

In summary, the facial feedback hypothesis, originally introduced by James (1890) and later discredited by Cannon (1927), has been revived within the theoretical frameworks of Tomkins (1962), Gellhorn (1964) and Izard (1971). The central common tenet of these authors was their claim that the primary response to emotion involved facial action. Following on from this emphasis on the face, the facial feedback hypothesis proposed that the facial expression of an emotion was responsible for the appropriate physiological response of the body. Further evidence for a variation on the hypothesis is considered in a later section (i.e. 1.3.4.) as the work of Paul Ekman.

Most recently, Izard (1990) has presented a developmental theory to explain the relationship between facial expression and the subjective feeling of emotion. With this focus, he attempts to explain the incongruent findings in facial feedback research. Five principles comprise the developmental model and are considered to assimilate controversial issues concerning the experimenter manipulated, self-initiated and spontaneous expression studies. The first principle claims that the expression/feeling relationship is innate. The second principle names the evaluation, expression and experience states as the the components of emotion. Thirdly, maturational forces operating on neural and cognitive sources allow learning processes to influence the evaluation, expression and feeling process. The fourth principle concerns the development of control over expression display (i.e. the ability to pose expression or initiate expression), an ability which is considered to contribute to the fine tuning of the expression, feeling and action systems. Finally, developmental forces such as language acquisition, cognition and goal setting behaviours, impinge on the innate expression/feeling relationship, consistently altering its makeup, allowing the individual more control through learning in the regulation of the emotional experience. Thus, these assumptions assign an innate expression-feeling relationship which can and does alter ontogenetically. This model then presents one theoretical framework which through its five principles attempts to explain the evidence showing that facial expressions may determine and regulate the experiential process. Izard (1990) concludes however, that;

> "*research on the FFH should be interpreted as testing the hypothesis that expressive behavior is one means of activating and regulating emotion experiences. There is no reason to believe that emotion experience is always dependent on, and signalled by, observable expressions*" (p.496).

1.3.4. Ekman's Neocultural Approach to Emotion

A review covering the categorical approach to emotion would not be complete without a discussion of the work of Paul Ekman and his colleagues. In as much as Darwin (1872) is accredited with the introduction of research methods and their application to the study of facial expression in humans (and animals), Ekman has been largely responsible (along with Izard, 1971; and Tomkins, 1962) for returning the focus of emotion-related research back to its expression and display, namely the face.

Although not espousing a theory of emotion as such, Ekman acknowledged the important role played by physiological, motor and verbal responses to emotion eliciting stimuli. However, in his view, it was the facial expressions which differentiated between the emotions. The face has been shown to elicit accurate judgements of emotion through the observation of spontaneous and posed behaviour (Ekman, Friesen & Ellsworth, 1982) as well as providing consistent evidence for the universality of emotion across cultures (Ekman & Friesen, 1971).

Ekman's (1971, 1977, 1980) "neocultural" theory emphasises the biological and social contributions to the study of emotion. It is an attempt to integrate the inconsistent findings in cross-cultural research as to the existence of certain pan-cultural emotions. He defines emotion as follows;

> "*emotion refers to the process whereby an elicitor is appraised automatically or in an extended fashion, an affect programme may or may not be set off, organised responses may occur, albeit more or less managed by attempts to control emotional behaviour*" (Ekman, 1977, p.61).

According to Ekman (1977) an elicitor is a stimulus which is evaluated by the appraisal mechanism and is specific for a given emotion. Elicitors initiate the production of an emotion rapidly, and although there is no evidence for the existence of universal elicitors, commonalities amongst them do exist. The continuous appraisal of specific elicitors, through repeated exposure, accentuated the similarities amongst them. The appraisal system, similar to the one espoused by some of the cognitive theorists (Arnold, 1960a, 1960b; Lazarus, 1968), interprets the incoming stimuli as emotion specific and activates the affect programme. The affect programme is the storage mechanism (Ekman does not indicate a particular localisation in the brain), which contains the emotional responses. These reponse systems are innate but may be influenced by experience. They share common characteristics amongst the emotions in that they have a rapid onset, short duration and involve complex interactions of the skeletal, facial, autonomic, vocal and central nervous systems. The activity of these emotional responses incorporate the activation of the above systems. However, each emotion has its distinctive pattern of changes. The role of learning and experience in affect programming is evident when such cognitive processes as memories, images and coping techniques are activated. Hence, Ekman postulates the following process in emotional experience, "*automatic appraisal →affect program →emotional response*" (1980, p.84.).

The above process usually leads to the display of the intended emotion. However, incongruent information in the form of another emotion, may inhibit a particular response. In other words, the affect program may be halted, intensified, relieved or masked, by the existence within cultures of "display rules", which through habit, govern the appearance of an emotion in public (Ekman, 1971). There are cultural and personal display rules. The cultural display rules are set down by the particular society, while the personal rules are learnt by an individual as a way of coping with an emotional experience. It is the existence of these culture-specific display rules which Ekman (1971) contends explaines the contradictory findings in the literature as to the universality of facial expression. The example he provides is of the expression of grief at a funeral. One culture may display a typically sad face, hence amplifying the emotion, while another may mask their true feelings, displaying a happy or neutral expression. This observation could lead to the incorrect conclusion that the expression of grief was not universal, or that a happy expression was multi-functional. However, the acknowledgement of the existence of display rules and their role in coping with the emotional experience circumvent such misinterpretations.

The facial affect programme activates the responses which mobilise the facial muscles in the production of the distinct emotional expressions. Six emotions, characterised by unique facial appearances, have been identified (Ekman & Friesen, 1975). They are happiness, sadness, anger, fear, disgust, and surprise. Their facial configurations are as follows:

1. Happiness, lips stretched and turned upwards. Mouth may be open, exposing teeth, or it may be closed. Naso-labial fold from nose to each side of upward turned lip. Wrinkles form under eyes and outer corners of the eyes.

2. Sadness, inner eyebrows drawn together and turn upwards. Lips turn downwards and may be trembling.

3. Anger, lowered eyebrows and drawn together causing the appearance of vertical wrinkles between the eyebrows. Wide open, staring eyes. Mouth closed tightly or open stretching the corners outwards. Flaring nostrils.

4. Fear, eyebrows raised. Wrinkles appear on centre of forehead. Eyes open and staring. Open mouth.

5. Disgust, if open mouth then upper lip is raised and lower lip is lowered revealing teeth. If closed mouth then upper lip is raised and lower lip is raised and protruding. Wrinkled nose. Slight narrowing of eyes. Lowering of eyebrows.

6. Surprise, raised eyebrows. Wrinkles across forehead. Wide, staring eyes. Lower lip drops.

They are universal and consistently found in other theories emphasising the role of the face in emotional expression (Izard, 1971; Tomkins, 1962). In a later study, Ekman and Friesen (1986) included a seventh emotion, considered to be universal with its own unique facial expression, i.e. contempt.

7. Contempt, three contempt expressions have been proposed:

a. Unilateral, tightening and raising of lip on one side only.

b. Bilateral, ightening and raising of outer corners of lips.

c. Upper lip raised slightly.

The evidence for the universality of the expression of contempt has not been as supportive as in the other expressions. A study of ten cultures revealed that the unilateral expression of contempt was accurately judged in 75% of cases (Ekman & Friesen, 1986). Izard and Haynes (1988) have questioned the universality of the contempt expression as described by Ekman and Friesen (1986). To support their argument they raise findings from their own and other research which has shown the importance of cues other than those mentioned by Ekman and Friesen, particularly the eyes and the position of the head, in the appearance of the contempt expression. They considered that the universality of contempt based on the Ekman and Friesen description was unlikely due to its specificity.

However, Ekman and Heider (1988) produced further evidence for the universality of the contempt expression in a replication study with an Indonesian sample. In two experiments, one where the subjects judged American and Japanese displays of a series of expressions and the second where the Indonesian subjects judged a number of different expressions produced by members of their own nationality, it was shown that the contempt expression was consistently delineated from the other posed expressions.

At the same time, Ricci Bitti, Brighetti, Garotti and Boggi-Cavallo (1989) in a study using encoders and decoders from America and Northern and Southern Italy concurred with the significance of the upper face and what they termed "*extrafacial cues*" (p. 338) in the display of the contempt expression. They also found that all subjects decoded contempt more accurately if the encoder was from the same culture, and that contempt was often misjudged as happiness and not surprisingly, disgust. They discuss the importance of display rules in the display and recognition of this expression.

It should be noted that the facial configurations described above are for the pure appearance of these emotions. However, these emotions can combine to produce blend expressions. For example, surprise may appear with fear or anger, and happiness may blend with surprise. Secondly, the appearance of these emotions may vary depending on the intensity of the emotion experienced. For example, surprise may be slight involving a slight drop of the lower jaw, or extreme, where the mouth opens forming an "O" shape. Happiness varies in intensity reflected in the broad grin of a smile or an open mouth when laughing.

In a study providing supportive evidence for the facial feedback hypothesis, Ekman, Friesen and Ancoli (1980) examined the spontaneous facial expressions of a group of subjects while they watched a number of films designed to induce positive and negative affect. The subjects were also asked to indicate the intensity of a variety of emotions which they may have experienced whilst viewing the films. The authors found that facial action accurately complemented the subjects' subjective experience for the emotions of happiness and disgust specifically.

In a further study, Ekman, Levenson and Friesen (1983) examined autonomic nervous system activity in a group of subjects who were asked to pose facial expressions of emotion under strict instructions as to which facial muscles to move during the separate expressive displays. Another group were asked to relive a number of emotional episodes from their past for a duration of thirty seconds. The authors found increased autonomic activity associated with the former group of subjects. They also found that different patterns of autonomic activity were generated for the different emotions expressed on the face. They concluded that "*it was contracting the facial muscles into the universal emotion signals which brought forth the emotion-specific autonomic activity*" (p. 1210).

Furthering this line of enquiry, Levenson, Ekman and Friesen (1990) repeated the experiment where subjects were guided as to which muscles to move to produce the expressions of fear, surprise, anger, sadness, disgust and happiness while simultaneously measuring their heart rate, skin conductance, finger temperature and muscle activity. Their findings confirmed earlier results and showed differentiated autonomic activity for the various emotional expressions posed. In an extensive series of experiments with actors, facial researchers and untrained others as encoders, the authors found that autonomic activity differed between positive and negative emotions and amongst some of the negative emotions, regardless of whether the subject reported accompanied subjective emotional experiences. For example, fear and anger displays were accompanied by an increased heart rate, as well as higher finger temperature for anger as compared to the emotions of happiness, surprise and disgust. The autonomic specificity of emotional arousal further supports Ekman's theory for the existence of at least six fundamental emotions which have unique facial and physiological characteristics. These findings fit in well with his current theory of a centrally based organ directing impulses simultaneously to the facial muscles and the autonomic neural pathways.

1.3.5. The Cognitive Theories of Emotion

In direct opposition to the facial feedback theorists are those investigators who argue that the subjective experience of emotion cannot be felt without some prior cognitive intervention. The cognitive theorists do not have the face as their major focus which is the case with the proponents of the facial feedback theory and furthermore have more difficulty testing their theories empirically.

Historically, the major theories of emotion proposed (for example by Darwin (1872) and James (1884)) assumed, but did not emphasise, the presence of an evaluative component preceding an emotional response. Piderit's (1925) sensory theory of the origin of facial expressions introduced the notion of ongoing cognitive and sensory processes which influenced the activity of the facial muscles. Thus, a pleasant thought produced a pleasant sensory impression on the facial muscles, resulting in a happy expression, and vice versa, an unpleasant thought led to an unpleasant expression. Wundt (1877) had earlier seen the relationship between sensations and muscle activity in the face but failed to acknowledge the cognitive component in this process.

1.3.5.1. Cognitive-Appraisal Approach to Emotion

One major cognitive approach to the study of emotion has come from those theorists who propose that cognitions cause physiological and behavioural change. Arnold (1960a, 1960b) falls typically into this tradition as does Lazarus (1968, 1982; Lazarus, Averill & Opton, 1970). These two theories will be examined in turn.

1.3.5.1.1. Arnold's Theory of Emotion

Arnold (1960a) emphasised the existence of specific patterns of neurophysiological reactions associated with the discrete emotions, resulting in their specific facial and postural manifestations. The emotion was aroused, once the situation or stimulus had been perceived and appraised. Her definition of emotion was;

"the felt tendency toward anything intuitively appraised as good (beneficial) or away from anything intuitively appraised as bad (harmful). This attraction or aversion is accompanied by a pattern of physiological changes organised toward approach or withdrawal. The patterns differ for different emotions" (p. 182).

Arnold (1960a) was convinced that the earlier theories of emotion only went part of the way to determining its causes and effects. She acknowledged that the lack of neurological and neurophysiological knowledge in the nineteenth century contributed to the unexplained concepts in many of the early theories. For example, Darwin (1872) was unable to formulate a clear indication of the function of the nervous system in emotional expression. He recognised their association however, insofar as he hypothesised that an oversupply of nervous energy triggered off various physiological changes which in turn lead to the emotional experience. Similarly, James (1884) believed that the visceral changes occurring when a stimulus was perceived was the emotion. Yet on the other hand, Arnold maintained that many researchers were aware of the crucial questions (i.e. what caused emotion? and what were its effects on the individual and the environment?), but provided incomplete or unsatisfactory answers.

In her review of the earlier neurophysiological theories, Arnold concentrated on the theories which have contributed to her hypotheses on the neural mechanisms involved in the expression of emotion. Cannon (1927) and Papez (1937) were regarded as the forerunners in the discovery of important neural circuits which lead to emotional awareness. Although Cannon's thalamic theory has not been supported empirically, he was the first to recognise the involvement of the brain in the production of emotion. Papez (1937) presented a more detailed involvement of brain mechanisms for mediating emotion. Emotional experience depended on the integration of physiological and cognitive processes which took place in the cortex. According to Papez, a stimulus must be perceived and in that way become known to the individual, permitting a psychological and neurological reaction to take place. Emotional expression was the direct result of cortical and hypothalamic messages arriving at what Papez considered the receptive organ, the cingulate gyrus.

Arnold's aim was to document the emotion process from the very beginning, accounting for the psychological and neurological influences, eventuating in the ultimate emotional display. The first step in the sequence of events leading to a discrete emotion was the perception of a stimulus impinging on the sensory receptors. Attending to the object created an awareness of its form, in a general sense, i.e. its colour, smell, taste. It was the integration of these scattered sense impressions and their inclusion in the neural sequence of events which resulted in a reaction to the perceived object. Arnold maintained that;

> "*some functioning system was required that will use the integrated product of sense impressions, will mediate some awareness of its import, and will provide access to somatic and autonomic motor systems that carry out appropriate action, emotional expression, and autonomic changes*" (Arnold,1960b, p.30).

This functioning system was part of what Arnold referred to as the "estimative system" which consisted of a series of connections from the "*sensory receptors to the brain stem reticular formation, the intralaminar and midline thalamic nuclei and the cortex of the limbic lobe*" (Arnold, 1960b, p.34). When the sensory impulses reached the limbic region, the object was "appraised" in terms of its effect on the individual or through the individual's past experience with this object. This resulted in approach or avoidance behaviour brought about by a feeling of liking or disliking, but was not the emotion itself. According to Arnold, the psychological appraisal of any perceived object or situation leads to an action sequence affecting bodily responses that aroused the emotion. In other words, the perception-appraisal-emotion sequence leads to the emotion experience.

Once the situation was appraised and an evaluation of pleasurable or unpleasurable was made, an action sequence was activated. Before the choice of action was decided upon, previous experience with a stimulus or a similar situation may be recalled and the appropriate action taken. Recall of past experiences involved the activation of memory which in turn resulted in the appraisal of that action. The action circuit began with the hippocampus which integrated the impulses sent by the limbic system and relayed these messages via the fornix, to the hypothalamus, midbrain, cerebellum and frontal lobe. The action impulses converge and are organised in the cerebellum and relayed to the frontal lobe and hence into the motor cortex region. This leads to a "*pattern of movement which includes varied and often complicated motions, autonomic changes, and the facial and postural expressions that go with a given emotion*" (Arnold, 1960b, p.87). Arnold contended that the face and posture reflected the emotions. She was an advocate for the existence of discrete emotions and discrete physiological changes for the different emotions. The pattern of changes for each emotion was repeated when that same emotion was experienced e.g. the physiological effects of fear aroused the same pattern of responses when the emotion of fear was further experienced.

To summarise Arnold's theory, a stimulus is perceived and appraised for its effect on the individual by activating the memory of past experience with the stimulus. Recall of earlier actions detemined the action pattern instigated, which resulted in the display of the various discrete emotions through the muscular movement of the face and body.

1.3.5.1.2. Lazarus' Cognitive Theory of Emotion

Lazarus (1968) also stressed the importance of appraisal as the intervening cognitive component preceding any emotional expression. Before detailing his theoretical contribution, it is useful to present his criticisms of the motivational theories of emotion, some of which have been described earlier. Lazarus (1968) has five main objections to this viewpoint which dominated the emotional theories of Freudian, Hullian and even some cognitive theorists (e.g. Leeper, 1965).

According to Lazarus, the analysis of emotion in motivational terms was primarily responsible for its neglect as a separate entity, as it was consistently equated with such terms as motivation and drive strength. Lazarus attributed its survival to the constant work of physiologists and ethologists, and more recently, to the neuropsychologists. Secondly, the causes of the various discrete emotions were overlooked, as the emphasis was placed on the more observable behaviours produced by the emotions. Thirdly, the "emotion-as-motivation" concept restricted emotional theorising to such negative terms as fear and anxiety. The approach-avoidance paradigms of the behaviourists and Freud's preoccupation with neuroses were largely responsible for this. A fourth disadvantage of the motivational theories of emotion was its separation of the total emotional process into individual processes. Lazarus, on the other hand, argued for the co-operation of the cognitive, physiological and motor systems of the individual in producing any given emotion, rather than focusing on any one of these processes. As Lazarus was interested in the adaptive role of emotional processes, his final criticism refers to the fact that the motivational approach did not predict the adaptive reaction to an emotional condition. Furthermore, in the past, emotion attracted attention only in regard to its maladaptive role (as in anxiety in Freudian theory).

Following on from the "perception→appraisal→emotion" theory of Arnold (1960a, 1960b), Lazarus (1968) defined emotion as a response, resulting from cognitive processes of appraisal and evaluation. Furthermore, these responses were adaptive in nature and contributed to the survival of the individual. Emotional expression was dependent on the interaction of biological, cultural and cognitive forces. The biological dimension included physiological, motoric and phylogenetic interplay. Culture influenced the appraisal of a stimulus or situation, in terms of its importance to the individual, whether it be a new stimulus or one which has previously been experienced. Also, the facial and postural displays of emotion were determined by cultural rules, as were interrelationships and social behaviour. In considering the cognitive role in emotion, Lazarus contended that appraisal and reappraisal of an emotional stimulus determined its significance to the individual. Each emotion was appraised differently, and the response produced involved unique physiological and motor action leading to its display or inhibition. Once the stimulus was perceived and appraised (e.g. as threatening or neutral etc.), an evaluation of coping strategies available to the individual followed. Thus;

> "*In short, feedback from the continuous interplay between the conditions causing an emotion and the effects of efforts to cope with them changes the cognitions shaping the emotion reaction*" (Lazarus, 1968, p.219).

Lazarus' emphasis on the adaptive role of emotion consequently restricted him to a discussion mainly of the coping methods needed in threatening or potentially harmful situations. The options available were either to take direct action (e.g attack) or when this was impossible, reappraisal (cognitive), which could be realistic or distorted, and arouse or inhibit an emotional response. Emotions were continually fluctuating, leading to continuous appraisal and reappraisal, which in turn affected the physiological, cognitive and behavioural responses.

In support of his theory, Lazarus, Averill and Opton (1970) described four laboratory conditions in which the action of the cognitive processes of appraisal and reappraisal could be validated. The first research method involved the direct manipulation of the stimulus presented. For example, by showing a group of subjects a highly emotive film and also a neutral film, the autonomic and subjective responses of an individual were seen to fluctuate according to the appraisal made of the situation by the individual. Secondly, via indirect manipulation (since direct action was not possible), a situation was introduced where the subject was told to expect a harmful stimulus. The roles of appraisal and reappraisal were seen as cognitive attempts made by the subjects at coping with the anxiety which the anticipation time created. A third method used to evaluate cognitive appraisal processes after a stressful experience was to compare the self-reports of various individuals directly after their exposure to stress with the psychophysiological data obtained during the experiment. The fourth and final strategy of assessing individual cognitive strategies was in the selection of individuals with different emotional predispositions, for example, individuals from different cultural backgrounds.

Contemporary support for Lazarus comes from the related works of Frijda (1987), Ellsworth and Smith (1988) and Manstead and Tetlock (1989). These studies investigated the causal relationship between cognitive appraisal and the differentiation of emotional experience. Manstead and Tetlock (1989) asked subjects to relive the experiences created by the emotions of joy, pride, hope, anxiety, anger, shame, guilt and embarrassment. Each subject was asked to describe these emotional episodes in terms of ten predetermined cognitive appraisals, many of which have been found to be relevant in the differentiation of the emotions (Smith & Ellsworth, 1985). Manstead and Tetlock found that different cognitive appraisal techniques were associated with different emotional patterns. Four appraisal dimensions, namely, Pleasantness, Responsibility, Expectancy and Situational Control were found to differentiate convincingly between the above emotions.

In a study focusing only on the differentiation of the positive emotions, Ellsworth and Smith (1988) asked subjects to indicate the degree to which each positive emotion was characterised by the cognitive appraisals of effort, agency and certainty. Their results showed that six positive emotions, namely, interest, hope/confidence, challenge, tranquility, playfulness and love were differentiated by the degree of emphasis on appraisal in those unique emotional situations. Similarly, Frijda (1987) showed that cognitive appraisal techniques differentiated between the emotions. Furthermore, he hypothesised that the type of cognitive appraisal used by an individual would affect the action response of that person to any given situational occurrence.

In conclusion, the appraisal theories of Arnold (1960a, 1960b) and Lazarus (1968) have taken the emphasis away from emotion as an intervening motivating variable between stimulus and action, and concentrated on the cognitive aspects of emotion. In so doing, the qualitative differences among the discrete emotions have been recognised and attributed to physiological, cognitive and motor reactions.

Zajonc (1980) published a provocative review article including much of the literature which was in direct opposition to the view held by Arnold and Lazarus. He argued for the primacy of affect and the difficulty involved in proving that any cognitive process did indeed precede an emotional episode. The two phenomena, cognition and affect, were considered separate and orthogonal systems, and although may function in a co-ordinated manner, need not necessarily do so. Zajonc argued that Lazarus had incorporated the primacy of cognition into his definition of arousal, hence not leaving the cognitive process open for critical review.

Zajonc (1984) provided evidence from five different sources to support his argument for the primacy of emotion. Firstly, results from the ontogenetic study of emotional development showed that very young infants experience emotion in the absence of cognitive activity. Also phylogenetically, emotional display is regarded as an adaptive reaction in approach-avoidance behaviour in animals. Secondly, with regard to hemispheric specialisation, emotions are right hemisphere controlled while cognition appears to be co-ordinated by the left hemisphere. Thirdly, Zajonc cited evidence showing that responses from tasks designed to instigate cognitive activity were not correlated with the subjective experiences of emotion given by the subjects. Fourthly, there is evidence to suggest that new emotional reactions can be experienced without prior cognitive activity. Finally, there is biochemical evidence which indicates that emotional states can be activated by drugs or hormones in the absence of cognitive appraisal. The facial feedback theorists would argue here that mere facial muscle manipulation into an expressive pose would also lead to the subjective experience of emotion.

Zajonc (1984) gains further support from Izard's Differential Emotions Theory which states that "*limbic-cortical integrative processing of the sensory feedback from the face generates emotion experience without self-inference or any other cognitive attributional process*" (1984, p.23). This theory relies heavily on the evidence associated with the neurophysiological, behavioural-expressive and subjective-experiential systems. Izard (1984) proposed that the two systems may indeed function independently although the more likely outcome is that the brain accommodates the integration of these two systems into "*affective-cognitive structures*" (p.24) which become embedded in consciousness and function at a rate dictated by learning through the individual-environment experience.

Lazarus (1984) challenged the evidence presented by refuting many of the studies cited by Zajonc based on what he considered to be methodological flaws or problems of bias in the interpretation of some of the findings. Indeed, Lazarus reaffirmed his conviction for the primacy of cognition noting that it was as difficult to prove that cognitive activity was not present as it was to prove that it was.

1.3.5.2. Perceptual-Motivational Theory of Emotion

The second major cognitive approach to the study of emotion was the perceptual-motivational theory espoused by Leeper (1965). In his original formulation, Leeper (1948) presented an argument which distanced itself from what was regarded as the current experimentalist view of emotion, i.e. as a disorganising event, and instead, highlighted its organising function. He contended that the disorganisation theory of emotion had its origin in the prevailing era of rationalism where individuals were expected to be intelligent, rational and organised. This state of well-being was achieved by reducing emotional episodes and replacing them with logical thoughts. The idea of emotion as a disruptive force to the individual was perpetuated by those researchers who drew attention to only the negative emotions such as fear, anxiety and anger, which were indeed affecting bodily responses such as heart rate and respiration. However, these reactions to the various emotions were interpreted by Leeper as a demonstration (except in extreme cases) of organisation involving the visceral organs, behaviour and conscious awareness. Furthermore, he stated that the kind of emotion aroused predicted the direct action taken. For example, anger resulted in a particular behavioural, visceral and conscious reaction. In other words, each discrete emotion influenced behaviour in a way that was consistent with that emotional response which in turn would differ if another emotion was activated. In conclusion;

> "*emotional processes operate primarily as motives. It means that they are processes which arouse, sustain and direct activity*" (Leeper, 1948, p.17).

In his later work, Leeper (1965, 1970) extended his motivational theory to include emotions and motives as perceptual or cognitive processes. The emphasis was taken away from emotions resulting from visceral actions (James, 1884) and motives as phylogenetically lower level processes. Instead, the status of emotion was elevated through its connection with the perceptual domain, which connoted higher level cortical functioning. Leeper stated that although subcortical and visceral processes influenced the individual's thoughts and resulting actions, it was the cortical processes which were motivational. Furthermore, these cognitive representational processes were hypothesised to lie on a continuum producing emotionally neutral perceptions to emotionally intense perceptions.

In summary, Leeper rejected previous interpretations of emotions as disruptive, mainly negative events, which were restricted to visceral processes on the one hand (James, 1884) or physiological impulses on the other (Allport, 1924). Instead, his cognitive-motivational theory of emotion emphasised the organisational aspects of emotion (and motives) when a psychological situation was encountered generating cortical activity, which in effect, motivated and directed the individual's behaviour. Thus, emotional processes acted as the motivating force influencing thoughts, perceptions and actions.

1.3.5.3. <u>Cognitive-Arousal Theory of Emotion</u>

The third cognitive approach to emotion was the cognitive-arousal theory of Schachter and his colleagues (Schachter, 1966; Schachter & Singer, 1962), who argued that physiological activity aroused in an emotional situation would be labelled as anger, joy, or another emotion depending on the individual's cognitive evaluation of that situation. In other words, cognition preceded and labelled the arousal. Schachter regarded cognition and arousal as highly interrelated and dependent on one another for the production of an emotion. Thus, the discrete emotion and the intensity of the emotional state were attributed to the cognitive appraisal of the stimulus and the level of arousal respectively.

Maranon (1924) had conducted a study which showed that cognition and arousal may be independant. Epinephrine, which produces a sympathetic discharge, was administered to 210 patients, and their subjective experiences recorded. Seventy-one percent of subjects reported only physical symptoms and twenty-nine percent reported only emotional effects. The emotional symptoms were not overtly expressed, but were labelled more in terms of "as if" an emotion was felt. Maranon could only induce "real" emotions if he provided the subjects with an appropriate cognition. Schachter suggested that the 71% who did not have an emotional experience, had a perfectly appropriate cognition supplied, i.e. the injection of epinephrine explained their current state.

Convinced that physiological arousal alone could not lead to an emotional state, Schachter and Singer (1962) carried out a series of experiments to test three theoretical propositions. Firstly, individuals may be similarly aroused but describe different emotions due to the cognitions with which they are supplied. Secondly, if there is an explanation for the physiologically aroused state, no other cognitive evaluation will influence the emotion felt. Thirdly, an individual will react similarly in the same cognitive condition, only if accompanied by physiological arousal.

To test their hypotheses, Schachter and Singer injected their subjects with epinephrine and designated them to one of three groups: the epinephrine informed group were correctly told of the side effects of this drug; the epinephrine misinformed group were told of false side effects, and the epinephrine ignorant group were told to expect no side effects. There was a fourth, placebo group, who were injected with a saline solution and given the same information as the epinephrine ignorant subjects. The induction of two separate emotional states was attempted by introducing a stooge who was instructed to act so as to induce euphoria or anger to the situation. Two measures of the current state of the experimental subjects were taken, i.e. observation and a self-report questionnaire.

The results showed that emotions could be manipulated by cognitions when no alternative explanation for a state of physiological arousal was available. The subjects in the epinephrine ignorant and misinformed groups tended to emulate the stooge's mood of euphoria or anger significantly more consistently than the epinephrine informed condition. From this finding, the investigators deduced that once an emotional state had been satisfactorily labelled, it was unlikely to change. The third proposition regarding emotion induction only in the presence of physiological arousal however, was only tentatively accepted.

According to Schachter, emotion was the result of cognitive and physiological reactions to a particular situation. In the absence of arousal, no emotion would be experienced. Furthermore, emotional states were seen to be physiologically identical but separated into the various categories of happiness, fear and so on, by cognitive influences.

Support for parts of Schachter's theory have come from related sources. Nowlis and Nowlis (1956), in their work on the effects of internal and external stimuli on mood states, administered drugs to four men who were free to interact with one another. When the same drug (Seconal, a barbiturate) was given to each subject, similar mood states were checked on the Adjective Checklist. However, when each man was given a different drug, the subject on Seconal did not check the same emotion words as he did in the previous task (i.e. when his colleagues were also on Seconal). This suggested that the mood states (i.e. external) of the other three men who were on different drugs affected the mood (i.e. internal) of the subject on Seconal.

Valins (1966) deceived subjects about their physiological reactions by presenting them with bogus audible feedback of their heart rate while watching a series of slides of female nudes. One group heard their "supposed" heartbeats increase for five slides and remain constant for the other five. A second group heard their beats decrease for five slides and remain constant for the other five. The control groups matched each of the experimental groups, however, they were aware that the heartbeats were contrived. The results showed that the experimental groups rated the nude slides as more attractive than the others. Valins (1966) concluded that internal cognitive events (instigated after listening to the heartbeat) acted to subsequently increase or decrease the emotional experience.

However, Schachter's theory has poor status currently due mainly to the evidence produced by the replication studies of Marshall and Zimbardo (1979) and Maslach (1979). With some improvement to the methodological paradigm, Marshall and Zimbardo repeated Schachter and Singer's experiment, using only the happy confederate as the situational factor expected to label emotional status (the angry confederate was not used due to ethical reasons).

In this study, a group of subjects were injected with epinephrine and given bogus information regarding the effects of this drug, and subsequently exposed to an euphoric confederate. Marshall and Zimbardo reported no differences in the degree of emotional affect experienced by the epinephrine group as compared to a control group. This finding does not support the earlier results of Schachter and Singer who concluded that situational factors, in the absence of an appropriate cognition, determined the degree of affect experienced by the subject.

To test further the power of situational cues, Marshall and Zimbardo repeated the procedure with a group of subjects who were administered a higher dose of ephinephrine than the first group. They found that as this higher dose increased the arousal level experienced by the subjects, most reported an unpleasant emotional state, even though they were in the presence of the happy confederate. This finding was in direct contradiction to the predictions of Schachter and Singer (1962).

In a similar study, Maslach (1979) used hypnosis to induce a level of unexplained arousal in a partial replication of the Schachter and Singer experiment. She also introduced the notion of a "cognitive search" undertaken by subjects who were experiencing arousal levels for which they could find no explanation. In other words, she questioned the power of one situational cue, i.e. a person, in determining the emotional status of the subject. Instead she proposed that subjects used past and present life experiences to label an emotional response.

Subjects were hypnotised to experience a level of arousal following the onset of a specific cue. A posthypnotic suggestion for amnesia (as to the causal precipitants of the arousal) was also induced. Subjects were paired with a happy or an angry confederate. The author found that those subjects who were hypnotised to experience unexplained physiological arousal reported an unpleasant emotional response, even in the presence of the happy confederate. Maslach explains this biasing of arousal (also found by Marshall and Zimbardo,

1979) in terms of what is clinically referred to as "free-floating anxiety", which is also equated with negative emotion. Maslach concluded that;

> "*emotional explanations appeared to be a complex function of their past experience, current life situation, and the immediate situational circumstances, rather than just the mood of the confederate*" (p. 965).

In reply to Maslach (1979), Schachter and Singer (1979) questioned the timing of the confederate's appearance. Specifically, the authors claim that in their experiment, the appearance of the confederate was accurately timed to coincide closely with the injection of the drug. Schachter and Singer point out that in the Maslach study, the arousal brought on by the hypnotic suggestion, preceded by minutes the appearance of the confederate. They claim that this error of timing was sufficient to result in the loss of the associative value created by the confederate, hence invalidating that part of the experiment.

Commenting on the Marshall and Zimbardo (1979) experiment, Schachter and Singer (1979) show concern at the high dosage levels of epinephrine administered to the subjects. They point out that high doses of this drug produce negative and extreme physiological responses such as shaking and pounding of the heart and these intense unpleasant feelings could not possibly be labelled as pleasant even after exposure to the happy confederate. Schachter and Singer also raised the issue of equivalence in group composition between their study and the Marshall and Zimbardo experiment. They suggested that at least one of the groups in the latter experiment did not match theirs.

An author's reply to work that has been challenged by others often results in a defensive stance. Predictably, Schachter and Singer found flaws in the new work and concluded that the replications of Marshall and Zimbardo and Maslach were not accurate repetitions of their original experimental paradigm. Nevertheless, the findings of these latter studies cannot be overlooked. These authors have shown that the relationship between cognition and arousal is not as dependent as Schachter and Singer had originally purported. Marshall and Zimbardo and Maslach provide evidence to show that cognition and physiological responses can indeed act independantly, and conclude that their interaction is more complex than originally reported. On a final note, Reisenzein (1983) collated the research evidence available testing what he considered to be the three most pertinent hypotheses set forward by Schachter's theory. These were (1) the positive association between arousal and emotional intensity, (2) the attribution of non-emotional arousal to an emotion intensifies the subjective feeling of emotion, and (3) attribution of emotional arousal as non-emotional reduces the subjective feeling of emotion. Twenty years of evidence revealed empirical support for the second hypothesis only.

1.3.5.4. Psycho-Evolutionary Theory of Emotion

The final cognitive theory of emotion to be considered is the psycho-evolutionary theory presented by Plutchik (1962). Using the semantic differential, subjects were asked to rate words on intensity scales such as good-bad, high-low etc, and to participate in a checking task of the similarity among various emotion words. Based on these data, Plutchik devised a theory of eight primary emotions varying in intensity, similarity and polarity, depending on their position on the "emotion wheel" (Plutchik, 1980). The eight discrete emotions were joy, acceptance, fear, surprise, sadness, disgust, anger and anticipation. Secondary emotions existed also, insofar as they represented combinations of these eight primary emotions. These basic emotions and their derivatives were considered to satisfy certain criteria in Plutchik's overall psycho-evolutionary framework. Firstly, from a biological and evolutionary point of view, all emotions were considered adaptive and present in animals as well as humans. Secondly, as Darwin (1872) maintained, emotion had a functional role in the natural selection of behaviour. Furthermore, he believed that survival in a constantly stimulating environment involved the ability to identify beneficial and harmful aspects of that environment. This evaluation process varied phylogenetically, with the lower species relying mainly on sense organs or instinct (McDougall, 1923), and higher order species, using their cognitive abilities to effect a particular response.

According to Plutchik, cognition and emotion are intimately related. The evolution of the brain has seen cognitive abilities evolve from imprinting and other forms of behaviour in lower animals which do not rely on previous experience to the highly complex, thinking and perceptual abilities of humans which generally depend on memory and previous learning capacity. Furthermore, he stated that an evaluation of the precipitating stimulus, internal or external, was vital in supplying information leading to approach-avoidance behaviour at all phylogenetic levels. The evaluation process does not necessarily lead to the production of an emotion, for example, the operation of some ego defense mechanisms may suppress the emotional feeling. Also, errors in cognition may occur, where the individual evaluates a certain stimulus as dangerous when in fact it is not. This is commonly seen in patients suffering from neurotic phobias. Finally, he held that cognitions may be unconscious and therefore unable to be recorded verbally, but inferred via behavioural indices, e.g facial expression. Plutchik emphasised that the survival of the individual depends on the accuracy of these evaluations and the emotional reactions produced.

Plutchik (1977) also postulated seven functional abilities associated with the cognitive process. These were scanning, orienting, attending, short-term registering, retrieving, predicting and emoting. He maintained that the maladaptive functioning of these individual cognitive tasks impaired the individual's ability to interact effectively with the environment. For example, psychiatric disorders such as schizophrenia, involve impaired scanning and ineffective attentive abilities.

Thus, in terms of Plutchik's cognitive/biological-evolutionary/adaptive theory, emotion is the result of a complex chain of events beginning with the evaluation of a stimulus or situation as beneficial or harmful. This cognitive ability has evolved along with the evolution of the brain to ensure the survival of an individual in a constantly changing environment. In Plutchik's view, "*cognition developed in order to predict the future*" (1977, p.20), utilising a "map-making" function, whereby information about the environment is perceived, learned and stored. Future predictions and actions are made possible by the individual's increased ability to classify environmental stimuli and appropriate responses. The emphasis is on the adaptive functioning of cognition and the cognitive process, rather than upon the neural mechanisms activated.

Contemporary support for Plutchik's theory comes from Dimberg (1988) who extended the biological-evolutionary framework to include the adaptive response of the decoder during face-to-face communication. He explored the actions of the receiver when confronted with a happy or angry facial expression and found that the former elicited facial electromyography (EMG) reactions (in the receiver) that were congruent with positive emotions while the latter evoked EMG patterns resembling the presence of a negative stimulus. Furthermore, aversive conditioning to angry faces activated the autonomic system (in readiness for fight or flight behaviour) while the happy faces inhibited reactions in the aversive conditioning situation. He concluded that an individual's response patterns to another's facial expression were genetically controlled and a product of evolution. However, unlike Plutchik (1962), Dimberg (1988) maintained that the emotional responses were automatic and not dependant on cognitive processes.

Frijda (1989) emphasised the adaptive role of facial expression, specifically its function in the regulation of an individual's interpersonal relationships, as well as the individual's interaction with the environment. Cognition is seen to play a mediatory role between incoming stimuli, patterns of action preparedness and the individual's behaviour. Thus according to Frijda, the different states of emotional experience are characterised by their unique appraisal structures and their different "*states of action readiness*" (p.205). Facial expressions form one link in a behavioural system incorporating stimulus appraisal and memory structures and action states, intended to influence the individual's interaction with the environment.

1.3.6. <u>The Categorical Approach in Summary</u>

The categorical approach to the structure of emotion emerged from the rudimentary theoretical framework which suggested the existence of neural and sensory activity unique to each emotion and resulted in the appearance of a specific facial expression (Allport, 1924; Darwin, 1872; James, 1884). The neurophysiologists henceforth searched for the mechanism in the brain which activated the emotional process (Cannon, 1927; Gellhorn, 1964). The popularity of the Behaviourist's S-R paradigm neglected emotion as a phenomenon and focussed on such terms as drive, motivation and instinct. The facial feedback approach and the cognitive theory of emotion (Arnold, 1960a, 1960b; Leeper, 1965; Plutchik, 1962) resurrected interest in this topic. Thus contemporary researchers (Tomkins, 1962, 1963; Izard, 1971; Ekman, 1980) into the facial expression of emotion have pursued an integration of the cognitive/affective, physiological and motor activity present during the experience of an emotion. The emphasis has returned to the face, and even with the development of recent methodologies, it seems as if the information concerning the display of emotions has not substantially increased since Darwin's time. Modern theories of emotion have evolved from studies on arousal and motivation (Freud, 1933; Hull, 1943), cognition, (Leeper, 1965), neuropsychological processes (Arnold, 1960a, 1960b) and personality (Ekman, 1971; Izard, 1971; Tomkins, 1962, 1963). It is difficult to find common themes running through these different viewpoints, due on the one hand to the varying emphases of each theory, and on the other hand, to the inconsistent definitions of emotions and emotion concepts.

A final point should be raised briefly in this section. The lack of a proper definition of emotion from the categorical theorists has prompted a challenge to the commonly held belief of the existence of a fixed and defined set of emotion categories. Referred to here as the "prototype approach to emotion", it concurs with the existence and need for categories, however, disputes the "all-or-none" claim espoused by the classical view. The classical view hypothesises that the fundamental categories are composed of unique and specific features, separated from members of other categories by sharp boundaries. The prototype approach, on the other hand, advocates that classes are composed of prototypes, some of which describe a class of objects better than others. Furthermore, it is the peripheral as opposed to the core descriptors of a class which may overlap into other classes, thus making boundaries between categories more "fuzzy". In other words, membership of a category is interpreted rather as a measure of degree as opposed to the all-or-none properties of the classical approach to category membership.

The concept of a prototype was introduced just over a decade ago by Rosch (1978), who applied it to the classification of various physical objects and colours. She hypothesised that objects could be classified in terms of a hierarchical structure consisting of superordinate, basic, and subordinate levels. Objects occupying the middle or basic level of the hierarchy have been shown to be more readily recognised than objects at the superordinate or subordinate levels (Fehr, Russell & Ward, 1982; Mervis & Rosch, 1981).

More recently, the prototype approach has been applied to the taxonomy of the emotions. Specifically, the cognitive organisation of emotion has been found to correlate with a prototypical perspective. The first study to relate the notion of prototypes to the concept of emotion was conducted by Fehr and Russell (1984). In a series of seven studies asking subjects to list and classify emotional words, they found the following:

1. The concept of emotion was best described in terms of its hierarchical properties, namely that the general term of "emotion" was found at the superordinate level of the structure. Furthermore, the middle or basic level comprised terms of the emotion categories which most people use and are familiar with such as happiness, fear, sadness, etc.
2. Prototypicality of emotion terms was ranked such that some emotion words were rated as better descriptors of a particular category than others. However, each category consisted of prototypical and peripheral members.
3. Prototypical members are more readily substituted for the superordinate category than are the peripheral members.
4. Finally, members of each category are linked to one another in terms of their "*family resemblance*" (p. 477). In other words, core prototypical features share common attributes.

Shaver, Schwartz, Kirson and O'Connor (1987) confirmed that emotion could be perceived as having an hierarchical structure, consisting of several vertical levels and ill-defined or fuzzy horizontal borders (at each level). However, their more important contribution was the description of the prototypes or sometimes called "scripts", which comprise the basic or middle level of the emotion hierarchy. Subjects were asked to relive and record (in writing) their feelings, thoughts, actions and physical symptoms, associated with a variety of given emotional experiences. Coded written samples revealed prototypical information for the emotions of fear, sadness, anger, joy and love (these emotion levels were selected from the results of a previous experiment which showed that these terms best described the category members at the basic level). From the results of their research, the authors hypothesised that once an incoming stimulus had been appraised, it then elicited the appropriate mental representation of one or more of the basic level emotion categories, which in turn produced facial expressions, symptoms, actions and feelings associated with that emotion category.

Other research from a prototype perspective has targeted love and commitment (Fehr, 1988), with findings supporting this approach, and aggression (Lysak, Rule & Dobbs, 1989), who found in favour of the classical view for the defining features of aggression.

Empirical research targeting the classification of emotion from a prototype perspective has just begun, as have the critical analyses of this approach. As the emotion categories are delineated by referring to prototypes or scripts which represent them, then clarification of the descriptors of the concept of emotion may follow. However, critics of the prototype approach do not dispute the existence of emotion categories which may be best represented by prototypes, but rather they argue that prototypes do not clarify the nature of emotion (Clore & Ortony, 1991; Johnson-Laird & Oatley, 1989). In other words, determining how people think of or categorise emotions in terms of prototypes does not contribute to our knowledge of the emotional experience. A second problem raised by Clore and Ortony (1991) is that the prototype view is constantly contrasted with the classical view to emotion classification. These authors raise serious doubts as to the attempt of some research to "prove" that one theory is more correct than another (see also Russell (1991) for a thorough review of the critical analysis of the prototype approach).

The most likely outcome of the debate between the classical categorical approach and the prototype approach may lie in the integration (in some form) of the two. Both Russell (1991) and Clore and Ortony (1991) have pointed out the promising features of each and in fact have made reference to the possibility of one theory in the future, drawing on the strongest attributes of each approach.

1.4. The Structure of Emotion: The Dimensional Approach

Controversy regarding the structure of emotion is not restricted to the study of aspects of the underlying phenomenological and experiential aspects of emotional expression as seen in the previous section. The category theorists (Ekman & Friesen, 1975; Izard, 1971; Tomkins, 1962, 1963) encounter strong opposition theoretically and empirically from a group of investigators who also study the structure of emotion, but emphasise the dimensions underlying the emotions. The dimensional approach represents the second major body of work in the study of emotion and facial expression.

Historically, the typological approach can be traced back to the work of Darwin (1872) and his description of discrete facial expressions. The same can be said for the dimensional approach with its beginnings stemming from Darwin's principle of antithesis. According to this principle, as seen from a dimensionalist's point of view, for every pleasurable emotion and expression, there existed an unpleasurable emotion and expression. Although not expressed in such terms by Darwin, his second principle may be construed as espousing a bipolar dimensional theory of emotion and expression.

Spencer (1890) confused emotional experience and sensory experience, but nevertheless, delineated the pleasantness-unpleasantness dimension, by his division of feelings into positive (pleasurable) sensations and negative (painful) sensations. He ascertained that the neural impulses impinging on the facial muscles resulted in the appropriate expression. Piderit (1925) maintained that sensations and feelings were influenced by cognition, in that a pleasant thought produced a pleasant sensory impression on the facial muscles, resulting in a happy expression and an unpleasant thought led to an unpleasant expression. As well as the pleasantness-unpleasantness dimension, Piderit noted that the facial expressions produced displayed a second dimension, that of attention-indifference. This was reflected in such emotions as surprise at one extreme and neutral at the other. Piderit illustrated the different expressions associated with these two dimensions by creating line drawings of the face and including such features as the eyes, eyebrows, nose and mouth. The Piderit faces have since been used in a number of judgement studies, in which the facial features have been easily manipulated to create a variety of different expressions (Boring and Titchener, 1923; Buzby, 1924; Fernberger, 1928).

With the existence of these line drawings and the later use of posed photographed expressions (Ruckmick, 1921; Feleky, 1914, 1924), experimental psychologists concentrated their efforts on the judgement accuracy obtained from various observers of these expressions. The early findings (Fernberger, 1928; Langfeld, 1918a) were unimpressive and resulted in the view that posed facial expressions were not interpreted accurately by judges.

Woodworth (1938) attempted to reconcile these findings and maintained that methodological flaws and dissimilarities amongst this early work (to be discussed later) contributed to their negative conclusions. In the main, errors of judgement were not graded for degree, but merely disqualified. Using the data collected by Feleky (1924) from one hundred subjects who were given a list of 110 emotion words and asked to judge 86 posed expressions, Woodworth (1938) found redundancy among many emotive words and by grouping these approximate similarities together, was able to reduce the list from 110 to 10. Taking into consideration the degree of judgement error in a limited number of categories, Woodworth created a unidimensional scale, so structured that the frequently similarly judged categories appeared side by side in a six step sequence. The six step linear scale was as follows: (1) love, mirth, happiness (2) surprise (3) fear, suffering (4) anger, determination (5) disgust, and (6) contempt. Using these categories, Woodworth obtained correlations of +0.92 between the posed expression and its judgement accuracy.

Schlosberg (1941), impressed by Woodworth's idea of classifying emotions along a continuum, presented evidence which firmly established the dimensional approach in the search for the structure of emotion. Subjects were asked to sort seventy-two facial photos of Frois-Wittman (1930) into the six categories found by Woodworth and the frequency in each category was recorded. Results showed as expected, some overlap in judgement between categories 2,3,4, and 5 (i.e. surprise, fear, anger and disgust respectively). However, subjects also showed misjudgement involving the opposite ends of the scale, i.e. (1) love, mirth, happiness, and (6) contempt. To account for this anomalous finding, Schlosberg suggested that the scale presented by Woodworth was not linear, but in fact, circular, comprising two orthogonal dimensions. The first dimension suggested by the judgement frequencies was classified as pleasantness-unpleasantness (P-U) and incorporated the Woodworth love, mirth, happiness category at one end and anger, determination at the other. The second dimension was labelled attention-rejection (A-R), mainly due to the differences between surprise at one end and disgust and contempt at the other.

Schlosberg (1952) conducted four experiments to discover whether these two dimensions would adequately encompass a variety of facial expressions. Subjects were asked to rate a series of posed expressions along a nine-point scale, separately for each dimension. In Experiment 1, the Frois-Wittman faces were used. Schlosberg found it difficult to describe the qualities he looked for in his attention-rejection dimension. He resorted to describing the facial expression of attention as "*openness to stimulation*" and in rejection, the "*eyes, nostrils and mouth tended to be constricted*" (p. 231). This problem was remedied in Experiment 2 where subjects were shown examples of attention and rejection using two facial expressions in the Ruckmick series. These were retained by the subjects as "anchors" for the extremes of the A-R dimension. Experiment 3 was a replication of Experiment 2 (conducted one year later). Experiment 4 used the 32 Ruckmick photos. All dimensional ratings were compared to the sorting of the faces into the six Woodworth categories, and before and after the ratings were made. Results showed that independent sorting into Woodworth categories and the ratings on the two dimensions correlated with r's of +0.94, +0.92 and +0.96 for Experiments 2, 3 and 4 respectively. When there was no adequate explanation for the attention-rejection dimension as seen in Experiment 1, the correlation was +0.76. Schlosberg (1952) concluded that the roughly circular scale supported by the two axes, adequately provided a position for the many facial expressions of emotion seen in the Frois-Wittman and Ruckmick series.

Two years later, Schlosberg (1954) suggested adding a third dimension to his newly formed dimensional model of expression. He referred to it as the sleep-tension (S-T) dimension, measuring the intensity or activation level (by using the Galvanic Skin Response (GSR) measure), which is low in sleep, moderate in attention, and high with the expression of strong emotions. Engen, Levy and Schlosberg (1957) with the help of a drama student made a new series of 48 facial photographs, (known as the Lightfoot photographs), including expressions of relaxed and highly activated states of the individual, thereby representing the new S-T dimension (Schlosberg, 1954). In 1958, the same authors presented the Lightfoot series to 400 subjects, who were asked to rate each photograph on a 9 point scale for the pleasantness-unpleasantness, attention-rejection and sleep-tension dimensions. Results showed that the first dimension (P-U) was rated most consistently, followed by S-T and then A-R.

Levy and Schlosberg (1960) conducted a further experiment to see how well the new Lightfoot series of facial expressions correlated with Woodworth's six categories. In support of Schlosberg's (1952) earlier work, the authors found a high correlation between the emotion categories and the independent dimensional ratings. However, the Lightfoot series were not found to be as good at predicting the dimensional ratings as were the Frois-Wittman or Ruckmick photographs. Levy and Schlosberg (1960) considered this to be a consequence of the deliberate emphasis on the sleep-tension expressions of the Lightfoot series, which were not adequately represented by the Woodworth scale.

Triandis and Lambert (1958), looking for pancultural elements in the facial dimensions, applied Schlosberg's approach to two different Greek populations. The Greek subjects were represented by students from a college in Athens and by adults from a small Greek village. Their results on a rating task were compared to the earlier findings with American subjects of Engen, Levy and Schlosberg (1958). The Greek subjects were asked to rate the Lightfoot series of facial expressions on the three dimensions of P-U, A-R, and S-T separately. The same photographs were then sorted into the Woodworth categories of emotion. The validity of Schlosberg's dimensions was established cross-culturally, as the Greek subjects' ratings were similar to those of the American subjects. Also, the dimensional ratings were more reliable than judgements of Woodworth's categories. There were some cultural differences however. Firstly, the Greek subjects rated the unpleasant expressions as showing more tension (on the S-T dimension) and more attention (on the A-R dimension). American college students, on the other hand, rated the pleasant emotions in this way. Secondly, although Schlosberg's dimensions have been reliably used in the Greek population, Triandis and Lambert (1958) questioned the circular model of emotion found in the American sample. Instead, they suggested an elliptical structure.

Cüceloglu (1970) used line drawings of faces with sixty different expressions as shown by varying the eyebrows, eyes and mouth features, to study the perception of facial expression in American, Japanese and Turkish subjects. The subjects were presented with forty emotion words and asked to rate the sixty drawings in terms of their similarity to these words. The cross-cultural dimensions resulting from a factor analysis were Pleasantness, Irritation and Non-Receptivity. Cüceloglu concluded that his first two dimensions were roughly equivalent to Schlosberg's P-U and A-R dimensions, hence supporting the validity of the dimensional approach.

Saha (1973) applied Schlosberg's three dimensions to an Indian population. The Lightfoot series were shown with Ruckmick photographs acting as "anchors" for the outer extremes of each dimension. Ratings were taken from the series for each dimension separately. The results showed that the P-U dimension was judged more accurately than the S-T or A-R dimensions respectively, providing further support for the cross-cultural applicability of Schlosberg's theory.

More recently, Russell (1983) provided evidence for the pancultural elements inherent in the dimensional approach, with his study of the translation of twenty-eight English emotion words into four languages: Croatian, Gujarati, Chinese and Japanese. Native speakers of these languages were asked to judge the similarity amongst the list of emotion words. Two dimensions named Pleasantness-Unpleasantness and Arousal-Sleep emerged from the findings. Secondly, a circular model of emotion encompassed many of the emotion words in all languages. Interestingly, in an earlier study, G. Ekman (1955) presented her subjects with twenty-three Swedish words, and using similarity ratings also produced a primary factor of Pleasure, similar to the Pleasantness-Unpleasantness dimension found by Russell (1983). Later, Nummenmaa and Kauranne (1958) applied Ekman's (1955) technique of similarity judgements to facial expressions and obtained four unipolar factors. These factors, Rejection, Pleasure, Surprise-Fear and Anger were interpreted in terms of Schlosberg's two-dimensional model.

In overview, the evidence provided by the cross-cultural research goes one step further in elucidating the universality of emotional expression. More importantly for the dimension theorists, the findings of the previous studies provides further support for a dimensional theory of emotion.

1.4.1. Semantic Dimensions in the Judgement Of Facial Expression

Osgood (1966) concentrated on "*the dimensional structure of the semantic space within which facial expressions are judged*" (p. 3). His primary concern was with the number, typology and representation of the basic emotions. His secondary concern was with the communicative value of the face in both encoding and decoding tasks. A judgement study was conducted with students posing an emotion in front of a group of judges, who had a list of forty emotion words from which to label the posed expression. Only 13% of the posed expressions were correctly labelled by the judges. However, factor analysis of the judged expressions yielded three dimensions (accounting for 46% of the total variance) resembling the Schlosberg dimensions. These dimensions were replicated in a later study by Hastorf, Osgood and Ono (1966). Osgood interpreted them as Pleasantness, Activation and Control. A second factor analysis on the intended emotions of the actors also produced the same three dimensions. Osgood concluded that the semantic systems of encoders and decoders were represented by these three dimensions. A pyramidal representation of the semantic dimensions was put forward as best describing the interrelationship between the dimensions.

Tomkins and McCarter's (1964) suggestion of a return to the discrete emotion categories in the structure of emotion, encouraged Osgood (1966) to carry out some post hoc analyses on his data. A cluster analysis of the forty semantic labels previously presented to the student judges yielded twelve groups, nine of which resembled the nine primary emotions of Tomkins and McCarter (1964). Osgood did not obtain the high percentage ratings reported by the previous authors. He attributed this discrepancy to methodological differences between the two experiments. Firstly, Tomkins and McCarter used still photographs as opposed to Osgood's live presentation of emotional expression. Secondly, only nine categories were used in the former study, while forty emotion labels were used in Osgood's (1966) study.

Finally, having determined the communicative value of the dimensions through facial expression, Osgood (1966) expected them to be related to the semantic differential factors of Evaluation, Activity and Potency. Indeed, Pleasantness and Activation are equated with the first two factors of Evaluation and Activity, while the Control dimension is similar to the Potency factor. Kauranne (1964) applied Osgood and Suci's (1952, 1955 and Osgood, Suci & Tannenbaum, 1957) semantic differential technique to the judgement of the Frois-Wittman facial expressions. A factor analysis revealed three factors named Hate, Pleasure and Contempt. The factors of Pleasure and Hate were related to the subsequent extremes of Schlosberg's P-U dimension. Contempt was equated with the rejection extreme of the A-R dimension.

The dimensions underlying the emotions using verbal reports have been investigated by Russell and Mehrabian (1974, 1977) in two separate experiments. Each revealed the existence of three dimensions: Pleasure-Displeasure, Arousal-Nonarousal and Dominance-Submissiveness. Once again the first two dimensions supported the findings of Schlosberg (1941, 1952) and Osgood (1966), even with the presentation of verbal as opposed to facial stimuli. In other words, emotion as represented by language, seems to concord with the same basic dimensions.

On the other hand, Russell (1980) suggested a circumplex model of emotion consisting of two interrelated bipolar dimensions: Pleasure-Displeasure and Arousal-Sleep. According to Russell, this circular model encompassed the emotion labels. His theory was based firstly on the assumption that the cognition of emotion determined one's response to both verbal descriptions of emotion and nonverbal descriptions of emotion, e.g. facial expressions. Secondly, a multidimensional scaling procedure provided a method whereby subjects were capable of applying their own cognitive representations to stimuli with minimal influence by the experimenter. The result was a circle, surrounding two axes representing the dimensions with the emotion categories spread around the circumference of the circle. Thirdly, Russell (1980) examined the structure of emotion when self-reported experiences were given. Factor analysis of subjective data revealed the same circular structure. Finally, Russell and Bullock (1985, 1986a) found that children aged between two and five years of age, when asked to rate photographs as to their degree of similarity, confirmed a circular ordering of emotions with Pleasantness and Arousal as the two pivotal dimensions.

One of the major problems faced by the dimension theorists, evident from this review, is the limited consensus (except perhaps with the P-U dimension) on the naming of the dimensions reported. A second and related problem is the number of dimensions derived from the data. The most obvious came from the work of Schlosberg (1941, 1952) where only two dimensions were initially reported and then presumably through the influence of Lindsley's (1951) and Duffy's (1962) activation theories, a third was added.

Frijda and Philipszoon (1963), using rating scores of thirty facial expressions, delineated four dimensions: Pleasantness-Unpleasantness, Intensity-Control, Attention-Disinterest, Social Submission-Condescension. The first three factors concord well with the findings of Schlosberg and Osgood. Factor 1 resembled the first dimension of both Schlosberg (1941, 1952, 1954) and Osgood (1966). Factor 2 related to Schlosberg's S-T dimension and Osgood's Intensity dimension. Factor 3 resembled Schlosberg's A-R dimension. A study conducted by Mordkoff

(1971) replicated these findings. Gladstones (1962) questioned the necessity for three dimensions. Using judgements made on ten of the Lightfoot facial expressions, Gladstones found that the S-T and A-R dimensions were not independent. This work was supported by the findings of Abelson and Sermat (1962) and Ekman (1964). The Pleasant-Unpleasant and Sleep-Tension dimensions were, however separate and unrelated. Williams and Sudenne (1965) investigated the stability of the dimensions across visual and vocal expression of emotion and found two dimensions, i.e. General Evaluation and Activity. A third dimension, Social Control, was not considered reliable, mainly due to the design of the experiment. Similarly, Graham and Argyle (1975) found Evaluation to be a major dimension of facial expression.

The inconsistency found in the literature for the number, and correct labelling of the dimensions of emotion can be attributed mainly to the differing methodological, measurement and statistical techniques used from study to study. Two types of facial experiments were generally conducted. One involved the judging of faces on a set of scales and the other measured the similarity ratings between pairs of faces. Hence, the stimulus expressions (i.e posed or spontaneous; photographs, line drawings or live presentations), the number and the variety of stimuli in the one experiment (e.g. different people), was crucial to the outcome. Similarly, the emotion labels given or elicited, and the number of emotion labels presented , would affect the number of dimensions produced. Frijda (1969) and Stringer (1967) have suggested that these two types of studies were so different methodologically that their findings were not easily comparable. For example, in the judgement experiments, subjects were looking for differences from one face to the next, while in the similarity experiments, subjects were looking for similarities between pairs of faces.

The question of ambiguity arises when asked what it is that the observer attends to, on making a judgement or similarity assessment. Schlosberg (1952) was unable to clearly express to the judges what was important in their judgement of Attention-Rejection indices. He later supplied them with "anchor" photographs which represented the two extremes of this dimension. The emotion labels chosen by the experimenter may further bias ratings achieved. Finally, observers may use cues on the face such as eyes, mouth or eyebrows, to make a judgement or rely on inferred feeling states or situational cues, if present.

The statistical analyses employed on the data are certain to affect the number and nature of dimensions encountered. Varying statistical procedures include multidimensional scaling (Abelson & Sermat, 1962), factor analysis (Osgood, 1966) and cluster analysis (Osgood, 1966; Stringer, 1967).

One of the most important criticisms levelled at the dimensional approach to the study of emotion and expression is the lack of a cohesive theory (Izard, 1971). The dimensions reported by several different investigators were not related back to any general conceptualisation of personality or behaviour in social interactions. By relating the dimensions to the discrete emotion categories which were generally engrossed in a much wider theoretical framework, this shortcoming may be overcome. Schlosberg (1952, 1954), Osgood (1966) and Frijda (1969) have attempted to study the correlation between the two. Schlosberg and Osgood considered the relationship among the emotion categories to be fixed and hence static within their respective models of emotion dimensions. Frijda on the other hand, proposed a hierarchical model, placing equal emphasis on the emotion categories and the emotion dimensions. The hierarchical model was predicated on the independence of emotion categories in the dimensional space, thus attributing emotional experience to the combination effect of category and dimension, as well as permitting each model its specific contribution.

Opposition to this reconciliation of ideas came from Russell and Bullock (1986b). They proposed that the discrete categories represented a taxonomy of emotion which was "fuzzy" or unclear, resulting in the judgement of similar facial expressions as equally likely to appear in one category or another. This "fuzziness" concept was equated with Woodworth's "judgement error" concept which lead to the formulation of his six step continuum. Russell and Bullock hypothesised that this overlapping of categories contributed to the adoption of a dimensional analysis of emotion. Four subsequent experiments were conducted to test this hypothesis and all four tasks obtained similar results. Subjects found it difficult to restrict the facial expressions to only one category. The same expressions were found in different categories. A consideration of the underlying dimensions however, revealed that subjects perceived facial expression in terms of degree of pleasure and arousal (i.e. after multidimensional scaling of similarity amongst categories).

In an attempt to integrate these two approaches, Daly, Lancee and Polivy (1983) have proposed a conical model of emotion. In addition to the pleasure and activity dimensions common to many studies, the authors introduced a third dimension, that of intensity of emotion. Two experiments were conducted. The first examined the dimensions from the placement of emotion words from the cognitive representations inherent in self-report data and secondly, in ratings of the emotion of others. The findings revealed that the emotion categories were scattered around the perimeter of a circle, consistent with the delineation of Pleasure and Activity dimensions. However, a third monopolar dimension emerged, representing the Intensity of an emotional experience. The Pleasure and Activity dimensions were orthogonal, with emotion words on the perimeter of the appropriate quadrant. With the integration of the intensity dimension seen to emerge from the circular base, a conical structure was formed. The intensity dimension was monopolar as it ranged from no emotion (neutral) to variations in one direction, i.e. increase in intensity. As one proceeds from the base of the cone to the tip of the cone, intensity of emotion decreased without affecting the status of the bipolar dimensions. Diener, Larsen, Levine and Emmons (1985) have provided evidence in support of the intensity dimension and suggested that its role was to maintain the independence of positive and negative emotions.

In an attempt to introduce a theoretical framework to a dimensional analysis, Smith and Ellsworth (1985) examined the cognitive appraisals associated with each of fifteen emotions and how these emotions varied along eight pre-chosen dimensions. The eight dimensions of cognitive appraisal were pleasantness, attention, control, certainty, perceived obstacle, legitimacy, responsibility and anticipated effort (Roseman, 1984; Scherer, 1982). The authors believed that the emotional experience felt in a particular situation depended on the cognitive evaluation of that situation, along certain dimensions.

Subjects were asked to recall verbally past emotional experiences, relating to fifteen emotion categories; happiness, sadness, fear, anger, boredom, challenge, interest, hope, frustration, contempt, disgust, surprise, pride, shame and guilt. They then rated each emotional experience on an eleven point scale for the eight proposed dimensions, e.g. for the pleasantness dimension, the question read "*How pleasant or unpleasant was it to be in this situation*" (p.822). Using both factor analysis and mutidimensional scaling, six dimensions were found to differentiate between the emotions. The six dimensions listed below resulting from these separate statistical techniques were: Pleasantness, Responsibility and Control, Predicted Certainty, Attentional Activity, Anticipated Effort and Situational Control. The first five support the dimensions found by Roseman (1984) and Scherer (1982), as follows:

1. Pleasantness: This is the pleasantness versus unpleasantness dimension.

2a. Responsibility: The responsibility of an individual in creating an emotional situation.

2b. Control: Taking control in the situation by initiating coping strategies to deal with the cognitive appraisal.

3. Certainty: Certainty versus uncertainty about ongoing events in a changing environment.

4. Attentional Activity: Cognitive appraisal of a situation resulting in attention or inattention.

5. Anticipated Effort: This is the activation dimension; i.e. what action is taken by the individual, e.g. approach-avoidance, fight-flight etc.

6. Situational Control: This dimension is not seen as a separate dimension by Roseman (1984). It refers to internal versus external locus of control in an emotional situation.

The following emotion categories were systematically organised along these dimensions, suggesting that the dimensions differentiated amongst the discrete emotions. Again, the Pleasantness dimension emerged as the most consistent in distinguishing between the emotions.

1. Happiness and Pride: pleasant states, situational certainty high, attention level high, attributions of self-control and responsibility.
2. Interest and Hope: attention high, external locus of control (i.e. situation determined). Interest is considered as a pleasant state in which certainty of ongoing events is high. Hope is considered as less pleasant than interest and more uncertain.
3. Challenge: high level of anticipated effort, less pleasant, certainty about situation, attention level high, responsibility and control attributed to self, internal locus of control of situation.
4. Surprise: pleasant state, low in effort, uncertainty about situation, attention level high, perceived external locus of control.
5. Boredom: unpleasant state, inattention, external locus of control, low effort.
6. Shame and Guilt: unpleasant states, high effort, some degree of certainty about situation, trend towards inattention, internal locus of control.
7. Disgust: unpleasant state, some effort, unwillingness to attend, external locus of control.
8. Anger and Contempt: unpleasant states, high effort needed, certainty about situation, low attention, external locus of control.
9. Frustration: unpleasant state, considerable effort needed, uncertainty high, attention high, external locus of control.
10. Sadness: unpleasant state, high effort, uncertainty high, inattention preferred, external locus of control.
11. Fear: unpleasant state, extreme effort, extreme uncertainty of situation, situational control associated with responsibility/control attributed to another.

According to Smith and Ellsworth (1985), the varied combinations of these dimensions made the cognitive appraisal of each emotion unique. Hence, in concordance with other cognitive theorists (e.g. Arnold, 1960a, 1960b; Lazarus, Kanner & Folkman, 1980; Plutchik, 1980), the authors concluded that "*emotions represent adaptive responses to the demands of the environment*" and the "*dimensions...are an important step in helping us understand the kinds of perceptions that trigger emotions*" (p. 836). In another study, Manstead (1989) used the same methodological procedure (with a variation on the appraisal dimensions) and found that the separate emotional experiences of shame and guilt were delineated, in addition to those emotions found by Smith and Ellsworth (1985). Manstead noted that these two emotions were intimately attached to those appraisal dimensions which focussed on the individual's sense of personal identity, both from an individualistic and social perspective.

1.5. Conclusion

This chapter has provided an historical overview of the emergence of emotion and facial expression as topics of interest and amenable to scientific scrutiny. Darwin (1872) introduced the concept of the existence of several discrete facial expressions servicing the universal, fundamental, genetically programmed emotions, of which he found nine. Subsequent investigators found it very difficult to conduct a controlled experiment assessing the function of facial action in the expression of the emotions (Goldstein, 1983). The emotions were difficult to capture and measure with any degree of precision. Also some early negative findings disassociating emotion from personality and intelligence, contributed to its further demise as an area of research. Its neglect was further highlighted in the motivational/drive theories of Freud and the S-R paradigm espoused by the behaviourists.

Contemporary theories espousing the existence of discrete categories of emotion generally agree that emotion is represented by the neurophysiological/autonomic, behavioural/expressive and subjective/experiential components of the body. There is, of course, the question of emphasis and varying degrees of salience accorded to each or all of these systems. The neurophysiological approach to emotion has speculated on the interaction of the brain with the somatic nervous system in the production of the different emotional states (see Levenson (1988) for a thorough discussion of the difficulties asociated with the psychophysiological measurement of emotion, particularly in relation to autonomic specificity). The behavioural/expressive or motor component involved in emotion seems to be the most definitive, with many studies concentrating on facial expression and the features which make each display unique. Finally, the subjective/experiential aspect of emotion has seen its proponents concentrate on cognition and its relationship to emotion.

The exponents of the dimensional approach to the study of facial expression did not emphasise the phenomenological and experiential aspects of the emotional display, although the nature of emotion from this point of view took into account the behavioural/expressive component of the body. Instead, the dimensionalists explored the relationship between the various emotions and their location along a two or three dimensional model (Levenson, 1988). The decoding of facial action by judges examining differing expressions from photographs provided the data for many empirical studies in this field. Although the number and naming of the dimensions may vary, the evidence supports the existence of two main dimensions, i.e. the Pleasure and Active dimensions.

Ney and Gale (1988) concluded from their discussion of the process of theory construction, that current theories of emotion were overly complex, thus hindering the definition of clear hypotheses. They stated that clarity in theoretical conceptualisation would facilitate the comparison of studies in this field of research. They also listed the problems commonly encountered by investigators in this area including, sampling difficulties, indiscriminant use of spontaneous and posed expressions, overgeneralisations from reported findings, inattention to individual differences in emotional reaction and the use of a variety of statistical analyses.

In his review of the two main psychological approaches to the structure of emotion, Ekman (1982b) concluded that personal choice factors such as preferred statistical analysis or data handling (e.g. nominal (categories) vs continuous (dimensions) variables), may be the deciding factor in which approach was taken. As a final point, the evidence relevant to each approach has been presented but the causal relationship between emotion, expression and any one model is as yet unclear.

PART 1

CHAPTER 2

BIOLOGICAL VERSUS SOCIAL DETERMINANTS OF FACIAL EXPRESSION

2.1. Introduction

The nature-nurture controversy, long an issue in other areas of general psychology (e.g. in relation to personality, sex roles, learning and intelligence), features prominently also in the study of emotion and in particular, with regard to the origin of facial expression. The research relating to whether human expression is innate or acquired has provided evidence for three schools of thought. Firstly, that facial expressions are innate. Secondly, that facial muscle movements are innate but require practice and experience (i.e. environmental influences) for communicative efficiency, and thirdly, that facial expressions are acquired through learning by social interaction.

This chapter will review three approaches to the investigation of the roles of biological versus social influences in the determination of the origin of facial expression: the comparative, the developmental and the cross-cultural.

The comparative approach, undertaken mainly by ethologists, involves the comparison of various animal displays with human behaviour and is based on the assumption that if phylogenetic continuity can be shown in certain expressive features, then an innate mechanism may play a major role in the evolution and determination of emotional expression.

The developmental approach, formulated by psychologists involves the assumption that the study of expression in children has provided valuable evidence concerning innate and learned influences in facial expressive ability. Research focusses mainly on infancy, when social mimicry is at its minimum and in the study of the blind, where visual mimicry is impossible. The identification of facial expressions in these two populations points to the innateness of certain expressive movements.

The third source of information in this debate comes from cross-cultural data obtained from a variety of cultures in the search for the universals of facial expression.

2.2. The Comparative Approach

According to Sir Charles Bell (1844), the existence of the facial muscles are a "*special provision*" (p. 131), the function of which is "*purely instrumental in expression*" (p. 121). However, Darwin (1872) in the light of his evolutionary theory, questioned Bell's conclusions for two main reasons. First, Bell did not concern himself with a theory of expression, namely, why certain muscle movements result in a certain expression formation and not in another, thereby making the above comment too generalised. Second, with the introduction of an evolutionary approach, the sole function of facial muscles for the expression of animal intentions is highly improbable. Thus, unlike many scientists of that time who attempted to draw clear distinctions between animals and humans (Bell, 1844; Duchenne, 1862; Gratiolet, 1865), Darwin turned to the objective study of animal expression as the important link for the origin and cause of facial expression in humans.

The comparative approach has successfully associated many facial and postural actions seen in animals to the expression of emotion in man. The phylogenetic similarities between the nonhuman primates and man are by far of the most important evolutionary significance to the facial muscle movements and expressions seen in humans. Table 2.1. summarises the expressive movements of the apes and the homologous expressions of humans, as compiled by six major researchers in the area.

In an attempt to explain the evolution of facial expression in humans, Darwin investigated the nature of primate expression using a comparative approach. By relying on descriptive accounts of animal facial displays and the context in which they occurred (given to him mainly by zookeepers), Darwin explored the functions of facial expressions for the individual animal and for the species as a whole. He concluded that the origin of most facial expressions can be explained in terms of his three general principles, namely, the principle of serviceable associated habits, the principle of antithesis and the actions of the nervous system, independent of habit.

With regard to the first principle, certain behaviours necessary for the survival of the animal, such as withdrawal or attack, are unconsciously associated with certain emotion states such as fear and anger respectively. The repeated association results in expressive habitual action which is passed on from generation to generation, even if the function is no longer of use. A similar habitual process may be set up with antithetical actions, hence supporting the principle of antithesis. Finally, the role of the nervous system is to instigate the appropriate action needed to deal with varying situations (e.g. escape). Hence, although Darwin conceded that practice and experience played a role in the determination of facial expression in humans and animals, in particular the non-human primates, he nevertheless strongly maintained the view that the tendency to display expressive actions via the face was innate.

Darwin's theory that non-communicative movements have evolved into communicative actions serving an expressive function, has been supported by the work of some ethologists. In particular, Hinde (1966) referred to the term "ritualisation" to encompass the process whereby certain actions, called "intention movements", evolve into expressive gestures. However, ritualisation resulted from natural selection only, hence omitting the role of the inheritance of acquired habits. Furthermore, van Hooff (1962, 1967) considered the evolution of four major functions in mammals as the important contributions to the refinement of the facial muscles leading to their expressive ability. These are:

1. The chewing of food engaging the teeth, cheeks, lips and tongue.
2. Evolution of the external ear and its mobility allows the animal to pick up sounds coming from varying directions.
3. Development of a mobile nasal region.
4. Development of whiskers, a sensory organ.

Opposition to the view hypothesising the evolution of facial anatomy came from Bolwig (1964), who highlighted the influence of environmental factors on the expressive patterning of primates. He used the term "*cultural variations*" (p. 190) in facial expression to refer to communication skills which were the result of external forces impinging on the animal and not the result of an inborn predisposition. Bolwig observed certain differences in expression amongst monkeys who were hand-reared as opposed to those existing in the wild. In particular, the hand-reared monkeys, forced

Table 2.1. Facial Expressions Exhibited by Apes which have Evolutionary Significance to the Facial Expressions seen in Humans as Documented by Six Researchers

Darwin (1872) Monkeys	**Kohts (in Foley 1935) Chimpanzees**	**Andrew (1963) Apes**	**van Hooff (1967) Catarrhine Monkeys and Apes**	**Chevalier-Skolnikoff (1973) Chimpanzees**	**Redican (1982) Non-human Primates**
1. Joy/pleasure/ affection Facial features include: protrusion of lips, mouth corners pulled back, upper canines concealed and wrinkling of lower eyelid. Human comparison: laughter and smiling	**1. Joy** Facial features include: corners of mouth raised, and "*a kind of smile*" (p.43).	**1. Grin** Facial features include: open, wide mouth, gums exposed.	**1. "Silent bared-teeth face"** Facial features include: eye opening varies markedly from slight, moderate or wide, fixed gaze or shifting gaze to and from opponent rapidly, eyebrows raised, mouth opening varies markedly from slight, moderate or wide mouth corners stretched and lips separated to show teeth, no vocalisation. **1a. "Bared-teeth gecker face"** Facial features include: facial expression is identical to "silent bared-teeth face" except that lips are not completely moved upwards and vocalisation is present. Human comparison: smile.	**1. "Silent bared-teeth face"** Facial features include: open or closed mouth, lips drawn back and upwards. Human comparison: smile.	**1. Grimace** Facial features include: lips drawn back and upwards, exposure of teeth, eyebrows raised, rapid shifting gaze towards and away from antagonist. Human comparison: smile.

Table 2.1. Continued..

2. Anger Facial features include: movement of scalp allowing forehead and eyebrows to be mobilein an upward or downward direction, protrusion of lips, fixed gaze, mouth open but lips conceal teeth (some species reveal teeth), baboons engage in a yawning movement when angered. Human comparison: anger.	**2. Anger** Facial features include: upper face wrinkled, lips pulled downward, teeth and gums revealed.	**2. Anger/Rage** Facial features include: as seen in "staring bared-teeth face", head shaking causing alternate staring and eye avoidance.	**2. "Staring open-mouth face" or "aggressive threat face" (1962)** Facial features include: staring, fixed gaze, wide, open eyes, eyebrow movement depends on species, however common movements involve upward lifting, no change and lowered eyebrows, mouth varies from slightly open to wide open, mouth corners are brought forward and lips are firmly pressed against teeth, vocalisation prominent. **2a.Tense mouth face or "attack face"** Facial features include: fixed staring, widely open eyes, lowered eyebrows, frown, closed mouth, tense jaw, corners of mouth are brought forward.	**2. Anger/threat** Facial features include: staring eyes, tightly closed mouth or mouth slightly open, teeth showing. Human comparison: anger.	**2. "Tense-mouth face"** Facial features include: fixed, staring eyes, tightly closed mouth, raised eyebrows. Human comparison: anger. **2a. Threat** Facial features include: staring eyes, mouth may be slightly or widely open, upper lip stretched over upper canines and lower lip stretched over lower teeth, raised eyebrows, flared nostrils.

Table 2.1. Continued..

3. Terror Facial features include: eyebrows move up and down, eyes wide open, lips pulled back, teeth exposed	**3. Fear/Terror** not identified	**3. Fear** Facial features include: contraction of upper lip, mouth corners pulled back.	**3. "Staring bared-teeth scream face" or "Scared threat face"** Facial features include: fixed gaze and eyes wide open, eyebrow movement is variable, mouth wide open, mouth corners stretched outwards, lips parted to reveal teeth, vocalisations prominent. **3a. "Frowning bared-teeth scream face" or "crouch face"** Facial features include: closed eyes or slightly open, eye gaze directed away from opponent, lowered eyebrows, open mouth and lips stretched outwards to reveal teeth vocalisation.	**3. Fear** not identified.	**3. Fear** not identified
4. Astonishment Facial features include: Eyebrows move up and down, eyes open and staring, mouth closed	**4. Astonishment** not identified	**4. Astonishment** not identified	**4. Alert face** Facial features include: eyes wide open, tension in skin around the mouth area.	**4. Astonishment** not identified.	**4. Astonishment** not identified.

Table 2.1. Continued..

5. Pain/grief Facial features include: as in moderate anger, some species weep.	**5. Sadness** Facial features include: eyes raised, lips protruding and closed, **5a. Crying** Facial features include: mouth open widely, teeth and gums revealed eyes closed, wrinkles form on upper face, vocalisation, no tears.	**5. Crying** Facial features include: open mouth, mouth corners pulled back and down.	**5. Sadness/crying** not identified.	**5. Sadness** Facial features include: raising of eyebrows forming wrinkles across forehead, lips stretching outwards and downwards. **5a. Crying** Facial features include: open mouth, raising of upper lip, lowering of lower lip.	**5. Sadness/crying** not identified.
6. "Teeth-chattering face" not identified.	**6. "Teeth-chattering face"** not identified.	**6. "Teeth-chattering face".** Facial features include: head shaking and blinking simultaneously, follows a smile, seen as parting or greeting in some species. Human comparison: human click teeth together after eating something with an unpleasant taste.	**6. "Teeth chattering face"** Facial features include: similar to lipsmacking face, teeth meet as mouth closes, lips do not meet.	**6. "Teeth chattering face"** not identified.	**6. "Teeth chattering face"** not identified.

Table 2.1. Continued..

7. "Lipsmacking" not identified	**7. "Lipsmacking"** not identified.	**7. "Lipsmacking"** Facial features include: lips open and close rapidly, tongue protrudes slightly between teeth. Human comparison: suckling, eating soft food, thumb sucking.	**7. "Lipsmacking"** Facial features include: lower jaw moves upwards and downwards, lips open and close, teeth do not meet, tongue protrudes between teeth, wide eyes and fixed, raised eyebrows, mouth opens and closes rapidly, vocalisation present.	**7. "Lipsmacking"** not identified.	**7. "Lipsmacking"** Facial features include: upward and downward movement of bottom jaw, meeting and parting of lips, raised eyebrows, direct gaze, protrusion of tongue between teeth. Human comparison: movements made by hungry infants as bottle approaches, human kiss, adult vocalisations toward infants.
8. Pleasure/joy/ affection Facial features include: lips protruded, laughing sound emitted, corners of mouth pulled back, wrinkling of lower eyelid, upper canines concealed when mouth is open, "bright" eyes. Human comparison: laughter and smiling	**8. "Play face"** not identified.	**8. "Play face"** not identified.	**8. "Relaxed open mouth face or "play face"** Facial features include: eyes not as fixed to opponent as in "staring open mouth face", eyebrows in neutral, open mouth, corners of mouth may be stretched outwardly and upwardly, upper lip covers upper teeth, lower teeth slightly revealed, no vocalisation. Human comparison: laughter.	**8. "Play face"** Facial features include: mouth open, lips stretched out and up, vocalisation. Human comparison: laughter.	**8. "Play face"** Facial features include: open mouth, corners of mouth slightly stretched outwards, upper lip covering teeth, downward gazing of eyes, vocalisations. Human comparison: laughter.

Table 2.1. Continued..

9. Yawn Facial features include: noticed in baboons when angered, open mouth revealing teeth. Human comparison: yawn.	**9. Yawn** not identified	**9. Yawn** Facial features include: closed eyes, open mouth, corners of mouth pulled back, upper lip raised. Human comparison: yawn	**9. Yawn** not identified.	**9. Yawn** not identified.	**9. Yawn** Facial features include: head raised as mouth opened and head lowered as mouth is closed, closed eyes as mouth open and eyes open as mouth closes. Human comparison: yawn.
10. Quiet/relaxed face not identified.	**10. Quiet** Facial features include: "quiet" features when not engaging in any activity.	**10. Quiet/relaxed face** not identified.	**10. Relaxed face** Facial features include: neutral face seen when monkeys are not engaging in any particular activity. Human comparison: neutral face.	**10. Quiet/relaxed face** not identified.	**10. Quiet/relaxed face** not identified.
11. Anxiety not identified.	**11. Anxiety and Excitement** Facial features include: protrusion of lips, vocalisation.	**11. Anxiety** not identified.	**11. Protruded lips face or "flehmen face".** Facial features include: protrusion of lips (in smelling), eyes may be fixed or shifting gaze, eyebrows raised, mouth closed tightly with lips protruding, mouth corners brought close together, no vocalisations.	**11. Anxiety** not identified.	**11. Anxiety** not identified.

Table 2.1. Continued..

12. Pout face not identified.	**12. Pout face** not identified.	**12. Pout face** not identified.	**12 Pout face** Facial features include: staring, open eyes, raised eyebrows, open mouth, mouth corners drawn forwards, protruded lips. Human comparison: pouting seen in children.	**12. Pout face** not identified.	**12. Pout face** not identified.

to adjust to and interact with a different species, i.e. humans, had larger, more gross facial expresssions than the equivalent behaviour seen of the monkey in its natural habitat.

Using a different focus, Andrew (1963) categorised the responses made by an animal to certain stimuli, in an attempt to discover the cause of facial expressions. He classified these responses into three groups and suggested that the adaptiveness of these groups and the process of natural selection have co-operated in the determination of facial expressions in animals and humans. The three groups of responses are the alerting responses, the protective responses, and the action responses. These responses are activated when there is a change of stimulation impinging on the organism. No change in stimulation is seen as a neutral event, small changes are pleasant and large changes are considered to be unpleasant. The alert responses activate the sense organs toward a particular stimulus. This movement has been used to explain the frown and the fixed stare seen in many animals (Andrew, 1972). The protective responses are so named as their function is to protect the sensitive bodily areas from harm, e.g. the act of closing the eyes in fear. Finally, the action responses, importantly respiration rate and the thermoregulatory responses, provide a clue as to the imminent behaviour of an animal.

Thus, following Darwin, a number of contemporary ethologists have concentrated on the evolution of the facial anatomy, in an attempt to discover the origin of facial expression in humans (see Table 2.1). Regardless of the emphasis, most researchers in this area agree that the mobility of the facial musculature provides an expressive function conveying the emotion of animals and humans.

2.3. The Developmental Approach

The discovery of certain facial expressions in the newborn and very young child, has lead to the conclusion by many researchers that these expressions are the result of an innate, phylogenetic programme at work (Darwin, 1872; Eibl-Eibesfeldt, 1973). The absence of certain expressions in infancy, but their later appearance in childhood however, does not rule out the possibility of their innate origin. Instead, as Lorenz (1965) has pointed out, some expressions need practice and training to achieve their adaptive function. This latter view, espousing the importance of maturational forces on the expression of emotion, is strongly related to the view proclaiming the genetic determination of emotional expression. The third approach, in direct opposition to the former, is presented by the learning theorists, who conclude that facial expressions are acquired via social and environmental influences.

2.3.1. Innate

Darwin (1872) was the first to study the possibility of the innateness of emotional expression by studying the facial expressions of his own child. Through close daily observation, Darwin kept a diary of his son's expressions as he interacted with the environment and socially, with other people. A number of reflex actions, considered instinctive, were immediately observed. These included "*sneezing, hickuping, yawning, stretching, and of course sucking and screaming*" (1877, p.19). From his detailed account of his son's behaviour which he described in *Mind* (1877), at least eight emotional states, each with a distinctive facial appearance, can be distinguished. (For a complete description of the facial features associated with these emotions, see Darwin, 1872; 1877). The eight emotions, all occurring at a very early age are:

1. Anger, characterised by reddened face as the "*blood gushed into his whole face and scalp*" (1877, p.287).
2. Fear, characterised by the startle reflex.
3. Pleasurable Sensations, characterised by smiling and later by laughing.
4. Affection, characterised by feelings of wanting to go to his nurse and by kissing his nurse if he had not seen her in a while.
5. Amusement, characterised by various noises produced by the infant if for example, he was surprised.
6. Pain or Discomfort, characterised by crying or screaming in response to hunger or other unpleasant stimuli.
7. Jealousy, noted when the infant was fifteen and a half months of age.

8. Shyness, seen when his son was two years and three months and directed toward Darwin after he had been away from home for a few days.

In their very comprehensive review of the literature on "*Facial Expression of Infants and Children*", Charlesworth and Kreutzer (1973) summarise the expressions produced by infants, as found by the many researchers since Darwin. They conclude that many of them were also observed by Darwin (1872, 1877). The expressions are distress, delight, anger, affection, fear, surprise, jealousy, shyness, shame and sympathy.

Perhaps the most convincing evidence that facial expressions are indeed innate come from the studies of emotional expression in children who are born blind. Goodenough (1932) observed and photographed the expressions of a ten year old girl, who was blind and deaf from birth. By dropping a small doll inside the child's dress, a number of expressions were distinguished. Firstly, a startle, as the child realised something against her body. Secondly, anger, as her clothing restricted her effort to grasp the doll. Then, interest and attention, as a new attempt was made to get the doll. This developed into what Goodenough interpreted as disappointment when the child was still unable to get the doll out from under her clothes. Finally, the look of pleasure, graded from a smile to laughter, as she succeeded in lifting the doll out through the neck of her dress. Other expressions also noticed were resentment and fear. Goodenough concluded that the display of these emotional expressions, present even though this child was deprived of visual and auditory stimulation from the environment, was suggestive of their innate origin.

Thompson (1941) observed and photographed blind and sighted children in their natural environment. She found that the facial expressions of laughing, smiling, and crying were similar for both groups and concluded that these were innate responses. She found that fear and anger expressions appeared in appropriate and inappropriate situations. However, their appearance did not seem to be associated with learning or imitation. Eibl-Eibesfeldt (1973) also found similarities in the expressions of deaf and blind children with those of normal children. Amongst the expressive behaviour of the former group, Eibl-Eibesfeldt described smiling, laughing, crying, anger, surprise or startle reaction and frustration.

Many studies have concentrated on the ontogeny of expression, effectively ignoring the ability of infants to recognise the facial expression of others. Darwin (1872) alluded to this phenomenon by what he referred to as sympathy felt by his son when the nurse pretended to cry. One reason for the lack of interest in this area may be the problem of knowing if the infant can discriminate between two expressions (Charlesworth & Kreutzer, 1973). Bühler and Hetzer (1928) provided evidence that infants can discriminate between an angry face and a smiling face by the age of five to seven months. The criteria used for discriminative ability were the responses made by the infants as they looked at the faces, i.e. positive characterised by smiling, kicking legs and moving arms, or negative such as crying, and laying motionless. Haaf and Bell (1967), recording the fixation time of the infant to a face, reported that infants respond to a face more readily than to other patterns presented, regardless of the complexity of the pattern. LaBarbera, Izard, Vietze and Parisi (1976) also measuring fixation time, concluded that four to six month old infants can discriminate between the expression of joy, anger, and neutral. Infants seem to fixate on the joy expression longer than the anger or neutral expressions. This is consistent with Izard's (1971) theory in relation to the recognition of emotion by infants. He theorises that the production of an expression is dependent on its adaptive function for the infant. In other words, an emotion will come into play or be recognised if it provides rewarding experiences for the infant. According to Izard (1971), the expression and recognition of joy strengthens the bond between parent and child, whereas no function of anger can be attributed as adaptive in such a young child.

2.3.2. <u>Maturation</u>

Although the ability of an individual to express or recognise certain emotions may begin early in life, there is evidence to suggest that this skill improves with age (i.e. maturation). Gates (1923) was the first to suggest the growth of social perception with age. She found that older children interpret expressions seen in photographs more accurately than do younger children, but still have some difficulty when compared with adult subjects. Honkavaara (1961) used students of various ages ranging from five years to twenty-six years and an adult teacher population aged thirty to forty-five years. She concluded that;

> "*little children while looking at pictures with expressional content, give matter-of-fact answers to questions asking what the pictures represent, and with mental maturity the expressional content of the pictures is recognised*" (1961, p.87).

Salzen, Kostek and Beavan (1986) using a series of Frois-Wittman and Ekman-Friesen photographs asked twenty adults and twenty children to indicate "*what the man/lady in the picture is doing*" and "*what the man/lady is feeling*" (p.328). They found that adults easily described the feeling states for the photographs, but that the children found this task difficult. In contrast, the children were as good or better than the adults in providing action terms for the photographs. This confirmed findings from an earlier study (Salzen, 1981). Izard (1971) notes that "*the child's ability to discriminate all of the fundamental emotions emerges with increasing maturation*" (p. 348). Furthermore, the recognition of emotion precedes the child's ability to correctly label the emotion.

2.3.3. The Learning Theory Approach

In direct opposition to the innate and maturational approaches to the ontogeny of facial expression is the position adopted by the learning theorists. Probably the earliest study suggesting that facial expressions are learned responses was conducted by Sherman (1927a, 1927b, 1928). Neonates were subjected to four stimulus conditions, i.e restraint of the head and face, dropping the infant suddenly from a height, pricking the infant with a needle, and hunger. The crying expressions during these four stimulus situations were then shown to adult judges who were unable to distinguish the different emotions, i.e. anger, fear, physical pain and hunger pain respectively. Sherman concluded that the judges needed more information (such as the situational context of the crying), before an accurate label to the emotion could be given. However, this conclusion may have been made prematurely since the more contemporary researchers in this area do not distinguish different categories of crying, but instead, include it under the general emotion heading of distress-anguish (Izard, 1971; Izard & Tomkins, 1966; Tomkins, 1963). Honkavaara (1961) also made the point that it is difficult enough to distinguish between the many crying responses found in adults. Hence, a discrimination in infants where the emotional experience is difficult to determine, minimises the chances of an accurate judgement. Other influential learning theorists include Kistiakovskaia (1965) who states that "*positive emotional expressive reactions are called forth by visual and auditory stimuli*" (p.41) and Dennis (1935) who found that smiling in infants is elicited by the human face.

The learning theory approach to the facial expression of emotion finds its greatest support in the work done with deprived or institutionalised children. Gaensbauer and Hiatt (1984) describe the facial expressions of abused and neglected children as compared to normal controls. Six stimulus conditions intended to elicit a number of expressions in infants ranging from one to six months were set up. Firstly, the mother/caretaker (e.g. foster parent) and child were involved in play. Secondly, a male stranger entered, approached and picked up the child. This was followed by similar approach and pick up behaviour by firstly the mother and then by a female stranger. A series of tests were then administered to the child after which the mother placed the infant back into its seat and left the room. The most obvious finding was the predominance of sadness and anger and lack of the joy expression in the abused and neglected group, whereas the normal sample showed more positive emotions throughout. The authors concluded that "*patterning of the infant's facial expressions were meaningful in relation to their specific life experiences*" (p. 212).

Other situations where children are denied the opportunity of a "normal" upbringing occur when they are institutionalised or are left to fend for themselves, as is the case with feral children. Charlesworth and Kreutzer (1973) report on two studies with feral children. The first one was reported by Zingg (1940), who found that anger and impatience were expressed. In contrast, Itard (1932), who kept a diary on an eleven or twelve year old feral boy, reported on the marked absence of any communicative-expressive skill. This, Itard concluded, was due to the absence of a social-communicative environment.

In reference to institutionalised infants, Gewirtz (1965) compared their smiling behaviour with children reared in a Kibbutz or at home. With the former group, the onset of the smiling response to a neutral human face appeared later as well as reaching a peak in frequency as much as four weeks after those in the latter groups.

To conclude, it is very difficult to come out in support of any one approach to the origin of facial expressions in infants and children. The genetic, maturational and learned theorists all have their supporters and their critics. Although the facial musculature appears to be fully formed and functional at birth, evidence for their mobility in the production of facial expressions is contradictory (Oster & Ekman, 1978).

Similarly contradictory are the findings produced by the studies on deprived children. For example, results on the blind and deaf tend to lean toward a genetic or maturational influence on the ontogeny of facial expression, whereas the work done with feral and institutionalised children support the learning theorists' viewpoint. Charlesworth and Kreutzer (1973) conclude after their extensive review, that the post-Darwinian studies on the origin of facial expression in infants, have come no closer to clarifying this issue. Perhaps the reason for this is that both genetic and experiential factors play such complex, interactive roles in the ontogeny of emotion. Nevertheless, most researchers agree on the vital role played by infant expression and recognition of emotion in bonding as well as in later social interactions (Ekman, Friesen & Ellsworth, 1972; Fried, 1976; Savitsky, Izard, Kotsch & Christy, 1974).

2.4. Universal Versus Culture-Specific Facial Expressions of Emotion

> "*Whenever the same movements of the features or body express the same emotions in several distinct races of man, we may infer with much probability, that such expressions are true ones, that is, are innate or instinctive*" (Darwin, 1965, p. 15).

In order to establish the innate origin of facial expression in humans, Darwin (1872) conducted the first cross-cultural study in this field. He proposed that the existence of universal facial expressions for the different races of humans, supported his hypothesis that facial expression in humans was the result of an evolutionary-genetic process.

Unable to travel due to ill health, Darwin compiled a list of sixteen questions and had these forwarded mainly to missionaries who worked in other countries, some in remote areas of the world. He asked them to attend to very specific aspects of the face during expression, for example, the position of the eyes, eyebrows and mouth during surprise, anger and joy, or the appearance of the frown and what emotion it accompanied. The fact that Darwin included the facial features expected with each emotion may have biased his findings (Ekman, 1973), however, the response of thirty-six different observers led him to the conclusion that there were indeed universal expressions for the display of emotion.

The first real challenge to the notion of the universality of facial expression came from Klineberg (1938). His review of Chinese literature and the description of facial expression and emotion given therein, led him to conclude that there were major differences in emotional expression between Chinese people and those from the West. He acknowledged the existence of certain similarities such as the literary description of fear, shame, sorrow and joy. However, his inclination toward a culture-specific view of emotion sparked another controversy in the origin of expression in humans.

Nine years later, LaBarre (1947), an anthropologist, queried the existence of innate behaviours and stressed that one's survival in foreign countries is dependent on acquainting oneself with cultural norms, behavioural and gestural. In fact, he stated that it was unsafe to assume universality of emotion amongst unknown races, as serious misunderstandings may occur. According to LaBarre, "*there is no "natural" language of emotional gesture*" (1947, p. 55). Examples given are taken from Gorer (1949), who observed Negros in Africa and found that laughter, for example, was used in many emotions from joy to surprise and shame.

Similarly to Klineberg, Asch (1952) while conceding the existence of some universals, e.g. the smile and cry, emphasised the differences determined by cultural values. These differences included the appearance of expressive gestures when culturally appropriate, e.g. weeping at funerals, as well as the frequency of expressive behaviour shown between cultures (e.g. Efron & Foley, 1947 found qualitative differences between the expressions of Italians and Jews living in New York City). Furthermore, Asch noted the importance of the situational and psychological context in which emotions appear. Other investigators to find inconsistencies, that is, similarities and differences in their research on cultural influences on facial expression were Triandis and Lambert (1958), Dickey and Knower (1941), Vinacke (1949), Vinacke and Fong (1955) and Keating, Mazur, Segall, Cysneiros, Divale, Killbride, Komin, Leahy, Thurman and Wirsing (1981).

Perhaps the most influential theorist denouncing the existence of universal expressions was Ray Birdwhistell. He concerned himself with the study of kinesics which he defined as the "*systematic study of those patterned and learned aspects of body motion which can be demonstrated to have communication value*" (1963, p. 125). Applying the science of kinesics to the study of facial expression, Birdwhistell admitted to his acceptance of Darwin's theory of universals until he noticed, particularly with the smile, that there was some ambiguity. He wrote;

> "*Not only did I find that a number of my subjects "smiled" when they were subjected to what seemed to be a positive environment but some "smiled" in an aversive one...It became evident that there was little constancy to the phenomenon*" (pp. 29-30, 1970).

In conclusion, he likens facial and body motion to language, in that it has communicative value, but also like language, is culture-specific. He noted;

> "*Insofar as I have been able to determine, just as there are no universal words, no sound complexes, which carry the same meaning the world over, there are no body motions, facial expressions or gestures which*

provoke identical responses the world over" (1970, p.34).

More recently, the views of Klineberg, LaBarre and Birdwhistell have found supporters in Leach (1972) and Mead (1975).

Using a different approach, Seaford (1975) entered the controversy with an emphasis on the cultural variation associated with the action of the facial muscles. He found a regional influence, in an American sample, for the contraction of the muscles around the mouth, resulting in a smile. A closer examination of 10,000 photographs of smiles, resulted in the identification of a series of movements displayed uniquely by residents of the neighbouring states of Virginia and Pennsylvania. These movements were later classified as the "Southern Syndrome" and were manifested in the display of the "pursed smile", which was frequently accompanied by the protrusion of the tongue. The historic involvement of the Virginian state in the contribution of a stable economy for the South, along with suspected English dialect filtration, has been considered as an explanation, with cultural implications, for this unique but widespread expression in the southern region.

Two major influences in the contemporary study of facial expression of emotion are Izard and Ekman. Both were influenced by Silvan Tomkins and both, working independently, found evidence for the universality of facial expression in humans. Izard (1971) compiled a series of photographs from actors and actresses as they posed the eight fundamental emotions based on Tomkins' (1963) theory of "primary affects". Four examples of each of the eight emotions were posed, resulting in a series of thirty-two photographs. These were then shown to a group of fifty American male students who were asked to judge each photograph and label the emotion appropriately. Sixty-two percent of responses were judged to label accurately the emotion intended. Following the labelling task, students were asked to place each photograph into the primary emotion categories of interest-excitement, enjoyment-joy, surprise-startle, distress-anguish, disgust-contempt, anger-rage, shame-humiliation and fear-terror. Eighty-three percent of responses were judged to classify accurately each emotion into its appropriate category. Hence, with such promising preliminary results, indicating that there were some expressions and emotions which were successfully matched amongst the American population, Izard (1971) was encouraged to extend his work to include other cultures.

Subjects from four different cultures, American, English, French and Greek, participated in the Emotion Labelling experiment, which was presented before the emotion recognition task for these cultures. They were asked to give their own emotion label to each of the photographs, which were later organised into categories by a separate group of judges. It was found that 56% of labels given by females and 50% of labels given by males, were judged as accurately representing the emotion intended.

Subjects from nine different cultural groups participated in the Emotion Recognition study (seven American and European cultures, one African and one Japanese). They were given a list of the fundamental emotions, and as each photograph displaying a particular emotion appeared on the screen, subjects were asked to place it into one of the fundamental emotion categories. There was 78% agreement across all the cultural groups. The higher level of agreement in the emotion recognition experiment was expected as it was assumed that emotion labelling was a more complicated task, involving language, and more dependent on experiential and cultural influences.

Boucher and Carlson (1980) replicated the emotion labelling and emotion recognition experiments of Izard using an American and a Malaysian sample. In the first experiment, encoders from both cultures were used to pose the six fundamental facial expressions. Subsequently, American and Malaysian (i.e. in Kuala Lumpur) students judged each of the photographs. The findings revealed that regardless of encoder and decoder characteristics, accurate judgements of facial expressions were made. In the second experiment, a comparison of the emotion labelling and emotion recognition methodology was tested with the group of Malaysian students using both American and Malaysian photographs. Like Izard, Boucher and Carlson found that the free emotion labelling task, although successful, produced less accurate judgements from the observers than when they were supplied with a list of emotion categories from which to choose. A third experiment exposed a group of Temuans who had had limited contact with Western culture, to the posed facial expressions of the American sample. The Temuan sample were able to decode accurately the American expressions. The findings of Boucher and Carlson collectively support the existence of at least six fundamental emotions, each characterised by their unique, universal facial expressions.

Izard (1971) concluded that the recognition accuracy shown by the participants in his study supported Darwin's evolutionary theory of the universal origin of facial expression in humans. Furthermore, he contended that this high level of agreement amongst students from such diverse cultural backgrounds, is seen to lay to rest the relativists' argument that expressions are specifically learned within each culture.

At the same time, Ekman (1971) was conducting an emotion recognition study with subjects from America, Japan, Chile, Argentina and Brazil. Over 3000 photographs were examined, until thirty were chosen to represent "pure" expressions, i.e. not considered to be a blend of emotions. These thirty photographs depicted six emotions, happiness, sadness, anger, fear, surprise and disgust. The findings confirmed Izard's (1971) results, that emotion recognition of the fundamental expressions extended across cultures.

Unlike Izard however, who concluded in favour of the existence of universals from his results, Ekman (1971) hesitated until a further study, eliminating the variable of visual contact with the media, could be performed. Birdwhistell (1970) claimed that universal expressions do not exist, but that certain expressions were recognised around the world because of media coverage portraying facial expressions of emotion. Responding to this criticism, Ekman, Sorenson and Friesen (1969) repeated their recognition task with people from two preliterate cultures, in Borneo and in New Guinea. The accuracy results obtained were weaker than those found for the literate sample. Attributing this to the judgement task, Ekman and Friesen (1971) returned to New Guinea a year later, with a judgement task used initially by Dashiell (1927). In the earlier study (Ekman, Sorenson & Friesen, 1969) the same set of emotion words were repeated after each photograph and subjects were asked to choose the word which fitted the emotion displayed by the photograph. In the second study (Ekman & Friesen, 1971), New Guinean subjects were shown two to three photographs at a time, and asked to select the photograph which best described the emotion felt, stated in a short story. The results were more conclusive, indicating that the photographs chosen by the New Guineans were the same as the ones chosen by the literate samples for anger, happiness, disgust, sadness and surprise. Ekman and Friesen (1971) concluded that there were universal facial expressions of emotions, recognised by people of varying cultures.

In an ambitious study reminiscent of Darwin's (1872) approach to the universality of facial expressions of emotion, Ekman, Friesen, O'Sullivan, Chan, Diacoyanni-Tarlatzis, Heider, Krause, LeCompte, Pitcairn, Ricci-Bitti, Scherer, Tomita and Tzavaras (1987), representing scientists from ten different cultures, participated in a judgement study, designed to investigate the efficacy of single and multiple choice emotion lists on the predicted response, as well as a cross-cultural examination of the judgement of emotion blends and the possibility of universal agreement as to the intensity of emotions. A variety of photographs representing the six fundamental emotions were shown to observers in Estonia, Germany, Greece, Hong Kong, Italy, Japan, Scotland, Sumatra, Turkey, and America. The authors found that the cross-cultural judges consistently rated the predicted emotion, including the primary and the secondary emotion when asked to look for a blend. They performed this task equally as well when given a multiple choice list of emotion words from which to choose the target expression. The authors thus have presented clear and robust evidence for the universality of facial expression.

However, the results also revealed some cultural differences in the judgement of the intensity portrayed by the photographs. In further investigations designed to elucidate these differences, Matsumoto and Ekman (1989) asked Japanese and American subjects to judge the intensity of several different emotions posed by both American and Japanese encoders. Irrespective of the encoders' gender or cultural background, the American subjects gave greater intensity scores than the Japanese for the emotions of happy, surprise, fear, anger and sadness. The Japanese on the other hand, produced higher intensity scores for the disgust emotions. The authors suggest that these differences may be due to the learned rules in each culture for dealing with the expression and judgement of emotion.

While arriving at a conclusion consistent with Darwin for the universality of expressions, Ekman (1971) also acknowledged the existence of culture-specific expressions. The development of a theory of facial expression, referred to as "neurocultural", attempts to assimilate the inconsistent findings shown in the literature with regard to universality. The neurocultural theory emphasises the existence of a "facial affect programme" which is universal. The "facial affect programme", once activated, determines the facial appearance of an emotion, as it triggers the facial muscles responsible for the unique expressions.

According to Ekman (1971), cultures differ in three ways with regard to their facial expressions. Firstly, events which result in one particular emotion over another will differ between cultures. Inconsistencies in findings appear quite frequently if cross-cultural studies are performed, using the same situational stimuli to elicit an emotion across two or more different cultures. Thus, the resulting differences in emotional expression found by the culture-specific theorists may be disputed, if it is taken into account that the same event may lead to different reactions by different cultural groups. For example, the facial expressions at funerals have been found to vary from culture to culture (LaBarre, 1947). Before concluding that no universal expression for grief exists, inherently assuming that funerals evoke grief reactions, it is important to ascertain the feeling and attitude each culture has toward funerals.

Secondly, there seem to be cultural norms which dictate the appropriate display or inhibition of an expression. Ekman (1971) refers to these as "display rules". Display rules govern the emphasis put on emotion following an event. The masking or neutralising of an expression is also very common and dependent on learned habitual processes. Killbride and Yarczower (1980) provide evidence to suggest that imitation plays a vital role in the ontogeny of the display rule process. Returning to the funeral example, and assuming that grief is common to both cultures

A and B, culture A may outwardly show the sad expression, but culture B, because of display rules, may show no expression, or mask their sadness by exhibiting a happy face. Ekman (1973) states that many of Klineberg's, LaBarre's and Birdwhistell's examples and observations which lead them to conclude against the universality of emotion, were directly attributable to either the elicitors of emotion or display rules of that culture.

Finally, an emotional reaction has different consequences for different cultures. Ekman (1971) distinguishes six different consequences:

1. The universal facial expression activated by the facial affect programme.
2. The appearance of facial expression dictated by the display rules of that culture.
3. The habitual association of two emotions, e.g anger and disgust, either one may be displayed whenever the other is experienced.
4. Action response involving facial and bodily muscles.
5. Language.
6. Physiological reaction.

Hence, many of the above consequences, apart from (1) and to some extent (6), are socially learned responses and modified by cultural influences.

Eibl-Eibesfeldt (1974) notes that similarities across cultures are difficult to find due to the poor coverage of facial expressiveness by field workers. He laments the fact that permanent records of ritualised behaviour have not been made and stored for historical and educational purposes. From his own work however, similarities between cultures have been found not only for the global expressions such as happiness and anger, but also in the specific movements of some facial features, e.g. eyebrow raising in greeting behaviour. Furthermore, several behavioural sequences, such as the turning away response in embarrassment and the embrace upon greeting a friend, are also common patterns seen cross-culturally. Amongst the differences, however, Eibl-Eibesfeldt found head shaking and head nodding to be culture-specific.

2.5. Conclusion

The culture-specific view of emotion has enjoyed a large following, mainly due to the rise and dominance of learning theory and the S-R paradigm. The neglected area of genetic influence is attracting more interest in psychology as theories of personality and individual differences find the learning approach lacking. In these current times, psychologists are beginning to appreciate the complex interplay between genetic factors and the environment. The work of Ekman and his colleagues excludes the complete control of nature or nurture, but rather focuses on the interaction between the two in the emotional process as it pertains to the display of facial expression. The neurocultural theory reconciles the important cultural and universal determinants in the origin of facial expression.

PART 1

CHAPTER 3

METHODOLOGY AND MEASUREMENT TECHNIQUES FOR THE JUDGEMENT OF THE FACIAL EXPRESSION OF EMOTION: 1. THE JUDGEMENT APPROACH

3.1. Introduction

The human face is a dynamic outlet for the expression of emotion. It is no wonder that many researchers studying nonverbal communication focus on the activity of the face primarily, as the qualifier of language. The facial responses exchanged between participants in a dialogue and the ability to recognise and respond to facial cues have long been of interest to social and clinical psychologists. An observer's judgement of attitude and emotion from the facial expression of another, in particular, has attracted researchers from a variety of disciplines, all hoping to contribute to the controversial findings of earlier pioneers.

Investigators studying the recognition of facial expressions of emotion have approached the problem from one of two perspectives. Firstly, there is the judgement approach, whereby observers are presented with photographs depicting various emotions, and they are asked to judge the expression shown. A list of emotion words may or may not accompany each photograph. Historically, this judgement design has dominated the methodological structure of many studies. A less popular, but nevertheless profitable method of analysis, has been the component approach. The methodology of this design involves a concentration on the facial features that are present and contribute to the appearance of the expression on the face. These two approaches will be considered separately (in this and the next chapter) and a review of the major work in each area will be presented.

The work of Darwin (1872) inspired the earliest researchers to study the judgement of facial expression of emotion in humans. Darwin obtained expressive photographs used by Duchenne, of the various expressive movements achieved by muscles when electrically stimulated. These photographs were distributed to over twenty of his colleagues who were asked to indicate which emotion they felt was being expressed. Many expressions were recognised and similarly judged. However, there were a few which were described differently amongst the observers. Darwin speculated that this confusion was due to the lack of instruction given to each judge before the task.

3.2. The Judgement Approach: A Question of Accuracy

The next two sections will explore the different methodological techniques employed by the judgement approach in an attempt to assess or improve the accuracy of observer judgement of facial expressions. The early studies using artists' representations or photographs of facial expressions of emotion as stimuli showed some positive findings in observer judgement of emotion. However, due to the influential uprising of the S-R or the Behaviourist approach in psychology, which virtually ignored the phenomenon of emotion or emotional states, and some early reported negative findings (associated with the judgement approach), methods for increasing or improving the accuracy of the judgement approach were needed and indeed emerged. These included the introduction of the motion picture (i.e. film or video) for the capture of facial expressions; presentation of expressions "live" for the observers; introducing the knowledge of situational context; preparing the raters for judgement by providing training in the analysis of facial expression; inducing specific mood or suggestive states in the observer; presenting either the upper or lower halves of the face; and an investigation of the facial asymmetry in the judgement of facial expressions. A review of many of the judgement studies follows, emphasising the above-mentioned accuracy techniques.

3.2.1. Artists' Drawings as Facial Stimuli

Langfeld (1918a) used 105 of Rudolph's (1903) 680 sketches of a bearded actor in various poses. Six subjects were asked to indicate the emotion expressed from their own experiences and attitudes. This experiment was repeated with the photographs being shown in a different sequence. A third time the subjects were presented with all the judgements made by the observers, as well as the artist's intended emotional expression. They were then asked to compare their own interpretation with that given by the artist, and to indicate their preference of descriptive category. Langfeld reported on consistent intra-observer judgements on the first two trials, with laughter being the most accurate. However, the subjects were unable to delineate their own judgement from those of others in phase three of the experiment.

3.2.2. Photographs as Facial Stimuli

After Darwin, the judgement approach to the recognition of facial expression was not pursued again until Feleky (1914) organised a more structured experiment using photographs of expressions she had posed for herself. That is, with the judgement of facial expressions from photographs came the development of various "face scales". Although constructed to measure different emotions, their design and implementation were basically the same. The procedure involves the collection of several photographs of faces displaying an array of emotional expressions appropriately placed in the set, which is scaled according to the intensity of the expression. This set of ten or twenty photographs is then shown to a homogeneous group of subjects who are asked to choose the targeted expression or emotion photograph. The advantage presented by this kind of pictorial analysis of emotion is that it does not require literacy skills on administration. The judgements provided by the photographic set can then be correlated with the scores obtained from self-administered questionnaires. Face scales have been used to assess job satisfaction (Dunham & Herman, 1975; Kunin, 1955); pain level (Addicoat, Champion, Feller, & Ziegler, 1988); and mood state (Lorish & Maisiak, 1986).

Feleky showed eighty-six photographs to one-hundred people, although no criteria for the selection of her materials or subjects were given. A list of 110 emotion words accompanied the photographs. This method allowed subjects to minimise the information given by slotting various poses into the same categories. However, there was also a great deal of disagreement regarding photographs and their appropriate categories. The subjects did not judge many of the photographs as belonging in only one category.

Ruckmick (1921) used thirty-five photographs of expressions posed by a female drama student. The clothing worn was the same in each photograph, as was the staging arrangement. Ten judges were asked to interpret the emotion portrayed and to comment on any personal feelings the separate photographs may have aroused. Pain and laughter were the most predominantly recognised expressions. "Primary" expressions as a whole (e.g. love, hate, joy) were more consistently agreed on than such "secondary" emotions as distrust, surprise, repulsiveness. He also found that judgements were influenced by an observer's mood.

Gates (1923), in keeping with the positive results obtained thus far, found that children as young as three years old could identify expressions, predominantly laughter and pain, from photographs. Furthermore, she concluded that the accuracy of this interpretation increased with age.

The negative findings reported by the two authors to follow, Landis and Sherman, were considered so influential and conclusive that studies on facial expression almost disappeared for the next twenty years. These experiments, which have since been widely criticised, coupled with the rise of S-R learning theory, together almost exclusively have been blamed for the neglect of research into facial expression in the first half of this century. A brief summary and critique of these two major works is necessary in any review of the judgement of expression literature.

Landis (1924) decided that the best way to induce an emotional response from a subject was to put the subject into an emotionally laden situation. The subjects were asked to participate in the following situations; listen to popular and technical music, read from the Bible, construct an alibi or speak the truth in a fabricated crime, smell ammonia, be surprised by a gunshot, record an embarrassing moment which was later read out aloud by the experimenter, look at pictures of skin infections, solve an arithmetic problem, look at pornographic and art pictures, read sex case histories, immerse a hand into a bucket containing live frogs, decapitate a rat, and receive an electric shock. A burnt cork was used to mark the muscles of the face of the participants. Photographs and subjective reports were taken after each situational reaction. He concluded that there was no particular muscle movement associated with any one expression. Furthermore, there were marked individual differences in the emotional reactions to the various situational cues.

Landis (1929) selected seventy-seven photographs from his previous experiment to be shown to forty-two judges who were asked to name the emotion and the situation which aroused it. The only expression and situation which were consistently recognised was joy. Otherwise, Landis concluded that;

> "*observers cannot make a statement more accurate than one would expect by chance concerning the emotion which a subject was undergoing when photographed or concerning the probable situation which might give rise to such an expression*" (p.67, 1929).

The experiments of Landis have been severely criticised by many researchers. Davis (1934) discovered an error in the statistical technique used by Landis, which he considered "*invalidates his conclusions*" (p.54). Subjecting the same data to a correlational analysis, Davis found some similarities among expressions and concluded they were indeed situation specific. According to Davis, a second serious flaw in the methodology was that Landis was interested in the cumulative result of the experimental procedure. The build up of emotion over the seventeen successive situations would not be conducive to a discriminatory analysis of the specific emotion per situation which was evoked. The cumulative effect failed to allow distinct emotions to surface, hence making it very difficult for the observers to judge the emotion accurately.

In a comparable study, Coleman (1949) asked a group of subjects (six males, six females) to pose the appropriate response to a series of stimuli, e.g. relaxation, squeezing a dynamometer, sudden noise, threatened shock, crushing a snail, being confronted with a snake, being told a joke. He recorded their expression on film. Acting on advice from Davis (1934), Coleman introduced rest periods between situations, in order to counteract any cumulative effect. Instead of asking for a label for the emotion expressed, Coleman instructed his judges to pick the situation from which the expression originated. He found that the judges were able to nominate accurately the experimental situation encountered.

Frois-Wittmann (1930), Arnold (1960a) and Honkavaara (1961) raise the third criticism of Landis' study. They suggest that the emotions aroused by the experimental manipulations may not have been the same in all of the subjects. In fact, Landis found that the subjects' own report of their feelings varied for the same situation, indicating the situations elicited a variety of emotions or blends of emotion.

Coleman's (1949) judges on the other hand, accurately associated emotion with situation suggesting that their behaviour was emotion specific.

The final criticism was raised by Murphy, Murphy and Newcomb (1937), and later by Arnold (1960a) and Honkavaara (1961) suggesting the possibility that Landis' subjects may have "masked" their facial responses, mainly because they knew Landis personally, and were also aware of the aim of the experiment. Coleman's (1949) subjects, however, were unknown to him prior to the study. Also, in the latter study, subjects were asked to comment on the eliciting situation, hence taking the emphasis away from their own faces.

The second author to obtain negative findings on accuracy judgements was Sherman (1927a) in his study of the facial expression of emotion in infants. He recorded on film the facial expressions of two infants, one three days old and the other six days old, in four different situations; hunger, dropping the infant, restricting the infants' movement, and pricking its cheek with a needle. The four major criticisms of this study are reported succinctly by Ekman, Friesen and Ellsworth (1972). Briefly, the major criticism is the same as the one applied to Landis' data, namely that the four situations in this study may not have evoked the same emotion in each infant. In other words, if different reactions were elicited by the same situation, then different judgements of facial expression were justified. If this was indeed the case, then the interpretation as stated by Sherman, that there are no emotion specific facial expressions, seems to be premature. Further criticisms centre around the specificity of the judgements collected, since Sherman scored all of the observations made, emotional or otherwise, for accuracy against what he believed should have been the correct response. Finally, Goodenough (1931) commented that at only a few days old, the facial responses of the infant may not have matured adequately to be successfully differentiated. The small number of infants sampled does not allow this issue to be clarified further.

It is difficult to understand, more so after reading the foregoing criticisms, the influential status achieved by the Landis and Sherman experiments. Their negative results, denouncing the ability to recognise facial expressions, and the emphasis on the importance of situational context were however, very popular at a time when the learning theory approach was gaining momentum through the work of Watson (1924) and Pavlov (1927). Furthermore, Sherman and especially Landis, gathered a great deal of data from their research which in many respects was unprecedented, as far as quantity of information generated was concerned. Sherman conducted what was probably the first major experiment on the delineation of facial expressions in infants, after Darwin's observations of his own children. Although many researchers have long discovered flaws in the methodology and data analysis of these studies, their popularity cannot be denied, and it is left to the contemporary researchers to speculate and wonder why?

Frois-Wittmann (1930) posed for his own series of photographs, choosing forty-six from a total of 120 expressions. These forty-six photographs were shown to 165 observers who made judgements on the whole face, the eyes and the mouth separately. Forty-three emotion words were supplied as a guide for each judge, and any personal descriptive terms were also accepted. Frois-Wittmann noted that thirty-two of the forty-three emotion terms were consistently and accurately checked with the corresponding photograph. He concluded that there was considerable agreement amongst the observers in their descriptions of the facial expressions.

Kanner (1931) showed ten to thirteen of the Feleky photographs to over 400 first-year medical students. They were asked to judge the emotional expression of each photograph as well as to indicate an appropriate situation which may have yielded the emotion. A third of the group was also asked to identify particular facial features which assisted in their judgement. The students returned a total of 365 emotional terms, which were put into one of thirty-seven categories. Kanner did not consider any one expressive word to represent the "correct" interpretation of any particular photograph. Rather, the number of emotion terms specific to a category ranged from two (shrinking away and wincing comprising one category) to forty different emotion words given to represent the "resentment" category (i.e. disagreement, disapproval, anger etc.). Judgements were then graded from 0 to 10 for how closely they approximated the intended expression. A score of seven and above was recorded as an adequate description of the photograph or imagined situation.

The expressions of surprise and fear were the most easily and consistently labelled, where 65% of the terms given by the students fell into the fear category. Pity, interest and justified anger were the least recognisable expressions. Although some categories were made up of many similar expressive titles, Kanner found that in most cases there were two or three more popular words in each category which were most often used to describe that facial expression. For example, the anger category which comprised of such terms as resentment, threatening and rage, was most frequently represented by the terms anger and rage (40% of the time). Similarly, mentioning the terms "surprise" and "astonishment" made up 71% of that category (which included such terms as wonder, amazement, astounded etc.). Kanner concluded that there were considerable individual differences with regard to the judgement of an expression and situation from the Feleky photographs. The students were seen to make satisfactory descriptions of the photographs at a rate greater than that expected by chance.

3.3. Improving the Accuracy of the Judgement Approach

In his review, Woodworth (1938) noted that a conclusion negating the influence of the face in the judgement of emotion seemed most likely. However, he did not support such a conclusion. Instead, he realised that in the earlier studies judgements were coded as right or wrong outright. In other words, it was an all or nothing situation where the degree of accuracy was not taken into consideration. He constructed a linear scale where similar emotions were placed alongside each other, hence enabling the judgement and error of judgement to be measured simultaneously. The original emotion categories represented by the scale were love, happiness, mirth, surprise, fear, anger, suffering, determination, disgust and contempt. The scale was tested on the data obtained by Feleky (1924) and a high correlation between the intended expression and judgement accuracy was found. The linear flow of the emotion categories, on the other hand, was not entirely successful. Measuring the degree of error associated with each photograph resulted in the confounding of several categories to produce a six-point scale consisting of (1) love, happiness, mirth, (2) surprise, (3) fear, suffering, (4) anger, determination, (5) disgust, and (6) contempt. The results obtained by Ruckmick (1921) and Gates (1923) fell neatly into these categories.

In his later work, Woodworth (Woodworth & Schlosberg, 1954) was drawn by the principles inherent in activation theory (Lindsley, 1951). This led to the suggestion that emotions were better represented along a dimensional scale, rather than by categorical groupings. A circular model of expression was created, with two pivotal dimensions; the vertical dimension accounted for the Pleasant-Unpleasant emotions (i.e. love, happiness, mirth-anger, determination), while the horizontal axis represented the Attention-Rejection dimension (i.e. surprise-disgust, contempt). It was envisaged that each judgement could be represented by a co-ordinate which accounted for its degree on each dimension. A circular scale was utilised to describe these points of location best.

3.3.1. Use of Film or Video

Following on from the use of photographs, Dusenbury and Knower (1938) introduced the motion picture to the study of the judgement of facial expression of emotion. A male and female subject were filmed as they posed eleven emotional expressions. Each expression lasted for approximately seven seconds. Still photographs of the best expression of each of the eleven emotions were also made, post hoc, from the film. A total of 569 students participated in this study. They were divided up into four groups; Groups 1 and 2 saw the motion picture of the posed expressions, while Groups 3 and 4 saw the photographs of the posed expressions. Group 4 also experienced many advantages not afforded the other groups, such as better lighting in the laboratory, chance for comparison amongst photographs and viewing the photographs on their own, and in their own time. The other subjects were seen in groups, supplied with a list of emotion words and asked to match the emotion words with the expressions seen on the screen (Groups 1 & 2) or in the photographs (Group 3). Groups 1 and 2 judged the expressions with the most accuracy (89%). Students in Group 3 judged the photographs with the least accuracy (62%). Group 4, given the most favourable experimental conditions, judged the photographs with greater accuracy than Group 3, but were not as accurate as Groups 1 and 2. Dusenbury and Knower concluded that facial expressions of emotion can be judged accurately, and further, promoted the use of film as a better mode of presentation. Furthermore, the judgements received from the photographs were influenced by the experimental conditions under which they were viewed.

Levitt (1964) showed fifty judges a motion picture of various facial expressions, produced by fifty students. Accuracy of recognition was defined by the ability of the judges to identify correctly the emotion intended by the subject. The results showed that the judges correctly recognised 56% of the emotions intended from a facial expression. Levitt (1964) concluded that the accuracy scores in this study which were contradictory to those obtained by Landis (1924) were directly due to the superiority of the motion picture over still photographs as a representation of facial expression[1]

3.3.2. <u>Use of "Live" Stimuli</u>

Uncertain about the conclusions reached by many authors who used photographs to depict the emotions, Thompson and Meltzer (1964) used "live" posers to communicate the emotion to a group of judges. Each encoder (there were fifty of them) sat in front of four judges and posed the emotion which was handed to them on a card. The following ten emotions were posed twice; love, happiness, bewilderment, surprise, fear, suffering, anger, determination, disgust and contempt. Thompson and Meltzer found that the judges accurately recognised the intended emotions in 60% of the trials. Happiness was the most recognised expression, while contempt was the least recognised. Also, although all of the encoders were able to pose some of the

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1 In a study, which is peripheral to this section, yet showing just how influential expressive behaviour via television/video can be, was conducted by Mullen, Futrell, Stairs, Tice, Baumeister, Dawson, Riordan, Radloff, Goethais, Kennedy and Rosenfeld (1986). The examined the relationship between the facial expressions of three popular news presenters, while referring to candidates for the 1984 American presidential election, and the subsequent vote cast by the viewers. A videotape of these recorded news bulletins was shown to 45 first year psychology students three months after the election results. The volume was turned down and students were asked to rate the facial expressions of the news broadcasters (as they presented a political story) on a scale ranging from "extremely negative" to " extremely positive". It was found that one of the three presenters showed some positive bias in his facial expressions, when reporting on a particular presidential candidate. A telephone survey was then conducted asking the receiver which television news service they watched and who they voted for in the 1984 presidential election. The results showed that a biased newscaster can influence the viewers' voting behaviour.

emotions effectively before the judges, considerable individual differences were found.

In a replication of the Thompson and Meltzer (1964) study, Drag and Shaw (1967) had forty-eight students pose "live" the same ten emotions before four judges. Their results agreed with Thompson and Meltzer's, in that happiness was the most frequently recognised expression and contempt the least frequently recognised.

Another study involving the judgement of emotions live in the laboratory was conducted by Gubar (1965). The students were occupied with a learning task which consisted of reward and punishment trials and each subject was under the observation of two judges. One of the judges had previously been given practical experience with the task at hand (experienced) while the other was only told what the subject was to expect (naive). The subject was presented with a stimulus, but had no way of controlling the reception of a reward or avoiding punishment. The observer, on the other hand, controlled the buttons and was told that the consequences of his button press would be experienced by both the subject and himself. The only cue to receiving a reward or shock available to the judge was the facial expression of the subject. Gubar found that the experienced judges significantly avoided more shock trials than did the naive subjects. Gubar attributed this finding to the greater ability of the experienced judges in using the facial expressions of the subjects as a guide to which button to press.

Savitsky, Izard, Kotsch, and Christy (1974) conducted a study which attempted to predict the aggressive behaviour of a subject, by presenting a small electric shock to a "victim" when associations were not paired correctly on a word list. The victim was a confederate of the experimenter and was asked to respond consistently to the simulated shock with one of the four facial expressions assigned, namely, fear, anger, joy or neutral. The victim knew of the supposed shock intended by the subject by way of a hidden light. The results showed that victims who smiled in response to the shock were given increasingly more powerful shocks by the subject. Subjects seeing an anger expression from the victim decreased the level of shock given. A fearful or neutral expression from the victim did not significantly influence the level of aggression shown by the subjects. Zimbardo (1969) had earlier provided similar evidence which indicated that the level of aggression shown toward a victim would be significantly influenced by the facial and postural response made by the victim following the aggressive act.

Eisler, Hersen and Agras (1973) presented evidence to suggest that the use of videotape in a judgement study was as reliable as presenting live posers in front of judges. The smiling and looking expressions in the interaction of six married couples was observed live or from a videotape, by four judges. The judges recorded the frequency of the looking and smiling expression for each couple as they engaged in a conversation. Inter-rater reliability of judgements was 93.8% for the live situation and 94.3% from the videotape. Eisler, Hersen and Agras (1973) concluded that given the similar results obtained using two different modes of presentation, the use of videotape in the judgement of facial expression has several distinct advantages. Firstly, it allows the observer to replay sequences of behaviour that may have occurred too quickly and so were subsequently missed. Secondly, scoring is more accurate as the expression can be scrutinised over many replays. Finally, a videotaped expression or interaction provides a permanent record which can be used at a later date to rate behaviour not originally measured. A point that has gone unnoticed here however, is that the use of film and video in the judgement of facial expression has shown that by control a group of judges can reach an outcome, but this may not necessarily generalise to naturalistic settings.

3.3.3. The Knowledge of Situational Cues and its Effect on the Judgement of Facial Expression

It is very rare to encounter a facial expression without being subjected to the situational cues that accompany it. In daily social interactions, these cues involve environmental and cognitive influences. Recognition of emotion seems to employ long and short term memory, i.e. previous experiential associations between emotion and its expression. Does contextual information supply the same information as the face alone or is the judgement of expression made easier or more difficult when the observer views a face in its naturally occurring context?

Fernberger (1930), writing after the very influential findings of Sherman (1927b), concluded from his experiments that;

> "*little can be determined of an emotional state in another individual from the perception of an abstracted facial expression (and we believe for postural expression as well) completely divorced from a general, total stimulus situation*" (p. 564, 1930).

He further adds;

> "*If a stimulus situation is indicated, the emotional state is judged in accordance with that situation rather than in accordance with the facial expression*" (p. 564, 1930).

These conclusions stemmed from his findings that misleading information given regarding the social stimulus resulted in the inaccurate judgement of that facial expression. Conversely, the reporting of an appropriate social situation led to an accurate judgement of the facial expression.

Goodenough and Tinker (1931) performed the first study which considered the separate contributions made by the exposure to the face alone, exposure to the situation alone, and the exposure to a combination of the face and situation. Using the Feleky (1924) expressions of fear, anger, sympathy and disgust, the authors paired each photograph with a short story relating an appropriate and alternately, an inappropriate context with each of the four expressions. When the context of the story matched the facial expression, 88.8% of judgements of the emotion were correct. When the expression and description did not match, there was a slight advantage given by the knowledge of context alone versus the face alone. Impressed with their addition of short stories to describe the context, Goodenough and Tinker concluded;

> "*short as the descriptions are, they probably approximate the total situation more nearly than the*

photographs approximate the total expression" (p. 368, 1931).

Munn (1940) used spontaneous expressions in his study of the potency of contextual information on the judgement of facial expression. A group of subjects were shown slides of various faces and asked to indicate in their own words, the emotion depicted by each of the faces. A week later, they were shown the same faces in their original photographed settings. Munn found that the number of accurate judgements increased when situational cues were provided. However, a good deal of accuracy was nevertheless achieved, on observation of the face alone, for various expressions. These findings do not support the claims made by Landis (1929) regarding the inability to accurately judge emotional expression from the face alone. The findings also refute Fernberger's assertion that the information provided by the contextual stimuli dominated the information supplied by the face alone. The experiment was later repeated with a second group of subjects (this time the photographs were accompanied with a list of emotion words) and the previous results were confirmed.

Also using spontaneous expressions (taken from magazines), Vinacke (1949) performed the first cross-cultural context experiment. Three different cultural groups, namely, Chinese, Japanese and Caucasian students, judged the spontaneous facial expressions of a Caucasian sample, from the face alone and from the face in context. A list of emotion words was provided and a high degree of agreement for intended emotion was demonstrated when there was some knowledge of the situation. There were a few expressions however, which were judged consistently even from the face alone slides.

Vinacke and Fong (1955) replicated the previous study, with the exception that the present task required the decoding of a series of Oriental faces. Again, judgement of expression using the face alone was compared to judgement of the face in its environmental context. The same three cultural groups were used, i.e. Chinese, Japanese, and Caucasian. The results supported earlier findings that knowledge of the situation aids in the interpretation of the facial expressions shown. Similarly, only a few expressions were judged equally well from the face and face plus situation slides. The results of these two studies support the earlier findings of Munn (1940).

Frijda (1969) hypothesised that the recognition of emotion takes place in two stages. The first stage involves the perception of the facial expression. Secondly, the judgement is modified and becomes more specific as the input of the situational stimuli impinge on the senses. This "specification" hypothesis was tested in a series of experiments. In his first experiment investigating the influence of situational cues on the judgement of facial expression, Frijda (1958) found that the accuracy of interpretation increased as a direct result of the specificity of information provided by situational cues.

Three experiments followed and were reported by Frijda (1969). The Goodenough and Tinker (1931) procedure was utilised, whereby the separate contributions of face alone, situation alone and the combination of the two, were studied separately in each of the three experiments. Unlike the previous authors who concluded in favour of the dominance of contextual cues, Frijda (1969) found that when there was a mismatch between photograph and context, the facial expressive cues outweighed the situational cues in the judgement of emotion. Watson (1972) supported these findings in an experiment which showed that when the clarity of context equalled the clarity of facial expression, then facial cues were primarily used in the judgement of facial expression.

Knudsen and Muzekari (1983) varied their methodology slightly by presenting verbal contextual statements, offering concordant or discordant information with each of four expressions, fear, anger, sadness and happiness. Although not comparing both the contextual and facial cues separately, the authors found that agreement of the facial expressions of emotion increased significantly when congruent verbal statements accompanied the face, as opposed to the face alone situation. Conversely, there was a significant decrease in the amount of agreement on the emotion shown by the face when presented with an incongruent statement than when seen on its own. These findings support the notion that knowledge of the context plays a vital role in the discrimination of facial expressions of emotion.

Cline (1956) approached the influence of social context from a different perspective. He used the presence of another face as the contextual cue. He combined smiling, glum and frowning sketches with each other to form six pairs of expressions (i.e. smiling-glum, glum-smiling, frowning-glum, glum-frowning, smiling-frowning, frowning-smiling). The respondents were asked to imagine a situation which would result in the interaction of the selected combinations of expressions. Also, each face was rated on a number of scales which related to such traits as dominance/submission, initiator/follower, doubtful/certain, etc. Cline found that the judgements of a particular facial expression varied according to the facial expression with which it was paired. For example, the glum-frowning association achieved ratings for the glum face such as dominant, aloof and independent. When glum was paired with smiling however, the glum face was described as submissive, unhappy and jealous. Cline concluded that these results suggested the importance of social context in the judgement of facial expression of emotion.

More recently, Russell and Fehr (1987) theorised that the same facial expression can be interpreted differently, depending on what other facial expressions it is paired with. A very detailed analysis of the relativity of facial expression judgement ensued, with the execution of six experiments. The design of each experiment was similar, involving an "anchor" expression and its influence on the judgement of a "target" expression. In other words, the respondents in each study judged the emotion displayed by an anchor expression before interpreting the emotion of a designated target face. In all six experiments, Russell and Fehr found that "*the emotional message read from a facial expression depends on previously encountered facial expressions*" (p.235, 1987). Specifically, the anchor expression had the effect of shifting the judgement of an expression which followed by 40%, in the opposite direction, as compared to the judgements made by a control group who were only exposed to the target expressions. The authors concluded that if the co-ordinates of the anchor expression in the bipolar "emotion space" (Russell, 1980) were known, then the shift in the judgement of facial expressions paired with the anchor, could be predicted. Indeed the shift would be "*40.6% of the average distance from the origin to the anchor*" (p. 235, 1987).

From a social interaction point of view, Thayer and Schiff (1969) questioned the robust nature of the facial expression stimulus to act as the superior differentiator when additional contextual information was provided. With the inclusion of a motion sequence in a face-to-face interaction, combination pairs of neutral, happy and angry faces were drawn together by various motion patterns. For example, the three stimulus situations involved were (1) as both faces approached each other, (2) one face stationary whilst the other approached, and (3) one face withdrawing as the other face approached it. Their findings showed that both facial expression and motion have a significant influence on observer judgement. The effect of motion pattern was particularly evident, as regardless of the facial expressions involved, the motion cue resulted in a negative interpretation of the situation which was judged as hostile.

Ekman, Friesen and Ellsworth (1982) reviewed the methodology and findings of the studies by Munn (1940), Vinacke (1949), Goodenough and Tinker (1931) and Frijda (1969). They decided that no conclusive statement could be made regarding the effect of the context and facial behaviour in the judgement of emotion from the results of the aforementioned studies. In sum, the conclusions in favour of the dominance of contextual cues come from the studies of Fernberger (1930), Goodenough and Tinker (1931), Munn (1940), Vinacke (1949), Vinacke and Fong (1955), Frijda (1958), Knudsen and Muzekari (1983), Cline (1956), Russell and Fehr (1987), Thayer and Schiff (1969). Conversely, the dominance of facial cues prevailed in the studies of Frijda (1969), Watson (1972), and Ekman, Friesen and Ellsworth (1982).

Three major difficulties in the research design of these studies have been emphasised. The problem lies with the ambiguous identification of the parameters of the facial and contextual cues which lead to the dominance of one over the other in a discrimination task. The important methodological criteria for research on this topic include (1) the clarity of each source, i.e. to discern the important contributions made by each single source as well as its combination, (2) the distinct emotions associated with each source, and (3) pairing of sources, i.e. this allows matching and mismatching of sources to yield concordant and discordant associations.

Embedded in the context versus face alone debate is the underlying, long running innate versus environment controversy. There is evidence which suggests that despite cultural differences and language barriers, there seem to be a few facial expressions which are primary and are generally agreed upon (Ekman, 1982a; Izard, 1971). There are the skeptics however, who acknowledge the influence of facial expressions and despite Ekman's "display rule" theory, emphasise the role played by the environment in the final analysis of emotion (Leach, 1972; Russell & Fehr, 1987).

3.3.4. The Effect of Training on the Judgement of Facial Expression

The marked individual differences in the ability amongst judges to recognise facial expressions of emotion has been noted by many authors (Ekman, 1978; Langfeld, 1918a; Thompson & Meltzer, 1964). Allport (1924) attempted to show that individual variations in a face judgement task were not due entirely to genetic, inherited factors, but also to the amount of training or experience obtained with such a task. He allowed twelve female subjects, who had previously acted as judges, a fifteen minute training period, before the task was again administered. They were presented with a list of emotions accompanied by the various facial features considered to be pertinent to the expression of that emotion. When re-tested, eight out of twelve subjects improved in their accuracy of recognition on a series of Rudolph's pictures. Training also had the interesting effect of decreasing the accuracy of those subjects who scored well in the first part of the experiment. Allport concluded that these subjects had probably acquired the skill of reading faces at an early age. A well defined training procedure may have interfered with their already existing schema constructed through continual use. The less accurate subjects, on the other hand, benefited from the use of something concrete and planned to aid them in idenification. Allport concluded;

> "*that while there may be innate differences of a general sort in the sensitivity required to learn facial*

expressions, the broad differences between individuals in this respect are due to differences of practice in reacting to the expressive criteria" (p.228, 1924).

Guilford (1929) extended Allport's work by increasing the number of Rudolph's faces, as well as extending the training period over ten days. Four sets of faces, comprising equivalent expressions were shown to fifteen social psychology students. The first set was presented and judged by a free labelling method at the beginning and at the end of the experiment to obtain a measure of baseline (original) ability and degree of improvement respectively, in the judgement of facial expression. After the first set was presented, subjects were asked to study Allport's account of the anatomy of facial expression. Set two was presented and judged as for Set one. The presentation of Set two was then repeated and this time accompanied with correct names and emotion-specific features for each expression. Set three was given as a direct replication of the Set two sequence. On the presentation of Set four, subjects were asked to judge the expressions on the basis of what they had learned, in the previous sessions. Set one was again shown and subjects were asked to use any judging method they preferred. Results confirmed Allport's conclusions that improvement in judgement accuracy was negatively correlated with the original score. Subjects with low baseline scores improved with training, while those with high baseline scores performed more poorly after the training procedure. The decline in accuracy of the superior judges was attributed to the cognitive intrusion of the analytical task. The poor subjects, on the other hand, were better equipped to deal with and adapted more easily to a planned practice session.

Jenness (1932) repeated Allport's (1924) procedure with sixty-six psychology subjects. Similarly, after a fifteen minute training period, the accuracy of judgement improved by 6.8% (compared to Allport's 5.9%). The experiment was again replicated with only one major change, that is, the length of the training session, which had increased to forty-five minutes. In accordance with Allport's conclusions, a gain of only 8.1 points was achieved with the extended period, suggesting that increasing the length of the training session did not significantly affect the end result.

Jenness also found a similar negative trend between pre-training and post-training judgement scores (-0.38 for 15 minutes practice and -0.29 for 45 minutes practice), although the correlation was not as marked as that found by Allport (-0.86). The experiment was repeated with a group of control subjects, who were shown the pictures, followed by a rest period, before seeing the pictures for a second time. In this case, where the training was omitted, a negative correlation between pre-test and post-test scores was also achieved (-0.63). This result led Jenness to reject Allport's and Guilford's conclusion that training influences judgement of facial expression. Jenness also questioned the reliability of the facial expression test, since he found a reliability coefficient of +0.42 between judgements made on the initial screenings and judgements made three months later. Controlling for the unreliability of the test, Jenness found that the negative relationship between pre-test judgements and post-test judgements disappeared. In other words, the positive effect of training could be discounted based on the threat of a regression artefact. Indeed, it has been shown that continuous sampling on a task results in measurements or scores which regress towards the mean (Cook and Campbell, 1979).

Jecker, Maccoby and Breitrose (1965) examined the effect of training teachers to interpret the nonverbal behaviour of their students' comprehension of educational material in the classroom. A film of several classes was taken as the teachers conducted the lesson. In the pre-training test, teachers were shown "silent" clips of the students answering a question and their task was to judge whether the student answered the question correctly or incorrectly. A separate group of judges also scored the students' comprehension, based on particular nonverbal cues, which included facial expression, gaze, blinking, hand and body movement. The teachers' judgements were scored for accuracy on the pre-existing criteria set by the independent judges. After a baseline measure of judgement ability was recorded, the teachers were assigned at random to either the experimental training group or the control group. The experimental group viewed several segments of film and judged the expressions with the aid of a cue form, outlaying all the criteria used by the independent judges. The correct judgements were then given and interpretations were discussed. The control group were also shown a film and, a general discussion of students' interpersonal communication skills followed. A post-training session involved viewing different excerpts of student behaviour than was presented in the pre-training and training sessions. The findings revealed that teachers can be successfully trained to recognise nonverbal cues of student comprehension. This has the advantage of alerting them to problems in the learning material or teaching style before major examinations and is independent of relying on the students to approach the teacher and request their help.

3.3.5. The Effect of Suggestion on the Judgement of Facial Expression

The effect of training subjects is only one of several experimental manipulations which have been used in an attempt to improve the judgement accuracy of observers of facial expressions. The effect of suggestion and its power to influence the judgement of facial expression was examined by Langfeld (1918b). Five subjects were shown three presentations of 105 pictures from the Rudolph collection. Once their own interpretations of the facial expressions had been recorded the subjects were given the correct and incorrect labels to each picture at subsequent presentations. The results showed that the degree of suggestibility varied depending on whether the subjects' original judgement was a correct one. Subjects were more likely to believe that the distrust expression was anything else that the experimenter said it was, followed by the aversion-hate expression. Furthermore, those subjects who had not given the artist's intended impression on the first task were found to be more conducive to suggestion on the subsequent tasks. There were marked individual differences in judgement accuracy, with one subject accepting 47% of the labels given by the experimenter, even when he (i.e. the subject) had previously judged the faces accurately. However, no association was made between accuracy and suggestibility. (The small number of judges precluded this sort of conclusion).

Jarden and Fernberger (1926) showed a demonstrational model of a face, representing the following six emotions to 995 students; anger, dismay, horror, disdain, disgust and bewilderment. In the first part of the experiment, the subjects were asked to rate the emotion term presented with the expression on a scale ranging from "poor", "fair" to "good". This was considered to be the first level of suggestion.

The same faces were shown to 861 of the original participants after a four month period. This time, a visual and a verbal component were added to the suggestive process. Before the experiment was repeated, each expression was carefully posed by one of the investigators. Special attention was paid to the important facial features involved in each expression, followed by a practical demonstration on the model. Using the earlier results obtained by Buzby (1924) who conducted the same experiment minus the suggestion, Jarden and Fernberger reported that their study yielded more accurate judgements than the former. The level of suggestion provided, i.e. naming the expression versus visual and verbal scrutiny, did not contribute greatly to the overall accuracy results. The power of suggestion at any level was enough to improve significantly the judgement ability of the observers.

3.3.6. Artificial Induction of Emotion

Like suggestion, mood induction is also seen to affect cognitive processes which serve to assimilate certain events, thus influencing emotional outcome responses. Indeed, psychiatrists have been well aware of this phenomenon for years as they have used this approach during psychotherapy for the treatment of a wide range of emotional disturbances (Eysenck, 1961).

Research studies investigating mood induction in the laboratory have produced some consistent findings as to the experience and perception of emotion. Velten (1968) discovered that the mood states of elation and depression could be induced in the laboratory, by asking subjects to read sixty emotionally laden statements. Trimbole (1973) automated Velten's mood induction procedure by having subjects listen to a tape recording of the sixty statements at a certain pre-determined pace. Natale (1977) used Trimbole's adaptation in a comparison of the speech samples of depression-induced subjects, elation-induced subjects and controls. His findings support the usefulness of the auto-suggestive technique in the elicitation of true emotional states. More recently, Riccelli, Klions and Dale (1984) exposed two groups of female subjects to a series of slides of the mood induction statements compiled by Velten (1968). One group acted as controls, while the second group were instructed to smile during the elation slides and frown during the depression slides.

All subjects were videotaped, and their facial responses were measured by the electromyographic equipment. From the responses given on the Multiple Affect Adjective Checklist, which was completed by each subject, Riccelli and his colleagues found that mood induction occurred more readily in the group who were asked to act out the expressions while they were reading the slides.

Izard (1972, 1977) was the first to question the reliability of mood induction techniques in the laboratory. Specifically, he wondered whether the induction of only one mood state in any procedure did indeed result in the production of only one authentic mood state. Some studies have shown that in an attempt to induce depression, subjects have not only reported feeling depressed but anxious and angry as well (Pittman & Pittman, 1979, 1980; Roth & Kubal, 1975).

Polivy (1981) conducted three experiments utilising different induction procedures in the laboratory, in an attempt to elicit the separate emotions of anger, depression and fear respectively. In all three experiments, designed to elicit only one emotion, various combinations of the other emotions were found. A fourth experiment was then conducted which allowed subjects to fill out a series of mood scales at home, every night for up to ten weeks. It was of interest to Polivy to get an indication of emotion blend (if any), outside the laboratory. The findings revealed that even in this natural setting, various emotions correlated highly and were reported simultaneously. These results confirm the multiple affect hypothesis espoused by Izard. Hence;

> "*one emotion can almost instantaneously elicit another emotion that amplifies, attenuates, inhibits or interacts with the original emotional experience*" (p.77, 1972).

More recently, Malatesta, Jonas and Izard (1987) induced sadness, anxiety and anger in the laboratory to examine the relationship between these expressions and the physical symptoms of arthritis, cardiovascular disorders and skin disease. A nine-point scale was used by the judges to rate the degree of facial expression shown by each encoder. Expression inhibition or low facial expressivity scores (as rated by the judges) were found to be significantly correlated with the presence of physical symptoms in the encoder. For example, those subjects who were judged to inhibit their anger and sadness, reported more problems with the conditions of arthritis and skin complaints respectively.

3.3.6.1. Artificial Induction of Emotion and the Judgement of Facial Expression

From the foregoing studies, some evidence has been provided for the artificial induction of emotion. Schiffenbauer (1974) has taken the induction of emotion in the laboratory one step further and examined the decoding of expression moderated by mood states. He investigated the effect of altering subjects' mood and how this would subsequently influence their judgement on a series of facial expression slides. Subjects were allocated to one of five experimental conditions, where they listened to the tape recording messages of one of the following: high volume white noise, low volume white noise, comedy, control and disgust. These tapes were interrupted frequently by the presentation of Ekman's facial expression slides. Subjects were asked to nominate the emotion portrayed by the face as well as to indicate the intensity of this emotion, on a ten-point scale. Schiffenbauer found that the experimental condition set up to arouse a certain mood state in the subject did affect their judgements of the facial expression slides. For example, the subjects in the comedy group presented fewer negative terms in describing the slides than did both the control and the disgust groups.

3.3.6.2. Hemispheric Asymmetry in the Production of Emotion

The induction of emotion and the recognition of these states by independent observers has been the focus amongst psychologists and neurologists studying the cerebral lateralisation of emotion.[2]

However, one of the most pertinent questions and one yet to be addressed adequately, involves the processing of emotion and hemispheric involvement in the production of the various mood states. Several theoretical models have been proposed

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2 The induction of emotion in one subject and the subsequent judgement of that emotion by another will not be discussed here. Suffice to say that this research goes back to the work done by Landis (1924, 1929), Sherman (1927a, 1927b) and Coleman (1949). However obtrusive their methodology may have been, it was regarded as an appropriate process for the elicitation of an emotional state which could be recorded and interpreted by a number of people.

but given the relatively small number of studies set up to address this issue, the conclusions are far from consensual.

A few early studies found that the production of emotion was the role of the right hemisphere primarily. The most commonly used methodology involved the presentation of emotional and non-emotional faces into the left and right visual fields of a subject, where the measure of reaction time generally showed a left visual field advantage in the processing of emotional faces (Suberi & McKeever, 1977). More recent research with brain damaged individuals further supports the finding of right cerebral dominance in emotion processing. For example, Borod, Koff, Lorch, Nicholas and Welkowitz (1988) found that patients with right hemisphere damage were unresponsive and inappropriate in their facial expressions when compared with left hemisphere damaged individuals or normal controls.

Contrary neurological evidence points to a differential emphasis of the hemispheres in emotion processing. As early as 1939, Goldstein coined the descriptive terms of catastrophic-indifference (or crying versus euphoria) to refer to the emotional reaction of patients with unilaterally left and right hemisphere lesions respectively. More recently, Sackeim, Greenberg, Weiman, Gur, Hungerbuhler and Geschwind (1982) investigated the hemispheric asymmetry in the production of positive and negative mood states. In support of other studies of affective lateralisation following unilateral brain dysfunction (Borod, Koff & Caron, 1983; Davidson, 1984), the investigators found that positive emotions, specifically, pathological laughing, were associated with damage to the right side of the brain. Conversely, a lesion in the left side of the brain was associated in the main, with negative mood states (Gainotti, 1972; Hecaen, 1962). Furthermore, a second study investigating the effect of right hemispherectomy on mood, revealed an increase in the elation state.

Kolb and his associates (Kolb & Milner, 1981; Kolb & Taylor, 1981) have provided further evidence to support the differential hemispheric emphasis of mood production with findings which indicate that it is not only the side of the brain which is important but also the site of damaged lobe(s) which play a role. For example, Kolb and Milner (1981) found that lesions in the frontal lobes significantly decreased the number and frequency of facial movements in afflicted subjects as compared to patients with damage to the temporal or parietal areas of the brain. Davidson, Schwartz, Saron, Bennett and Goleman (1979), using electroencephalogram (EEG) measurements found that positive and negative affect was related to left and right activation of the frontal lobes respectively.

Subsequently, Davidson, Ekman, Saron, Senulis and Friesen (1990) found that the emotion of happiness was distinguished from disgust based on the differential arousal of the frontal and anterior temporal sites. Electroencephalogram patterns from subjects experiencing the emotions of happiness and disgust showed that arousal in the right frontal and the right anterior temporal sites accompanied the negative emotion of disgust while the happy condition activated the left anterior regions.

3.3.7. Facial Asymmetry and the Judgement of Facial Expression

Cerebral hemispheric specialisation in the production of emotion has inspired the recent surge of interest into the asymmetry of facial expression as a means of providing vital clues both psychologically and neurologically, for emotional encoding and processing.

Research in this area has usually been approached from one of three directions. The first approach has compared facial laterality with personality and an investigation of which side of the face best represents the display of the face as a gestalt. Wolff (1933) was the first to suggest that the personality of a subject could be gauged from the right side of the face as this side "*roughly agrees with the impression caused by the original, merely intensifying the latter*" (p.173). Subsequent reports from McCurdy (1949) and Lindzey, Prince and Wright (1952) supported Wolff's earlier assertion. These investigators also examined the relationship between facial dominance and neuroticism but obtained conflicting findings. Whereas McCurdy concluded that there was no relationship between facial asymmetry and neuroticism, Lindzey and his colleagues found a positive correlation between clinical reports of neuroticism and facial asymmetry.

Further studies by Lynn and Lynn (1938) investigated the relationship between facial asymmetry, eye and handedness dominance and personality. Facial laterality was defined with regard to smiling intensity. Their findings showed that judges were able to determine facial asymmetry (i.e. they agreed that 26% of the encoders were left or right dominant in their expression of the smile) if it existed, and the relationship between handedness and facial dominance correlated with the judges' ratings on certain positive and negative personality traits. For example, subjects who were right hand and right face dominant or left hand and left face dominant were judged as "*aggressive*", "*self confident*" and "*dominating*" (i.e. positive traits). On the other hand, subjects who were left face, right hand dominant or right face, left hand dominant were seen as "*retiring*", "*shy*" and "*subservient*" (p. 321.). In a later study using the semantic differential to assess personality, Karch and Grant (1978) found that composites of the left face were rated as "*healthier*" and "*stronger*" and right face composites were rated as "*sickly*" and "*weaker*" (p. 727).

A second approach has focussed on the visual field of the observer. In contrast to the findings of McCurdy (1949) and Lindzey, Prince and Wright (1952), this approach has taken the emphasis of a superior right hemisphere recognition ability away from the facial content of the right side of the face (i.e. as believed to resemble the whole face more closely). Instead, it has concentrated on the activated neurological pathways in the observer whilst attending to left and right composites of faces or otherwise, tachistoscopically being presented with faces in the left or right visual field.

Following this approach, Gilbert and Bakan (1973) concluded that the judges perceived the right side of the face in their left visual field, thus engaging the right hemisphere in the processing of the stimulus. In other words, the right side of the face concords more favourably with the whole face because of the preference shown to this side as it lies in the observer's left visual field. Campbell's (1978) findings supported and extended the work of Gilbert and Bakan (1973) in that the ratings of intensity of expression were greater when presented to the judges left visual field.

The third approach and the one which will feature most prominently in this section involves the judgement of facial expression when observers are presented with asymmetrical faces. Sackeim and Gur (1978) found that by showing left face and right face composites displaying a number of facial expressions, that judges rated the left composites as more intense than the right composites of the face (composites are constructed by cutting photographs vertically through the midline of the face and then joining two left and two right sides together).

Various experiments followed using similar methodology but slightly varying the focus of the study. For example, Heller and Levy (1981) related facial dominance in expressiveness to handedness and found no relationship between the two. However, both left and right handed individuals judged the left facial composites as portraying more intense emotion than other facial composites. Furthermore, Moscovitch and Olds (1982) state that facial asymmetries during an expressive display are common. They also found that right handers showed more facial activity on the left side of their face and attributed this finding to the right hemisphere dominance in the perception and production of facial expressions. Bruyer (1981) showed judges the facial composites of unilaterally brain damaged patients. Patients with damage to the left hemisphere were judged as left face dominant for expression. Thus, as the right hemisphere was not affected, the left side of the face was perceived as more expressive.

Sex differences and facial asymmetry of the expression of emotion has also received some attention. Borod and Caron (1980) found that females were judged as expressing pleasant emotions with greater intensity on the left side of the face while males showed more intense negative emotions on the left side of the face. The authors concluded that this gender difference in the expression of positive and negative affect may be a result of cultural influences on women suggesting that they are discouraged from displaying negative emotions in their formative years. Looking at more specific facial actions such as winking and eyebrow raising, Alford and Alford (1981) found that males had significantly dominant left face participation in both of these movements than did females. In a subsequent study, Alford (1983) supported and extended his earlier findings to include gender differences in the laterality of other facial actions including raising the corners of the mouth and nose wrinkling.

Ekman, Hager and Friesen (1981) investigated the possibility that spontaneous versus posed emotions may indeed differ in facial expression symmetry. Using FACS, (the Facial Action Coding System developed by Ekman and Friesen (1978) to be described in Chapter 4, section 4.4.2.4) to measure facial action, and studying the smile in both children and an adult sample, posed expressions were more asymmetrical (favouring the left face) than spontaneous expressions. Cacioppo and Petty (1981) asked subjects to look at left and right facial composites of the spontaneous and posed emotions of sadness and thoughtfulness (a neutral expression for each encoder was also obtained). Contrary to Ekman, Hager and Friesen (1981) they found that posed expressions were asymmetrical but right side dominant and spontaneous expressions were more dominant on the left side of the face. This issue needs further clarification given the controversy surrounding the use of spontaneous versus posed photographs (Hunt, 1941).

Dopson, Beckwith, Tucker and Bullard-Bates (1984) further investigated the differences in asymmetry beween posed and spontaneous expressions. A mood induction technique was used whereby subjects were asked to remember happy or sad events in an attempt to obtain spontaneous expressions of these emotions. Another group of subjects were asked to pose a happy and sad expression. Left and right composites were compiled and the raters judged the left side of the face to show more emotion for both the naturally occurring and deliberate facial actions. The left side was also dominant for both the happy and sad conditions thus incongruent with findings that positive and negative emotions show facial lateralisation.

Using EMG to measure zygomatic and corrugator activity, Schwartz, Ahern and Brown (1979) elicited spontaneous expressions by inducing happiness, excitement, neutral, sadness and fear in the laboratory. A second group of subjects was asked to pose these emotions. Measuring the facial activity in the aforementioned sites, the authors found that laterality differences in the zygomatic muscle were evident in the spontaneous expressions and that positive emotions resulted in an increased activity on the right, whereas there was greater left zygomatic involvement for the negative emotions. In contrast, asymmetry of the corrugator muscle was present for the posed emotions but was not related to the positive or negative expression.

McGee and Skinner (1987) were interested in evaluating the degree of asymmetry in a number of faces at rest while providing subjects with emotionally laden adjectives with which to describe these faces. Again left and right composite photographs were prepared and the results showed that even a resting face was judged as left side dominant for emotion.

In summary, the evidence for the asymmetry of facial expression remains at best tentative and becomes even more so when considering handedness, sex differences, spontaneous versus posed expressions and the display of positive or negative emotions. There is consensus that the left and right sides of the face are differentially lateralised for the expression of emotion. There also appears to be good evidence that the left side of the face displays more emotion than the right side of the face. The question arises as to whether this is the case for all emotions, as most studies reported, only use the general dichotomy of positive versus negative emotions. There has been consistent evidence to show that the left side of the face is dominant in the production of more negative emotions whereas the smile seems to be symmetrical (Sackeim, Gur & Saucy, 1978). It remains an interesting exercise to use a facial measurement technique to determine left and right side differences in the six fundamental emotions of happiness, sadness, anger, surprise, fear, and disgust while spontaneously and deliberately produced..

3.3.8. Upper or Lower Parts of the Face as Cues for the Judgement of Facial Expression

The anatomy of facial expression described by Rubin (1977) is such that the contraction and relaxation of facial muscles mobilises the facial features into action. As will be seen later from a closer analysis of the component studies, there are certain facial features that are more dominant in a variety of facial expressions. While many researchers concentrated on the global expressive display, there are several judgement studies investigating the likelihood of the superiority of the upper or lower face, thus attempting to localise the dominant facial area associated with each emotion.

Ruckmick (1921) was the first to conduct an experiment where the upper and lower parts of the photographed face were used as cues in the recognition of expression. He found that the cue value of the bottom half of the face more closely resembled the judgements made on the basis of the whole face.

Dunlap (1927) supported these findings, insofar as the judgement of pleasant versus unpleasant expressions could be predicted from the mouth region. Dunlap was the first to show composite photographs to a group of observers. By combining the eyes of one photograph with the mouth of another and seeing which composite best resembled the whole face, Dunlap found in favour of the mouth region.

Contrasting evidence was produced by Buzby (1924). Using a model composed by Boring and Titchener (1923), he demonstrated six different facial expressions and found that significant accuracy was achieved in the judgement of four of the six expressions (i.e. horrified, disdainful, disgusted, bewildered; there was some confusion with the anger and dismay expressions). A post hoc analysis of the facial area involved revealed that it was the upper part of the face, namely the eyes and eyebrows, which contributed to the correct judgements made by the observers.

The stimuli used by Frois-Wittmann (1930) were photographs of his own face, as well as drawings of different expressions, made by the composite rearranging of the top and bottom halves of the photographs. When one of the facial areas was exposed, the other was covered by a piece of cardboard. In contrast to the findings of Ruckmick (1921), Dunlap (1927) and Buzby (1924), Frois-Wittmann concluded that neither the upper or lower parts of the face played a superior role in the judgement of facial expression.

Similarly, Coleman (1949) recorded on film the facial expressions of twelve subjects, as they responded to a number of situations, similar to the ones employed by Landis (1924). The filmed records of two subjects were selected to act as stimuli in the study. Copies of both films were made, firstly blacking out the eyes for the entire film and alternatively, removing the mouth region from each frame of film.

Coleman concluded that in comparison with the judgements made on the whole face, the mouth and eye area offered no unique dominant contribution.

In a preliminary study on the judgement of facial expression from a series of paintings, as compared to photographs of sculptured busts, Hanawalt (1942) concluded that there were no upper or lower face advantages in the judgement of expression. Judgements were more easily made on the paintings however. In a second study, Hanawalt (1944) compared the judgements made on a series of Ruckmick's photographs (posed) versus Munn's candid camera photographs (spontaneous). Three groups of subjects were exposed to the whole face, the upper half or the lower half of the face respectively. Hanawalt found in support of his first study, that there were no differences in the judgement accuracy between the groups who relied on either the upper or lower half of the face. Furthermore, his results indicated that the cue for happiness came from the mouth region, while surprise, anger and fear were more easily recognised from the upper half of the face.

From Hanawalt's (1944) findings, Boucher and Ekman (1975) hypothesised that the dominance of one facial area over another may be related to the emotion expressed on the face. To test this hypothesis, Boucher and Ekman (1975) conducted an experiment in which three areas of the face, rather than two, were shown to a group of judges. The facial areas were brows/forehead, eyes/eyelid and cheeks/mouth. The six expressions used were happiness, disgust, fear, sadness, anger and surprise. Each observer was asked to decide on the emotion shown, from a list of the six emotions provided, as well as to give some indication as to the intensity of that emotion, on a seven-point scale. The results supported the hypothesis that the dominant facial area differs from one emotion to the other. Boucher and Ekman's findings revealed the following facial areas best predicted the respective emotions: happiness from cheeks, mouth and the eye region; disgust from cheeks/mouth region; fear from eyes and brow regions; sadness from the eyes and mouth regions.

Bassili (1979), similarly found that happiness, disgust and surprise were more accurately judged from the lower half of the face, while anger, fear and sadness were more successfully judged from the upper half of the face. He favours the view that facial motion is emotion-specific. In an earlier study, Bassili (1978) had ascertained that facial motion alone provided enough information for a significantly accurate recognition of the six fundamental emotions.

Keating, Mazur, Segall, Cysneiros, Divale, Killbride, Komin, Leahy, Thurman and Wirsing (1981), commenting on the evolutionary role of dominance and assertion attributed to the brow and mouth areas, conducted a study of the universality of these two facial regions, as they pertain to human social dominance. Brow raising and grimacing in primates are associated with a submissive role (Andrew, 1963; van Hooff, 1967). Keating, Mazur and Segall (1977) in an earlier study, had offered some support for the phyletic origins of brow motion. They found that photographs of subjects from different racial backgrounds were judged as more dominant by a group of observers when the eyebrows were in a lowered position. A second study was conducted to see if the association between brow movement and social status ranking was universal. Judges from eight different cultural backgrounds were shown a series of paired facial photographs where the eyebrows were either raised or lowered and the mouth was smiling or neutral. From each pair, some of the subjects were given the task of deciding which photograph displayed the most dominant expression while others decided which photograph showed the happier expression. The smile was judged by all cultures to depict happiness but was not universally associated with status. Furthermore, lowered eyebrows were only considered a dominant feature by the Westerners. The authors concluded that there was some evidence to support van Hooff's (1972) assertion that the human smile evolved from the primate submissive grimace but that eyebrow motion was more culturally determined and depended to some extent on the display rules (Ekman, Friesen & Ellsworth, 1972). Nevertheless, the role of the mouth region in the judgement of happiness is further supported by this work. Ekman (1979) highlights the involvement of the eyebrows in the emotions of sadness, surprise and fear. Blurton-Jones and Konner (1971) found eyebrow raising was associated with visual searching in children, suggesting that this action increases the visual field.

In summary, the evidence presented on the contribution of the eye and mouth regions to the judgement of facial expression is varied and contradictory. Ruckmick (1921) and Dunlap (1927) maintain the dominance of the lower half of the face, Buzby (1924) favours the upper half of the face, while Ekman, Friesen and Ellsworth (1972), Boucher and Ekman (1975), Hanawalt (1942, 1944), Bassili (1979), Keating, Mazur and Segall (1977) and Keating, Mazur, Segall, Cysneiros, Divale, Killbride, Komin, Leahy, Thurman and Wirsing (1981) emphasise that the importance of the facial area is dependent on the emotion expressed. Frois-Wittmann (1930) and Coleman (1949) agree that neither facial region has anything unique to contribute to the overall judgement accuracy. These contradictory findings have been attributed to methodological diversity from one study to the next (Coleman, 1949; Ekman, Friesen & Ellsworth, 1982). Contributing factors include different and inadequate sample size; variability of eliciting stimuli; certain experimental manipulations; judgement versus component analysis studies; individual differences; and the number of facial areas exposed to the judges. In short, a valid standardised measurement technique seems to be needed if the methodological flaws evident in the judgement of facial expression are to be overcome.

3.4. Conclusion

Selection of the judgement approach for the analysis of facial expression of emotion has its distinct advantages. Its popularity since the time of Darwin (1872) has established its legitimacy as a research methodology which seems to be conducive to the design of most facial expression research. In fact, the major attraction in using a judgement approach has been the ease with which an experiment could be conducted. In addition, the experimental procedure was not intrusive and well accepted by its participants. Consequently, this methodology has dominated the literature on the judgement of the facial expression of emotion for the best part of this century.

The judgement approach has been applied to many theoretical issues in the study of facial expression of emotion. Amongst the most important, there have been studies on the early signs of imitative facial behaviour in infants, developmental occurrence of expression recognition and display in children, existence of universal versus cultural-specific expressions in humans and the debate over whether facial expressions are innate, learned or a combination of both.

The most important concern to arise from the use of the judgement approach in the study of facial expression is the question of accuracy, namely accuracy of observer judgements and accuracy of the facial expression stimuli[3]

The accuracy of judgement studies has been difficult to ascertain due to methodological differences between studies. For example, observers in one study may be asked to rate spontaneously occurring facial expressions, while others may be asked to judge the expressions posed by actors. Hunt (1941) ascertained that these two methods of presenting stimuli were indeed different, leading to different facial displays for the emotions, and thus not reliable as interchangeable modes of eliciting stimuli. Confounding this problem is the way in which the facial expressions are presented to the judges. The three most popular techniques have been firstly the early use of artists' drawings of facial expressions, photographs, and finally a motion picture (film or video) displaying facial expressions in real time and usually with some reference to the context in which the emotion was aroused.

In an attempt to answer both judgement and component issues in the analysis of facial expressions, some investigators relying on the judgement approach have used split-face designs. Judgements between raters have been found to vary depending on whether the whole face or a variation of the upper or lower and right or left side of the face have been shown. In addition, the inclusion of social context, previous training in judgement accuracy, induction of a specific mood state or the presentation of an emotion word list versus a free labelling exercise, have already been shown to affect the responses of the observers. Thus interpreting negative results or

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3 There is a school of thought which reports a fundamental problem with all of this research. Referred to as the social constructivist view of emotion, it questions the notion of accuracy in the judgement of facial expression. For example, the proponents of this approach would argue that there may be complete consensus by a group seeing a person weep and concluding that that person is sad. However, these judges could all be wrong. The social constructivist theory suggests that there is a construction of emotion and emotional expression (in the above example) and that is what the judgement approach is studying. They would argue that the preoccupation with accuracy of judgement studies stems from the advocates of a biological and genetically determined theory of the structure of emotion. According to the social constructivist viewpoint, "*when a person makes a self-attribution of emotion, he enters into a transitory role*" and "*a person's emotional behavior and experiences are determined by the meaning of the emotional role as he interprets it*" (Averill, 1980, p. 314).

"error" judgements in this type of research design needs careful scrutiny of the observer responses with particular attention paid to the variations in methodological procedure across studies.

Observer accuracy in the judgement of facial expression is variable and dependent on a number of contributing factors. Indeed, the judgements made are usually subjective with the observer having no previous training in the analysis of facial movement or facial patterning in expression. Individual differences in encoding and decoding of facial expression have been well documented (Hager & Ekman, 1979; Thompson & Meltzer, 1964). Thus, if raters do not agree in a judgement task, the "error" judgements may be attributable to individual differences in rater ability or to the display of emotion by the stimulus encoder.

Furthermore, the existence of blends of emotion (Ekman, Friesen & Ellsworth, 1982) may serve to confuse the observer, if their task is to classify the stimulus into only one expression category. Giving his subjects the opportunity to select blend categories (e.g. happy/angry) if they so existed, Nummenmaa (1964) found that observers made more "accurate" ratings of expressions for emotion blends, and for the "pure" emotion stimuli. Thus the appearance of emotion blends may further complicate the analysis of judgement accuracy between observers.

Although offering no direct measurement of the face, the judgement approach has nonetheless produced consistently similar findings over time from one study to the next. Darwin (1872) introduced the possibility of the existence of a static number of emotion categories (i.e. nine) which he considered to be a product of evolution and universal across all cultures. In more contemporary times, prominent researchers in the field (Ekman & Friesen, 1975; Izard, 1971; Tomkins, 1962) have agreed that eight emotion categories have been found, namely, happiness, surprise, fear, anger, disgust/contempt, distress/anguish, interest and shame. Similarly those investigators who have conducted judgement studies on the dimensions of emotion and usually working with photographs of the face (Frijda, 1958; Osgood, 1966; Schlosberg, 1952, 1954) have found at least two dimensions in common, i.e. Pleasantness-Unpleasantness and Intensity or Attention.

Given somewhat differing approaches to the question of observer judgement of facial expression, the judgement approach has proved to be adaptable in procedure and robust in its findings.

PART 1

CHAPTER 4

METHODOLOGY AND MEASUREMENT TECHNIQUES FOR THE JUDGEMENT OF THE FACIAL EXPRESSION OF EMOTION: 2. THE COMPONENT APPROACH.

4.1. Introduction

The earliest studies of the face were descriptive and the face was static, so the reliability and accuracy of these descriptions may be questioned given the speed with which facial movements occur. To overcome these problems, an alternative approach to the study of facial expression emerged. Known as component analysis, it focusses on the dynamic features of the face and involves the identification and measurement of those components which move during various expressive gestures. This chapter reviews the major component analytic studies, highlighting the central problems which have been encountered in this body of research.

The component analytic approach began with descriptions of the physiognomic features of the face and the construction of demonstrational models. It subsequently progressed to more sophisticated coding systems emphasising the ethological, theoretical, and anatomical approaches to facial measurement. More recently, computer and video technology have been brought to bear on component analysis of the face. This review discusses this innovation and finally explores possible future directions for facial research.

4.2. The Contribution of Physiognomy

Component analysis had a rudimentary beginning with the emergence of the pseudo-science of physiognomy. An individual's physiognomy refers to the static features of the face and includes the length and shape of the face, curvature of the mouth, thickness and height of the eyebrows, eye opening, nostrils, skin texture, facial wrinkles and the distance between facial features. It is these traits, their mobility and configuration in displaying the facial expressions of emotion, which have been the focus of component analysts throughout history. Supporters of this approach contend that it is the face itself and the position of its various components which are related to emotional expression, and personality.

Human physiognomy studies were based chiefly on the work of artists and writers trying to capture and record facial expression. In the nineteenth century there was an attempt to build a science around the workings of the face, its function, its features and the personality it represented. From the studies presented in Table 4.1,

Table 4.1. Early Studies Investigating the Relationship Between Physiognomy and Personality and Age

AUTHOR(S) & AIMS	METHODOLOGY	RESULTS	CONCLUSION
Darwin (1872) on the physiognomy of the insane	From the photographs obtained from James C. Browne, (a psychiatrist), Darwin was looking for an evolutionary trend in the perpetuation of raw, uncontrollable emotions in humans which he saw as the mark of the animal kingdom.	He described the appearance of the contraction of the grief muscles (or corrugators) in depression, bristling hair when agitated and a lack of the blushing response in the severely mentally impaired.	The insane formed a "missing link" between animals and humans insofar as the control of their emotions was concerned.
Secord, Dukes and Bevan (1954) investigated the relationship between physiognomy and personality	Photographs of faces of varying expressions were shown to judges. Physiognomic rating scale used.	People who were judged to be similar physically, (e.g. older face, thin lips, medium eye depth) were judged as displaying similar personality traits (e.g. intelligent, distinguished and responsible).	Support for the influence of the physiognomic characteristics on the perception of personality
Stritch and Secord (1956) investigated the relationship between physiognomic alteration and personality.	Judges were presented with photographs of different male faces. Eight physiognomic traits were targeted.	Alteration in one facial feature resulted in a difference in the way an observer perceived the other facial features. Personality impressions, however, were not affected by physiognomic changes.	Change in one facial feature gave the impression of a change in appearance of the face. However, an impression once formed could not be changed by the alteration of a single physiognomic feature.

Table 4.1. Continued..

Laser and Mathie (1982) investigated the relationship between physiognomic alteration and personality	Subjects were shown a drawing of a male face which was artistically manipulated to display thick, thin or normal eyebrows, thick, thin or normal lips and broad, narrow or long face.	Structural appearance of a face was most important in forming an impression of certain personality traits, e.g. thick eyebrows and narrow face conveyed more negative impressions, while thick lips and thin eyebrows contributed to a positive evaluation of the face.	Impression formed from a facial expression can be inflenced by the manipulation of physiognomic characteristics.
Shoemaker, South and Lowe (1973) studied the physiognomic features for four deviant acts: homosexuality, murder, robbery and treason.	Subjects were divided into three groups and asked to judge the guilt or innocence of the main character pertaining to the four crimes. Group one were shown twelve photographs only. Group two were presented with a series of contrived short stories. Group three were presented with the stories and slides of the photographs.	Judged stereotypes were crime-specific.	No mention was made of the deviant physiognomy in terms of facial features and facial shape.
Pittenger and Shaw (1975) investigated the relationship of physiognomy to age.	Two analyses: 1. Longitudinal-judges saw photographs of children 11-18 years as they matured. 2. Cross-sectional-judges saw photographs of different individuals at different ages.	Perception of age was more accurate in the longitudinal condition and for photographs which provided more details of the face.	Younger faces had more immature features e.g. chubby, freckles, shape of jaw and length of nose.

Table 4.1. Continued..

Berry and McArthur (1986) examined the relationship between physiognomy and age.	Review article.	Childlike facial features involving facial shape, feature placement on the face, feature length, eye characteristics, quality of skin and shape of the craniofacial profile attracted nurturing and protective responses from others.	Childlike features influenced the judgement of certain personality traits, suggesting that the perception of facial appearance and of particular personality traits were linked.
Aronoff, Barclay and Stevenson (1988) studied the physiognomic characteristics of an angry/threatening expression.	Subjects were asked to draw masks which represented a tribal mask or courtship mask.	Significant differences emerged between the frequency of threatening and non-threatening facial components displayed by two different sets of masks.	Spatial orientation of facial components may provide a vital clue for judgement of a particular emotion. Drawings made to represent a threatening display, consisted of angular and diagonal configurations; courtship drawings were more curvilinear.
Bellak and Baker (1981) constructed a facial coding system with a physiognomic bias.	Split face technique where upper and lower facial zones are delineated.	The zone system has been presented in a popular form with the aim of encouraging its use in daily interpersonal situations. There has been no scientific validation.	Bone structure and facial muscle patterning influence facial appearance and inference made when judging personality characteristics.

it can be seen that physiognomy has made a significant contribution to the evaluation of certain personality traits including deviancy, age and intelligence. However, investigators interested in expression and emotion were drawn to the mobility of the facial features as opposed to their static appearance. Nevertheless, physiognomic studies drew attention to and laid the foundations for the descriptive analysis of the face. After several years of neglect due to the early negative associations between physiognomic features and personality (Darwin, 1872; Allport, 1937) and physiognomy and ability (Anderson, 1921; Landis and Phelps, 1928; Pintner, 1918), some positive findings rekindled psychologists' interest. Secord, Dukes and Bevan (1954) introduced the importance of the components of the face and the manipulation of these components in the judgement of another's personality traits. Furthermore, Stritch and Secord (1956) made the important early finding that impressions of personality were influenced by facial expression. Laser and Mathie (1982) supported and extended these findings to conclude that stereotyping was related to physiognomy, while Shoemaker, South and Lowe (1973) reported on the consistent judgement of facial photographs as representing a "criminal" face.

Studies of the shape and structure of facial features have also provided some interesting findings on the role of physiognomy in the inferences made concerning the age of an individual. For example, researchers in this field (Aronoff, Barclay & Stevenson, 1988; Berry & McArthur, 1986; Pittenger & Shaw, 1975) found that curvilinear faces were judged to be younger and associated with the existence of certain personality traits, more so than faces which did not have this shape.

The study of the effect of one's physiognomic structure on others has wide ranging implications for professions and occupations other than psychology. Firstly, it is of considerable importance to the legal system and judiciary (Shoemaker, South & Lowe, 1973) since a defendant's face may influence a judgement of innocence or guilt made by a judge or jury. Secondly, those involved in the occupation of modelling are well aware of the facial attributes which make certain individuals more successful than others. Closely related to this, the cosmetics industry involving manufacturers and artists alike, can create a desired "look" for their clients by the skillful application of their product. Cosmetics are also used to accentuate those facial features which are considered an asset, or disguise those regarded as a flaw. Finally, the enhancement of facial beauty is important to some sub-specialties within the medical profession, especially plastic surgery and orthodontics (Peck & Peck, 1970).

Human physiognomy has been implicated in the inferences people make of another's age, personality and ability. It has been demonstrated that many of these inferences made are inaccurate, can be misleading, and may lead to stereotyping. As will be seen later in this chapter, physiognomy is important in componential analysis to the extent that these static features are used as landmarks in the assessment of the effect of the mobility of these features on the expressive display. More recent studies have employed increasingly more complex and objective methods for the assessment of the role of physiognomy in the delineation of facial expression of emotion.

4.3 Demonstrational Models of Facial Expression

At this point, brief mention should be made of the contribution of the demonstrational models to the judgement of facial expression, since they were instrumental in setting the scene for an analysis of the components of the face. Demonstration models (see Table 4.2) were constructed in such a way that separate parts of the face could be interchanged. One of their functions was to teach psychology students about emotion, specifically, the expression of emotion. With access to any number of facial components, a variety of expressions could be compiled and discussed. This presented an immediate advantage in terms of time, cost and simplicity over the method of instructing an actor to produce expressions by manipulating isolated facial components so as to achieve the predetermined emotion. In a teaching situation, the use of models encouraged far more group involvement, when compared with the use of slides of posed expressions. Some attempt was made to extend the function of these models (Fernberger, 1930; Rubenstein, 1969) but the ease of using photographs as research instruments restricted their further use (for example, the photo sets of Frois-Wittman, Schlosberg and Tomkins). As teaching

Table 4.2. Demonstrational Models

Author(s)	Description	Utility
Boring and Titchener (1923)	Wooden profile of head, consisting of nine possible alternative mouths, five eyes, four eyebrows, and two noses	Buzby (1924) Jarden and Fernberger (1926) Fernberger (1927)
Guilford and Wilke (1930)	Wooden frontal view of the face.	Teaching tool.
Rubinstein (1969)	Simultaneous profiles photographed of faces in a resting position. Significant differences found between smiles of depressed patients versus a group of controls.	No evidence that this model was further used as either a teaching tool or for research.

tools however, they were successful in encouraging group participation, although the accuracy of the expressions used may be questioned.

4.4. Contemporary Approaches

Static facial features may suffice if an observer is asked to make a judgement about another's facial expression from a model or from a photograph, however, the componential theorists explore the movement of the facial features during an expressive display. This section will concentrate on the contribution of dynamic components of the face and their relationship to expression. It will not explore facial movements related to conversational regulation and gestures. (see Ekman, Friesen, O'Sullivan, & Scherer, (1980) for a thorough review of this area).

4.4.1. The Ethological Approach

Human ethology grew out of the comparative evolutionary approach begun by Darwin (1872) and continued more recently by van Hooff (1962) and Andrew (1963). Its contribution to the study of the components of the face was in the area of methodology, specifically, the compilation of a detailed and accurate list of behavioural movements (both facial/vocal and gestural). A basic tenet of ethology is that the formulation of extensive lists known as "ethograms" is essential for a clearer understanding of behaviour. The ethological approach therefore utilises a component focus to the study of behaviour and emotions in humans and animals. Furthermore, it has a behavioural emphasis with a focus on the observation and description of each individual component or unit of behaviour as it takes place in its social setting. These behaviours are subsequently related to defined emotional states. Further, an ethological description would almost certainly take into account the environmental cues which surround the organism during an expressive display (Eibl-Eibesfeldt, 1970), thus highlighting the role of the social context.

The ethological approach to the study of facial expression involves the classification of behaviour patterns, following intense and systematic recordings of facial action, usually in the natural environment of the target group. A review of the research using ethology-based techniques is presented in Table 4.3. Grant (1969) compiled the first detailed checklist of recognisable facial/vocal and gestural behaviour patterns which were described in terms of the smaller elements of which they were comprised. Thus, ethological analysis, unlike the early descriptions of the physiognomists, promoted the development of scientific techniques of observation and description.

Grant (1969) presented a comprehensive ethogram compiled from his observations of hospital patients, student controls and preschool children. Other researchers in the field used the ethological approach to classify the behaviour of a specific group of subjects. For example, Pitman, Kolb, Orr and Singh (1987) classified the facial appearance of patients suffering from schizophrenia; McGrew (1972) investigated the social behaviour of preschool children; Blurton-Jones (1971) described the facial actions of children; and Young and Decarie (1977) observed the facial/vocal patterns of infants.

The future success of the ethological approach for the study of human behaviour depends on the compilation of a common and accurate taxonomy. Its major aim has been stated succinctly by Tinbergen (1951): to contribute to the understanding of the causation, ontogenesis, function and evolution of behaviour. The road to an understanding of these areas lies in the accurate observations and interpretations of behaviour. The observational and descriptive skills of the investigators, however, are undermined by the very complexity and flexibility of the phenomenon studied. It is this complexity which hinders progress in the field of human ethology and facial expression.

Brannigan and Humphries (1972) suggested that the breakdown of complex behaviour into smaller observable units was an efficient method of analysis and one which is germane to the study of facial expression. The major obstacles to this process are firstly, the difficulty in obtaining consensus amongst ethologists as to which behavioural units are to be included in the overall checklist; secondly, the problems of developing a standard representation of these units; and thirdly, opposition from "gestalt" exponents, i.e. an anti-reductionist position which has enjoyed some popularity in psychology.

Finally, the introduction of film and video recording to the study of human ethology has provided a tool which surpasses direct observation, thereby overcoming the problems entailed in maintaining constant attention and concentration over lengthy periods of time. Furthermore, sequences can be replayed to obtain an accurate recording of a unit of behaviour. Eibl-Eibesfeldt (1967) suggested that the use of a camera equipped with a lens which can film behaviour occurring to the left and right (as well as in front) of its location was less disruptive and did not inhibit naturally occurring behaviour.

4.4.2. Anatomical Theories: Facial Coding Systems

The descriptions of facial behaviour set the scene for face research by classifying facial movements in terms of emotion categories or dimensions. Contemporary component research has moved away from the descriptive approach towards the quantification of facial movements using increasingly sophisticated measurement systems. The approaches which have emerged have focussed on facial anatomy using a theoretical framework connoting the relationship between particular facial movements and emotions, at times with the aid of electromyographic techniques.

Table 4.3. The Ethological Approach To The Measurement Of Facial Expressions.

Author(s)	Methodology	Results
Grant (1969)	Descriptive comparison of psychotic, non- psychotic and general hospital patients, theology students and nursery school children. All adult subjects were observed interacting with a doctor.	Four emotional states were delineated: Flight, Assertion, Relaxation and Contact. The facial expressions accompanying these emotions were delineated. 118 movements were catalogued.
Blurton-Jones (1971)	Working with children, he divided the face into eight sections comprising the position of each of the eyebrows and eyes, mouth, lips and tongue.	Fifty-two components catalogued.
McGrew (1972)	Preschool children: Detailed description from direct observation. Taxonomy of the performance, development and function of facial expressions, head movements, gestures, postures and gross body movements.	An attempt was made to include a reference to each element's evolutionary adaptiveness and the non-human homologue (if one existed).
Eibl-Eibesfeldt (1973)	Observed the autistic-like, functional, social and expressive behaviour of the deaf and blind born.	Facial expressions observed: smiling, laughter, crying, fear, pouting, surprise, and clenched teeth.
Young and Decarie (1977)	Facial/vocal behaviour of infants.	Facial expressions of infants were catalogued as they engaged in the following activities: exploring, play, toy removal, approach of stranger, departure of mother, reunion with mother.
Pitman, Kolb, Orr and Singh (1987)	Subjects suffering from paranoid and non paranoid schizophrenia. Controls were substance abusers in a rehabilitation programme.	Paranoid group showed a lack of facial affect. Non-paranoid group were verbally less expressive than controls.

More selective than the previously described ethogram, these methods employ a facial action coding system technique to quantify facial activity during an emotional display. Still or video recordings of the face are used[1].

The theory-based procedures however, were instrumental for the integration of descriptions, observer judgements and direct facial measurements, aiming for a delineation of facial action associated with each emotion. Two of the first theory-based facial scoring systems were The Maximally Discriminative Facial Movement Coding System (MAX) (Izard, 1979) and the Facial Affect Scoring Technique (FAST) (Ekman, Friesen and Tomkins, 1971).

4.4.2.1. MAX

The Maximally Discriminative Facial Movement Coding System (MAX) (Izard, 1979) adopts an anatomical basis to the study of emotional behaviour and was originally derived from the Differential Emotions Theory put forward by Izard (1971). Briefly, this theory postulates that the emotions are activated in the nervous system by neurochemical substances which act on the facial and postural muscles. The face is the primary site of differentiation between the various emotional expressions. Nine fundamental emotions are distinguished: joy, contempt, distress, disgust, anger, fear, surprise, interest and shame. MAX has been developed to measure the facial movements associated with these emotional states in infants and children.

In the preparation of MAX as a functional coding system (Izard, 1979), the face was divided into three primary segments: the forehead/eyebrows/nasal root; eyes/nose/cheeks; and the mouth/lips and chin. Twenty-nine "appearance change" codes have been identified and judgements of facial expression are made on the basis of the presence or absence of these appearance changes (AC). The facial movement of

1 It is of historical interest to note that one of the first investigators to directly measure facial movement from a moving picture was Lynn (1940). He constructed a "facial cinerecorder" which presented the subject with a movie designed to elicit a specific emotion and expression, which was then photographed for subsequent analysis. The subject placed his head in the cinerecorder unit that was covered with a black piece of material to minimise any distractions. Directly in front of him was the movie screen and the camera. In order to produce and measure a smiling response, Walt Disney films were shown to 108 psychiatric patients, individually. A baseline measure of facial expression was taken by tracing the position of the corners of each eye, the teeth, hair line and face outline around the zygomatic muscles. The amount of smiling activity was then calculated as the significant change from the reference location of the position of the corners of the mouth during the smile sequence.

a noted twenty-five facial muscles is the key to the analysis of emotion using MAX. Verbal descriptions of appearance changes are also provided.

MAX was used by Langsdorf, Izard, Rayias and Hembree (1983) in a study investigating the appearance of the interest expression. They found that the duration of the expression was differentially associated with the visual fixation time observed in the infants whilst they were exposed to a human face, a mannequin and a face with scrambled features. In a more recent study, Haviland and Lelwica (1987) found that ten-week old infants imitated their mothers' expressions of joy, anger and sadness, measured by MAX. Also, MAX differentiated between expressions as they changed from joy to interest, for example, during mother-infant interactions. In another study, Lewis, Sullivan and Vasen (1987) drew attention to one of the advantages of a facial action coding system like MAX. They were able to measure complete and partial expressions posed by two to five year old infants, and an adult sample. Expressions were considered as complete if the correct patterns appeared in each of the eye/cheek, brow and mouth regions. Expressions were only partially displayed if one or two of these facial areas were represented.

4.4.2.2. <u>AFFEX</u>

MAX was designed to provide a fine-grained analysis of the face and its appearance changes, targeting the components of facial movement. An alternative but complimentary "System for Identifying Affect Expressions by Holistic Judgements" (Izard & Dougherty, 1982, p. 114; Izard, Dougherty & Hembree, 1980), or AFFEX, has been devised to provide a more global or gestalt assessment of facial expression. As with MAX, AFFEX was derived from Izard's Differential Emotions Theory as well as the findings from cross-cultural research and data from work with infants and children.

AFFEX is considered to be more time-efficient than MAX in the analysis of the sequencing and duration of facial movement. Whereas MAX details an objective scoring of appearance changes, AFFEX requires the rater to recognise specific expressive patterns and to group these movements into the appropriate emotional category, i.e. interest, joy, surprise, sadness, anger, disgust, contempt, fear, and pain. Prerequisite training in MAX as well as frequent inter-rater and inter-system (i.e. MAX versus AFFEX) reliability checks ensure the consensuality of scoring, thus minimising the risk of subjective labelling judgements by the rater.

Using AFFEX, Hyson and Izard (1985) conducted a longitudinal study to examine the facial expressions of toddlers during a brief separation from their mothers. Judges were able to discern the expressions of interest, anger and sadness. Furthermore, AFFEX was successful in recognising emotion blends, which the authors found increased in frequency from thirteen to eighteen months of age.

4.4.2.3. FAST

Like Izard's construction of MAX and AFFEX, Ekman, Friesen and Tomkins (1971) compiled a facial measurement system based on the findings from their research into the facial expression of emotion. According to Tomkins (1962, 1963), each affect has a specific activation network which is innate and when aroused (at inherited subcortical sites), influences facial and bodily responses. For Tomkins, the face acts as the primary site for the expression and identification of the emotions. Ekman's (1971, 1977) neocultural theory emphasises the biological and social factors in the study of emotion. Although espousing the universality of the six fundamental emotions (happiness, sadness, surprise, fear, disgust and anger), Ekman also acknowledged that certain expressions may be culture-specific. Universal emotions are activated by the "facial affect programme" (located in the brain) which is responsible for the action of the face during the display of emotion. Thus, each emotion has a unique set of emotional responses. Cultural rules may also influence the affect programme in such a way so as to mask or exaggerate facial expression, thereby displaying emotions expected by society in various situations.

The Facial Affect Scoring Technique, or FAST, was constructed to describe facial behaviour and to distinguish the involvement of the facial components which are specific to each emotion. The findings of previous studies (Ekman, 1968; Ekman, Sorenson & Friesen, 1969; Izard, 1968, 1970, 1971) showed that a number of emotion categories were consistently recognised by groups of American judges as well as cross-culturally. The Facial Affect Scoring Technique was devised to differentiate between six discrete emotions: happiness, surprise, disgust, anger, sadness and fear.

Measurements were taken from three areas of the face, namely brows-forehead; eyes-bridge of nose; and the cheek-nose-mouth-chin-jaw. The Facial Affect Scoring Technique consisted of a series of photographs of the three main facial areas as they appeared for each of the six fundamental emotions, e.g. sadness is comprised of eight separate brow-forehead movements, eight separate eye motions and ten different lower face photographs. A number of different human models captured the appearance of an emotion by learning to move the appropriate facial muscles within each facial area. The result was an index of seventy-seven photographs, thirteen of the brow-forehead area, twenty-one of the eye area and forty-three representing the lower face region.

A cross-cultural study performed by Ekman, Malmstrom and Friesen (1971) further validated the usefulness of FAST in the judgement of emotion from facial expression. Their aim was to match the heart rate and skin conductance of a number of Japanese and American subjects with their spontaneous facial expressions made while watching both a pleasant and an unpleasant film. Ekman (1971) showed that the FAST system could distinguish between those subjects who were watching a pleasant film and those who were watching an unpleasant film. Furthermore, FAST operated equally well in the measurement of both Japanese and American faces. The authors found that the physiological measures associated with surprise and disgust were concordant with the facial expressions of these emotions in both the Japanese and the American population.

Izard and Ekman's approaches to the study of facial expression provided a basis for the scientific study and standardisation of the facial components of the various emotions, based on the previous research and theorising of the investigators.

The major disadvantage of this scoring system was its selective approach to the measurement of facial action. MAX and FAST were developed to distinguish one emotion from the another by studying the face directly. Their emphasis on emotion-specific movements ignored such critical influences as individual differences and developmental changes in facial appearance (Ekman & Oster, 1982).

Seaford (1978) found shortcomings in both the ethological and the early theoretical approaches to the study of facial expression. He emphasised the importance of the anatomy of the face. Disagreeing with Blurton-Jones (1971), who broadly segmented the face for ease of interpretation, Seaford promoted the use of a division of the facial area into smaller units for a more comprehensive component analysis. While Blurton-Jones accepted the adequacy of description by observation, Seaford expected that the assessment of muscle contraction by the naked eye was inaccurate. He insisted that each serious investigator of facial expression should have a detailed knowledge of the anatomy of the face, and be familiar with the action of each facial muscle.

Seaford (1975) found that the Facial Affect Scoring Technique developed by Ekman, Friesen and Tomkins (1971) was unsuitable due to its limited descriptive vocabulary and the selective inclusion of certain facial movements, viz., a problem inherent in all theory-based facial measurement techniques. According to Seaford, facial expressions could be more accurately described in terms of the contraction of facial muscles. He based his work on the dissection of the face of a chimpanzee, electromyography on his own face and from the closer post-mortem anatomical scrutiny of the human facial muscles. For Seaford, the advantages of this approach were its objectivity and replicability. Furthermore, it employed "minimal unit" terminology - that is to say, it identified contractions of specific muscles or groupings of muscles which perform a single function.

4.4.2.4. FACS

Following Seaford's lead, Ekman and Friesen (1978) were encouraged to re-evaluate the usefulness of the Facial Affect Scoring Technique and indeed to formulate a new facial measurement tool designed to incorporate each movement made by the facial muscles. The Facial Affect Scoring Technique was limited in its application, constructed from a theoretical standpoint to measure the facial expressive movements of the six aforementioned fundamental emotions. Its successor, the Facial

Action Coding System (FACS), aimed to be more comprehensive. It was designed to measure all visible facial movement, emotionally intended or otherwise. Anatomically focussed, it complied with Seaford's (1975) criteria of objectivity, replicability and composition of minimal units for analysis.

The Facial Action Coding System emphasised the visible muscular action responsible for the movement and location of facial features during an expressive display. This anatomical approach deals more effectively with individual differences in physiognomic characteristics which may confound the purely descriptive approaches to the analysis of facial movement (Ekman & Friesen, 1976). Furthermore, the design of the Facial Action Coding System circumvents the temptation to infer an emotion from a particular facial motion. By concentrating on the muscular movements during an activity sequence, subjective descriptions such as drooping mouth (Allport, 1924); bright eyes (Darwin, 1872); and flared nostrils (Ekman & Friesen, 1975) can be avoided (Hager & Ekman, 1983). A description of the pattern of behaviour is mandatory with inferential analysis kept to a minimum.

Thus the Facial Action Coding System describes facial behaviour in terms of "action units" which generally represent the action of individual muscles. In some cases, however, an action unit may comprise two or three different muscles. Forty-four action units have been identified. Each action unit (AU) is defined descriptively, e.g. AU15 or lip corner depressor "*emerges from the side of the chin and runs upwards attaching to a point near the corner of the lip*" (Ekman & Friesen, 1976, p. 66). It is also defined diagrammatically. Secondly, the changes in appearance affected by the movement of the action unit are noted, e.g. "*pulls the corners of the lips down*" (p. 66). A trainee is then provided with detailed instructions under a "How to do" section which provides information on how to mimic the facial movement under scrutiny. The investigators found that this practice gave the student a greater awareness of the capabilities and limitations of each facial muscle. Finally, a set of criteria accompany each action unit specifying the number of changes necessary, albeit minimal, of an observed movement of the muscle(s). The reliability of scoring the location of facial behaviour has been demonstrated in a study by Ancoli (1979) and the assessment of the validity of the Facial Action Coding System has concentrated on both the type of action as well as the intensity of action (Ekman, Schwartz & Friesen, 1982).

4.4.2.5. EMFACS

Like Izard's AFFEX, EMFACS (Friesen and Ekman, 1984) has been designed to target the facial expressions of prototypical or certain specific emotions. EMFACS is based on FACS, thus using this coding system requires prerequisite training in FACS. EMFACS is not comprehensive and uses codes from only a subset of the total action units available with FACS. Furthermore, all facial actions are scored in real time, thus expediting the total scoring time involved with each expressive movement. A five-point intensity scale is used to record the intensity of each expression.

Camras, Ribordy, Hill, Martino, Spaccarelli and Stefani (1988) employed EMFACS as well as judgement scores obtained from a number of raters in the assessment of the appearance of six posed expressions (i.e. happiness, surprise, anger, disgust, fear and sadness) in abused, and non-abused children, and their mothers. Moderate concurrent validity was established. However EMFACS, using a stricter regime for the recognition of responses, tended in general, to produce lower coding scores for the successful appearance of an emotion than the ratings made by the judges.

4.4.3. Summary of the Facial Action Coding Systems

In summary, facial action coding systems emerged as an extension of the theoretical and to some extent the ethological approach to facial measurement. The shortcomings of the latter two approaches have been largely overcome by the comprehensive nature of the anatomically based coding systems which classify muscle movements into minimal units of behaviour. With the construction of FACS, the methodological problems associated with previous approaches have been minimised by the application of a comprehensive and standardised measurement tool assessing visible action, which appears to be reliable and valid. FACS allows direct comparisons to be made between different studies as the number and name of each facial action is standardised. Furthermore, this technique can be used to describe all visible action as it is intended, or selective actions can be used if the investigator so desires.

The shortcomings associated with these systems include the extensive and time consuming training required to be undertaken by coders. For example, Ekman and Friesen (1976) estimated that forty hours were needed to master their scoring procedure. Secondly, coding systems can only be applied to visible facial muscular activity, thus invisible actions or facial changes unrelated to muscular involvement cannot be taken into account. Thirdly, Buck (1990) and Vanger and Ellgring (1989; reported by Buck, 1990) concluded that FACS was not sensitive enough in the coding of spontaneous facial expressions. Instead they found that communication scores obtained from observer judgements or rating scales were more likely to demonstrate that communication via facial expression was achieved even when FACS revealed that no codable facial action had occurred.

4.4.4. Anatomical Approach: Facial Electromyography (EMG)

A second anatomical approach in the analysis of expressive reactions is facial electromyography. The following statement succinctly outlines the relationship between the facial muscles and the activity of the nervous system in producing a facial display;

> "*The neural activation of the striated muscles results in the release of acetylcholine at motor end plates, which in turn leads to muscle action potentials (MAPs) that are propogated bidirectionally across muscle fibers and activate the physiochemical mechanism responsible for muscle contraction*" (Cacioppo, Martzke, Petty &Tassinary, 1988, p. 593.)

A relatively recent methodological advance, it has featured in face studies investigating such phenomena as facial laterality (Schwartz, Ahern & Brown, 1979; Sirota & Schwartz, 1982); individual differences in encoding ability (Schwartz, Brown & Ahern, 1980); validity of visible coding systems of the face (Ekman, 1982b); cognition and attitude change (Cacioppo & Petty, 1979; Cacioppo &

Sandman, 1981). However, its main focus has been on establishing a connection between facial sites or regions and the distinct facial expressions of emotion. Table 4.4. summarises some of the most prominent research utilising EMG methodology (more recent methodological and conceptual issues will be presented in the text).

A great deal of interest has surrounded the physiological correlates of human emotion since Darwin (1872) and James (1884). Facial electromyography has seen the disciplines of psychology and physiology come together in the interest of contributing to the existing knowledge of the production of facial outcome (Allport, 1924; Arnold, 1960a, 1960b). It was Darwin (1872) who noted that "*the study of expression is difficult, owing to the movements being often extremely slight and of a fleeting nature*" (p.12). The availability of facial EMG apparatus has provided the empirical evidence for the existence of slight and fleeting facial movements but more importantly, has demonstrated the existence of covert facial actions which are so slight, and/or fleeting, that they are not visible to the naked eye. These subtle but rapid movements as well as the more overt facial movements, can be recorded by electromyography. Thus from a social interaction point of view, although visible differences are all important, a physiological standpoint considers all movements significant and worthy of study. The study of facial EMG if successful, may have implications beyond the laboratory and the field of psychophysiology. For example, it may provide additional information clinically to the psychiatrist in the assessment of affective disorders (e.g. depression); for the social psychologist trying to understand social interaction, or for the personality theorist searching for a model of emotion. Thus far, facial EMG studies have generally examined the predictive value of the intensity and change of EMG scores across various affective states (Carney, Hong, O'Connell & Amado, 1981; Greden, Price, Genero, Feinberg and Levine, 1984; Schwartz, Fair, Mandel, Salt, Mieske & Klerman, 1978).

In the past, electromyographic techniques were equated with general somatic arousal and it was assumed that more specific and unique affective experiences were out of reach (Cacioppo, Petty, Losch & Kim, 1986). It has only been in the last twenty-five years that this notion has been challenged and indeed facial EMG research has shown specificity and consistency of arousal at certain muscle sites accompanied by certain emotional states. Sumitsuji, Matsumoto and Kaneko (1965) introduced the EMG methodology and rationale to the study of the facial expression of emotion. This technique had previously been used in conjunction with self-regulatory biofeedback procedures. The apparatus employed by these current investigators included a circular head frame and thin, sharp wire electrodes extending from the frame to the face. The wire electrode was inserted, like a needle, into any of a number of facial muscles, thus enabling simultaneous measurements of muscle movements to be obtained. Table 4.4. shows that facial EMG techniques have been successful in consistently differentiating between positive and negative states at the zygomatic and corrugator muscle sites respectively. In fact, the application of facial EMG, although not restricted to these two areas of the face, has produced its most consistent findings when these two sites are activated. The contribution of Gary Schwartz and his colleagues (Schwartz, Fair, Greenberg, Mandel & Klerman, 1974, 1975) to the behaviour of facial muscles has been substantial and their validation studies have centred on facial electromyographic analysis in depression. However, facial EMG research has not achieved a level of acceptance equal to its potential capabilities. If facial EMG research is to grow, its application has to be expanded beyond the positive versus negative dichotomy, to other possible facial movements. If this is to be achieved, certain methodological problems inherent in the measurement of facial activity using electromyography must be addressed.

Fridlund and Cacioppo (1986), responding to the increased interest in EMG techniques, published their extensive "*Guidelines for Human Electromyographic Research*". Working from surveys they collected from one hundred psychophysiologists in the field, they collated pertinent information ranging from technical issues such as noise reduction in the laboratory, and extraneous noise levels interfering with the target signal, to type and placement of electrodes (i.e. incorporating such issues as size of electrodes and distance between electrodes; monopolar versus bipolar recordings and electrode site preparation). The authors discuss the collection of physiological data in terms of recording and presentation

Table 4.4. Review of the Research Employing Facial Electromyography for the Measurement of Facial Expression

Author(s)	Methodology	Results
Schwartz, Fair, Greenberg, Mandel and Klerman (1974); Schwartz, Fair, Salt, Mandel and Klerman (1976a)	Depressed and control subjects asked to induce a happy, sad, angry and typical day imagery. Regions: corrugator, lateral frontalis masseter and depressor anguli oris.	Differences in EMG activity were found only in the happy condition. In the "typical day" situation, non-depressed patients had scores resembling the "happy" situation, whereas depressed patients produced a recording similar to those obtained in the "sad" induction situation.
Schwartz, Fair, Salt, Mandel and Klerman (1976b)	Depressed and control subjects were asked to "feel" the appropriate emotion.	EMG recordings showed corrugator-zygomatic involvement in the sad-happy conditions respectively. Depressed group expressed weaker EMG recordings associated with happy imagery.
Schwartz, Fair, Mandel, Salt, Mieske and Klerman (1978)	Depressed population. Induction of pleasant vs. unpleasant cognitive states. Muscle sites: corrugator.	Degree of corrugator involvement correlated negatively with clinical improvement in depression. The degree of EMG activity at the corrugator site predicted the change in depressive symptomatology.

Table 4.4. Continued..

Carney, Hong, O'Connell and Amado (1981) in a replication of above study.	Depressed population. EMG electrodes on corrugator, zygomatic and splenius capitus (neck) sites.	No significant correlation was found between clinical improvement and EMG activity at any of the muscle sites. However, the predictive indication of higher baseline EMG activity was replicated.
Greden, Price, Genero, Feinberg and Levine (1984)	Patients with Affective Disorder. Three imagery states, i.e., happy, sad and typical day. Muscle sites: corrugator and zygomatc.	Support for finding that baseline EMG levels may predict outcome in depression.
Brown and Schwartz (1980)	4 muscle sites: zygomatic, corrugator, masseter, lateral frontalis. Subjects were asked to imagine events leading to the emotions of happiness, sadness, anger and fear.	Only the zygomatic and corrugator muscles correlated with happy and sad imagery respectively.
Dimberg (1982)	Subjects' reactions to a series of happy and angry facial expressions were monitored. Corrugator and zygomatic activity targeted.	Happy pictures lead to zygomatic responses and angry pictures lead to corrugator responses.

Table 4.4. Continued..

Cacioppo, Petty, Marshall-Goodell (1984)	Facial regions: corrugator, zygomatic, levator labii superioris, masseter, obicularis oris. Two conditions: 1. physical: Subjects were asked to lift or imagine lifting a light or heavy weight. 2. non-physical: Subjects read or imagined reading prose with which they agreed or disagreed.	No significant differences at any site during physical task. Increased perioral activity during reading task regardless of valence. Facial activity at corrugator, zygomatic and levator labii differentiated between positive and negative prose texts.
Cacioppo, Petty Losch and Kim (1986)	Pilot study: Subjects presented with slides and tones simultaneously to induce mild and moderate positive and negative affective reactions. EMG sites: corrugator, zygomatic, orbicularis oculi, medial frontalis, orbicularis oris. Main study: mild and moderately positive and negative slides shown.	Facial EMG responses at corrugator and zygomatic sites predicted valence and intensity of emotion experienced. Independent judges viewed videotaped facial behaviour and were unable to distinguish valence and intensity of emotion presented. In Main study, results were replicated.
Greden, Genero, Price, Feinberg and Levine (1986)	Endogenous, nonendogenous depression and control subjects. Three imagery states: happy, sad, and typical day. Muscle sites: corrugator and zygomatic.	Facial EMG sites respond differently to varied induced imagery states. Endogenously depressed patients generally have overactive corrugator activity, but depressed activity in other sites.

Table 4.4. Continued..

McCanne and Anderson (1987)	EMG sites: corrugator and zygomatic. Three experimental conditions: 1: Subjects were asked to imagine positive and negative scenes. 2: Subjects were asked to exaggerate movement in zygomatic region for positive scenes. 3: Subjects were asked to suppress the muscle activity in these two sites.	Increased zygomatic activity for positive and increased corrugator activity for negative imagery. Subjects reported less positive affect when asked to suppress zygomatic activity in positive scenes.

procedures, standardised measurement units, and appropriate use of baseline information and data reduction analysis.

Early criticisms attacking the intrusive nature of the procedure (Fridlund & Izard, 1983) have been addressed by Fridlund and Cacioppo (1986) who suggest possible solutions such as the use of surface electrodes in preference to wire electrodes, and adopting an appropriate distancing strategy between electrodes.

A second problem has been the lack of a standardised convention for the positioning of the electrodes on the face (Ekman, 1982a). This raises the question as to the number of muscles which can be observed at any one time, especially as the facial area is somewhat limited, and whether the unreliable placement of electrodes may lead to inhibition of facial activity or cross talk activity, thus not reflecting accurate activity levels at the muscles sites. This problem has been addressed by Tassinary, Cacioppo and Geen (1989) in a study designed to measure smiling, brow knitting and nose wrinkling. Three respective facial areas were recommended for the measurement of the aforementioned facial activity.

Another problem which has been raised repeatedly in relation to facial EMG research has been the notion of demand characteristics (see Fridlund & Izard, (1983) for a comprehensive review of this problem). A related problem has been that the experimenter-subject interaction may leave the subject anxious or with the feeling that they are being watched. Fridlund and Cacioppo (1986) found that the investigators they surveyed used simple techniques such as employing staff trained to interact with subjects in this situation, briefing the subjects about the experiment, not being in the same room as the subject when recording begins, and the use of same sex experimenters. Cacioppo and his colleagues (Cacioppo, Petty , Losch, & Kim, 1986; Cacioppo, Petty, & Marshall-Goodell, 1984) found that subjects' anxiety was reduced if the briefing avoided notions of facial reaction, and the use of hidden cameras were recommended as well as providing subjects with an interesting task.

The final methodological problem that will be addressed here has been resolved to a certain extent with the application of multivariate statistical analysis to EMG recordings (Fridlund & Izard, 1983; Fridlund, Schwartz & Fowler, 1984). Since many investigators report on recording EMG activity from facial "regions" (Ekman, 1982b) which encompass a number of facial muscles, some doubt is placed on the validity of the facial EMG process. Clear distinctions must be made between activity obtained from muscle regions and those found from a single muscle. Furthermore, extraneous "noise" which may be recorded, but is actually the result of activity in a separate area, i.e. not under immediate review, must be differentiated from the recordings made which directly represent the target muscle site. In an attempt to overcome this problem Fridlund and Izard (1983) have applied a "pattern classification" approach to the study of facial EMG activity so as to embrace, from a theoretical point of view, the utility of facial EMG for the differentiation between several distinct emotions, as identified by the Differential Emotions Theory of Izard (1971) and the neocultural view of Ekman (1971, 1977). Fridlund and Izard point out that many facial EMG studies rely on univariate analysis methods to distinguish one particular emotion from another, based on responses from a particular muscle site. This, they argue, may confuse a true emotional response with extraneous psychophysiological arousal. On the other hand, a multivariate procedure, which the pattern-classification approach employs, takes into account "*the configurative response of physiological systems in emotion*" and "*offers the possibility of disentangling arousal processes from those representing emotional states*" (Fridlund, Schwartz & Fowler, 1984, p. 623). A pattern classification approach offers the ability to discriminate between emotional states by recognising their unique physiological activity responses. This procedure has supported the previous findings, that the corrugator muscle is the primary facial site offering a discriminative function for positive versus negative emotions (Fridlund & Izard, 1983; Fridlund, Schwartz & Fowler, 1984).

One study which attempted to investigate the sensitivity of the brow region in distinguishing between the various negative emotions was conducted by Cacioppo, Martzke, Petty and Tassinary (1988). The activity of the corrugator supercilii muscle was measured whilst a group of subjects were interviewed and asked to reveal demographic and personal details about themselves. Four different types of electromyographic responses were produced during the course of the interview. These actions were labelled, baseline activity, spikes, mounds and clusters and they were found to vary according to the valence of the emotion experienced. For example, clusters occurred more frequently during reported negative states and spikes and mounds were more prominent as the emotional episode stabilised over a period of time. However, there were no differences in EMG form for the separate negative emotions of fear, anger, sadness or disgust. Once again, facial EMG has been a successful index of positive versus negative emotions but has been unable to differentiate amongst the negative states.

While there are methodological problems which need attention, there are also three advantages presented by facial EMG which makes it a viable alternative to facial action coding systems. Firstly, facial activity results are available immediately, in contrast to coding techniques which require many training and recording hours. Secondly, a psychophysiological index of change and intensity of facial activity is considered as a more direct approach to facial component analysis than ratings produced by judges, and thirdly EMG is capable of monitoring invisible muscle activity. The high resolution produced by modern equipment provides the opportunity for the measurement of rapid and slight muscle activity.

Finally, Cacioppo and Tassinary (1990) have warned of the dangers in making inferences regarding psychological events from physiological activation.

Although technological advances in equipment and methodology of signal detection improve the reliability of psychophysiological relationships, the authors state that more is needed before a causal link between psychological and physiological activity can be established. They suggest that the conclusions about the relationship between psychological significance and physiological signals should only be considered after the nature of the psychophysiological interaction has been determined. Four separate psychophysiological relationships are discussed: outcomes, markers, concomitants and invariants. Briefly, any relationship found between psychological and physiological responses is referred to as an "outcome". It can subsequently be reinterpreted as a "marker" if one event predicts the other; as a "concomitant" if the events covary; and as an "invariant" if either event occurs only in the presence of the other. Invariant relationships are considered to be the most salient when inferring psychological significance from physiological signals. Keeping in mind that no consensus was found amongst the psychophysiologists surveyed by Fridlund and Cacioppo (1986) regarding the appropriate statistical analyses used in EMG research, the abovementioned model may standardise this process to the extent that the questions asked of the research and the analyses performed go beyond being dependent upon the preferred data handling method of each investigator.

4.5. Computer-Assisted Approach to the Measurement of Facial Expression

Computer technology has influenced facial research and now plays a major role in the simulation and quantification of the facial expression of emotion. Computer generated faces were first used by Chernoff (1973). He employed these faces, in a novel and unusual role, to display multivariate data graphically[2].

More importantly, computers can be used to generate facial expressions from a still image of a person's face. A computer model of the face has been produced by Platt and Badler (1981). Face simulation and facial action were modelled after the Facial Action Coding System's Action Units (Ekman and Friesen, 1978). The three

2 The methodology involved the manipulation of facial features as the key points of data variation. Each face represented the location of a particular data point along a dimension. Facial characteristics vary as the individual variable values differ. In this way, Chernoff argued that the variation of the data, represented as faces, would become more obvious. Similar techniques have been used in studies by Jacob (1978), Flury and Riedwyl (1981) and Harmon, Kuo, Ramig and Raudkivi (1978).

dimensional model represents the skin, muscle and bone features of the face. The face is scanned by a "Camera Processor" which identifies the action units performed. The "Action Unit Parser" then converts all noted action units into muscle actions. Finally, the face "Simulator" produces the output as a facial display. A "contraction algorithm" is calculated with the effect of contracting the target muscle by applying a measure of force or tension on a point of skin, muscle or bone.

Platt and Badler's model gave an indication of the role a computer can play in the simulation of a face. Although muscles, skin, and bone were represented, the major disadvantage with their facial characterisation was that the expressive features of the face were difficult to elucidate due to the "busy" representation caused by the inclusion of all muscle fibres. Musterle and Rossler (1986) have generated a more human-like face and have differentiated between five facial expressions: friendliness, surprise, disgust, anger and grief.

In an attempt to devise a more accessible and clinically useful methodology, Pilowsky and his colleagues have developed a microcomputer-based approach to the simulation and quantification of facial expression (Pilowsky, Thornton & Stokes, 1985, 1986; Thornton & Pilowsky,1982) and a system which achieves the objective description of facial movement (Katsikitis & Pilowsky,1988, 1991; Katsikitis, Pilowsky & Innes, 1990). This technique is referred to as the Facial Expression Measurement (FAC.E.M.) System. Working from a mathematical model of the face, sixty-two points on a still image of the face are located and digitised using a digitising pen and a graphics tablet. The location of the facial points on the source image were determined after extensive review of Ekman and Friesen's (1978) FACS manual and Izard's (1979) MAX coding system. Once the facial points have been located and digitised, a curve drawing programme (Yamaguchi, 1978) connects all the points to form a line drawing representation of the source image. The consequently anonymous line drawing of the face displays the major facial landmarks, i.e. the eyebrows, eyes, nose, mouth, as well as the facial outline. It is at this point that the quantification of facial expressions or facial movement is possible, with the use of twelve computer generated measures each representing distances between two facial landmarks. The twelve facial measures are: End-Lip Measure, Mouth-Width Measure, Mouth-Opening Measure, Mid-Top-Lip Measure, Mid-Lower-Lip Measure, Top-Lip Thickness Measure, Lower-Lip Thickness Measure, Eye-Opening Measure, Top-Eyelid/Iris Intersect Measure, Lower-Eyelid/Iris Intersect Measure, Inner-Eyebrow Separation Measure, and Mid-Eyebrow Measure. The microcomputer-based approach has the potential to compare computer scores for the various emotions.

The application of this computer assisted approach to facial measurement has expedited the scoring of facial action. The techniques previously mentioned in this chapter (with the exception of facial EMG techniques) have concentrated on visible facial activity, i.e. the location of action or intensity of action. The need for lengthy visual scoring practices requires a great deal of time and effort in their training of observers and in the application of such procedures. The computer techniques, on the other hand, have the ability to measure distances between vital facial landmarks quickly, thus presenting the researcher with displacement measures, which can later be subjected to multivariate analyses. As well as presenting quantifiable data and eliminating visual scoring procedures, the computer approach has explored the possibility of using facial features as data points in multivariate analyses, simulating faces and face profiles[3], and more recently, measuring the distances between facial landmarks in the quantification of facial expressions.

4.6. Some Methodological Problems in Component Research

The contemporary researchers using the component approach have encountered three major problems. Firstly, when establishing measurement units or

3 Beyond the academic pursuit of face simulation, one of the more practical uses for complete face simulation has been in police departments as a replacement for the traditional Identikit or so called "mug-shot" systems. The Identikit procedure firstly requires the witness to reconstruct the face of the offender from a pre-existing composite of facial parts. This involves the extensive recall of detailed features from a glimpse that may have lasted only a few seconds. Alternatively, the eyewitness is asked to look through the photographic records held of persons suspected of criminal behaviour. The "mug-shot" procedure requires skill in recognition but even so, it is an easier task than the recall of individual facial features. However, the sheer volume of photographs which need to be scanned may interfere with memory of the targeted face. A computer system seems well suited to the task of simulating, searching and retrieving facial representations of mug-shot faces. Laughery, Rhodes and Batten (1986) reviewed the status of computer-assisted retrieval applications and found that feature selection and algorithms based on feature similarity were the keys to a cost-efficient and labour saving system. Also, Shepherd (1986) has constructed FRAME, a computer-based retrieval system consisting of a data base of 1,000 faces, from which accurate retrieval rates have been reported

quantification formulae, the researcher must decide whether to embark on a comprehensive or selective representation of facial behaviour (Ekman, 1982b). Selectivity may lead to selection bias or may falsely question the validity of a technique, as the selection process itself may miss certain pertinent facial components. A comprehensive approach on the other hand, does not assume expertise in the entirety of facial action possibilities. On the contrary, discovering and differentiating the range of potential actions is the aim of every measurement system. The major advantage of a selective approach is the time saved in the recording and subsequent scoring process. However, selectivity can still be possible with comprehensive measurement systems if only those actions pertaining to the appropriate phenomena are scored. Thus, a comprehensive coding technique offers the choice of being selective or otherwise, when looking at the facial actions associated with a particular emotional sequence or other activity.

A second problem associated with component techniques lies in the facial action terminology itself (Ekman, 1982b). The description of facial activity varies, as many researchers derived their units de novo and post-experimentally. The nett result is the existence of over twenty different measurement systems, describing from twenty to eighty actions, and all aimed at measuring facial activity. Each technique uses its own descriptive terms, making the reconciliation of techniques almost impossible. It becomes even less feasible if the lists of facial movements were compiled using different behavioural samples. For example, in a comparison of twelve different facial action measurement techniques which quantify only visible activity, Hager (1985) encountered several difficulties. He compared the description units used by each technique in an attempt to bring together the diverse terminology representative of the facial component research area. The only way he was able to achieve this was by interpreting all facial action from an anatomical point of view. Only by using a common reference point such as muscular activity (although many measurement techniques do not refer to the contracted muscles) was it possible to find some correspondence between the different methodological approaches. Indeed, Hager (1985) concluded that research which aims to compare various techniques in this way, may be the initial step toward the formulation of a more universal measurement system.

The third problem and major difference amongst measurement techniques stems from the disciplines within which they were originally formulated. For example, the emphasis placed on unit derivation may be based on functional, anatomical or theoretical principles. This focus will further determine what aspect of facial behaviour requires measurement, the size and number of facial components, how to represent facial components (i.e. individually or part of a group or blend), and finally, the application of suitable quantification techniques. The ideal facial measurement system would have a comprehensive focus, be functional with photographic and moving picture displays, as well as adjusting for age and posed versus spontaneous differences in facial expression.

4.7. Conclusion

Historically, face research has been hindered by the frequency and speed of expressive reactions. With recent advances in technology, comprehensive measurement systems have been designed to monitor neuromuscular activity in greater detail. Ethological, theoretical and anatomical scoring systems have considerably increased our knowledge of facial activity, and particularly, facial expression. Their contributions include emphasising the components of the face through the compilation of standardised scoring systems or by the direct measurement of facial action.

There are several key conceptual issues which call for consideration in any review of the facial measurement of expression and emotion. One concerns the construction of the facial coding systems. Focussing on the works of both Ekman and Izard (who have in recent times been pre-eminent in the resurgence of interest in the study of the face, as well as providing comprehensive coding systems), the question follows: how did the authors arrive at their descriptions of facial action? Significantly, both Ekman and his colleagues and Izard's team who worked independently of one another, commenced with the study of the anatomy of the face despite separate theoretical frameworks and empirical research targeting the fundamental emotions. Both teams focussed on the facial muscles and facial areas which contributed to the display of emotion. Furthermore, both Ekman's and Izard's teams have used cross-cultural evidence to support and further validate their descriptions of various expressions. This has been accomplished by asking observers from different cultures to judge or recognise expressive displays from a series of photographs representing the fundamental emotions. Some current investigators have taken the information provided by Ekman and Izard and have either applied a coding system such as FACS in the measurement of facial action to their respective populations or have developed computer systems which can measure the emotions deemed by these authors to be fundamental.

Secondly, Ekman and Izard describe configurations of facial action which purport to represent expressions of emotion. Have these configurations been adequately validated as expressions of emotion? As with any tool which has proven reliable and has been validated by its authors, its predictive power and utility will be borne out only when it is employed in a variety of experimental situations and correlated with psychometric tests measuring affect, subjective experiences and physiological indices of emotion. This is the case for FACS (and to some extent EMFACS) which have been used to study the startle response (Ekman, Friesen & Simons, 1985); infant facial behaviour (Oster & Ekman, 1978); facial activity during conversation (Camras, 1977); the perception of emotions (Wiggers, 1982) and schizophrenia (Krause, Steimer, Sänger-Alt & Wagner, 1989).

Izard, from research in his laboratory (Izard, Hembree & Huebner, 1987; Izard, Huebner, Risser, McGinnes & Dougherty, 1980; Langsdorf, Izard, Rayias & Hembree, 1983; Termine & Izard, 1988) and Yorczower and Kocs (1980) independantly, have contributed to the validity of MAX and AFFEX by using the two systems in a complementary fashion to measure facial action in children. A particularly useful function of the AFFEX system is in its ability to provide a quick method of determining onset and offset of an emotion display on the face. MAX is then used for the microscopic assessment of facial action during the expression.

MAX has also been compared to the Monadic Phases Coding System (MP). Matias, Cohn and Ross (1989) used both systems in the measurement of infants' behaviour whilst interacting with their mothers. They found convergent validity for positive, negative and interest expressions, although MP, not relying solely on facial information (vocal and postural activity are also coded) had more codable movements than MAX. Also there was greater inter-observer agreement for the MP system.

Finally, both Ekman and Izard have been influenced by the work of Darwin (1872) and Tomkins (1962, 1963) and have predicated their work on the assumption that discrete emotions exist which are not only characterised by distinct facial patterns, but are also innate and universally experienced and recognised. Yet Ekman and Izard have produced somewhat differing descriptions of the emotions. How has this come about? An obvious reason may be the fact that Izard designed MAX to measure the facial behaviour of children while FACS and EMFACS were designed for adults. This is probably not the case as MAX has been successfully applied to adults and very recently, FACS was used in a study of two to five year old children and found to reliably locate at least four action units (Unzner and Schneider, 1990).

A second and more likely explanation may lie in the fact that Ekman and Izard have approached the issue of facial measurement from two different theoretical frameworks. Ekman (1971) has described the existence of six (later seven) fundamental emotions based on his neocultural theory of emotion incorporating biological and cultural influences in the display of emotion, while Izard (1971) nominated nine primary emotions as defined by Differential Emotions Theory, which assumes the operation of evolutionary-genetic mechanisms and emphasises the feedback from the face to the brain in the production of the discrete emotions. Thirdly, the functional utility of MAX and FACS is different. The FACS system was designed to be comprehensive. It utilises a "minimal units" approach to monitor each movement or muscular action in the face. Hypotheses may have been tested, supported or disproved according to some theoretical framework, however, this would not interfere with the validity of FACS as a measurement system. MAX on the other hand was constructed on the basis of theoretical and empirical research findings. Moreover, it is a theory which applies predominantly to adult emotions. Apart from the obvious mentioned physiognomic differences between adult and children faces mentioned by Izard (1983), i.e. furrows and ridges in adults and fatty tissue in infants, it is not clear how MAX deals with developmental changes in an infant's appearance or individual differences in expressive ability. The appearance changes of three facial regions are targeted and judges rate whether an action, typical of one of the fundamental emotions, is present or absent. Thus, as MAX is more inclined to measure patterns of facial behaviour, this leaves the way open for inference and bias which is unlikely with FACS as all movements are recorded and not only those associated with the emotions. Furthermore, FACS is unique in its descriptive criteria for the assessment of the appearance of a facial movement, both on its own, and in a blend with other facial actions.

4.7.1. How to Decide on a Measurement System?

This review has concentrated on those measurement systems which have enjoyed some popularity in the literature, in particular the contemporary, ethological, theoretical and anatomical approaches to the measurement of facial action. An historical overview showed that early interest in the face by psychologists was related to their underlying personality theories. When no correlates were found between the two, facial expression was abandoned as a scientific measure of psychological processing. Of course, the difficulty with this early research was its narrow focus on static facial features, in the main, physiognomy, and not until the dynamic features of expression were associated with emotion, did the face emerge as a viable alternative to global arousal measurement techniques.

So which measurement system should be used in a study on facial action? Different methods have value in answering different questions. If all that is needed is a confirmation that an emotion has been communicated, then a study using AFFEX may be sufficient. If on the other hand, all visible actions involved in the expression of an emotion whilst using conversational signals are desired, then FACS would be more appropriate. Computer techniques may be helpful in pilot research (until they are properly validated) where other resources are limited (e.g. funding for coders or judges).

Methods are valid only in relation to the questions asked by the investigator. For example, if spontaneously occurring emotions in a natural context were targeted, then EMG methodology is an impossibility. Similarly, measurement systems like FAST and MAX reliably distinguish amongst a set number of emotions, making them adequate for such a purpose. The rationale here is that if only some facial movements are relevant to emotion, why should a system not be designed to measure facial emotion limited to these movements? Stated simply, it should be, unless it is found, like Camras, Ribordy, Hill, Martino, Spaccarelli and Stefani (1988) using EMFACS, that the coding system dictionary of emotional responses was incomplete. Similarly, ethological techniques may not be used if what is needed is a complete and accurate assessment of facial behaviour, yet if the social context was of importance, this method would be attractive. The investigator must decide on the components of the face which need to be measured and if comprehensiveness is not a goal, then a system which measures a specific phenomenon may well be the answer.

The study of facial expression and emotion has enjoyed some recent popularity. Future experimentation needs to work towards a common measurement system, which will provide reliable and valid measurements which are comparable across all disciplines. The component approach, especially with the aid of computer science, may be a viable alternative to the much used observer in the judgement of emotion, or at the very least be shown to be compatible with it. Indeed, this methodology has the potential to be extended to such areas as the measuring of the dynamics of expression, measuring face and body movements concurrently, studying developmental changes in facial appearance and expression, hemispheric specialisation and face asymmetry, and the responses of the face during pain or illness. Currently, an assessment of muscular activity appears to be the most accurate and thorough technique for the measurement of facial expression in humans, and with the aid of computer technology, some of the problems associated with component research, viz, training time and time consuming scoring systems, may be reduced.

PART 2

CHAPTER 5

THE DEVELOPMENT OF A MICROCOMPUTER-BASED APPROACH TO THE QUANTIFICATION OF FACIAL EXPRESSION

5.1. Introduction

This section, including the next two chapters, will outline the development of a computerised system for the quantification of facial activity and provide information regarding the reliability, validity and utility of the system which will assist users in future applications to various research problems.

The impetus for the development of such a system came from Professor I. Pilowsky of the Adelaide University, Department of Psychiatry who was interested in quantifying the facial expression of emotion displayed by patients (in particular those who denied affect) during a therapeutic encounter. It was envisaged that a reliable and objective measurement system could provide specific clues as to the emotional condition of psychiatrically disturbed patients in general, and that furthermore, any change in the facial expression of a patient during treatment might be used to monitor the efficacy of certain treatment procedures.

The interpretation of nonverbal reactions by an untrained observer, however, have been shown to be quite misleading (Ekman, 1982b). Reading faces has produced some ambiguous and contradictory findings (Ekman, Friesen & Ellsworth, 1982). Hence, the development of a model for the quantification of facial expression has as its the aim the rapid and efficient clarification of facial movements. Furthermore, it may elucidate the relationship of facial activity and emotion provided that such a model can accommodate the range of information required for the recognition of facial expression.

It was during his sabbatical at the University of Washington Pain Centre and Department of Psychiatry, Seattle, in 1976, that Professor Pilowsky began to formulate his ideas for an objective facial measurement system (in the main to detect depression in chronic pain patients). It was also at this time that he became aware of Ekman, Sorenson and Friesen's (1969) cross-cultural research involving the recognition of the fundamental emotions. Ekman and his colleagues subsequently developed the Facial Action Scoring Technique (FAST: Ekman, Friesen & Tomkins, 1971). Professor Pilowsky, wanting to apply a measurement tool clinically, searched for a more efficient method of capturing facial expression, i.e. one that would not involve the amount of training and analysis time which was associated with FAST. With the advent of low cost videorecorders equipped with a freeze frame facility and the availability of microcomputers, it seemed more appropriate to computerise the facial measurement process. Thus, on his return from sabbatical, Professor Pilowsky approached Professor Ren Potts from the Department of Applied Mathematics at the University of Adelaide who suggested this project to one of his Honours students, Mark Thornton.

5.2. A Mathematical Model of the Face

Mark Thornton (1979), an honours (i.e 4th year) student in Applied Mathematics at the Adelaide University, devised a new measurement technique for the study of facial expression, by the development of a mathematical model of the face. This involved the choice of certain easily located key facial points or "landmarks", which were the most relevant to the detection of emotional signals. Employing a dimensional approach to the study of facial expressions, Thornton utilised a mathematical technique for scaling expressions along a happiness-sadness axis. It was envisaged that the model would be designed to rate expressions along any expressive bipolar dimension.

The development of a mathematical model which was capable of scaling a variety of facial expressions involved the following stepwise process: (a) selection of a facial source to be used as input data ,(b) definition of point locations to identify facial "landmarks", (c) definition of facial "muscloids" which would simulate facial muscles, and (d) definition of a skin network which would simulate facial skin.

5.2.1. Selection of a Facial Source

The first consideration in the construction of a mathematical face model addressed the issue of a suitable source of facial input. Thornton sought quantitative data which were conducive to mathematical manipulation. Electromyographic techniques were considered, but later discarded due to their intrusive nature. Photographic displays of facial expressions were chosen as they were easy to obtain from subjects. This was not without its problems however. A photographic image was found to provide more information than the working computer could handle. A line drawing representation of a photograph of a face, on the other hand, was preferred as it substantially reduced the data output, without sacrificing vital facial information. In other words, Thornton produced and worked with a line drawing from every expressive display. Ekman, Friesen and Ellsworth (1972) point out the difficulties associated with any drawing of a facial expression. They explain that, specifically, an artist's representation of a facial expression may involve features or feature combinations which do not take place. It will be appreciated however, that in the case of Thornton's line drawing representations, a true reproduction of facial configuration is achieved from the key landmarks.

5.2.2. Definition of Point Locations

The location and definition of facial points was preceded by the selection of the facial features which contribute to the display of a facial expression. Each feature was surrounded by point "markers", which had the effect of positioning and shaping the feature for graphic representation on the line drawing. Fortunately, the face has a limited number of facial landmarks. Thornton included the eyes (six points on left eye, six points on right eye); eyebrows (three on left eyebrow, three on right eyebrow); mouth (ten points; six on upper margin of upper lip, two on upper margin of bottom lip, two collectively for the mouth corners, i.e. one for the each of the mouth corners). The nose and outline of the face were also represented with point markers, and added the finishing touch for an acceptable line drawing. These point locations, as outlined above, were considered to describe accurately the position of the facial features. In this way, a detailed numeric record of a photograph, consisting of relatively few numeric co-ordinates of the landmark points, with emphasis on position and proportion of facial features, can be easily stored onto a floppy diskette.

With the use of a lightpen and a transparency, Thornton marked fifty points on to a sensitive computer screen from a single source image (i.e. a photograph) by concentrating on such areas as the mouth, the eyes, the nose, the eyebrows and the outline of the face. These points were then joined using a sophisticated mathematical technique called the B-spline method (Yamaguchi, 1978) to form the basic structure of the face, i.e. in line drawing format. The graphic presentation of the point locations involved the establishment of a general drawing capability. The B-spline technique (originally used by the Renault Car Company in the 1960s) produces a curved line drawing of the face, i.e. the connection of the landmark points. The program which generates the curve is simple, reasonably fast and effectively connects a minimum number of facial points to produce a smooth curved line drawing. Continuous curvature is achieved by setting up a parametric equation system. Specifically, the application of an inversion logarithm produces a piece-wise linear approximation to a second order continuous curve. Interestingly, Yamaguchi (1978) specifically applied his B-spline method to a face profile, demonstrating the smooth finish achieved by the new curve fitting technique.

5.2.3. Definition of the "Muscloids"

A third consideration in the development of the model was its capacity to function as a true simulator of facial activity. In other words, it is possible that a mere graphical reconstruction of a facial expression can be achieved by schematic faces or caricatures, both of which are adequate for quantification procedures. The mathematical model has the capacity to modify and manipulate the location of facial landmarks on the line drawing. This is achieved by mathematically contracting or relaxing the facial "muscloids". The facial muscloids are defined so as to represent only one muscle action as needed, or the activity of a group of muscles in the execution of a particular facial action. In essence, the modification of the line drawing involves the manipulation of muscloid activity. With regard to the graphic display of the face, muscloids are reduced to a straight line connecting two facial landmarks. For example, one of the muscloids is defined as the movement of the Risorius and Zygomaticus Major muscles (or the line joining points 1 and 16, see Figure 5.1.), which have the effect of raising the outer corners of the mouth.

5.2.4. Definition of the Skin Network

The final addition to the line drawing representation of a real face was the graphic display of facial skin. Facial muscloids are unable to simulate the folds of the skin apparent with muscle contraction. The major skin fold on the face lies between the nasal wing and the corner of the mouth (the nasolabial fold). The skin network is active over the entire face and thus the model can be made to simulate any folds of facial skin during an expression.

To summarise thus far, the development of the model has arisen out of the strictest adherence to a certain goal, i.e. the quantification of facial activity. Fifty points were digitised from a photograph by attending accurately to the predetermined point locations. The digitised points were located around the eyes, nose and mouth with points also to complete the facial outline. Muscle groups defined as "muscloids" act on selected facial points. Skin connections contribute to the simulation of facial skin. The graphic display of the photographic image is achieved by the automatic graphic procedure which is designed to produce a line drawing by the smooth connection of the facial points.

The information required for any given face simulation is constant as the input points are common for all faces. The digitised facial landmarks do not change and so the only variability expected is in the shape and proportion of the landmarks. Similarly, the position of the facial muscles will be common to most faces, with possible variations in the function of muscles, for example in stroke or car accident victims. Hence, the generation and operation of each face is point specific, a function of its common features.

5.2.5. Application of Thornton's Model: The Development of an Expression Scale

The model was first applied to generate expressions which fall along the happiness-sadness dimension. The extremes of the axis were chosen from Ekman and Friesen's (1975) documented representations of the facial configurations of these bipolar emotions. The essence of the model is to provide a range of expressions from happy to sad by manipulating the facial muscloids of a targeted neutral expression. Thornton and Pilowsky (1982) presented an example of the mathematical scaling of facial expressions, using a photograph of a neutral expression as their baseline measure. By contracting or relaxing the muscloid groups around the mouth and activating the appropriate skin links, the model is capable of generating a diverse set of line drawing representations of facial expressions. Furthermore, these simulated expressions may be used as cues in facial recognition studies, or as an assessment of mood status by the patient him/herself, for example, when language may be a problem. Due to the anonymity and simplicity of the line drawings and the loss of detailed identity information, a standard set of data points are attributable to all faces.

5.3. The Modification of Thornton's Model: The Introduction of a Microcomputer

The second stage of research has concentrated on the development of a system which will achieve the objective description of facial movement. This has involved a modification and extension of Thornton's original model. In fact, the current state of knowledge and research interests regarding the model have required the painstaking progression through a series of three planned, predetermined exercises: (a) acquisition, programming and implementation of new equipment, (b) location, encoding and verification of landmark points, and (c) quantification of facial action.

5.3.1. Equipment

Thornton's work made use of a DEC GT40 graphics terminal connected to the Adelaide University Computing Centre's Cyber. An added consideration following the completion of Thornton's thesis was the need to centralise operations in the Adelaide University Department of Psychiatry, (as opposed to campus oriented operations of Thornton). Rather than operating from a remote terminal site connected to the University of Adelaide Cyber, (as the Department of Psychiatry is not on campus) the granting of research funds by the Ramaciotti Foundation allowed for the purchase of a microcomputer, i.e. Columbia "IBM-PC clone", with 10 megabyte winchester and 8087 floating point processor, as well as the services of a programmer[1]. A graphics tablet (Bitpad) and a digitising pen for an existing Apple 2e were also acquired. A JVC U-Matic videorecorder with a freeze frame and a frame advance facility, and a Mitsubishi video-printer were also purchased. In this way, a hard copy of each source image could be made from the videotape.

Programming both the Apple 2e and the Columbia followed. Firstly, the Apple 2e was set up to receive the encoded messages from point locations marked on a source image of input. Thornton used a lightpen and transparency to mark the facial

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1 Programming by Brett Stokes.

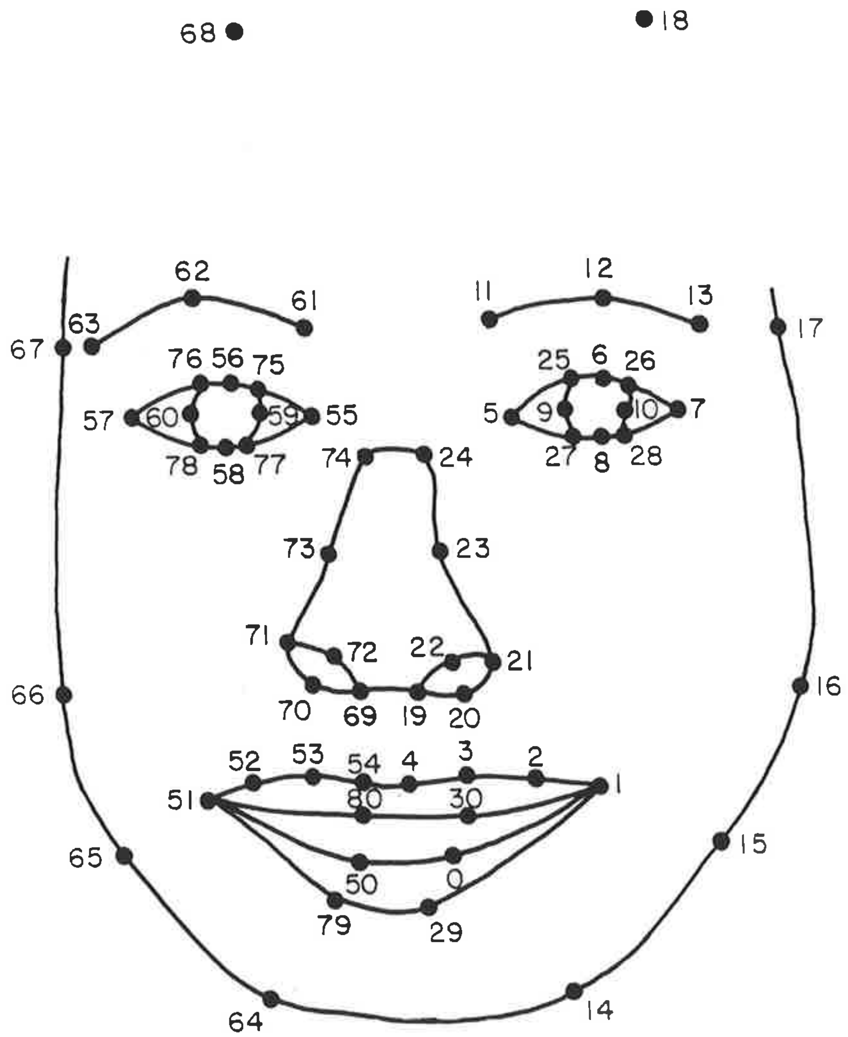
points on to a computer screen. The new system worked by encoding facial landmark points using a graphics tablet attached to the Apple 2e. A pen is used to digitise or locate the facial points on the source image. The Columbia has been programmed to receive these point co-ordinates from the Apple 2e and to feed the information into Thornton's model. This involved a rewrite of the original programme into a language (i.e. Basic) suited to the new system.

In specific terms, a photograph (i.e. a hard copy obtained from the videoprinter) is placed on the bitpad (using tape to minimise movement) and the pen is used to digitise the preselected facial points which are called up by the computer. To speed up the digitising procedure, each facial point inputted into the system is followed by its mirror image. For example, after the point locating the right outer corner of the mouth has been digitised, the computer calls for the location of the point of the left outer corner of the mouth. This saves digitising time by facilitating user memory of the location of the facial points. With the implementation of a serial communication system, the points are relayed to the Columbia, which integrates the information and produces a graphic display of the points in a line drawing format. The Columbia also produces a number of other related measures which will be discussed below. The end result is an integration of all "Face Laboratory" functions into one menu driven system (on the Columbia), with the Apple 2e as control and operator display, and the Columbia containing the relevant facial information and graphics programme.

5.3.2. Encoding and Verification of Point Locations

The location of facial points on the source image were determined after extensive review of Ekman and Friesen's (1978) FACS manual and Izard's (1979) MAX coding system. The number of digitised points have increased to sixty-two, with the addition of more detail to the lips and eyes, thus producing a more aesthetically appealing line drawing (the points at the top of the head are digitised but have been omitted in the process which connects the points to produce the line drawing). Figure 5.1. displays the location of the facial points on a line drawing representation of a real face, taken from a photograph in Ekman and Friesen's (1975)

Figure 5.1. Line Drawing Representation of a Real Face Showing the Location of the Digitised Facial Points



"*Unmasking the Face*". The use of landmark points provides an efficient and economical method of encoding (for storage or computational processing) of the absolute and relative positions and proportions of facial features. The source image can be a still photograph. However, more often the source image is a photographed image of one frame of videotape or film material. The imaging system used is a thermal printer attached to a video monitor. In this way, a hard copy can be obtained from any piece of videotaped material. This hard copy is then used as a source of input of the point locations. The verification of point locations occur at the graphic stage when the line drawing appears on the screen.

5.3.3. Quantification of Facial Action

Once the facial points have been located and digitised and the curve drawing programme has connected all the points, the graphic procedure initiates a line drawing representation of the source image. The anonymous line drawing of the face displays the major facial landmarks, i.e. the eyebrows, eyes, nose, mouth, as well as the facial outline. It is at this point that the quantification of facial expressions or facial movement is possible, with the establishment of twelve computer generated facial measures each representing distances between two facial landmarks. Point definitions were refined and euclidean distances between points were measured. The twelve computer generated facial measures consisting of eight "vertical" and four "horizontal" measures are presented in Figures 5.2. and 5.3. The anatomical features associated with each landmark point are described below, and Figure 5.4. shows the muscle groups associated with each measure:

1. End-Lip Measure: the averaged distance between the outer corner of the lip and the outer corner of the eye for the left and the right sides of the face.

Active Muscles: Zygomaticus major, Caninus, Buccinator, Depressor labii inferioris, Depressor anguli oris.

Nerve Supply: Buccal branches of the facial nerve and the mandibular marginal branch of the facial nerve.

Figure 5.2. Vertical Facial Measures

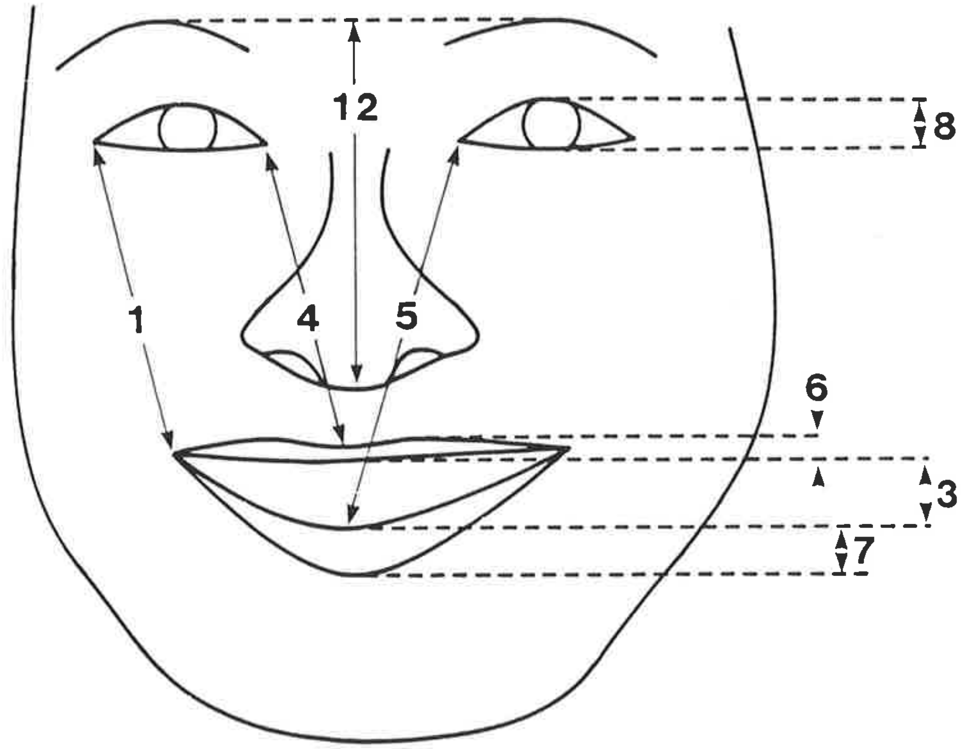


Figure 5.3. Horizontal Facial Measures

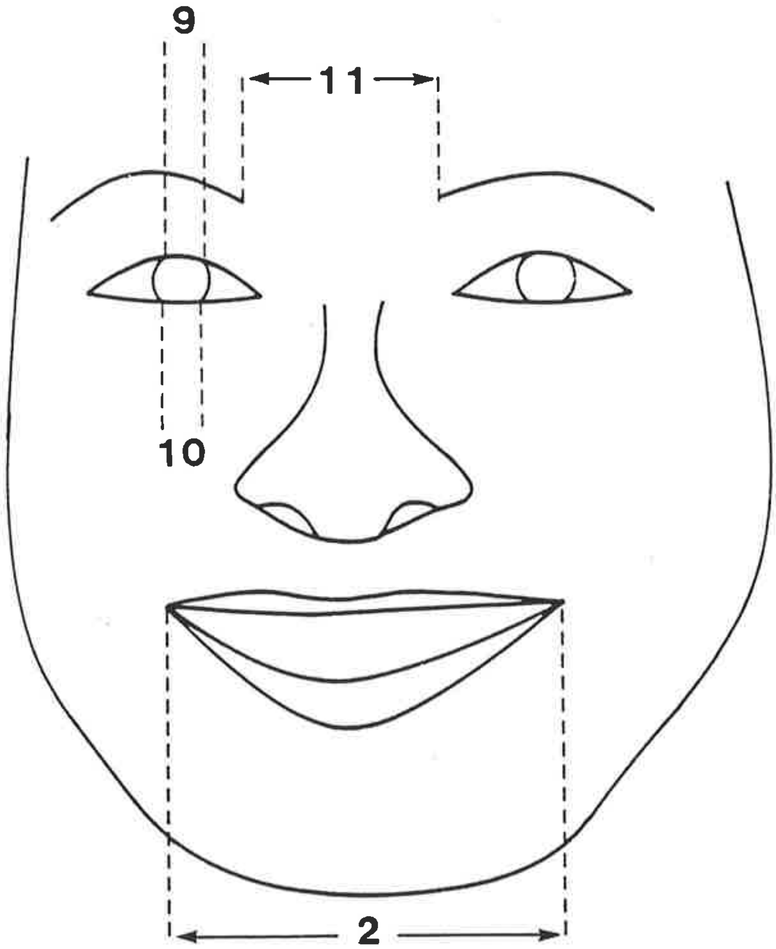
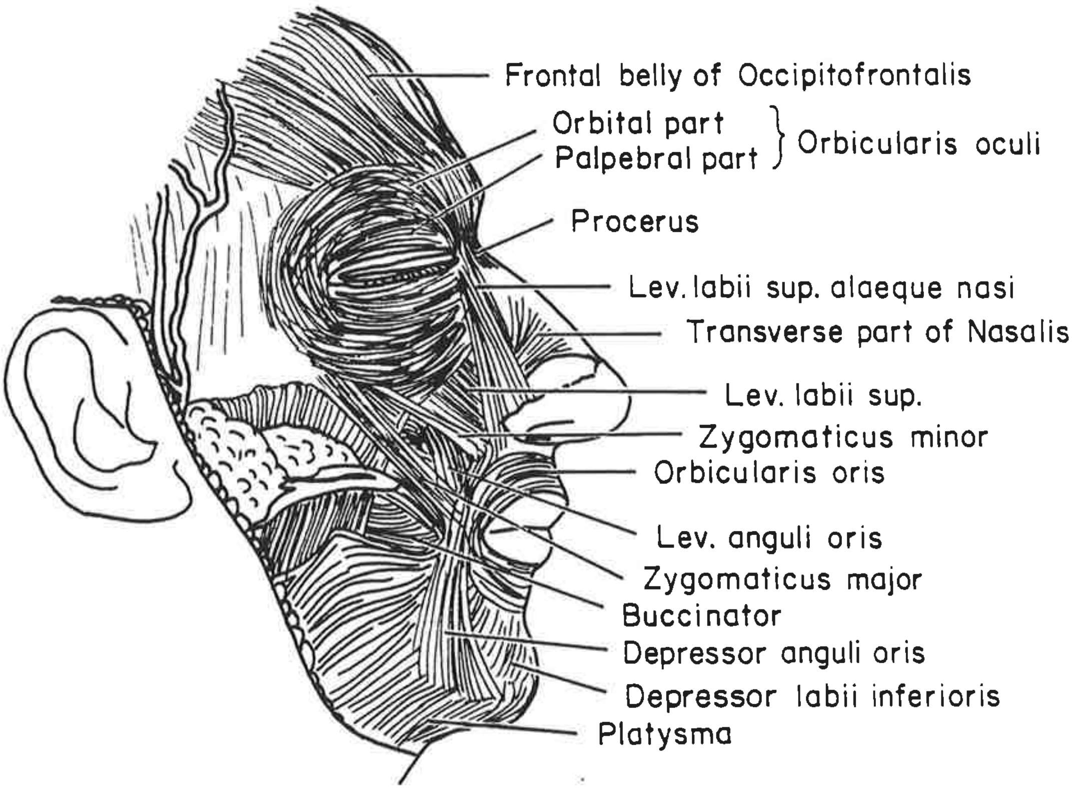


Figure 5.4. Muscles of the Face



2. Mouth-Width Measure: the distance between the outer corners of the right and left side of the mouth.

Active Muscles: Obicularis oris, Risorius.

Nerve Supply: Buccal branches of the facial nerve.

3. Mouth-Opening Measure: The distance between the centre of the upper border of the bottom lip and the centre of the lower border of the top lip.

Active Muscles: Obicularis oris.

Nerve Supply: Lower buccal and the mandibular branches of the facial nerve.

4. Mid-Top-Lip Measure: the averaged distance between the centre of the bottom of the top lip and the inner canthus of the eye for the left and right side of the face.

Active Muscles: Levator labii superioris, Zygomaticus minor.

Nerve Supply: Buccal branches of the facial nerve.

5. Mid-Lower-Lip Measure: the averaged distance between the centre of the top of the bottom lip and the inner canthus of the eye for the left and right side of the face.

Active Muscles: Depressor labii inferioris, Mentalis.

Nerve Supply: Mandibular marginal branch of the facial nerve.

6. Top-Lip Thickness Measure: distance between the upper and lower borders of the upper lip at the midpoint.

Active Muscles: Obicularis oris, Risorius.

Nerve Supply: Buccal and mandibular marginal branches of the facial nerve.

7. Lower-Lip Thickness Measure: distance between the upper and lower borders of the lower lip at the midpoint.

Active Muscles: Obicularis oris, Risorius.

Nerve Supply: Buccal and mandibular marginal branches of the facial nerve.

8. Eye-Opening Measure: the distance between the lower margin of the upper eyelid and the upper margin of the lower eyelid.

Active Muscles: Obicularis oculi.

Nerve Supply: Temporal and Zygomatic branches of the facial nerve.

9. Top-Eyelid/Iris Intersect Measure: part of the eye which is covered by the lower border of the upper eyelid.

Active Muscles: Obicularis Oculi, Levator palebrae superioris.

Nerve Supply: Temporal and Zygomatic branches of the facial nerve.

10. Lower-Eyelid/Iris Intersect Measure: part of the eye which is covered by the the upper border of the bottom eyelid.

Active Muscles: Obicularis oculi.

Nerve Supply: Temporal and Zygomatic branches of the facial nerve.

11. Inner-Eyebrow Separation Measure: the distance between the innermost points of the left and right eyebrows.

Active Muscles: Corrugator supercilii.

Nerve Supply: Temporal branches of the facial nerve.

12. Mid-Eyebrow Raise Measure: vertical distance of midpoint between the two nostrils and midpoint between highest point of right and left eyebrows.

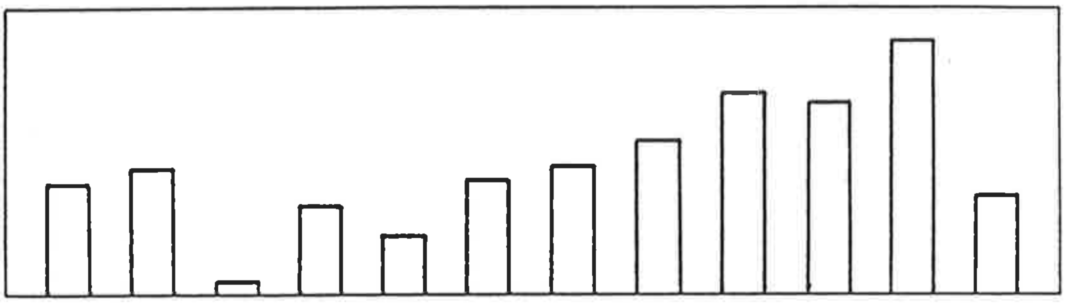
Active Muscles: Frontalis.

Nerve Supply: Temporal branches of the facial nerve.

5.3.4. Standardisation of the Facial Measures

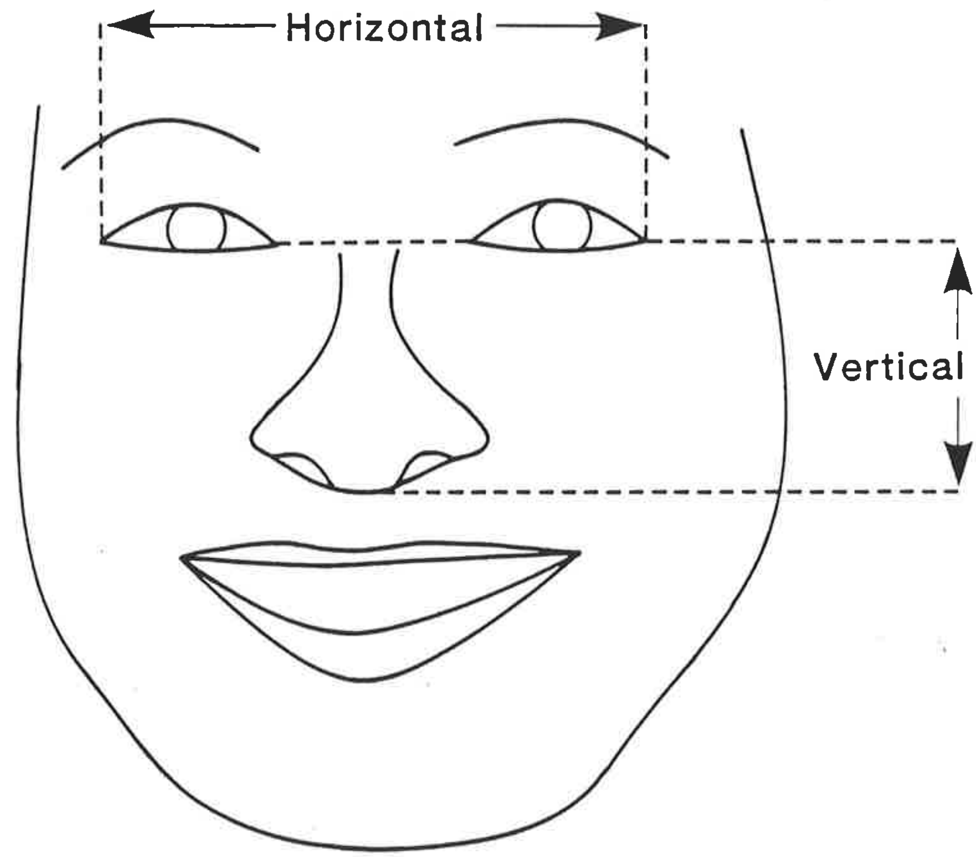
The distance values associated with each facial measure do not represent distances in millimetres or centimetres between key points, but are better regarded as numerical representations of those distances, expressed as a value within a hypothetical range, reflecting the greatest possible excursion of those points on the face. Since each facial measure has a unique minimum and maximum value, a scaling

Figure 5.5. Profile of a Facial Expression Including the Twelve Facial Measures



Facial Measure	1	2	3	4	5	6	7	8	9	10	11	12
Standardised Values	38.8	44.2	5.1	31.3	20.5	40.0	45.0	53.7	70.1	66.4	88.7	34.8
Raw Values	1.4	0.6	0.0	1.3	1.4	0.1	0.1	0.2	0.1	0.1	0.7	1.5

Figure 5.6. Reference Measures



procedure is applied which allows for the comparability of all facial measures making up the profile of a particular facial expression (see Figure 5.5.). This scaling process involves the subtraction of each of the minimum scores from its associated obtained distance measure, multiplication by 100, and then division by the predetermined range value associated with that facial measure. In this way twelve scaled facial measures are produced. Each scaled facial measure is then divided by a one of two reference measures: the distance between the outer canthi of the eyes for "horizontal" measures and the length of the nose for "vertical" measures (see Figure 5.6.). This process compensates for head movement during filming or the size of the source image on the graphics terminal and allows for the direct comparison of facial expressions between subjects.

Each measure can thus be defined in terms of the digitised points which have to be joined in order to obtain a facial measure. Referring to Figure 5.1.:

1. End-Lip Measure: distance between points 51 and 57 on the right hand side (RHS) divided by the length of the nose + the distance between points 1 and 7 on the left hand side (LHS) divided by the length of the nose, averaged[2] .
2. Mouth-Width Measure: distance between points 1 and 51 divided by the distance between the outer canthi of the eyes[3].
3. Mouth-Opening Measure: distance between the midpoint of points 0 and 50 and the midpoint between points 30 and 80, divided by the distance between the outer canthi of the eyes.
4. Mid-Top-Lip Measure: the distance between points 54 and 55 (RHS) divided by the length of the nose + the distance between points 4 and 5 (LHS) divided by the length of the nose, averaged.
5. Mid-Lower-Lip Measure: the distance between points 50 and 55 (RHS) divided by the length of the nose + the distance between points 0 and 5 (LHS) divided by the length of the nose, averaged.

2 Length of the nose refers to the distance between points 55 and 69 (RHS) + the distance between points 5 and 19 (LHS), averaged.

3 Distance between the outer canthi of the eyes refers to the distance between points 57 and 7.

6. Top-Lip Thickness Measure: distance between the midpoint between points 30 and 80 and the midpoint between points 2 and 52, divided by the length of the nose.
7. Lower-Lip Thickness Measure: distance between the midpoint between points 29 and 79 and the midpoint between points 0 and 50, divided by the length of the nose.
8. Eye-Opening Measure: distance between points 58 and 56 (RHS) divided by the length of the nose + the distance between points 8 and 6 (LHS) divided by the length of the nose, averaged.
9. Top-Eyelid/Iris Intersect Measure: distance between points 76 and 75 (RHS) + the distance between points 26 and 25 (LHS), averaged. The averaged value is then divided by the distance between the outer canthi of the eyes.
10. Lower-Eyelid/Iris Intersect Measure: distance between points 78 and 77 (RHS) + the distance between points 28 and 27 (LHS), averaged. The averaged value is then divided by the distance between the outer canthi of the eyes.
11. Inner-Eyebrow Separation Measure: the distance between points 7 and 61 + the distance between points 57 and 11, averaged. This averaged value is then divided by the distance between the outer canthi of the eyes.
12. Mid-Eyebrow Measure: the distance between points 69 and 62 (RHS) divided by the length of the nose + the distance between points 19 and 12 (LHS) divided by the length of the nose, averaged.

A limitation of Thornton's earlier work was the limited array of muscle control points assigned to simulate the activity of real facial muscles. Only three muscloids were included on the line drawing and graphics procedure such that the expression management was located and focussed solely around the activity of the mouth. With the modification of the model, however, the twelve facial measures represent the facial muscloid activity responsible for that localised movement. Using the model, the relationship between the facial measures and the various pancultural expressions can be established. In addition, a profile of the twelve measures (see Figure 5.5.) is produced and gives some indication of the associative relationship between each of the measures. A further dynamic profile can be generated, which represents a description of the activity of a single measure over time, i.e. over several frames of video, or alternately, the measurements obtained of a single muscloid action during the display of several different expressions (see Figure 5.7.).

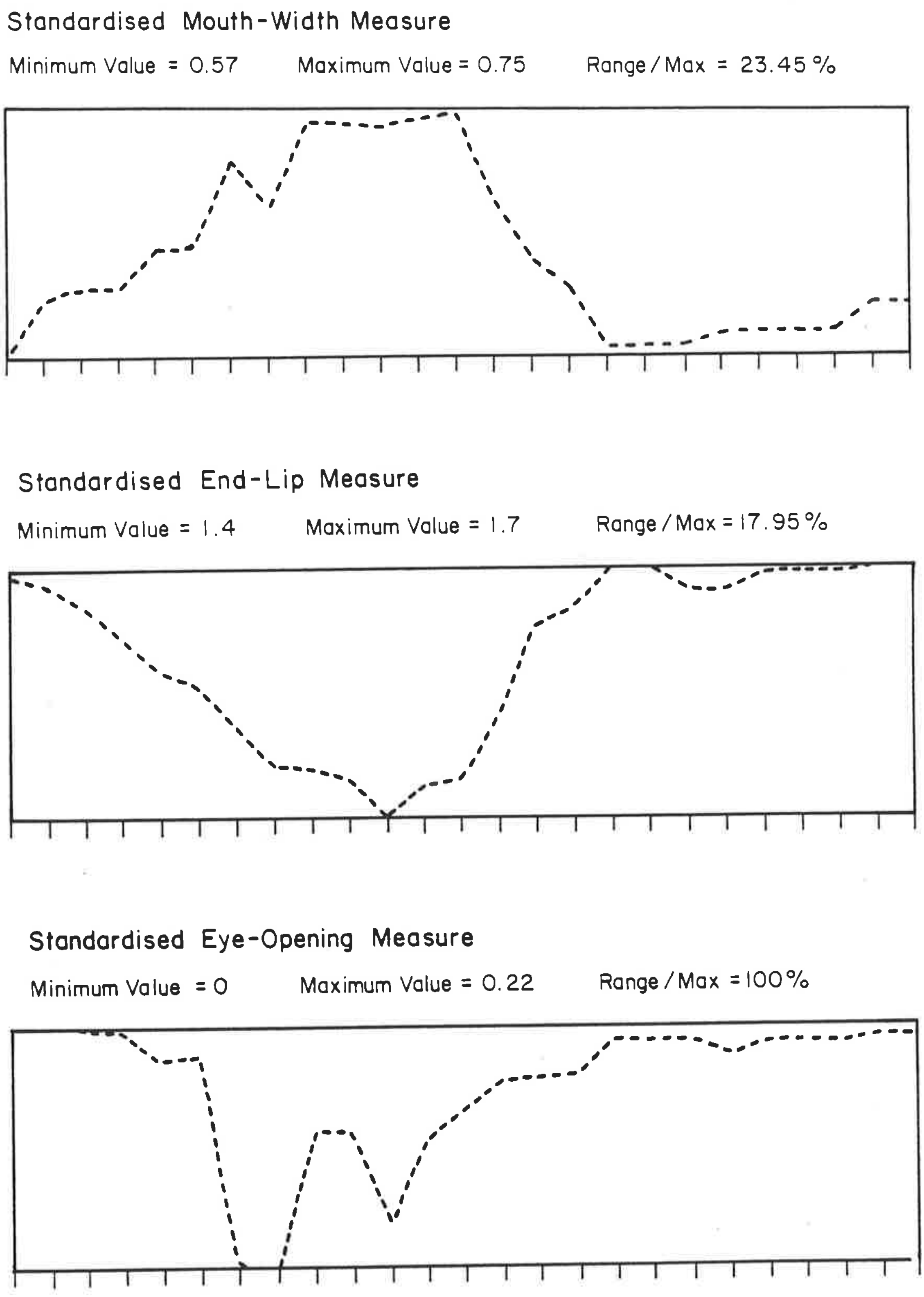
5.4. Reliability of the Digitising Procedure

The aim of the procedure is to provide a quantitative measure of facial expression. It is necessary to ensure that the process of entering (digitising) the facial points into the model is of high reliability. The reliability of the digitising procedure was assessed in two ways: firstly, inter-rater reliability of the results produced by two judges were examined and secondly, test-retest reliability of one of the judges' performance (i.e. that of the author). The material providing the input data were randomly selected facial photographs from Ekman and Friesen's (1975) book "*Unmasking the Face*". Twenty-three faces displaying an array of facial expressions were photocopied and enlarged slightly, in order to enhance the definition of the outlines of the key facial landmarks. The photographs were randomly allocated a number from one to twenty-three and this sequential order was followed by each of the raters. The entire set of faces were digitised by rater one (the author) and followed immediately by rater two[4].

As mentioned earlier, the computer programme has been written in such a way so as to call up each point of the face in turn which needs to be inputted. Reiterating, each point that is asked for and subsequently digitised, is followed directly by its mirror image point. The rater marks off every point using the digitising pen. This computer assisted scoring procedure is facilitated by the availability of an enlarged photograph of a female actress showing a neutral expression which rests alongside the bitpad (also from Ekman & Friesen, 1975). The sixty-two input points

4 I would like to acknowledge gratefully the help of Ulana Sudomlak (B.A.) who acted as the second rater for this reliability test.

Figure 5.7. Display of One Facial Measure over Time



required by the computer digitising procedure are represented on the photograh as an "x" in each of the targeted locations (see Figure 5.1.). This has the advantage of acting as a reference photograph which can be used by the novice rater or indeed by any rater who is unsure about the placement of any of the points if presented with a somewhat fuzzy source image. It is most useful in training raters in the use of the digitising equipment, insofar as the trainer has a visual display of the location of the points which acts in conjunction with and supports the verbal description of the placement of the points.

5.4.1. <u>Inter-Rater Reliability</u>

Two judges digitised twenty-three photographs consisting of thirteen female and ten male actors displaying a diverse array of facial expressions. Reliability coefficients were calculated firstly on the raw distance measures between key facial landmarks. Where the magnitude of distance measurement was sufficiently large and it was possible to measure variation, the reliability measures are as follows: End-Lip Measure ($r=0.96$, $p<0.001$); Mouth-Width Measure ($r=0.89$, $p<0.001$); Mouth-Opening Measure ($r=0.95$, $p<0.001$); Mid-Top-Lip Measure ($r=0.71$, $p<0.001$); Mid-Lower-Lip Measure ($r=0.96$, $p<0.001$); Eye-Opening Measure ($r=0.79$, $p<0.001$); Inner-Eyebrow Separation Measure ($r=0.66$, $p<0.001$); Mid-Eyebrow Measure ($r=0.96$, $p<0.001$). The inter-rater scores for Top-Lip Thickness Measure, Lower-Lip Thickness Measure, Top-Eyelid/Iris Intersect Measure and Lower-Eyelid/Iris Intersect Measure were extremely similar due to the small range of possible variation in measurements, and it seemed inappropriate to consider reliability scores for these distance points.

To complete the reliability analysis, t-tests were performed for the two raters for each of the raw distance measures. No significant differences were found between the raters on the twelve measures.

The analysis was repeated for a reliability check of the standardised scores between raters. Again, considering only the face measures where a reliability index is considered appropriate, the following results were obtained: End-Lip Measure ($r=0.98$, $p<0.001$); Mouth-Width Measure ($r=0.98$, $p<0.001$); Mouth-Opening

Measure ($r=0.99$, $p<0.001$); Mid-Top-Lip Measure ($r=0.84$, $p<0.001$); Mid-Lower-Lip Measure ($r=0.98$, $p<0.001$); Eye-Opening Measure ($r=0.89$, $p<0.001$); Inner-Eyebrow Separation Measure ($r=0.89$, $p<0.001$); Mid-Eyebrow Measure ($r=0.97$, $p<0.001$). No significant differences were found between the raters' scores on each of the face measures.

5.4.2. Test-Retest Reliability

The test-retest reliability of the digitising equipment was examined by comparing the performance of one of the raters at the initial rating session with the results obtained from the same rater from a subsequent digitising of the same photographs in identical sequential order, three weeks later. Firstly, reliability analyses of the raw scores were as follows: End-Lip Measure ($r=0.98$, $p<0.001$); Mouth-Width Measure ($r=0.88$, $p<0.001$); Mouth-Opening Measure ($r=0.95$, $p<0.001$); Mid-Top-Lip Measure ($r=0.94$, $p<0.001$); Mid-Lower-Lip Measure ($r=0.99$, $p<0.001$); Eye-Opening Measure ($r=0.91$, $p<0.001$); Inner-Eyebrow Separation Measure ($r=0.77$, $p<0.001$); Mid-Eyebrow Measure ($r=0.95$, $p<0.001$). No significant differences were found between the mean scores on the facial measures obtained by the rater at the initial digitising session as compared to the same raters' scores at a three week follow-up session.

With regard to the standardised scores, the reliability coefficients are as follows: End-Lip Measure ($r=0.99$, $p<0.001$); Mouth-Width Measure ($r=0.98$, $p<0.001$); Mouth-Opening Measure ($r=0.99$, $p<0.001$); Mid-Top-Lip Measure ($r=0.84$, $p<0.001$); Mid-Lower-Lip Measure ($r=0.99$, $p<0.001$); Eye-Opening Measure ($r=0.97$, $p<0.001$); Inner-Eyebrow Separation Measure ($r=0.87$, $p<0.001$); Mid-Eyebrow Measure ($r=0.97$, $p<0.001$). No significant differences were found between the raters mean scores obtained from the initial digitising session as compared to the results obtained three weeks later.

In conclusion, it can be seen from the results obtained, that the digitising process is a reliable method of locating and inputting facial points from a facial photograph. In those instances where there is scope for variation, that is, where the magnitude of measurements are sufficiently large so as to make it possible to measure variation, reliability tests have been performed and the results presented above. However, where the resultant facial measures leave minimal scope for error due to the small distance measurement between certain landmarks, e.g. Top-Lip Thickness Measure, Lower-Lip Thickness Measure, Top-Eyelid/Iris Intersect Measure and Lower-Eyelid/Iris Intersect Measure, and where in some cases the inter-rater and test-retest score is identical, i.e essentially there is only one answer, consistency is complete.

A final point that should be noted with regard to the digitising procedure, is that this task does not seem to require a great exercise of judgement. When judges are instructed on the location of the facial points and the resultant facial measurements to be made, their performance is extremely reliable.

5.5. Conclusion

This chapter has described the development of a microcomputer-based approach to the quantification of facial expression using a mathematical model of the face. A collaborative involvement of the Departments of Psychiatry, Applied Mathematics and Computer Science has resulted in the development of a simple working model, capable of quantifying facial activity from a still image, with the ability also to track the development of an emotion over time. Furthermore, the model has been shown to have high reliability of quantification.

The next chapter will report two experiments conducted to validate the utility of the model as a working measurement tool. The functions under investigation include (1) substituting the line drawing representation of a "real face" as a stimulus source, (2) the generation of the distance scores as measures of facial movement and their relationship to ratings (from a group of judges) of emotion, (3) the variability of distance measures over time as an indication of the development of an expression, and (4) encoder "profile" differences as rated by a group of judges. Following the validation procedure, the final section will report results from the application of the model to other contexts.

PART 2

CHAPTER 6

THE QUANTIFICATION OF SMILING USING A MICROCOMPUTER-BASED APPROACH

6.1. Introduction[1]

This chapter focusses on the expressive display of the smiling response in the investigation of the process of encoding and decoding of facial information. Much of the recent work on the face has focussed on the expression of emotion, or encoding (Ekman & Oster, 1979), and the perception of emotion, or decoding (Salzen, 1981). In addition, stimuli used have included drawings and sketches of faces in early studies (Allport, 1924; Langfeld, 1918a); photographs of actors (Ruckmick, 1921) or others (Landis, 1924); photographs taken from magazines (Munn, 1940) and film or video segments incorporating sound (Dusenbury & Knower, 1938). These judgement studies have been crucial in providing evidence for dimensions of emotion (Schlosberg, 1954) on the one hand and categories of emotion (Ekman, Friesen & Ellsworth 1972; Izard, 1971) on the other, as discussed in earlier chapters.

The general significance of smiling in the development of human emotions has been studied from a number of different perspectives. A brief overview will be presented encompassing the ontogenesis and function of smiling, the signals producing the smile response, and finally the measurement of smiling.

6.2. Ontogenesis and Function of the Smile

Ethologists have been concerned with the function of the human smile, and hence have tended to concentrate on the infant smile on the one hand, or the facial expressions exhibited by higher primates, on the other (see section 2.2. for a detailed account of the comparative approach of the phylogeny of facial expressions). The ontogenesis of smiling has been recorded in the main by ethologists, who provide detailed descriptive accounts of occurrences and context of the smiling response in children. The ethological approach has been very thorough in its reporting of the ontogenetic influences of the development of the smiling response, using description and noting frequency and onset of activity. These descriptive accounts of the smile focus on the movement of the facial features during an expressive display (Brannigan

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1 An earlier version of this chapter has been published; Katsikitis, M., Pilowsky, I., & Innes, J.M. (1990). The quantification of smiling using a microcomputer-based approach. *Journal of Nonverbal Behavior*, 14, 3-17 (see Appendix D.1.).

& Humphries, 1972). A more comprehensive standardised measurement tool is needed however, to elucidate the phenomenological attributes of the smile.

The ethological approach was essentially formulated by Darwin (1872) who considered the evolutionary origins of all the fundamental emotions and their expressive outcomes. The smiling expression was not discussed in great detail by Darwin, but consumed under the heading of the joy or pleasure emotion in humans. Charlesworth and Kreutzer (1973), after an extensive review of the infant literature regarding emotional behaviour, concluded that crying, smiling and laughter were the three most common expressions displayed by infants.

Wolff (1963) and later Bowlby (1969) pointed out the value of smiling for the bonding of mother and infant. The following is an extract from Wolff's writings about the smile;

> "*What at birth appears to be a simple reflex movement caused by physiological conditions which can only have limited "meaning" for the child, rapidly acquires a whole range of different meanings in the sense that complex and specific stimulus configurations can elicit it; thus it appears to become a "psychologically caused" behaviour. A study of the developing smile therefore provides not only information about an important communication signal that establishes a social bond between the mother and her offspring, but offers clues about the larger problem how a congenitally present expressive movement acquires affective and cognitive meaning for the child*" (1963, p. 115).

Trevarthen (1985) observed the faces of infants as they interacted with their mothers and presented a theory for the existence of an innate co-ordinative system which evaluates mothers' communication patterns, via her face and "baby-talk" vocalisations. This presumably sets into motion the internal interactive events mainly through the facial movements of the infant.

The empirical evidence suggests that smiling is an innate response (Tomkins, 1962). The smile develops from a reflex action or from subtle internal physiological occurrences, to have the most significant life-lasting nonverbal social value, of all the expressions. Darwin (1872) noticed that his child smiled when only forty-five days old, but many researchers agree that the onset of the smiling response varies according to social stimulation and other environmental influences (Spitz & Wolf, 1946; Wolff, 1963). As for the contribution of the imitation of expressive gestures by the infant, the early onset of the smile seems to exclude the effective role of imitation in the early production of the smiling response (Darwin, 1872; Freedman, 1964). Moreover, Eibl-Eibesfeldt (1973) and Freedman (1964) report findings which show a normal smiling response in deaf and blind born infants, hence excluding the imitative influence.

A cognitive view of the ontogenesis of the infant smile was proposed by Zelazo (1972). A "recognition assimilation hypothesis" has been put forward to account for four characteristics of the smile, namely, smile occurrence to both social and non-social stimuli, speed of habituation and recovery. The recognition hypothesis encompasses all four smile attributes and proposes that all stimuli impinging on the infant are assimilated to existing schema. When a match has been successfully achieved, the smiling response ensues. This theory does not replace the ethological emphasis on mother-infant bonding which is dependant upon the smile, but rather, enhances the value and meaning of the smile for the elicitor (Haith, 1972).

Furthering the cognitive point of view, Sroufe and Waters (1976) assimilated the physiological, social correlates and cognitive components of the smiling response. The tension-release hypothesis is so named because it describes the assimilation of novel stimuli to existing schema (Zelazo, 1972), and emphasises the production of tension in incongruous stimulus provoking situations. The resultant smile was seen to depend considerably on the context, as well as the stimulus itself. The dissipation of tension highlights the ontogenetic progression from "endogenous" smiles which require a minimal amount of stimulation and are seen in early infancy to the "elicited" smiles which are the result of cognitively activated tension (Sroufe &

Waters, 1976). A similar notion has been proposed by Tomkins (1962) who states that the smiling response is innate and is activated by a relief of intense ongoing positive and negative stimulation.

The social theory of smiling, on the other hand, (also borne out of the ethological approach), emphasises the function of the smile more so for its social value, i.e. mother-infant interaction (Bowlby, 1969); approval-seeking behaviour (Rosenfeld, 1966); approach behaviour (Vine, 1970, 1973), and to convey the emotion of happiness (Ekman & Friesen, 1975). Kraut and Johnston (1979) examined the motivational state of a group of people engaging in the social sporting activities of bowling and hockey, and observed the facial expressions of a number of pedestrians walking alone or with company, in differing weather conditions. From their results, Kraut and Johnston concluded that "*social involvement is a major cause of smiling, independent of the smiler's emotional state*" and that "*smiling is socially produced and has social consequences*" (p. 1549). In other words, happiness was not a necessary condition for the elicitation of the smiling response, but rather, more importantly, was the influence of the social environment on the individual.

The most contemporary proponent of the sociality of smiling is Alan Fridlund. Although acknowledging the social role an audience has on facial behaviour, Fridlund, Sabini, Hedlund, Schaut, Shenker and Knauer (1990) recently extended the theory and investigated the effect of "*imaginary others*" (p. 116) on facial expression, namely, smiling. A group of subjects were allocated to one of two groups and EMG recordings of the zygomatic major muscle were monitored. The first group were exposed to high sociality imagery, (i.e. story involving a number of imaginary others) and the second group were read stories involving a few imaginary participants. Controlling for reported happiness between conditions (using a self-report emotion scale) , Fridlund and his colleagues found that greater zygomatic activity was evident for the group who were exposed to the high sociality imagery. The authors concluded that the social context and not the subjective feeling of emotion, predicted smiling in their study. In another more recent study (Fridlund, 1991), all subjects viewed an amusing videotape, either (1) alone, (2) alone but with the belief that a friend was in an adjoining room occupied with psychological tests, (3) alone but with the belief that a friend was watching the same video in another room, and (4) with a friend. Subjects in Groups 1 and 2 showed the least amount of zygomatic activity as measured by EMG recordings. Fridlund (1991) argues that the greater zygomatic activity shown by Groups 3 and 4 was due to the implicit imagery created by the subject as to the presence of others or imaginary others.

Finally, the proponents of the facial feedback theory maintain that the function of the smiling expression is to induce physiologically the emotion of happiness (Tomkins, 1962). Similarly, Laird (1974) espousing a self-attribution theory of emotion, found that subjects who were asked to smile and to subsequently frown, reported feeling happier during the smile induction session, than they did whilst they were frowning.

6.3. Elicitors of the Smile

As has already been noted, the early non-elicited smiles are fleeting and usually the result of internal reflex actions (Tomkins, 1962). The main research interest, however, is concerned with the elicited smiles and their triggering stimuli. Tomkins (1962) proposed that the elicited smiling response is evoked by the sudden reduction of intense stimulation, either positive or negative. Gesell, Ilg and Bullis (1949) reported that an infant is able to fixate on objects at four weeks of age, and can also follow moving objects confidently, once visual fixation has occurred. Kaila (1932) and Spitz and Wolf (1946) agree that the human face is a powerful stimulus for the elicitation of the smiling response in the infant. A gestalt configuration of the features of the face produces a smile at five weeks of age, but soon after the fifth month, the discerning infant reserves the smile for familiar faces.

Ambrose (1961) found that attaching movement to a stimulus also evokes the smile in the infant under fourteen weeks of age. Similarly, Spitz and Wolf (1946) found that a nodding head elicited more smiling from infants than one which was stationary.

Ahrens (1954) discovered that stimuli which evoke the smile vary as the infant increases in age. Using two dots, horizontally aligned, a smile was produced in infants up to eight weeks old, but after this, an object resembling the human eye more closely was more effective. Only by the twelfth week, according to Ahrens, is the smile evoked by the mouth and its movement. A smiling stimulus, however, does not result in a smiling response from the infant until five months of age. Of all the mouth movements, mouth width was the most effective in evoking a smile in infants who were between three and seven months old.

Although the human face is the most frequent and potent elicitor of the smiling respone in infants (Tomkins, 1962), there is evidence to suggest that non-visual stimuli also play a role in the production of an early smile. Indeed, Wolff (1963) reported that a smile in response to auditory stimuli appears earlier ontogenetically than a smile in response to a visual stimulus. Of the non-visual stimuli, rattles, bells and whistles have been found to produce a smile, but the human voice, especially a high-pitched voice, has been found to be the most effective auditory stimulus for smile production (Spitz & Wolf, 1946). Not surprisingly, blind children have been noted to respond with a smile to familiar voices, at an early age (Gesell, Ilg & Bullis, 1949).

6.4. Measurement of Smiling

The measurement of emotion has already been extensively covered in Chapter 4. This chapter will introduce the quantification of smiling using the microcomputer-based technique described in Chapter 5, in an attempt to make a contribution empirically, to the measurement of smiling.

In capturing the attributes of the smile in particular, researchers have worked on disentangling such phenomena as the dynamics of smiling, the physical appearance of the smile, and the asymmetrical properties of the smile to name just a few.

The study of the dynamics of the smile has been a popular avenue of exploration for many investigators. Ambrose (1961) examined the duration of smiling and smiling latency in a group of institutionalised infants and those reared by their mothers at home. The strength of the smiling response varied from a peak in the first few weeks after birth, to a gradual decline over time. The home reared infants exhibited a smile up to three weeks earlier than the institutionalised infants. Similarly, the smiling response peak was reached earlier by the former group of infants. The decline in response strength with age has been attributed to the expanding cognitive capacities of the infants and their ability to discriminate between the varying environmental stimuli.

Shor (1978) examined the position of the facial features during various intensities of the smile. Pieces of adhesive tape were placed around the mouth and cheek areas of the subject's face, in order to extract physical measurements from photographic representations of the smiling expression. Smile magnitude was determined by measuring the distances between the targeted taped features. Shor found that during the smile, the mouth opens, widens and the outer corners are raised forcing the cheeks to rise. Furthermore, the encoders were found to accurately judge their own smile magnitudes. Shor demonstrated the quantifiable nature of the smile, albeit intrusively, using information obtained by overt facial movement. The model devised by Pilowsky, Thornton and Stokes (1985) automates the calculation of distance measures by using a non-intrusive microcomputer-based technique, as detailed in Chapter 5.

The most comprehensive measurement system designed to quantify facial activity has been prepared by Ekman and Friesen (1978). The Facial Action Coding System (FACS) is capable of differentiating smiles by the subtle facial actions produced. (Ekman, Friesen & O'Sullivan, 1988; Steiner, 1986). It has been validated in several studies, which independently pinpoint Action Unit 12, i.e. the facial action produced by the zygomatic major muscle, as the smile muscle (Ekman, Friesen & Ancoli, 1980). However, Ekman and his colleagues have shown that the smile response is not only prominent during a positive emotive display, but may occur at other times, for example, during the emotions of fear, disgust or in deception.

In distinguishing between felt and false smiles, Ekman (1989) has suggested that the term the "Duchenne smile" be reserved for the form of smiling which is involuntary, spontaneous and a truly felt emotion of joy. It is differentiated from other forms of smiling as it involves both the muscle which lifts the outer corner of the mouth toward the outer canthus of the eye and the muscle which surrounds the eye. It is described in the following way;

> "*the emotion of frank joy is expressed on the face by the combined contraction of m. zygomaticus major and the inferior part of m. obicularis oculi*" (Duchenne, 1990, p. 126.).

If smiles can be distinguished in this way, then according to Ekman, Friesen and O'Sullivan (1988), it may explain the contradictory evidence regarding, for example, cultural differences in smiling (Birdwhistell, 1963; LaBarre, 1947) or masked smiles when deceiving (Ekman, Friesen & O'Sullivan, 1988) or in the case of learned display rules (Ekman & Friesen, 1969).

Other studies which have recently been concerned with the measurement of smiling utilise facial electromyographic techniques and emanate from the laboratory of Schwartz and his colleagues (Schwartz, Fair, Salt, Mandel & Klerman (1976a, 1976b). A detailed account of the use of facial electromyography in the measurement of facial movement can be found in the previous chapter on the discussion of the various component approaches to the analysis of facial expressive information.

Finally, measurement of the degree of the asymmetry of the smile has concerned attempts to relate the side of facial smile dominance to handedness, personality (Lynn & Lynn, 1938; 1943) and hemispheric specialisation (Graves, Goodglass & Landis, 1982), as discussed in Chapter 3. Further studies carried out by Chaurasia and Goswami (1975) for example, have examined the activity of those facial features which were considered symmetrical. These authors concluded that in both left and right handed individuals, facial asymmetry is the "norm". Facial dominance was measured by the frequency and speed of smiling activity on the two sides. Furthermore, Ekman, Hager and Friesen (1981) found that smile asymmetry favouring the left side of the face was more pronounced when the smile was posed, suggesting important implications for the recognition of false smiles as well as for the measurement of posed versus spontaneous smiles.

The present study attempts to extend the measurement of the judgement of facial expression, with the quantification of facial action by measuring distances between certain key facial "landmarks", based on a mathematical model of the face (Thornton & Pilowsky, 1982) and a measuring system using a microcomputer (Pilowsky, Thornton & Stokes, 1985, 1986). The computerised method of measuring facial expression has already been discussed in great detail in the previous chapter so it will suffice here to only briefly reiterate the capability of this technique. The model is able to represent the action of facial muscles with mathematical muscloids. These connect points on the model, so that the length of a muscloid functions as a measure of distance, and this property of the model has been used in the present study. Twelve facial muscloids are generated, representing distances between key facial features. It should be emphasised that the muscloids do not represent individual muscles, but rather their actions. Thus a group of muscles may be represented by only one of the model's muscloids. A line drawing representation of the face is generated which can be used as a stimulus in expression judgement studies.

The focus on the quantification of the smile in this study stems firstly from previous work which has shown that the smile is the most easily recognised of all the fundamental expressions (Drag & Shaw, 1967; Ekman, 1978; Thompson & Meltzer, 1964; Wagner, Macdonald & Manstead, 1986) even in a deteriorated state of reproduction (Wallbott, 1991). Secondly, in a laboratory setting, the smile is the easiest to evoke and from an ethical point of view, the most readily justified. Finally, the mathematical model of the face was originally validated using the smile expression (Thornton & Pilowsky, 1982). Thus, the microcomputer-based approach will be utilised in this study in an investigation of relationships between the smiling expression and the computer generated facial measures.

6.5. Study 1

The present study has two aims. First, to compare judgements of expressions from computer-created line drawings with those made in response to the corresponding real faces, with a view to further validating the computer model.

Second, to delineate the relationship of the individual computer-generated face measures to the ratings of smiling made by a group of decoders.

6.5.1. Method

Four encoders, two males and two females, were asked to view a series of amusing and neutral slides while their expressions were video-recorded. Two independent judges with no previous training in the recognition of facial expressions (i.e. no instructions were given as to criteria for the selection of smile and neutral expressions) chose the most animated smile and one neutral expression per encoder to act as the stimuli in this experiment. Each expression was divided into five stages, using the freeze-frame facility of the video-recorder, so as to achieve a variation of expression development with encoder held constant. This process offered a broader sampling of expressions, and also allowed for the detection of the ability of a sample of decoders to perceive the natural growth of an expression (the latter use of the five stages was not pursued further in this study). This involved counting the video frames from the beginning to the end of an expression and dividing that number of frames by five. The videotape was then rewound to the beginning of the expression and a hard copy of the expression at five regular intervals, designated by the frame counter, was made using a Mitsubishi video-printer. The ten expressions, i.e. five smiles and five neutrals per encoder were digitised, using an Apple 2E graphics tablet and a digitising pen. The line drawings representing these expressions were used in Study 2. Eighty slides were shown to the judges; forty slides of the photographs of the faces, (i.e. four encoders x two expressions x five stages of smile development) and forty line drawings corresponding to the real face slides.

6.5.1.1. Subjects

Four hundred and two first year students enrolled in Psychology participated as judges in this study as part of the requirements of the first term Social Psychology course.

6.5.1.2. Procedure

Thirty-one group sessions were conducted over a two week period. As students entered the laboratory they were randomly allocated to one of seven cubicles, each cubicle seating two people. The cubicles faced a screen and were separated from each other by partitions. Each participant was given a response sheet with eighty rating scales corresponding to the eighty slides. The nine-point rating scales ranged from "definitely not a smile" at the lower end to "definitely a smile" at the other extreme. The experimenter then read out a standard set of instructions as follows,

"This is an experiment on the judgment of facial expression. You will be shown eighty slides of faces, some of which will be smiling and some of which will not be smiling. The faces presented here will be in one of two modes; the real face of a person either smiling or not smiling or a computerised line drawing representation of a real face smiling or not smiling. You have been given a response sheet with eighty rating scales corresponding to the eighty slides. Your task will be to rate on a 9-point scale, the degree to which you think the slide represents a smile from "definitely a smile" to "definitely not a smile". Place a check mark on the scale which you think best represents that slide. Each slide will have a number on the top right hand corner, so will you please ensure before responding, that the number on the rating scale corresponds to the number of the slide. The eighty slides are the faces of four people. For each person there will be twenty slides, ten line drawings and ten real face slides. The first twenty will be of person A, the second twenty of person B etc. You will be informed when we move on to a new person's series of twenty slides. Any questions?"

It was decided that the entire series of eighty slides should not be put in random order as this would be likely to increase random error in the judges' reactions. Instead, the slides pertaining to each separate encoder were blocked together, in random order. The four blocks of slides, one for each encoder, were then randomised. This design does not allow for the identification of any order effects of encoders. In view of the size of the design, however, and the number of separate interaction effects which exist, it was decided that randomisation would provide a sufficient control for present purposes. The slide projector was fitted with an automatic timer programmed to release a slide every ten seconds. When all slides had been scored, the response sheets were collected from the students (see Appendix A.1.

which shows the random ordering of the stimuli and Appendix A.2., which presents the stimuli as shown to subjects).

6.5.2. Results

Of the 402 Psychology I students who participated in this study, forty-eight were excluded due to incomplete data on the response sheets. The remaining total of 354 comprised 139 males and 215 females with a mean age of 19.5 years (s.d=5.1). In view of the large numbers of degrees of freedom in the analysis reported, with the consequent inflation in the number of statistically significant effects which may emerge which are associated with small effect sizes, only effects which are significant at the one per cent level or less will be presented. A repeated measures analysis of variance with Expression (smile vs neutral) and Mode of Presentation (line drawing vs photograph), Stage of Development of Expression, and Encoder as independent variables was carried out. A discussion of the significant Encoder effects and Stage of Development effects is beyond the scope of this study. However a preliminary report of the Encoder effects has been presented elsewhere (Innes, Pilowsky & Katsikitis, 1988)[2]. The mean ratings (and standard deviations) for degree of smiling on the four Encoders' faces presented in two modes for the entire group can be seen in Appendix A.3.

The MANOVA (complete details of this analysis are presented in Appendix A.4.) revealed a significant main effect of Expression indicating that subjects reliably judged expressions of smiles differently from neutral ones ($F(1,353)=5325.25$, $p<0.001$). The means (and standard deviations) for the line drawings were 7.49 (1.08) for the smile expressions and 3.56 (1.03) for the neutral expressions, while for the photographs, the means (and standard deviations) were 7.58 (1.27) and 3.44 (1.09) for smile and neutral expressions respectively. It is clear from inspection of these means that substantive differences in ratings of smile and neutral expressions were obtained. There was no significant main effect of Mode of

2 The stage of development effects were not pursued further in this study. Instead, the stages of each expression were used as further examples of that expression for the purposes of increasing the number of smiles and neutral expressions available to be presented to the judges. In other words, the five stages of a smile and neutral expression obtained from each encoder were treated as five different smiles and five different neutral expressions produced by the encoder.

Presentation, which indicates that the respondents were reacting in a like manner to the line and photographic representations of the expressions. There was however a significant interaction effect for Mode x Expression ($F(1,353)=36.32$, $p<0.001$) with a smaller difference between the ratings of the smile and the neutral expressions in the line drawings (MS-MN=3.93) than between the smile and neutral expressions in the photographs (MS-MN=4.14). It seems that respondents used fewer of the extremes of the rating scales for the line drawings than they did for the faces. Thus, real faces may allow more confident judgements than do the computer representations.

The role of the twelve individual facial measures in relation to judgments of expression was examined by two-way analyses of covariance (i.e. Expression (smile, neutral) x Encoder (4 encoders)) performed on the mean rating judgment. This rating was calculated by averaging the responses over subjects obtained for each of the forty line drawing slides and the forty real face slides separately. This yielded five scores within each cell of the analysis. Initially the twelve computer generated facial measures were entered as covariates individually for the line drawing slides and the real face slides separately[3].

6.5.2.1. Individual Covariance Analysis

Six measures had a significant covariate effect: End-Lip Measure , Mouth-Width Measure, Mouth-Opening Measure, Mid-Top-Lip Measure, Lower-Lip Thickness Measure and Eye-Opening Measure. The same measures had significant covariate effects on the mean ratings given to the real face slides. The analysis thus indicates that a subset of the measures derived from the model predicts the rating made of the expression.

3 In the analysis of covariance the information provided by the significance of the adjusted sums of squares, after the covariate effect has been removed, is equivalent to the information given when testing the significance of regression coefficients. The analysis of covariance using multiple covariates provides separate assessments of the role of each parameter in the model and in combination in predicting the rating judgement of an expression. Analysis of covariance was selected as the means of analysis instead of regression analysis because the use of the latter was based upon only the means of the subjects' ratings of the separate expressions for each encoder. Therefore, the regression analysis was based upon a very much smaller number of degrees of freedom than was possible with the covariance analysis.

Table 6.1. displays the significant covariate effects of the face measures for smiles and neutral expressions both for line drawing and real face data. The significant covariate measures are examined in turn.

6.5.2.2. Mouth Measures[4]

In the case of End-Lip Measure, i.e. the distance between the outer corner of the mouth to the outer canthus of the eye, in response both to the line drawing and real face slides, there is a trend to rate a line drawing as a smile if the End-Lip Measure measure is below 40, on a scale ranging from 0 to 100. As the mean rating score in favour of a smile increases the End-Lip Measure measure decreases, i.e. as the corner of the mouth is drawn closer to the outer canthus of the eye. The situation is reversed in the case of the Mouth-Width Measure, i.e. the distance between the left and right corners of the mouth. Here, the greater the Mouth-Width, the greater the likelihood of a mean rating score of five and above. Mid-Top-Lip Measure, a measure which involves the raising of the upper lip, also had a significant covariate effect. For three of the four encoders, the mean rating score decreased when the Mid-Top-Lip Measure score increased. A further mouth measure to reach significance was Lower-Lip Thickness Measure, i.e. the distance between the midpoint of the upper border of the lower lip to the midpoint of the lower border of the lower lip. Again, with the exception of one of the encoders, mean rating score decreased as Lower-Lip Thickness Measure increased. The final mouth measure to show a significant covariate effect was Mouth-Opening Measure, i.e. the distance between the centre of the upper border of the bottom lip and the centre of the bottom border of the top lip, but in this case the interpretation is more complex. A closed or near closed mouth of an encoder was usually viewed by this group of decoders as a non-smiling expression, but with a Mouth-Opening score in the range of 0 to 76, it seems that the degree to which the mouth is open is not the only criteria for deciding on the expression. Two of the four

4 Beginning from Appendix A.9., all standardised values for each facial measure in turn are presented separately for each Encoder, Expression, and Stage of Development.

Table 6.1. Significant Covariate Effects of Face Measures on the Mean Ratings given to the Line Drawing and Real Face Slides.

Face Measures	F*	p
Line Drawing		
End-Lip Measure	30.03	<0.001
Mouth-Width-Measure	22.62	<0.001
Mouth-Opening Measure	15.31	<0.001
Mid-Top-Lip Measure	16.03	<0.001
Lower-Lip Thickness Measure	10.66	0.003
Eye-Opening Measure	11.46	0.002
Real Face		
End-Lip Measure	54.46	<0.001
Mouth-Width Measure	57.35	<0.001
Mouth-Opening Measure	15.76	<0.001
Mid-Top-Lip Measure	25.44	<0.001
Lower-Lip Thickness Measure	12.35	0.001
Eye-Opening Measure	10.05	0.003

*Note: df=1,31 for all the F tests.

encoders in this study did smile at times without opening their mouths a great deal, and were given a mean rating score for smiling of five and above.

6.5.2.3. <u>Eye Measures</u>

The significant covariate effect of Eye-Opening in the recognition of a smile indicates that the eye appears to be more open during a neutral expression and tends to narrow during a smile (Eye-Opening Measure represents the distance between the lower margin of the upper lid and the upper margin of the lower lid).

6.5.2.4. <u>Multiple Covariance Measures</u>

These six independantly significant face measures were used in a further two-way covariate analysis, and entered as simultaneous covariates for the line drawing and real face slides separately. The findings revealed significant covariate effects for End-Lip Measure, Mouth-Width Measure, Mouth-Opening Measure and

Lower-Lip-Thickness Measure for both modes of presentation. The main effect of Encoder remained significant after entry of the covariates for both the line drawing faces ($F(3,26)=4.23$, $p<0.02$) and for the real faces ($F(3,26)=16.1$, $p<0.001$). However, the main effect of Expression for the line drawings ($F(1,26)=2.98$, $p>0.05$) and for the real faces ($F(1,26)=3.65$, $p>0.05$), and the interaction between Encoder and Expression for the line drawings ($F(3,26)=2.25$, $p>0.05$) and for the real faces ($F(3,26)=2.73$, $p>0.05$) were not significant. This indicated that these mouth measures acting together accounted for the difference found in the mean ratings of the judges with regard to smile and neutral expressions. Judges remained sensitive to the differences in encoders' expressions, but within encoders, the subset of model parameters predicted detection of smiling.

6.6. Discussion

The main aim of this study was to ascertain whether line drawings of faces produced the same responses in decoders as the photographs from which they were derived, and to establish the relationship of the twelve computer generated facial measure scores to the ratings obtained for the smile and neutral expressions. These findings indicate that the judges were able to recognise these expressions from the limited information presented by a line drawing of the face, and the patterns of data for these drawings were similar to those for judgements of the equivalent real faces. These data may also support Wallbott's (1991) finding that expressions with deteriorated reproduction can also be decoded successfully. However, the raters scored the real face slides more decisively using the extremes of the rating scale. Furthermore, certain parameters generated from the model were significantly more important than others in predicting the mean rating score.

The results of the present study demonstrated that a computer model of facial expression can generate measures of expression which are correlated with the ability of human judges to discriminate expressions. The discrimination of expressions from photographs is predicted by the same variables that predicted discrimination in line drawings. Thus, the human observer, in judging the quality of an expression, and its development, is differentially sensitive to a subset of features of the face which can be decoded from minimal information.

The evidence presented in the literature on the contribution of the eye and mouth regions to the judgement of facial expression is varied and contradictory. These results support the findings of Bassili (1979) who reported that the emotion of happiness was more successfully judged from the lower half of the face, and those of Boucher and Ekman (1975) who found that both the mouth and the eye regions were important in the judgement of happiness. These findings point to the mouth as the predominant cue for the judgement of smiling. They are also consonant with the suggestion that smiling has its origin in the bared-teeth display of primates which shows the mouth characteristics of lip corners pulled back and up, with the mouth either open or closed (Lockard, Fahrenbruch, Smith & Morgan, 1977; van Hooff, 1972). These features of the mouth resemble the End-Lip Measure, Mouth-Width and Mouth-Opening Measure generated in this study.

The computer model differs from such facial measurement systems as FACS and facial electromyography in that facial action is quantified in terms of distances between facial landmarks rather than actual muscle action, which is characteristic of the latter techniques. Nevertheless, our findings accord well with those of Ekman and Friesen (1975) who found that movements in the lower half of the face, especially those involving mouth activity, were most salient during the emotion of happiness. Similarly, with regard to electromyography, there is evidence (Brown and Schwartz, 1980) which points to the action of the zygomaticus muscle (represented by the actions of our End-Lip Measure, Mouth-Opening and Mouth-Width Measures) in the expression of a smile. These concordant observations contribute to the concurrent validity of the facial measures. The use of the computer approach to the quantification of facial expression has several advantages. Firstly, it is non-intrusive, in that no sensors are physically attached to the encoder's face. Furthermore, minimal training time is required in the digitisation of a face. In addition, the use of distances between facial points leads to a reduction in the number of facial movements which are analysed, hence saving time. Finally, the line drawings allow the encoder to remain anonymous in terms of identity, age, sex, race and social class. This has advantages in the experimental context and when findings are reported.

The findings of this study are similar to the earlier results of Pilowsky, Thornton and Stokes (1986) who found consistent correlations between the computer measures and smiling behaviour. In that study, the investigators obtained computer scores on ten smile and ten neutral expressions. The graphs presented in their paper show that the clear-cut differences between the smiling and neutral expressions were found in: End-Lip Measure, Mouth-Width Measure, Mouth-Opening Measure, Mid-Top-Lip Measure, Eye-Opening Measure, and Lower-Eyelid/Iris Intersect Measure. These are essentially the same as the measures found to discriminate in the present study, except for the addition of the Lower-Eyelid/Iris Intersect Measure. This last measure indicates closing of the eye during a smile due to raising of the lower lid.

Clearly, a great deal of further research using the model for facial representation remains to be done, but the results achieved in this study are promising for future work. Indeed use of the model has already been extended into the clinical arena where Katsikitis and Pilowsky (1988) have quantified the smiling expressions in patients with Parkinson's Disease.

Recent studies by Brennan and co-workers (Brennan, 1985; Rhodes, Brennan & Carey, 1987) have demonstrated the utility of a computer model for generating faces in exploring the process whereby familiar faces are recognised. Subjects were shown stimuli which were line drawings produced from digitised photographs and two sets based on the computer model. One set was of caricatures of the faces, representing exaggerated differences between the line drawings of the face and a predetermined "norm" face of the same sex, the other an anticaricature, where the differences between the line drawing and the "norm" were minimised. No differences were found between the different representations in accuracy of recognition of the faces, but caricatures were more quickly identified than the line drawings which, in turn, were more readily recognised than the anticaricatures. Rhodes, Brennan and Carey (1987) were concerned with the identification of a mental holistic representation of classes of stimuli, including faces. The aim of the present model, however, is to identify the representations of components of expressions of the face and their role in enabling discriminable response to the expression, where the person may be unknown to the observer.

Further research is needed to explore other fundamental expressions such as anger, surprise and others. Additional research should also establish whether the information supplied by the model is sufficient for accurate judgments and discriminations to be made. Also, the speed of response to varying expressions needs to be assessed. The sensitivity of the observer to the expressions of familiar others versus strangers may be an especially interesting avenue to explore. The development of acquaintance may allow, and may indeed be partially based upon the ability to judge expressions earlier in the development. It is possible that the perceiver relies on a smaller or different subset of facial components to make a judgement if the person is familiar. Further, the model may allow not only the identification of decoder characteristics correlated with discriminating responses to particular components of a facial expression, but also the measurement of encoder characteristics in the ability to express a range of emotions (Innes, Pilowsky & Katsikitis, 1988). It should be noted that the methodology also makes possible the study of the dynamics of onset and offset of expressions by digitising multiple frames during the course of an expression (Pilowsky, Thornton & Stokes, 1986). Such multiple views may also be used to elucidate thresholds for decoding expressions in clinical and non-clinical populations.

6.7. Summary of Study 1

The first experiment had two aims. Firstly, it was designed to assess the judgement accuracy of a group of observers who were exposed to various photographs of facial expressions and to the corresponding computer generated line drawing representations of these photographs and asked to rate the degree of smiling activity present. Secondly, it investigated the discriminant validity of the facial measures, in particular, the configuration of measures, in the delineation of smile and neutral expressions.

6.8. Study 2

A second experiment was designed to some extent as a replication of the first. However, there were three important variations. Firstly, excluding real face photographs, an increased number of line drawing representations of facial expressions were presented to the judges. Secondly, rater differences during the different stages of expression development were measured, and finally, gender differences in the decoding of expressions were examined. In accordance with Study 1, the validity of the computer model for the quantification of facial expression was measured by firstly analysing the ratings made by the observers for the smile and neutral expressions, and secondly, by assessing the salience of the computer measures in distinguishing between smile and neutral displays.

6.8.1. Method

6.8.1.1. Overview of Study 2

The findings of Study 1 showed that Mode of Presentation (i.e. real face slides versus line drawings) did not make a significant contribution to the observer ratings of the degree of smiling shown by the slides, hence only line drawing representations of smiling and neutral expressions were presented in this study.

The procedure used to obtain facial stimuli slides in Study 1 was also applied here. That is, two independant judges chose two animated smiles and two neutral expressions (only one smile and one neutral expression was used in the previous study) per Encoder (same Encoders as in Study 1) to act as the stimuli to be rated. Again the duration of each expression was recorded using the counter on the video-recorder and the number of frames from the beginning to the end of the expression was "divided" into five stages, using the freeze-frame facility. This procedure was followed for two separate smiles and two neutral expressions per encoder, so as to achieve a variation in expression as well as to increase the number of different expressions available for rating. A hard copy of each expression was made resulting in twenty expressions per encoder (i.e. two smiles x five stages and two neutrals x five stages). Each expression was digitised and the corresponding line drawing was generated. A total of eighty slides of line drawing representations of facial expressions were shown to the judges (i.e. four encoders x two smiles x two neutrals x five stages).

6.8.1.2. Subjects

As part of their first year practical assignment in Psychology, all first year students (N=381) were required to participate in this project.

6.8.1.3. Procedure

Twenty-four groups with a maximum number of twenty people per group participated in the experiment over a two week period. The conditions in the laboratory were similar to the previous experiment with cubicles seating two people and partitions separating the cubicles. In this study, students were randomly allocated to one of ten cubicles and given a response sheet with eighty rating scales corresponding to the eighty slides. The nine-point rating scale ranged from "definitely not a smile" at the lower end to "definitely a smile" at the other extreme. The instructions were essentially the same as in the previous experiment, with the main difference being that eighty slides of line drawings only were presented to the raters in this study. The slide projector was fitted with an automatic timer programmed to release a slide every ten seconds. When all the slides had been presented, the response sheets were collected from the students (see Appendix A.5. showing the random ordering of the stimuli, and Appendix A.6. which displays the stimuli as they were shown to the subjects).

6.8.2. Results

Of the 381 subjects who participated in this study, forty-six were excluded due to incomplete data on the response sheets. Furthermore, the data from those subjects who were seated in cubicles to the far right and to the far left of the screen were eliminated from the analysis (N=127), as these students may have seen the line drawing slides from a markedly different angle due to the awkward positioning of the seating in those cubicles. A sample of 208 remained comprising of 139 males and 69 females with a mean age of 19.9 years (sd=5.2).

Figure 6.1. Mean Ratings Across the Five Stages of Development for Smile and Neutral Expressions for each Encoder

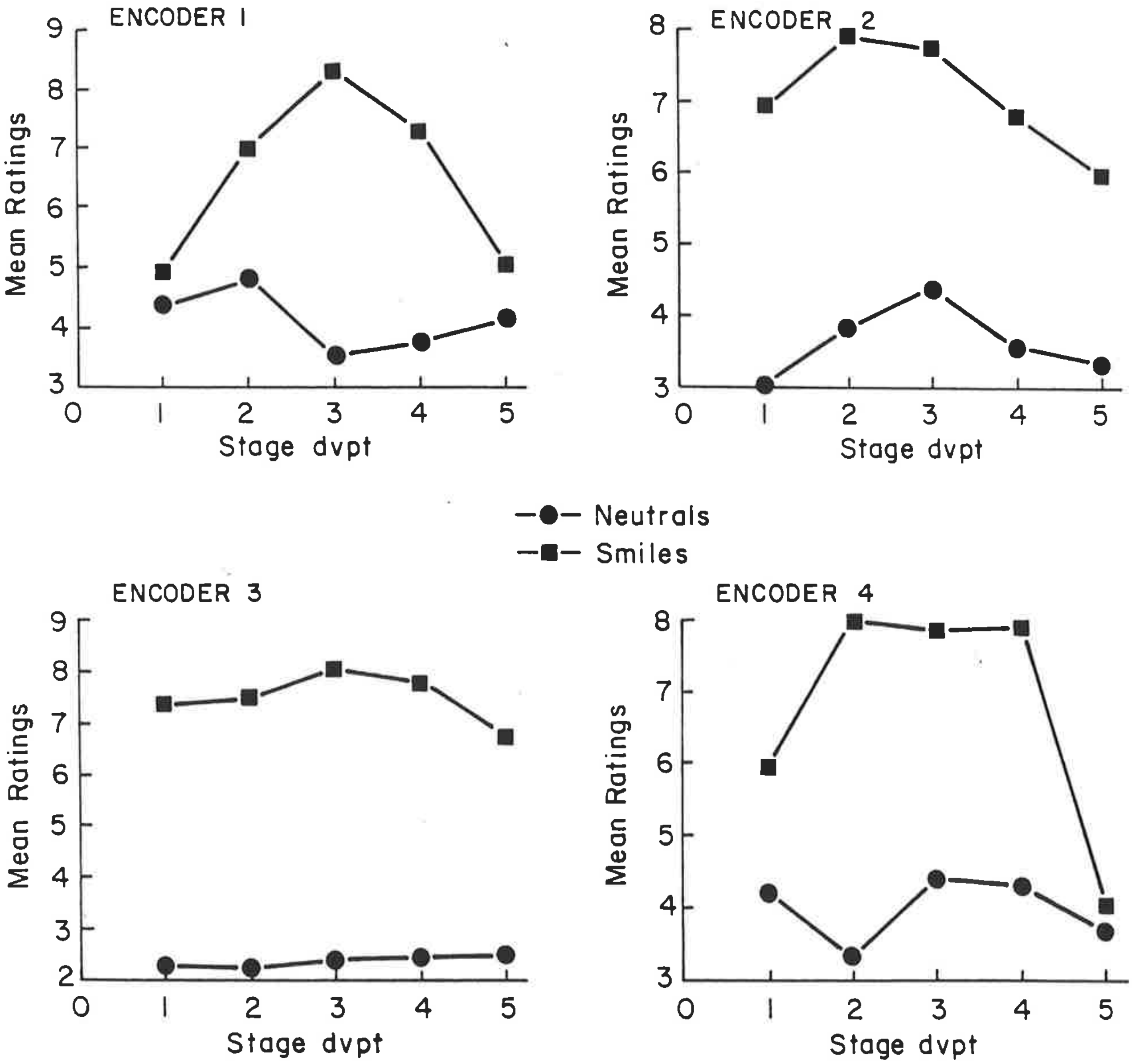
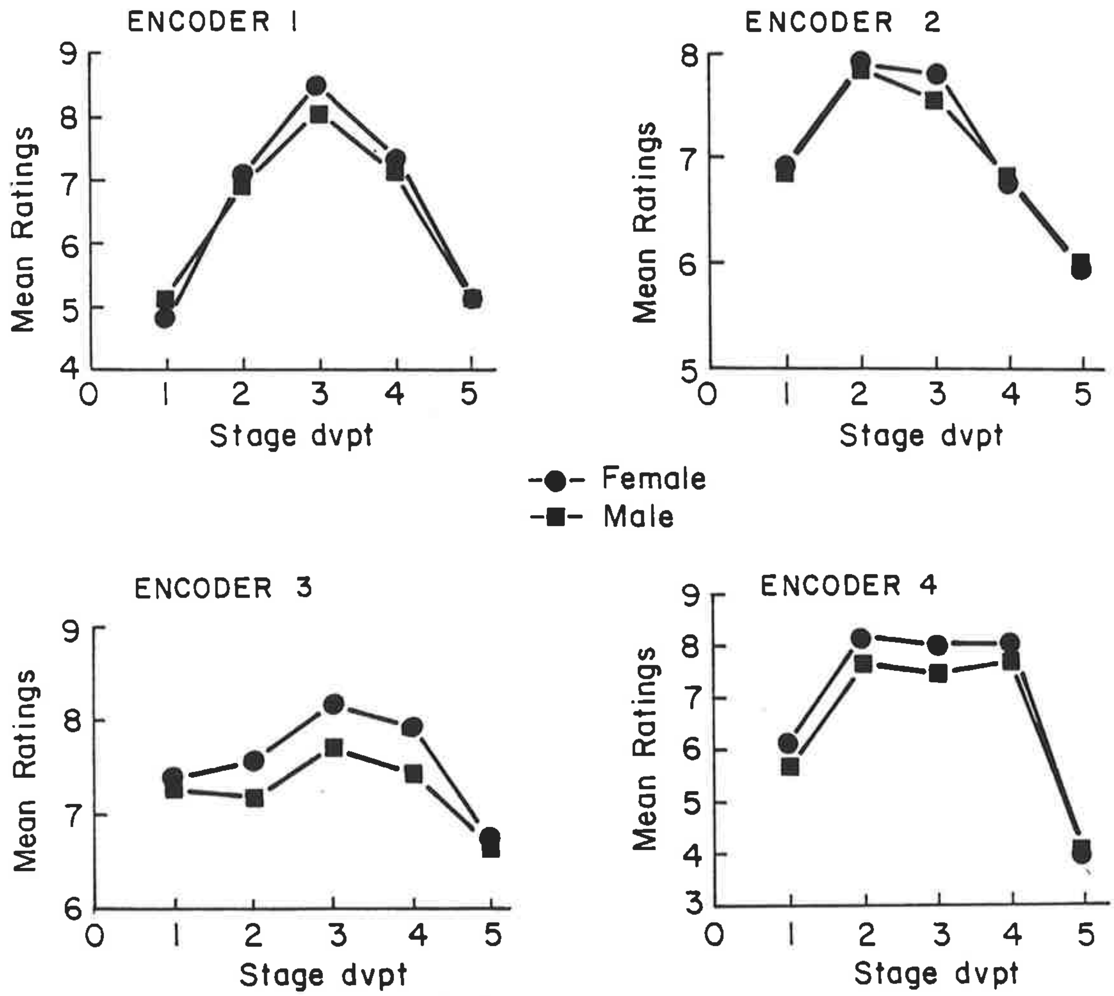


Figure 6.2. Gender Differences Between Raters During the Smile Expression for each Encoder



6.8.2.1. Expression Development

Trend analyses were performed to investigate the pattern of the raters' responses across the five stages of expression development. A significant linear ($F(1,207)=244.62$, $p<0.001$) and a significant quadratic ($F(1,207)=916.89$, $p<0.001$) effect emerged. Figure 6.1. shows the ascending and descending trend as the smile reaches its peak and then dissipates respectively for each encoder separately, resulting in an overall "hump" effect across the five stages of development. Figure 6,2. displays the gender differences for smile ratings per encoder for each stage of development, accentuating the curvilinear relationship between mean ratings and stage of development of expression. There was also a significant Encoder by linear trend effect ($F(3,621)=79.32$, $p<0.001$) and Encoder by quadratic trend effect ($F(3,621)=110.75$, $p<0.001$) suggesting that the pattern of responses to the smile and neutral expressions made by the judges differed for the separate encoders.

6.8.2.2. Encoder Differences

A repeated measures analysis of variance with Encoder, Expression, and Stage of Development of Expression as independant variables was carried out. The five stages for each of the two smiling and the two neutral expressions were averaged resulting in five stages of only one smiling and one neutral expression per encoder. Table 6.2. presents the means (and standard deviations) for the judges' ratings per encoder for the averaged smile and the averaged neutral expressions at each stage of development (see Appendix A.7. which shows the mean ratings and standard deviations before the averages were calculated).

The MANOVA revealed a significant main effect of Encoder ($F(3, 621)=22.36$, $p<0.001$) suggesting that the judges' ratings as to the degree of smiling varied across encoders. A significant main effect of Expression, ($F(1, 207)=2595.0$, $p<0.001$) indicated that the subjects reliably judged the smiles differently from the neutral expressions. The main effect of Stage of Development was also significant ($F(4, 828)=631.6$, $p<0.001$) showing that the raters perceived differences in the expressions across the various stages of development.

Table 6.2. Averaged Smile and Neutral Mean Ratings (and standard deviations) in Study 2 (N=208)

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	4.92 (1.39)	6.90 (1.22)	7.34 (1.31)	5.95 (1.30)
Stage 2	7.00 (1.19)	7.89 (1.15)	7.46 (1.73)	7.96 (1.22)
Stage 3	8.33 (1.02)	7.72 (1.03)	8.03 (1.49)	7.83 (1.13)
Stage 4	7.28 (1.05)	6.78 (1.20)	7.77 (1.56)	7.89 (1.10)
Stage 5	5.09 (1.19)	5.96 (1.29)	6.70 (1.40)	4.02 (1.33)
NEUTRAL				
Stage 1	4.35 (1.29)	3.03 (1.38)	2.25 (1.04)	4.23 (1.43)
Stage 2	4.80 (1.26)	3.80 (1.49)	2.21 (0.93)	3.36 (1.40)
Stage 3	3.53 (1.42)	4.37 (1.36)	2.39 (1.40)	4.40 (1.26)
Stage 4	3.77 (1.47)	3.58 (1.54)	2.46 (1.18)	4.31 (1.29)
Stage 5	4.14 (1.41)	3.31 (1.45)	2.50 (1.05)	3.69 (1.44)

*NOTE: All stimuli are line drawings in Study 2

Table 6.3. Averaged Smile and Neutral Expressions (with standard deviations) across Stages for each Encoder separately to show Encoder by Expression Interaction

Encoders	Smile	Neutral
Encoder 1	6.53 (0.84)	4.12 (1.13)
Encoder 2	7.05 (0.97)	3.62 (1.26)
Encoder 3	7.46 (1.25)	2.36 (0.83)
Encoder 4	6.73 (0.85)	4.00 (1.14)

6.8.2.3. Encoder by Expression Interaction

All first order interactions were significant. The interaction between Encoder and Expression, ($F(3, 621)=343.4$, $p<0.001$) indicated that the judges responded more confidently by using the extreme of the scales for the expressions displayed by Encoders 2 and 3 as opposed to Encoders 1 and 4 who showed less of a difference between the expressions. By averaging the responses across the stages of development, Table 6.3. shows the Encoder by Expression interaction more clearly, with more confidence shown in rating Encoders' 2 and 3 for smile (i.e. higher score on the rating scale) and neutral expressions (i.e. lower score on the rating scale). The significant interaction between Encoder and Stage of Development ($F(12, 2484)=80.92$, $p<0.001$) revealed that Encoders 2 and 3 showed a consistent pattern of variation across the development of the expression whereas Encoders 1 and 4 showed peaks only in the middle of the expression. The significant Expression and Stage of Development interaction ($F(4, 828)=490.1$, $p<0.001$), revealed that the raters perceived differences in the development of the smile more so than in the developmental stages of the neutral expression. Finally, there was a significant second order interaction between Encoder, Expression and Stage of Development ($F(12, 2484)=139.8$, $p<0.001$) reinforcing the finding that judges perceive differences in the encoding abilities of individuals and differences in the different stages of the expression as it develops and diminishes.

6.8.2.4. Decoder Gender Differences

The MANOVA procedure (see Appendix A.8. for complete details) was repeated with the inclusion of Sex of Decoder as a between subjects factor in the analysis. Tables 6.4. and 6.5. show the means (and standard deviations) for the ratings given by the male and female judges respectively across encoders for smile and neutral expressions at the different stages of development. The main effect of Sex of Decoder was not significant. There was a significant interaction between Sex of Decoder and Expression ($F(1, 206)=12.43$, $p=0.001$) and Sex of Decoder and Stage of Development ($F(4, 824)=4.26$, $p=0.002$). Females appeared more confident in their ratings at all stages of development of the smile and neutral expressions than

Table 6.4. Averaged Smile and Neutral Mean Ratings (and standard deviations) in Study 2 for Males (N=69)

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	5.10 (1.36)	6.88 (1.19)	7.27 (1.30)	5.67 (1.42)
Stage 2	6.89 (1.22)	7.84 (1.31)	7.20 (1.77)	7.59 (1.53)
Stage 3	8.03 (1.38)	7.56 (1.13)	7.71 (1.76)	7.44 (1.45)
Stage 4	7.14 (1.10)	6.83 (1.18)	7.44 (1.69)	7.66 (1.38)
Stage 5	5.09 (1.12)	5.99 (1.22)	6.65 (1.45)	4.08 (1.19)
NEUTRAL				
Stage 1	4.56 (1.37)	3.33 (1.52)	2.33 (1.09)	4.26 (1.48)
Stage 2	4.91 (1.28)	4.01 (1.43)	2.28 (1.11)	3.45 (1.36)
Stage 3	3.80 (1.52)	4.64 (1.29)	2.53 (1.56)	4.48 (1.24)
Stage 4	4.26 (1.49)	3.89 (1.42)	2.80 (1.47)	4.37 (1.18)
Stage 5	4.45 (1.45)	3.60 (1.49)	2.54 (1.04)	3.75 (1.43)

Table 6.5. Averaged Smile and Neutral Mean Ratings (and standard deviations) in Study 2 for Females (N=139)

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	4.82 (1.41)	6.91 (1.24)	7.38 (1.32)	6.09 (1.22)
Stage 2	7.06 (1.17)	7.91 (1.07)	7.59 (1.69)	8.14 (0.98)
Stage 3	8.49 (0.74)	7.80 (0.97)	8.18 (1.32)	8.03 (0.88)
Stage 4	7.36 (1.02)	6.76 (1.22)	7.93 (1.47)	8.00 (0.92)
Stage 5	5.09 (1.23)	5.95 (1.32)	6.73 (1.38)	3.99 (1.39)
NEUTRAL				
Stage 1	4.25 (1.25)	2.88 (1.29)	2.21 (1.02)	4.21 (1.42)
Stage 2	4.74 (1.25)	3.69 (1.52)	2.18 (0.83)	3.31 (1.42)
Stage 3	4.00 (1.36)	4.24 (1.38)	2.31 (1.32)	4.36 (1.27)
Stage 4	3.53 (1.40)	3.42 (1.58)	2.28 (0.96)	4.28 (1.34)
Stage 5	3.98 (1.36)	3.17 (1.42)	2.48 (1.05)	3.66 (1.44)

males. The significant second order interaction between Sex of Decoder, Expression and Stage of Development ($F(4, 824)=5.77$, $p<0.001$) further elucidates this finding. Female judges rated the neutral expressions as non-smiles more definitely than the male subjects. Similarly, females were more confident in giving a higher rating to a smile expression than were the male subjects. Furthermore, with reference to the significant Sex of Decoder, Encoder, Expression and Stage of Development interaction ($F(12, 2472)=1.81$, $p=0.041$), the female judges, although rating smiles and neutrals more decisively than males, were able to recognise individual differences in the encoders and rated the separate encoders differently for their expressions.

6.8.2.5. Distance Measures[5]

The role of the twelve distance measures in the judgement rating made by the decoders was examined in a two way analysis of covariance with Expression (smile, neutral) and Encoder (4 encoders) as the independant variables and the mean rating judgement as the dependant variable. The mean rating was calculated by averaging the subjects' ratings for the eighty line drawing slides, resulting in eighty averaged responses (i.e. one averaged response per line drawing). The following six facial measures had a significant covariate effect: End-Lip Measure ($F(1,71)=21.97$, $p<0.001$), Mouth-Width Measure ($F(1,71)=34.08$, $p<0.001$), Mouth-Opening Measure ($F(1,71)=14.05$, $p<0.001$), Mid-Top-Lip Measure ($F(1,71)=12.59$, $p<0.001$), Lower-Lip Thickness Measure ($F(1,71)=4.76$, $p=0.03$) and Eye-Opening Measure ($F(1,71)=13.28$, $p=0.001$). These were the same measures which Katsikitis, Pilowsky and Innes (1990) found contributed significantly to the judges' ratings on the line drawing slides in their study, thus further validating the facial measures derived from the computer model as predictors of the ratings of expression given by the judges.

Taking the significant covariates in turn and commencing with the mouth measures, the findings show that (with the exception of one encoder who had a high

5 Appendix A.9. to Appendix A.32. display the standardised values for each facial measure in turn, as well as the averaged standardised scores (used in Study 2) for each of the facial measures.

score) when End-Lip Measure is below 40 (on a scale from 0 to 100), the mean rating from the judges is above five, at all stages of the smile expression. The End-Lip Measure score decreases during a smile as the corners of the mouth are elevated, thus shortening the distance between the mouth corners and the outer canthi of the eyes. In the case of the second significant covariate, the greater the Mouth-Width Measure, i.e. the distance between the left and right corners of the mouth, the more likely that the judges would rate the line drawing as a smile. The Mid-Top-Lip Measure represents the degree to which the upper lip is raised during an expression and in the case of three of the four encoders' smiles, the mean rating score increased as the Mid-Top-Lip Measure score decreased. Lower-Lip Thickness Measure, i.e. the distance between the midpoint of the upper border of the lower lip to the midpoint of the lower border of the lower lip, was the fourth mouth measure to reach significance and was found to decrease as the mean rating score increased. The final mouth measure to show a significant covariate effect was Mouth-Opening Measure, i.e. the distance between the centre of the upper border of the bottom lip and the centre of the bottom border of the top lip. With the exception of one of the encoders who had a near closed mouth, the more open the mouth the greater the likelihood that the expression would achieve a rating of five and above from the judges.

Eye-Opening Measure was the only eye measure to have a significant covariate effect, indicating that the eyes are more open during a neutral expression.

A further two-way analysis of covariance was performed in which these six independantly significant covariates were entered simultaneously into the analysis. The findings revealed significant covariate effects for End-Lip Measure, Mouth-Width Measure, Mouth-Opening Measure, Mid-Top-Lip Measure and Lower-Lip Thickness Measure. The main effect of Encoder ($F(3,66)=5.85$, $p=0.001$) and the main effect of Expression ($F(1,66)=7.10$, $p=0.01$) remained significant after the entry of the covariates. However, the interaction between Encoder and Expression ($F(3,66)=0.59$, $p>0.05$) was not significant.

6.8.3. Discussion

This study had three aims. Firstly, as a partial replication of the first experiment (Katsikitis, Pilowsky & Innes, 1990), it has attempted to consolidate the earlier findings which showed that subjects were able to distinguish between smile and neutral expressions when presented with only a line drawing representation of those expressions. This study supports those earlier findings which showed that judges were able to distinguish the different expressions depicted by a line drawing representation of a photograph of a face. The current study has shown that the judges reliably differentiated between smile and neutral expressions based on the limited information available from a line drawing. In addition, support was also given for the existence of a number of parameters which were significantly more important than others in the rating of the degree of smiling shown by a line drawing.

A second aim of this study was to investigate the responses made to a set of line drawings where the expressions differed in intensity during five stages of expression development. The findings revealed that judges rated the expressions differently during the five stages of development. There was a greater variation in ratings for the development of the smile than there was for the five stages of the neutral expression. Furthermore, there were encoder differences in the emergence of each expression. Specifically, Encoders 2 and 3 showed a consistent pattern of variation in the development of the smile whereas the ratings for the smiles of Encoders 1 and 4 peaked in the middle of the expression. Evidence for the existence of encoder differences in the expression of emotion is not new. Individual differences in encoding abilities have been well documented investigating such correlates as aptitude and personality (Thompson & Meltzer, 1964), mode of visual presentation (i.e. still versus dynamic, posed versus spontaneous) (Hager & Ekman, 1981; Wagner, Macdonald & Manstead, 1986), and physiological indices (Buck, Savin, Miller, & Caul, 1972). However, inconsistent findings in the literature regarding gender differences in encoding has left this matter far from conclusive. For example, Thompson and Meltzer (1964) concluded in favour of male superiority in encoding, while Fujita, Harper and Wiens (1980) and Wagner, Macdonald and Manstead (1986) found females to be better communicators of affect than males. Given the small number of encoders in this study, i.e. two males and two females, gender differences in encoding were not analysed, however the judges rated the encoders differently for their expressions in that they showed more extreme scores for degree of smiling for Encoders 2 and 3 (a male and female respectively). These results emphasise the need for more research on the dynamics of a smile including its intensity, duration and timing.

The third aim of this study was to investigate the likelihood of gender differences in ratings of the expressions. Significant gender differences were found in the decoding abilities of the raters. Females were more confident in rating a smile as a smile and this was especially evident as the smile was reaching its peak (usually stages 2-4). Furthermore, females provided lower scores for the neutral expressions than the males. This finding is in keeping with the evidence in the literature which suggests that females are superior in the decoding of nonverbal cues. In her review of the literature, Hall (1979) found that females came out as better decoders in 84% of the studies and as better encoders in 71% of the studies reviewed. In addition, females more readily pick up differences in smile and neutral expressions which are not so obvious, as was the case in the expression display of both Encoders 1 and 4. Males will perceive differences when they are marked, but this tends not to be the case when the differences are not obvious.

Finally, the validity of the computer model for the quantification of facial expression was examined by looking at the relationship between the judges' ratings of the line drawing slides and the facial distance measures accompanying each expression. The findings from this study suggest the importance of certain facial parameters in the delineation of a smile, namely, End-Lip Measure, Mouth-Width Measure, Mouth-Opening Measure, Mid-Top-Lip Measure and Lower-Lip Thickness Measure. In a study which also varied the stages of a smile (from no smile to its peak), Shor (1978) found that similarly the magnitude of a smile correlated positively with several facial distance measures including, "*rising of the cheeks*", upward movement of the corners of the mouth, mouth width, mouth opening and "*mouth* *height*". (pp. 88-89). These measures correspond to the End-Lip Measure, Mouth-Width Measure, Mouth-Opening Measure and Mid-Top-Lip Measure used in the current study.

A promising field of further research and one for which the computer model would be appropriately suited is in the investigation of the dynamics of smiling. The poor representation of research into the area may be as a result of the lack of adequate technology to capture and measure the fleeting nature of most expressions. However, with the advent of more sophisticated audio-visual and computer technology, this task seems not only possible but expeditious.

6.9. Conclusion

This study provides encouraging evidence to suggest that the model may be used to provide the stimuli for future experimentation involving the presentation of a series of facial expressions to judges as it preserves anonymity amongst encoders by utilising a line drawing representation of their emotional display. However, it is currently restricted to smile and neutral expressions and more research needs to be applied to the area of rater delineation of the other fundamental expressions.

PART 3

CHAPTER 7

THE CLASSIFICATION OF FACIAL EMOTIONS

7.1. Introduction

The structure of emotion has long been a subject for debate, focussing specifically on the classification of emotion and facial patterning during an expressive display. Reviews of research focussing on the ontogeny of emotion have shown that the display of emotion begins at an early age, with crying (distress), the startle response (surprise) and the smile (happiness) emerging with some frequency during the first three months of life (Charlesworth & Kreutzer, 1973). There is also evidence to suggest that by seven months of age a child can encode a face (Carey, 1981). Although the recognition of emotion and expression has been difficult to measure, this skill has been found to increase between the ages of three and ten (Ekman & Oster, 1979), and four month old infants have been found to discriminate between happy and surprise faces (Young-Browne, Rosenfeld & Horowitz, 1977) and happy, neutral and angry faces (LaBarbera, Izard, Vietze & Parisi, 1976).

As previously noted, Darwin (1872) proposed the existence of a number of facial expressions in humans and animals which he considered to be universal, therefore the product of an evolutionary process and evidence for the existence of a "common stock" before homo sapiens' separation from the main branch. From Chapter 1 which presented the theories of emotion in detail, it was evident that in contemporary facial expression research there is general agreement amongst the categorical theorists as to the existence of six "fundamental" facial emotions which are recognised cross-culturally (Ekman & Friesen, 1975). These are happiness, surprise, fear, disgust, anger and sadness. This implies that there exist facial configurations which, within each class, resemble each other closely and may be readily distinguished from configurations forming other classes of facial emotions. Faces displaying such emotions should therefore lend themselves to objective classification and the classes should be characterised by the key features of each fundamental expression.

The evidence with regard to the classification of the facial expression of emotion has already been discussed in Chapter 1, which emphasised the taxonomy of emotion in terms of discrete categories on the one hand, or with regard to one or two dimensions associated with each of the emotional groups on the other. This chapter will present three experiments which have been designed to examine this issue further.

This chapter has two aims. Firstly, with regard to the debate presented above, it intends to elucidate further the structure of emotion from both a categorical and a dimensional perspective. Secondly, it will build on the findings of the previous chapter in an attempt to extend the application of the computer model to include the quantification of a variety of different facial expressions.

This chapter describes three studies. The first study is designed to investigate whether a sample of posed facial expressions can be classified into the discrete fundamental emotions (Ekman & Friesen, 1975) using a numerical taxonomy package. The second and third studies investigate the underlying dimensions of emotion from the judgements made of the posed expressions presented to a group of subjects in the form of either photographs or line drawings.

7.2. Overview of Study 1: A Numerical Taxonomy Approach

Numerical taxonomy has the following objective;

"*Given a set of S things and for each a set of D measurements (attributes), to form a partition of the set of things, or, equivalently, a partition of the D-dimensional measurement space within which each thing may be represented by a point, such that the things within each subset, or region of measurement space, may usefully be treated as equivalent in some discussion*" (Wallace & Boulton, 1968, p.185).

In recent years, numerical taxonomic procedures have been applied in a variety of scientific fields where the classification of quantifiable data has been of interest, for example, biology, entomology, plant taxonomy, and microbiology (Lange, Stenhouse & Offler, 1965; Sokal & Sneath, 1963). It has been particularly successful in medicine where the classification of diseases has usually been extrapolated only from the medical diagnoses of clinicians (Patrick & Wallace, 1990; Scatterfield, 1967). For example, an application of numerical taxonomy in medicine has been described by Baron and Fraser (1968) concerning the classification of liver disease, and by Pilowsky, Levine and Boulton (1969) in the classification of depression.

One way to minimise error and deal with the enormous data bases usually associated with taxonomic analysis is to classify an object in terms of one or two properties that it may possess (i.e. monothetically). With the advent of high speed computers many of the current classification packages allow a more attribute-encompassing "polythetic" approach (i.e. including many like-properties or attributes of an object). Thus, it is the nature of similarity or resemblance of given attributes that is the fundamental question addressed by numerical taxonomy (Sokal, 1966).

The purpose of Study 1 is to apply a numerical taxonomy procedure to data from 161 posed fundamental facial expressions. The data consisted of twelve standardised measures, representing the distances between key facial landmarks. The objective of this study is to establish whether facial expressions of emotion possess intrinsic configurational properties which lead to their being grouped in a particular way, independent of any affect they may represent. This was done by submitting only information about the distances between key landmarks in faces to numerical taxonomy by a method based on information theory.

7.2.1. Method

7.2.1.1. Subjects

The expressions analysed in this study were posed by twenty first year drama students from The Centre for the Performing Arts, Adelaide, South Australia, and three psychology graduates. All subjects were informed that the study was concerned with the classification of emotion based on the facial expression of six fundamental emotions.

7.2.1.2. Procedure

Subjects were seen individually and asked to adopt a comfortable position facing a portable video-camera on a tripod. The camera was focussed on the face and the "actors" were asked to pose each of the following expressions in turn, i.e. happiness, surprise, fear, disgust, anger, sadness and a neutral expression. No guidance or advice was given as to the facial appearance of any emotion. All expressions were video-recorded.

Two independent judges, with no training in the judgement of facial expression, observed the videotaped expressions on a monitor and selected the peak of an expression of each emotion for each actor by pressing the "freeze-frame" button. A black and white hard copy was made of the chosen expression from the still image of the face on the screen (see section 5.3. for technical details). A total of 161 expressions (23 actors x 7 expressions) were thus obtained.

The computer programme for the quantification of facial expression (FAC.E.M.) has previously been described (in Chapters 5 & 6) and is based on a mathematical model of the face (Pilowsky, Thornton & Stokes, 1985, 1986; Thornton & Pilowsky, 1982). Twelve facial measures are generated which represent the distances between facial landmarks. Each facial expression is described by these twelve measures (see Figures 5.2. & 5.3.), and these twelve measures were derived from all of the photographs.

The facial measures were analysed using the numerical taxonomy programme, SNOB (Wallace, 1986; Wallace & Boulton, 1968). This programme seeks to establish classes that are the best fit for a particular set of data. To achieve this, an information measure is utilised which calculates the effort required to achieve the classes, i.e. the effort required to classify the data into classes representing the best fit for that data. The shortest message length is used as the "measure of goodness". Unlike many clustering procedures which depend on the user's judgement to decide on the number of classes present, SNOB provides its own classification based on the likeness of the attributes describing the members of classes. The significant attributes in each class are also calculated in terms of the difference between the mean class value and the population mean[1] .

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1 The information measure which SNOB uses to cost its model is the length of a communication (of 0's and 1's) which would be required to communicate the model and all its details from a transmitter (who knows the model) to a receiver (who is to be informed of the model). All facial measures are continuous-valued variables and assumed (by the SNOB model) to be Normally distributed. For each class in the SNOB model, the mean and standard deviation for each attribute must be transmitted. For each "thing" in a class, a piece of code of length corresponding to how many standard deviations its various attribute values are away from the class mean must be transmitted. Every time a new class is introduced, there is an information trade-off

7.2.2. Results

Optimal minimisation of the information measure was achieved when 160 expressions were grouped into five main classes (a sixth class contained only one member, i.e. one expression). The distribution of posed expressions across classes is presented in Figure 7.1. Figures 7.2. to Figure 7.6. display the actual line drawing representations of the expressions within each class[2]. From Table 7.1. it can be seen that 16 (89%) of the 18 members of Class 1 were happiness expressions. In Class 2 (N=13), 8 (61%) members were posing the surprise expression. In Class 3 (N=13) all expressions were represented, but none by more than three faces. Class 4 (N=59) was characterised by predominantly negative emotions with 14 (24%) fear, 10 (17%) surprise, 9 (15%) neutral, 8 (14%) disgust, 8 (14%) anger, 7 (12%) sadness and only 2 (4%) happiness expressions. Class 5 was distinguished from all the other classes by a total absence of the happiness expression, with 97% of the class consisting of the negative emotions of sadness (23%), neutral (23%), anger (21%), disgust (19%), fear (11%), and surprise (4%) expressions.

The means of the facial measures for each class are presented in Table 7.2. The significant facial measures characterising each class are as follows: Class 1, End-Lip Measure, Mouth-Width Measure, Mouth-Opening Measure, Mid-Top-Lip Measure and Top-Lip-Thickness Measure; Class 2, Mouth-Opening Measure and Mid-Lower-Lip Measure; Class 3, End-Lip Measure, Mid-Top-Lip Measure, Mid-Lower-Lip Measure, Eye-Opening Measure and Mid-Eyebrow Measure; Class 4, End-Lip Measure, Mouth-Opening Measure, Mid-Top-Lip Measure and Mid-Lower-Lip Measure; Class 5, End-Lip Measure, Mouth-Width Measure, Mouth-Opening Measure, Mid-Top-Lip Measure, Mid-Lower-Lip Measure and Eye-Opening Measure.

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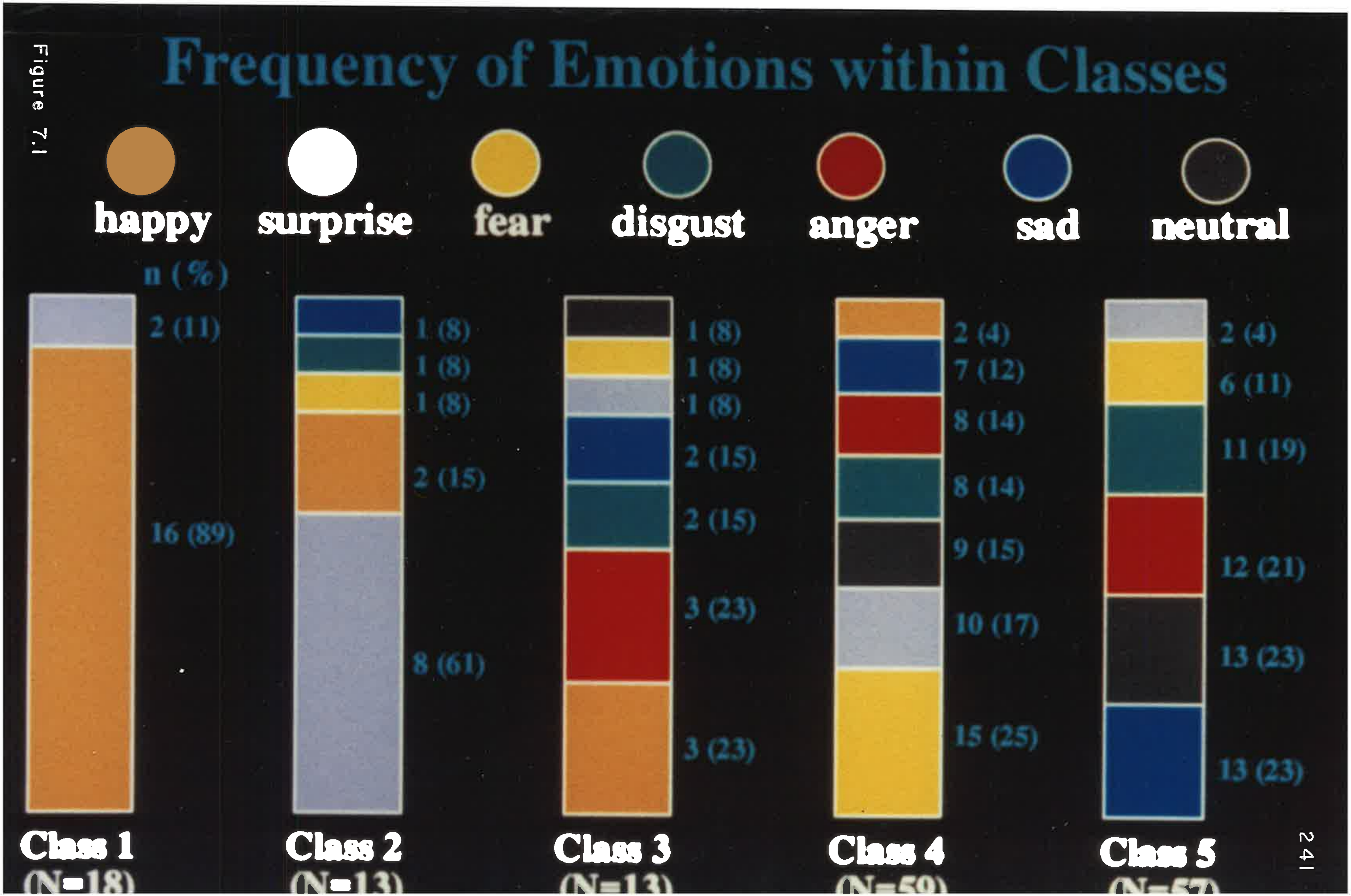
between the cost of having to specify a new class (and transmit the mean and standard deviation of attributes for that class) and the saving inherent in having the classes better represent their constituent things.

2 Appendix B.1. presents the actor membership within each class as produced by SNOB.



Frequency of Emotions within Classes
happy
surprise
fear
disgust
anger
sad
neutral
n (%)
2 (11)
16 (89)
Class 1
(N=18)
1 (8)
1 (8)
1 (8)
2 (15)
8 (61)
Class 2
(N=13)
1 (8)
1 (8)
1 (8)
2 (15)
2 (15)
3 (23)
3 (23)
Class 3
(N=13)
2 (4)
7 (12)
8 (14)
8 (14)
9 (15)
10 (17)
15 (25)
Class 4
(N=59)
2 (4)
6 (11)
11 (19)
12 (21)
13 (23)
13 (23)
Class 5
(N=57)

Figure 7.1

Figure 7.2. Line Drawing Representations of the Expressions in Class 1

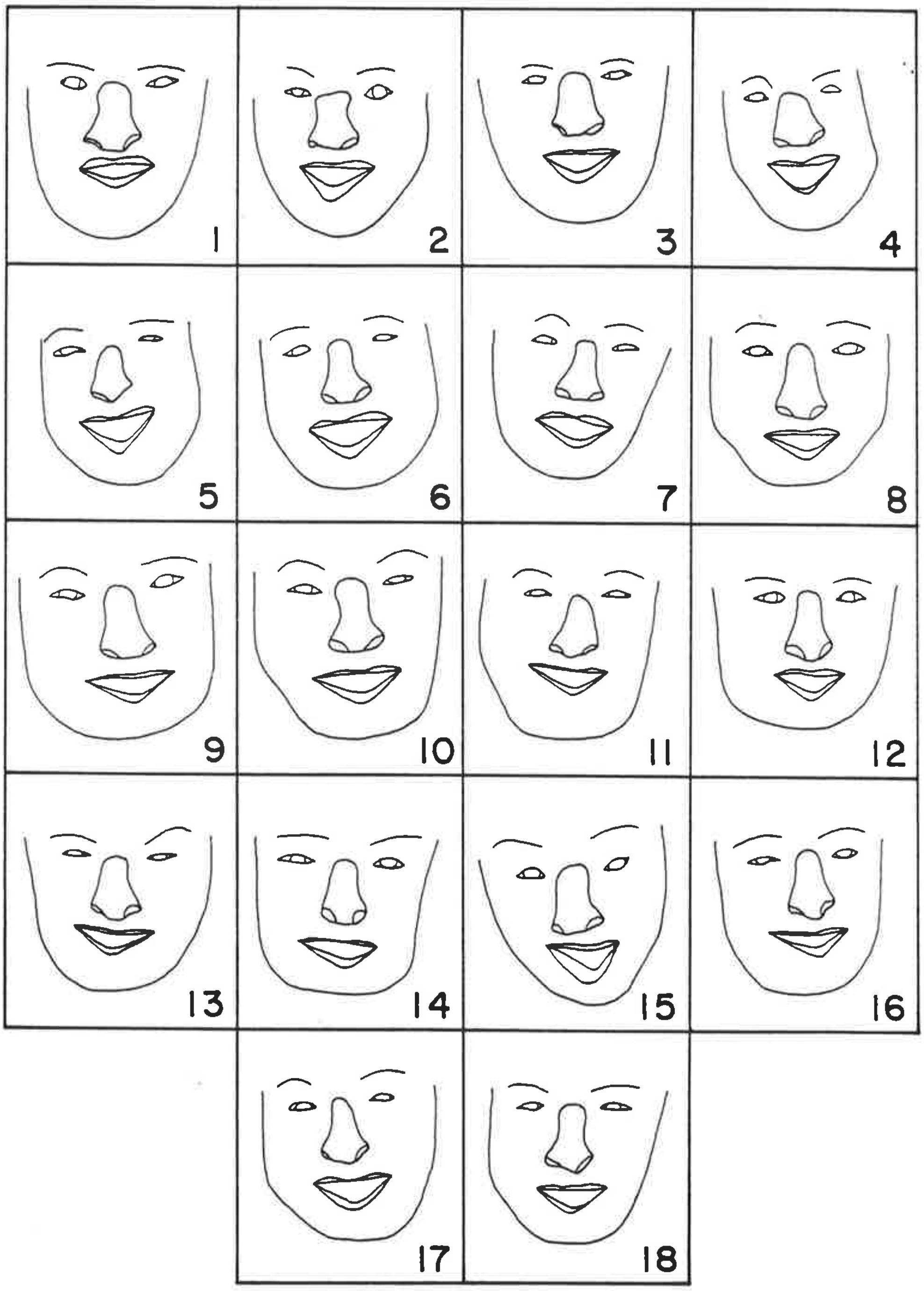


Figure 7.3. Line Drawing Representations of the Expressions in Class 2

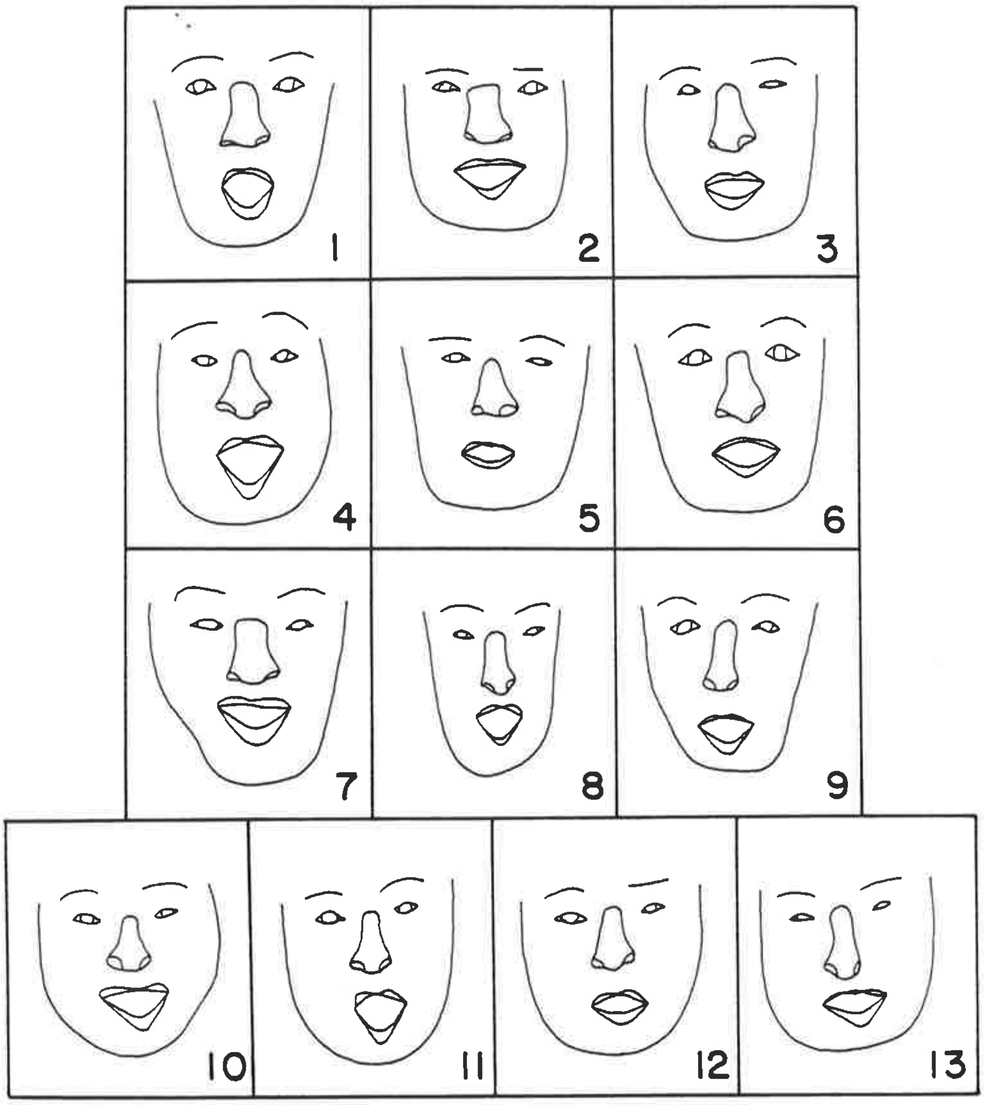


Figure 7.4. Line Drawing Representations of the Expressions in Class 3

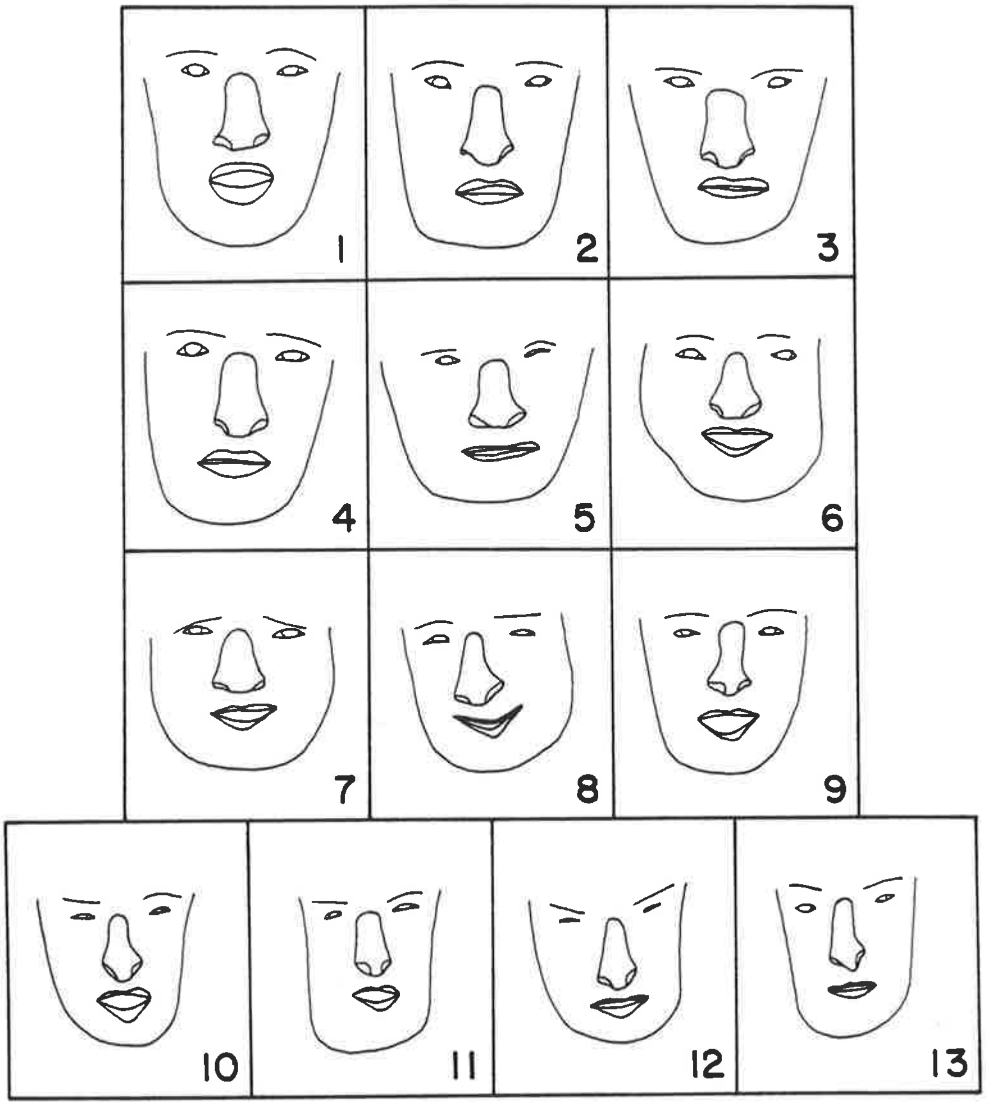


Figure 7.5. Line Drawing Representations of the Expressions in Class 4

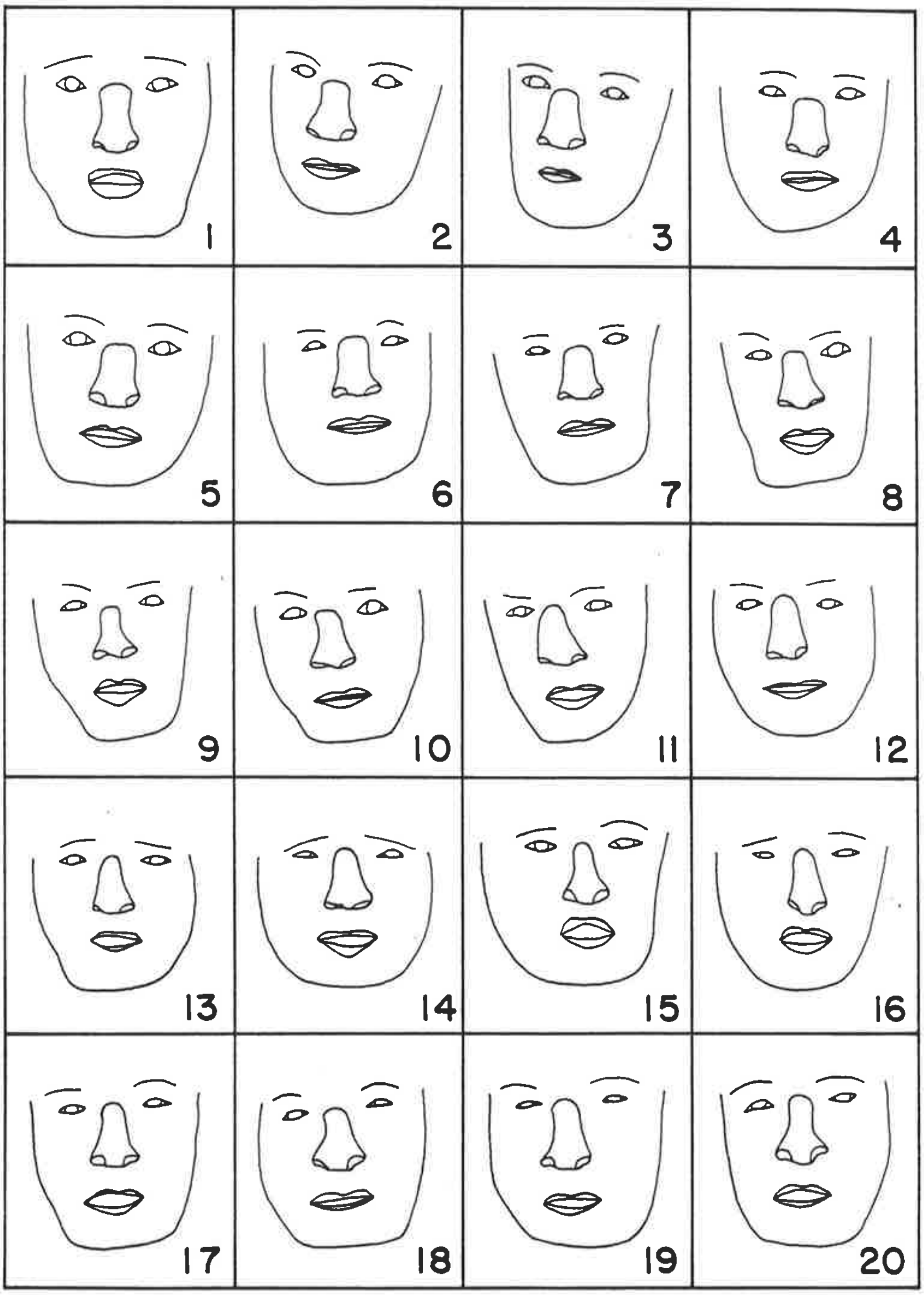


Figure 7.5. Continued..

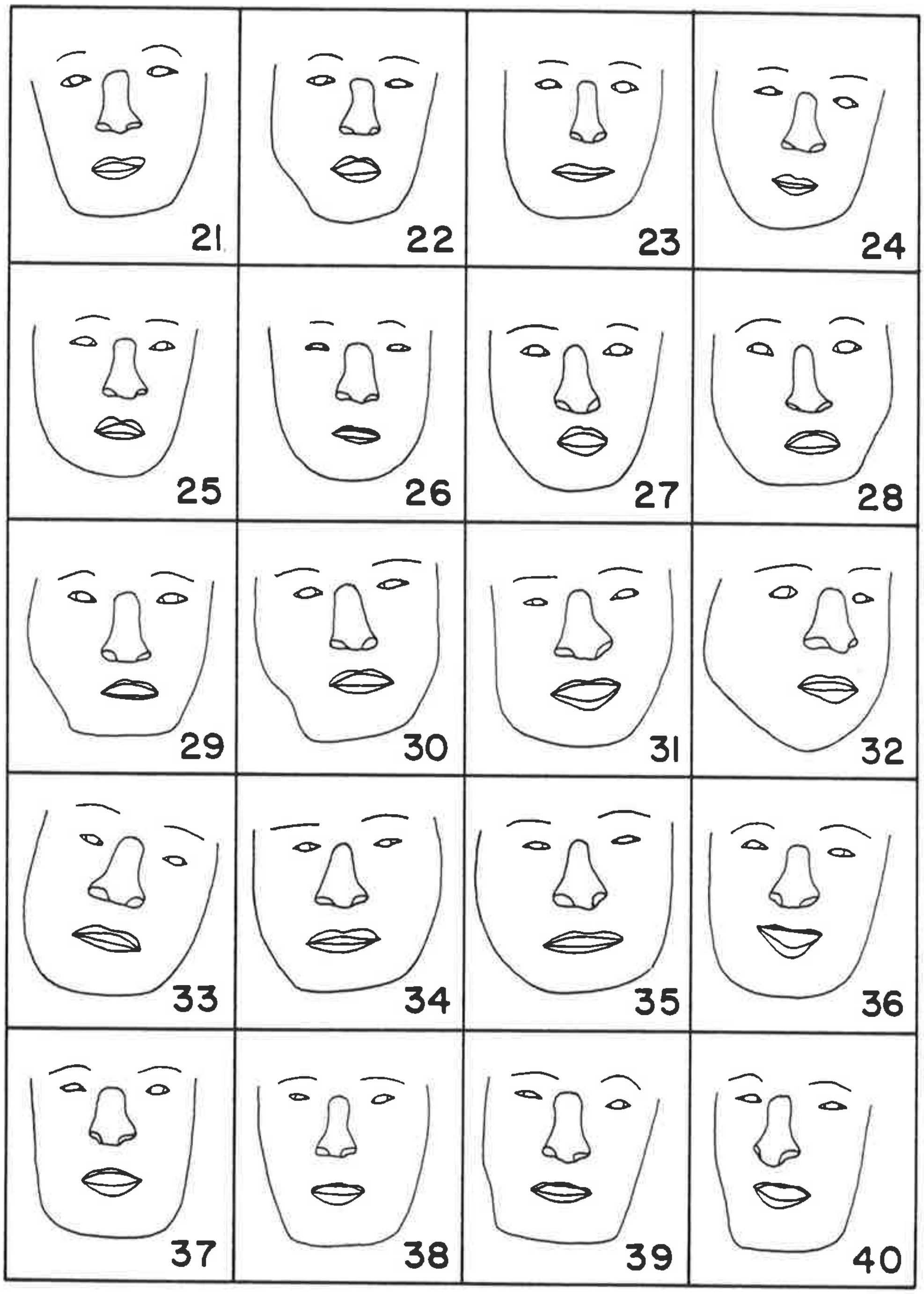


Figure 7.5. Continued..

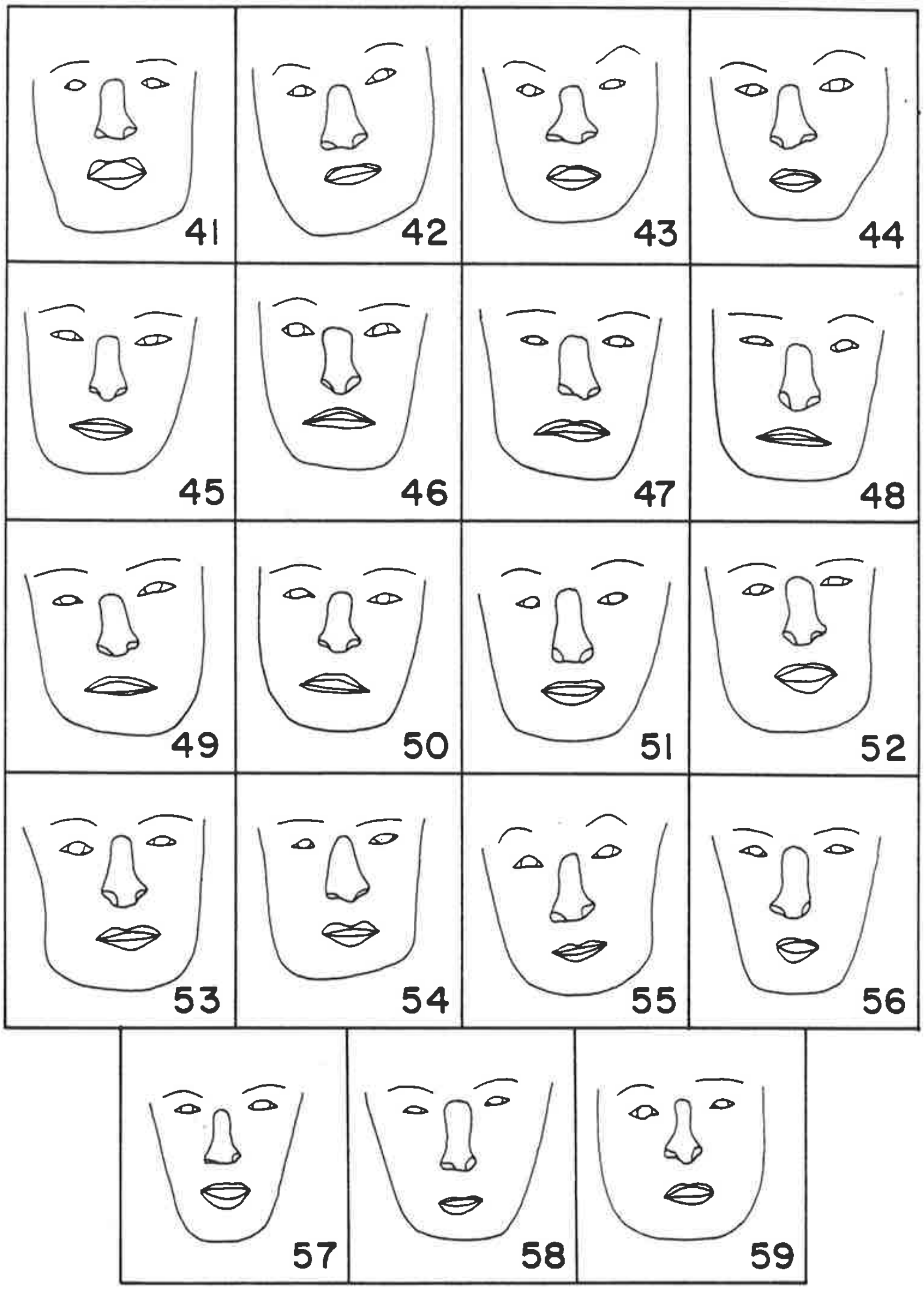


Figure 7.6. Line Drawing Representations of the Expressions in Class 5

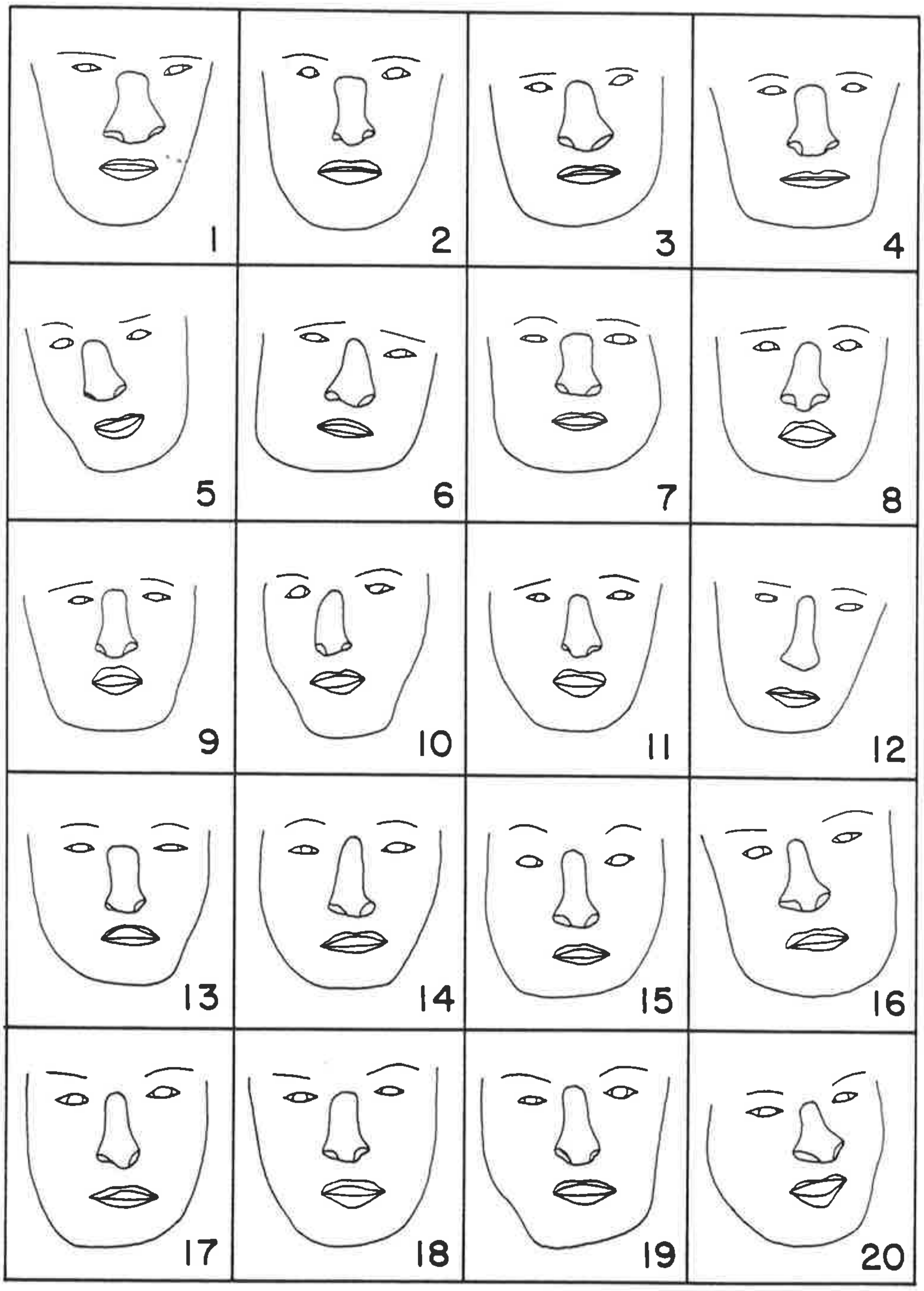


Figure 7.6. Continued..

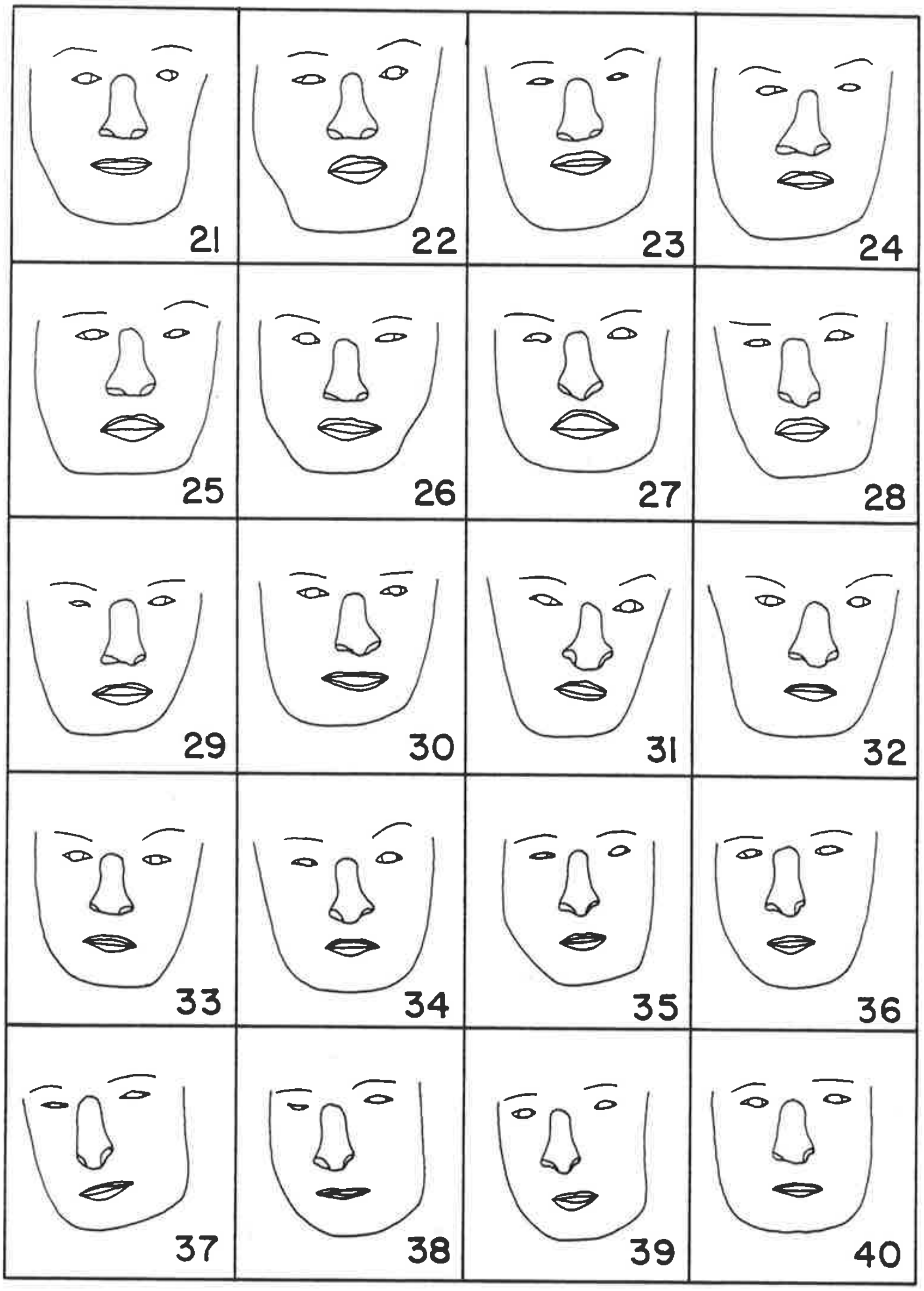


Figure 7.6. Continued..

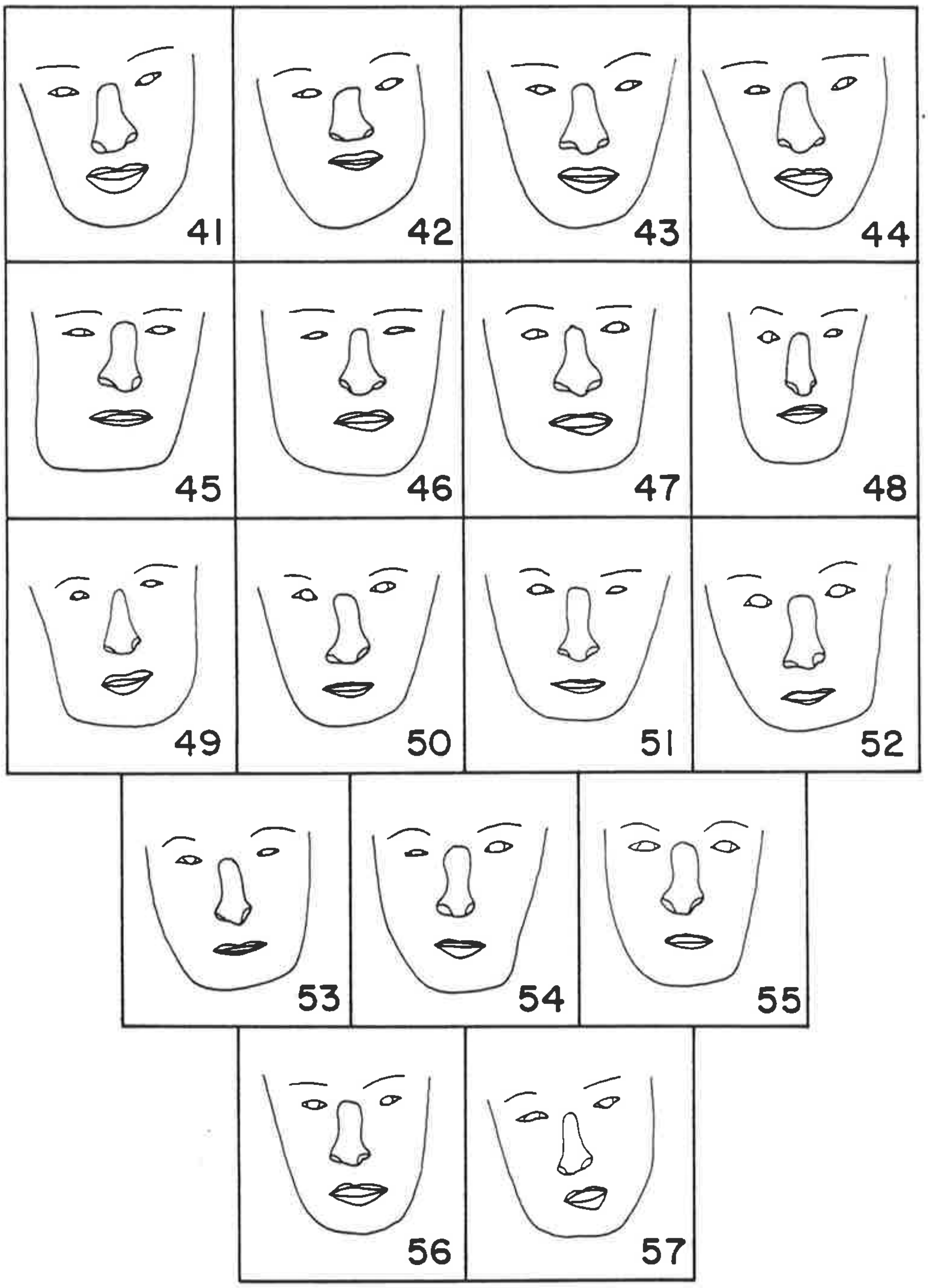


Table 7.1. Frequency of Emotions Within Classes

Class	H	Su	F	D	A	Sa	N
1 (N=18)	16	2	-	-	-	-	-
2 (N=13)	2	8	1	1	-	1	-
3 (N=13)	3	1	1	2	3	2	1
4 (N=59)	2	10	15	8	8	7	9
5 (N=57)	-	2	6	11	12	13	13

Note: H=happiness; Su=surprise; F=fear; D=disgust; A=anger; Sa=sadness;

N=neutral

Table 7.2. Means (and standard deviations) of Facial Measures Within Classes

Facial Measures	Popn Mean	Class 1	Class 2	Class 3	Class 4	Class 5
End-Lip Measure	45.6 (11.6)	27.3*** (5.2)	54.6 (10.6)	30.9*** (9.1)	55.1*** (6.1)	42.8*** (3.8)
Mouth-Width Measure	33.8 (15.2)	60.2*** (9.7)	33.7 (13.9)	36.7 (8.9)	29.8 (13.9)	28.9* (10.3)
Mouth-Opening Measure	36.2 (24.0)	58.7*** (12.0)	90.9*** (28.1)	32.0 (20.4)	30.6*** (13.6)	24.0*** (9.3)
Mid-Top-Lip Measure	45.0 (15.3)	31.5** (10.4)	50.1 (15.6)	24.9*** (6.7)	57.6*** (10.8)	39.4*** (9.3)
Mid-Lower-Lip Measure	31.5 (9.3)	33.1 (7.5)	51.4*** (9.0)	21.1** (7.2)	34.9*** (4.6)	25.2*** (3.1)
Top-Lip Thickness Measure	24.3 (17.4)	45.6*** (16.9)	24.9 (18.1)	23.6 (19.4)	20.3 (15.0)	21.3 (14.7)
Lower-Lip Thickness Measure	44.7 (15.1)	47.2 (15.0)	58.6 18.3)	45.5 (14.5)	44.9 (15.0)	40.1 (12.8)
Eye-Opening Measure	46.4 (10.0)	43.6 (10.2)	55.2 (7.7)	35.1** (7.7)	51.2 (9.7)	42.8** (6.5)
Top- Eyelid/ Iris Intersect Measure	76.0 (11.1)	80.9 (12.9)	75.4 (13.6)	76.5 (8.1)	76.7 (9.0)	75.2 (7.2)
Lower-Eyelid/ Iris Intersect Measure	49.4 (11.6)	55.2 (12.3)	46.6 (9.9)	49.0 (7.6)	50.5 (11.4)	47.4 (12.2)
Inner-Eyebrow Separation Measure	83.9 (19.1)	79.1 (17.6)	95.6 (16.7)	71.2 (20.7)	80.9 (18.2)	88.3 (18.5)
Mid-Eyebrow Measure	28.2 (18.5)	30.4 (14.8)	46.7 (17.5)	1.4*** (8.6)	32.9 (16.6)	24.8 (15.9)

Note: *sig 0.05, ** sig 0.01, *** sig <0.001, denotes significance levels for difference from the population mean

7.2.3. Discussion

The present study involved the classification of emotional expressions based on the distance measures between facial landmarks. Two main classes showing dominant membership of the smile (Class 1) and surprise (Class 2) expression respectively, were differentiated. The third class was not as clearly characterised by one dominant expression but included faces representing all of the emotions. Class 4 was characterised by predominantly negative expressions while the striking feature of Class 5 was the complete absence of the happiness expression.

With regard to Class 1, End-Lip Measure, Mouth-Width Measure, Mouth-Opening Measure, Mid-Top-Lip Measure and Top-Lip Thickness Measure were found to be significant contributors to the class membership. The facial expression for members of this class is characterised by elevated corners of the mouth, an elevated and "thicker" (i.e. showing more mucosa) top lip, the mouth open and wide. This finding is congruent with mouth measures found in previous work using the distance measures to distinguish smiles from other expressions[3].

This study provides support for the primacy of happiness and the smile in the delineation of the emotion categories. It is well documented that smiling is the most common expression of emotion seen in human interactions (Drag & Shaw, 1967; Ekman, 1978; Thompson & Meltzer, 1964; Wagner, Macdonald & Manstead, 1986). Its absence may be as potent a signal as its presence, even if a specifically sad expression is not perceived. There is a sense in which smiles function as regulators of interpersonal relationships. They certainly play a striking role in early childhood, as seen so clearly in parents' search for the first smile which seems to be responded to as

3 For example, Pilowsky, Thornton and Stokes (1986) obtained facial scores on ten smile and ten neutral expressions and found clear cut differences between these expressions in the degree of End-Lip Measure, Mouth-Width Measure, Mouth-Opening Measure, Mid-Top-Lip Measure, Eye-Opening Measure and Lower-Eyelid/Iris Intersect Measure. Similarly, Katsikitis, Pilowsky and Innes (1990) conducted a study in an attempt to relate the distance measures to ratings of degree of smiling seen in a series of smiling and neutral expressions observed by a large number of judges. Using analysis of covariance they found that End-Lip Measure, Mouth-Width Measure, Mouth-Opening Measure, Mid-Top-Lip Measure, Lower-Lip Thickness Measure and Eye-Opening Measure contributed to the differences found in the expression ratings of judges. When these measures were entered as collective covariates, End-Lip Measure, Mouth-Width Measure, Mouth-Opening Measure and Lower-Lip Thickness Measure were significant. Of these measures, only Lower-Lip Thickness Measure failed to discriminate in the present study. These findings indicate the particular importance of the mouth region in distinguishing smiles from other expressions.

a developmental milestone akin to the infant's first steps. The early emergence of the smile in the infant and the evidence for the universality of smiling, suggest the uniqueness of this facial display. The findings from this study are also in keeping with those of Ekman, Sorenson and Friesen (1969) who reported more consistent findings across literate and preliterate cultures when the subjects were asked to recognise the happy emotion as compared with other fundamental emotions.

In the case of Class 2 (surprise), the significant attributes were the Mouth-Opening Measure and the Mid-Lower-Lip Measure. The combination of these measures represent a characteristic feature of surprise, i.e. an open mouth as the jaw drops (Ekman & Friesen, 1975). This expression frequently blends with happiness as is the case in Classes 1 and 2.

Class 3 is characterised by the relatively short distances of End-Lip Measure, Mid-Top-Lip Measure, Mid-Lower-Lip Measure, Eye-Opening Measure and Mid-Eyebrow Measure. The facial expression represented by these facial measures may be described as follows; raised upper and lower lips, raised outer corners of the mouth, narrow palpebral fissures and lowered eyebrows. Ekman and Friesen (1975) describe a very similar profile in the description of the blend of the two emotions of anger and disgust, which are also two of the prominent emotions found in Class 3. Happiness, which is also represented in this class is found commonly in blends with anger and contempt. However, it is difficult to label this class of thirteen faces due to the very limited representation of each expression.

Class 4 consists of the simultaneous occurrence of fear with sadness, anger or disgust as reported by Ekman and Friesen (1975). The fear/surprise association is the dominant blend in this class and End-Lip Measure, Mouth-Opening Measure, Mid-Top-Lip Measure and Mid-Lower-Lip Measure were the significant facial measures. The facial display of this group consists of the outer corners of the mouth being drawn inwards, a slightly open mouth and the lowering of the top and bottom lips. This finding accords with the evidence for the involvement of the mouth in the display of both fear and surprise expressions. The role of the upper facial area including the movement of the eyes and eyebrows was not evident here.

Class 5 was characterised by the total absence of any faces presenting the happiness expression. It consisted almost entirely (with the exception of two surprise faces) of the "negative" emotions: fear, disgust, anger, sadness and "neutral". It is characterised by significantly greater distance measures on End-Lip Measure and Mid-Top-Lip Measure with shorter distances for Mouth-Width Measure and Mid-Lower-Lip Measure than the happiness class (Class 1). It is, in essence, a "long" face.

It may be reasonable to speculate that any neurophysiological process subserving the recognition of facial emotions such as described by Perrett, Mistlin, Potter, Smith, Head, Chitty, Broennimann, Milner and Jeeves (1986) functions by discerning facial patterns grouped on the basis of a classification of the sort found in this study. If this is so, it would suggest that the ability to detect the presence (or absence) of smiling might be a fruitful focus when assessing brain regions or populations of neurones considered likely candidates for a role in the recognition of facial emotions.

In considering the significance of these findings it may be useful to use a developmental analogy. The computer, with its classification programme, can be conceptualised as a newborn infant with a potential for recognising facial expressions (or configurations). This analogy suggests that the infant is likely to classify faces into three main groups, viz, those which are smiling, those which are not, and those which show a surprised expression. It may be reasonable to speculate that these internal templates are "hardwired", while the ability to recognise or discriminate other expressions such as fear, disgust and anger require socialisation. This would be consonant with the findings of Field, Woodson, Greenberg, and Cohen (1982) who found that neonates could discriminate between happy, sad and surprised expressions. Furthermore, they fixated on the mouth for the recognition of happiness and sadness, and on the mouth and eyes for surprise. Remarkably the infants were also able to produce matching expressions, a behaviour suggesting evidence of early imitation or indeed a manifestation of the capacity for "*emotional resonance*" (Bremner, 1988, p.169).

There may be a number of reasons why the other five expressions considered universal were not as clearly delineated as the happiness or surprise expressions. For example, some investigators may suggest that the analysis of spontaneous expressions may produce a different series of configurational classes than those reported here where posed expressions were used (e.g. Hunt, 1941). Others may argue that the knowledge of situational cues may also alter these findings (Knudsen & Muzekari, 1983; Russell & Fehr, 1987). However, the search for such explanations assumes that the existence of the "fundamental" facial expressions has been demonstrated beyond doubt. The literature does not support such a conclusion. Darwin of course used mainly anecdotal and subjective data, while Ekman, Sorenson and Friesen's (1969) more recent transcultural findings are not totally convincing. Indeed their data suggests that only smiling can be regarded as a "fundamental" or universal expression. Examination of the table of data presented in their paper shows that the rates of recognition varied from 82% to 99% for happiness, 23% to 88% for fear, 19% to 82% for anger, 33% to 91% for surprise, 29% to 86% for disgust, and 26% to 82% for sadness. Furthermore, the non-Western cultures had lower recognition scores than the American, Brazilian and Japanese samples.

It should be pointed out that this study has taken a categorical approach to facial expressions, and by inference, to the emotions. However, a dimensional approach is equally as valid, and these findings are compatible with such a model of emotion in that any expression can be assessed for the amount of smiling present.

This study has purposely taken a purely numerical approach in which a computer has been required to apply a numerical taxonomic classification programme to data consisting only of relationships between facial landmarks presented as standardised distance measures. The result was not six classes into which each of the posed fundamental emotions were allocated. Instead the procedure yielded five classes with only one being a "pure" expression, i.e. smiling, and another "pure" only in the sense that faces showing smiles were completely absent. The possibility remains that this lack of congruency with the emotions, generally accepted as fundamental, reflects their derivation from work with adults capable of giving a verbal response to a stimulus. The findings from this study may better describe a preverbal stage of facial emotion classification. It would seem important to delineate and study such protoclassifications in order to improve our understanding of the facial emotions and their neurophysiological correlates.

The next study investigates whether human judges would be able to reproduce the findings of the numerical taxonomy, in a judgement study, where they are asked to categorise a series of photographs into the expression groups.

7.3. Overview of Study 2: A Multidimensional Scaling Approach

This study further utilised the photographs of the facial expressions produced by the actors from The Centre for the Performing Arts in Adelaide, South Australia. To reiterate briefly, the photographs were obtained by asking twenty-three actors (seen individually) to pose the following emotions in consecutive order; happiness, surprise, fear, disgust, anger, sad and neutral. Each expression was recorded and a video-print of the still image was processed. A total of 161 photographs were obtained (i.e. 23 actors x 7 expressions).

7.3.1. Method

7.3.1.1. Subjects and Procedure

Seventeen volunteers classified the photographs into one of seven given emotion categories, namely, happiness, surprise, fear, disgust, anger, sadness and neutral. They were asked to view the photographs one at a time, make their judgement and move on to the next, without comparing consecutive photographs. Appendix B.2. and B.3. present the random ordering of stimuli as seen by the subjects in this study.

7.3.2. Results

Data were entered in the form of similarity judgements. Stimulus and response scores were handled as a pair, with the response score reflecting the similarity to the stimulus. The seven stimulus categories, i.e. happiness to neutral, were given a number of one to seven respectively, and the response of each subject, similarly happiness to neutral, was also given a number of one to seven. The response represented the emotion category into which each photograph was classified regardless of whether it was "correctly" placed.

Table 7.3. Frequency of Responses in each of the Stimulus Conditions in Study 2

STIMULUS

	Happiness	Surprise	Fear	Disgust	Anger	Sadness	Neutral
RESPONSE							
Happiness	377	46	1	17	6	0	6
Surprise	3	198	68	9	9	16	21
Fear	1	41	108	6	12	16	13
Disgust	3	9	17	128	68	33	13
Anger	3	11	55	89	181	58	29
Sadness	0	10	47	48	62	146	68
Neutral	4	76	95	94	53	122	241

Table 7.4. Conditional Probabilities in Study 2

STIMULUS

	Happiness	Surprise	Fear	Disgust	Anger	Sadness	Neutral
RESPONSE							
Happiness	.96	.12	.00	.04	.02	.00	.02
Surprise	.01	.51	.17	.02	.02	.04	.05
Fear	.00	.10	.28	.02	.03	.04	.03
Disgust	.01	.02	.04	.33	.17	.08	.03
Anger	.01	.03	.14	.23	.46	.15	.07
Sadness	.00	.03	.12	.12	.16	.37	.17
Neutral	.01	.19	.24	.24	.14	.31	.62

A 7 x 7 crosstabulation table (Table 7.3.) was produced from the similarity judgement data, showing the frequency of the responses in each of the stimulus conditions.

Cohen's Kappa statistic (Landis & Koch, 1977)[4] was performed to measure the degree of agreement between stimulus and response categories, e.g. was there agreement between the happiness judgement and the happiness stimulus across judges? The best agreement was found on the happiness responses for the happiness stimulus (K=0.89) followed by the surprise responses for the surprise stimulus (K=0.45). The other five expressions of fear (K=0.36), disgust (K=0.32), anger (K=0.38), sadness (K=0.25) and neutral (K=0.29) had very poor agreement between the response and stimulus categories.

Conditional probabilities of the response, given the stimulus, were calculated from the crosstabulation data by dividing the frequency in each cell by the product of the number of raters and the number of actors (17 x 23, i.e. the number of times each expression (or stimulus) occurred)). These probabilities are presented in Table 7.4. In this study a conditional probability is used as a measure of similarity (Davison, 1983). A multidimensional scaling (MDS) procedure, ALSCAL, from the Statistical Package for Social Sciences (SPSS, 1988) was applied to the conditional probabilities. Multidimensional scaling uses similarity data, i.e. pairs of similarities, to establish a dimensional pattern amongst a set of objects (Davison, 1983). An iterative process, ALSCAL, fits the information provided by the similarity responses into dimensional space. The programme aims to reduce "stress" by achieving optimal goodness of fit for the data. The resultant (diagrammatic) spatial map yielded by the analysis represents the proximity of each object to another. Multidimensional scaling will uncover a pattern if one exists, but the interpretation of the mapped data points is often subjective or intuitive (Schiffman, Reynolds & Young, 1981; Wish & Carroll, 1982).

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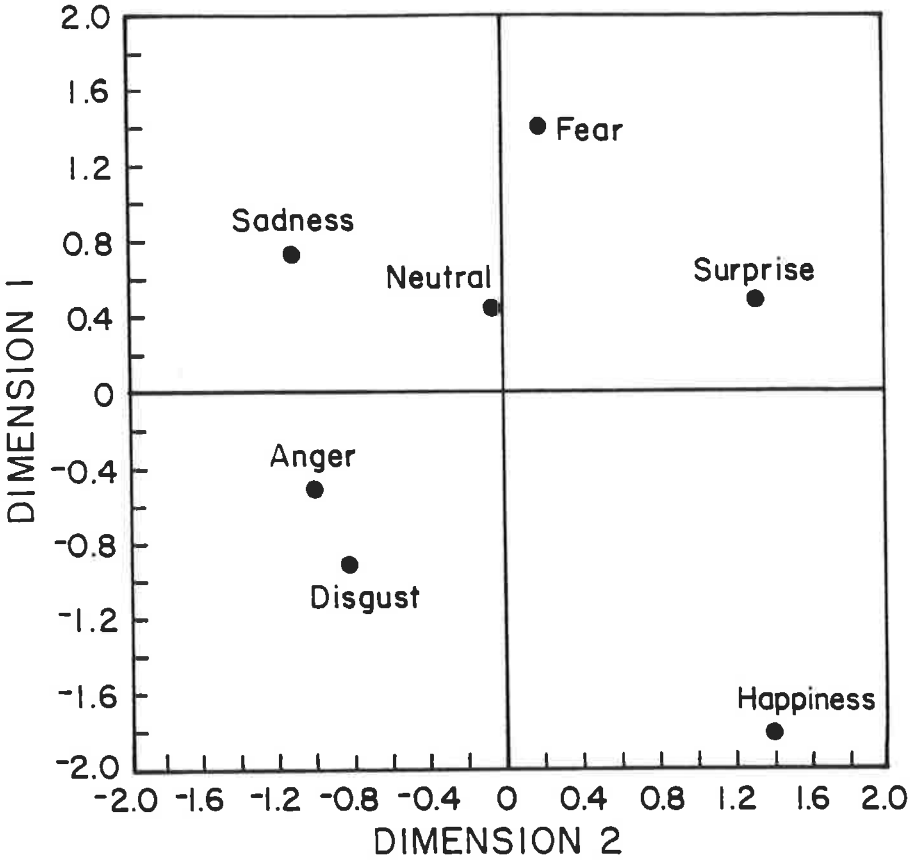
4 Kappa tables can be found in Appendix B.4.

Figure 7.7. Two-Dimensional MDS Outcome for the Photograph Stimuli



The resultant two-dimensional representation of the seven stimulus categories accounted for 88% of the variance with a stress factor of 0.18[5]. Figure 7.7. shows the spatial representation of the emotion categories in two-dimensional space. As is clearly evident, the happiness expressions were grouped on their own in the lower right hand quadrant; surprise was in the upper right hand quadrant; fear was also positioned in the right hand quadrant, but at a co-ordinate north-west of surprise; sadness was diagonally opposed to happiness in the upper left hand quadrant; disgust and anger were clustered together in the lower left hand quadrant and neutral was quite close to the pivot position at a co-ordinate which placed it almost on the vertical dimension.

Cohen's Kappa was used as an aid in the interpretation of the two-dimensional MDS outcome, by investigating the degree of agreement between stimulus and response for any two emotions. This was achieved by constructing a 2 x 2 table for each pair of emotions considered, and examining the proportions within the cells on the diagonal of the table, which represented agreement between stimulus and response on Emotion A, and agreement of stimulus and response on Emotion B. The values for Kappa were very high for happiness with each of the other emotions, i.e. surprise to neutral, indicating that the judges had no difficulty distinguising between happiness and the other emotions. Similarly, surprise was easily distinguished from happiness, disgust, anger, sadness and neutral. However, the moderately low agreement found for surprise and fear indicates that the judges may have had some difficulty distinguishing between these two emotions. Disgust was easily distinguished from all expressions with the exception of anger. Finally, the Kappa values showing poor agreement between the anger and sadness, and sadness and neutral categories suggest that the judges may have had some difficulty in distinguishing between these emotions. All Kappa tables are presented in Appendix B.4.

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5 Given the small number of stimulus categories (seven), a two-dimensional solution proved to be the most optimal, taking the amount of variance accounted for and the associated stress value into consideration. Furthermore, a three-dimensional solution was considered to be unreliable (SPSS, 1988).

These findings are concordant with the positioning of the emotions in the two-dimensional display resulting from the MDS analysis. Happiness is quite separate from the other emotions suggesting that this expression had a unique facial display which was not confused with any other emotion. The difficulty in the delineation of surprise/fear and disgust/anger can be seen by their close proximity to each other in their respective quadrants (i.e. upper right for fear/surprise and lower left for disgust/anger). Interestingly, neutral was confused with fear and also with sadness. Figure 7.7. shows that these emotions have positive vertical co-ordinates, with the neutral expression positioned between fear and sadness. Finally, anger and sadness have very similar horizontal co-ordinates. Anger has a negative vertical position while sadness has a positive vertical co-ordinate which place these emotions in close proximity but on opposite sides of the horizontal axis.

In the definition of the dimensions, there appear to be some trends in the point locations of each emotional category within the generated dimensional space. Dimension 2, or the horizontal dimension, can be labelled as Pleasant-Unpleasant, with happiness and surprise at one end and disgust, anger and sadness at the other end. Interestingly, neutral occupies a position in the middle of this dimension. However, Dimension 1, or the vertical dimension, is not so clearly marked. The emotions of surprise, fear and sadness at one end have the similar feature of eyebrow involvement in their expression. At the other end of this dimension are happiness, disgust and anger which have been characterised by the movement of the mouth in their respective displays of expression. Thus, the vertical axis may be interpreted as a Facial Action dimension, and is characterised specifically by the involvement of the upper or lower face.

7.3.3. Discussion

This study presented photographs of actors portraying the six fundamental emotions, as well as a neutral expression, to a group of judges who were asked to categorise them into these seven emotional groups. The findings showed that the judges were unable as a group to categorise the photographs into the seven mutually exclusive emotional classes. In fact, only happiness and to some extent surprise, were "correctly" placed with greater frequency than any of the other emotions. Fear, disgust, anger, sadness and neutral showed very low agreement between stimulus (photograph) and response from the judges.

As the emotions were not classified into seven well defined categories, the data were subjected to a MDS analysis in an attempt to investigate the underlying structure of these emotional states. The responses from the judges resulted in a two-dimensional structure with the six fundamental emotions positioned along the perimeter of a circular model. Neutral, however, was situated almost centrally, near the pivot of the two dimensions. One dimension resembled a Pleasant-Unpleasant dichotomy with happiness and surprise at one end and sadness, disgust and anger at the other end of the axis. The other dimension, the Facial Action dimension, indicated that the raters' judgements were influenced by the movement of the facial landmarks with the eyebrows featuring prominently in surprise, fear and sadness, and the mouth region for anger, disgust and happiness.

A circular model of the structure of emotion is not a new concept. Schlosberg (1941) found that the classification of the six emotion categories presented by Woodworth on a linear continuum, were actually better described in terms of their co-ordinate position in a two dimensional plane. He found that these categories formed a circle around two orthogonal, perpendicular, bipolar dimensions which he termed Pleasant-Unpleasant and Attention-Rejection respectively. This model has been well supported by other researchers in the field (Daly, Lancee & Polivy, 1983; Russell, 1980), despite the practice of varying methodologies (Russell, 1978) and cultures sampled (Saha, 1973; Triandis & Lambert, 1958).

Although the Pleasant-Unpleasant dimension concords well with the literature, a Facial Action dimension is novel and has not previously been reported. These results show that this dimension is characterised by the salience of the upper or lower parts of the face in the display of emotion. The issue of dominance of the upper or lower face in the expression of the emotions remains controversial and contradictory (see section 3.3.8.). However, the salience of certain facial actions in the patterning of expressions is now well accepted. In this study, the Facial Action dimension presented the configuration of surprise, fear and sadness at one end, and anger, disgust and happiness at the other. This dichotomy may signify the role of the eyebrows and eye region for the former group, as opposed to the predominance of the mouth region in the latter. Indeed, Bassili (1979) found that happiness and disgust were more accurately judged from the lower half of the face while fear and sadness were more successfully judged from the upper half of the face. Similarly, Boucher and Ekman's (1975) results supported the hypothesis that the dominant facial area differs from one emotion to the other with happiness and disgust best predicted from the mouth region, while fear and sadness involved the involvement of the eye and brow region. Furthermore, Ekman (1979) highlighted the role of the eyebrows in the emotions of sadness, surprise and fear and noted that the emotions of happiness and disgust do not initiate any specific eyebrow movement. Finally, facial electromyographic research has supported the involvement of the brows in sadness or depression as a predictor of clinical improvement (Schwartz, Fair, Greenberg, Mandel & Klerman, 1974, 1975). The aforementioned discussion is not intended to disregard the role of the mouth in surprise or the eyebrows in anger, for example, but it is an attempt to emphasise the more salient features of each expression.

The finding of the close proximity of certain emotions in a two-dimensional plane has convergent validity with other judgement studies which show that raters do have difficulty in distinguishing between certain emotions. Specifically, the similarity between surprise and fear and disgust and anger is apparent by their close co-ordinate positions in the circular model. Ekman and Friesen (1975) describe the facial actions of these two groups of emotions as they are quite commonly found to blend with one another. For example, the anger/disgust blend emphasises the action of the mouth more so than the brow movements, while the raised and arched eyebrows in surprise/fear are more prominent than the mouth in that display. Happiness is often found to blend with anger, which may explain their likewise positioning on the vertical dimension, as the smile may be used to mask the latter emotion. Sadness is found to blend with both anger and disgust where the sadness emotion is represented by the brow region and the mouth region characterises both disgust and anger. This concords well with the position of each of these emotions on the horizontal dimension. Finally, in this study, the judges confused neutral with fear and also with sadness. The absence of marked facial activity in both sadness and neutral may explain their resemblance and thus confusion in a judgement task. However, the reasons for the similarities between fear and neutral are not clear. This may well be an artifact in that the neutral category may have been a "dumping" ground for emotions which were too difficult to classify into one of the six fundamental classes. Alternatively, this finding may indicate that without any reference to the context in which an expression is displayed, then a neutral expression may be construed as quite threatening. More research which focusses on the display of a neutral expression is needed before any firm predictions can be made.

In summary, the results of this study show that firstly, observers make a global assessment of a face in terms of the degree of pleasantness it shows, and secondly, judges rely on facial landmarks to provide clues in the delineation of one emotion from another. These findings support the dimensionalist viewpoint which argues that the various emotions are not independent, but in fact are related to one another and are characterised by their position in a dimensional plane.

It is necessary at this point to reiterate briefly that the findings of Studies 1 and 2 in Chapter 6 revealed no significant differences in the ratings obtained from judges with regard to photographic or line drawing displays of smile and neutral expressions. Following the methodology of the previous experiment, the final study in this chapter explores further the utility of the model to present line drawing representations of facial displays as stimuli in a judgement task. Thus, the next experiment was conducted as a replication of Study 2, thereby extending the utility of the model beyond the judgement of smile and neutral expressions as previously described.

7.4. Overview of Study 3: Replication with Line Drawings

Each photograph was digitised and the data were fed into the mathematical model. A curved line drawing procedure connects the points to produce an outline of the face incorporating the eyebrows, eyes, nose and mouth. Thus, 161 line drawings corresponding to the total number of photographs were compiled.

7.4.1. Method

7.4.1.1. Subjects and Procedure

Eighteen volunteers were asked to classify each of the line drawings into one of the six fundamental emotion categories of happiness, surprise, fear, disgust, anger and sadness. In addition, a neutral category was also provided. The line drawings were placed into categories without reference to the preceding or consecutive line drawings. Subjects in Study 2 judged the line drawings in the same sequence as the photographs were judged in the previous study (see Appendix B.2. and Appendix B.3.).

7.4.2. Results

Similarity measures were compiled from the stimulus and response groupings. Each line drawing acted as a stimulus and the classification provided by the rater was the response. The stimuli categories were given a number of one to seven (happiness to neutral respectively) and the raters' responses were similarly numbered. Thus a stimulus, response score of (1, 1) was entered into the analysis if the line drawing stimulus represented a happiness emotion and the rater placed it in the happiness category provided. A similarity score of (1, 2) represented a happiness stimulus which was placed in the surprise category.

Table 7.5. presents the results of a frequency analysis indicating the number of chosen responses given in relation to the stimulus categories provided. Cohen's Kappa[6] statistic was used as a measure of stimulus-response agreement. As with the photographs, the best agreement was achieved by the happiness response to the happiness line drawing stimulus (K=0.96). The raters had more difficulty with the category of surprise (K=0.26) and only slight agreement for the categories of fear

6 Kappa tables can be found in Appendix B.5.

(K=0.09), disgust (K=0.05), anger (K=0.09), sadness (K=0.12) and neutral (K=0.04) were achieved.

The conditional probabilities entered into the MDS analysis are shown in Table 7.6. Figure 7.8. shows the resultant spatial configuration which is best described by two dimensions which account for 89% of the variance, with a stress factor of 0.18. Happiness and surprise occupy the bottom right and top right quadrants respectively. Fear and neutral appear together in the top left quadrant while sadness, anger and disgust are found together in the lower left quadrant.

Cohen's Kappa (Landis & Koch, 1977) was used as a measure of agreement between stimulus and response for every combination of two emotions at a time, i.e. happiness with surprise, happiness with fear, surprise with disgust, etc. As in Study 2, a 2 x 2 table was constructed for each pair of emotions and the proportions within the cells on the diagonal of the table (i.e. those cells targeting agreement) were examined.

The Kappa values are in keeping with the spatial configuration shown in Figure 7.8. Firstly, the happiness expressions, occupying a quadrant on their own, were readily distinguished from fear (K=0.76), disgust (K=0.60), anger (K=0.69), sadness (K=0.87), and neutral (K=0.85). A moderate Kappa value for the happiness/surprise combination (K=0.49) however, implies that the judges experienced some difficulty in distinguishing between these two emotions from the line drawing stimuli. Some confusion between happiness and surprise may account for their similar co-ordinate status on the horizontal dimension. Moderately high Kappas were obtained for the surprise/anger (K=0.68), surprise/disgust (K=0.57) and surprise/sadness (K=0.64) responses, but the judges found it more difficult to distinguish between surprise and fear (K=0.31) and surprise and neutral (K=0.40). Fair agreement was obtained for fear with disgust (K=0.24); anger (K=0.36) and sadness (K=0.22) respectively. The very low Kappa value for fear with neutral (K=0.04) on the other hand, indicating that the judges found a resemblance between these two emotions, accords well with the location of these two emotions which are found clustered in the same quadrant. Finally the negative emotions of disgust, anger

Table 7.5. Frequency of Responses in each of the Stimulus Conditions in Study 3

STIMULUS

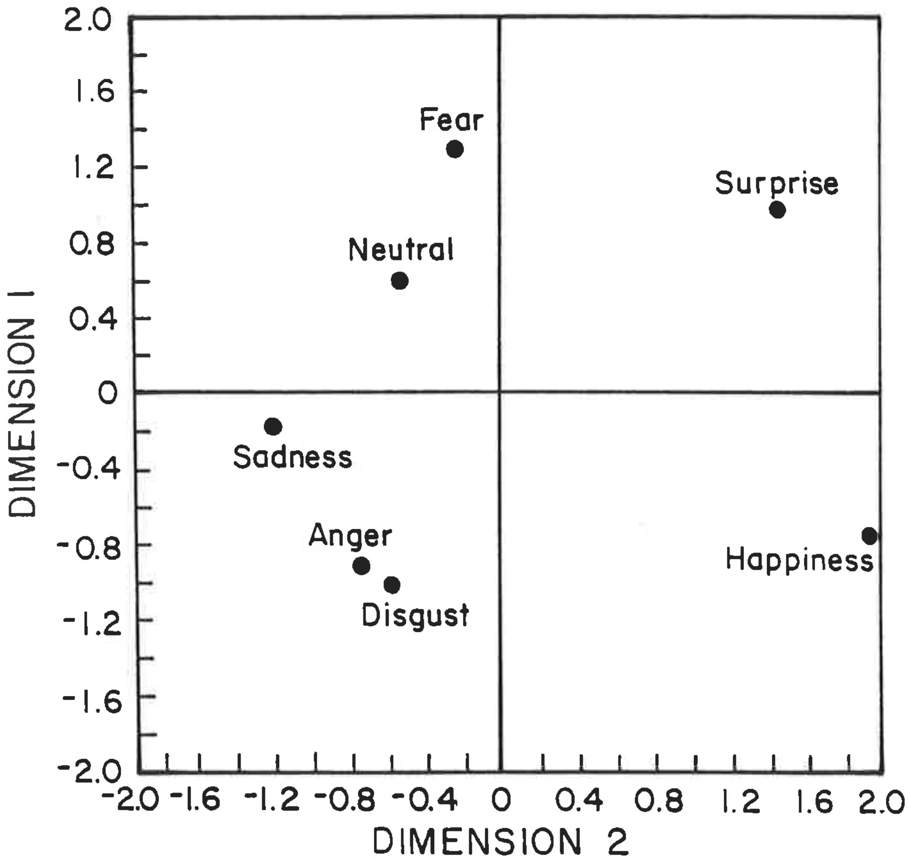
	Happiness	Surprise	Fear	Disgust	Anger	Sadness	Neutral
RESPONSE							
Happiness	316	87	25	50	42	21	13
Surprise	45	136	60	29	23	29	32
Fear	8	50	74	42	39	43	66
Disgust	13	20	47	70	67	56	56
Anger	16	23	43	77	101	69	59
Sadness	3	24	64	70	81	100	81
Neutral	13	74	101	76	61	96	107

Table 7.6. Conditional Probabilities in Study 3

STIMULUS

	Happiness	Surprise	Fear	Disgust	Anger	Sadness	Neutral
RESPONSE							
Happiness	.76	.21	.06	.12	.10	.05	.03
Surprise	.11	.33	.14	.07	.06	.07	.08
Fear	.02	.12	.18	.10	.09	.10	.16
Disgust	.03	.05	.11	.17	.16	.14	.14
Anger	.04	.06	.10	.19	.24	.17	.14
Sadness	.01	.06	.15	.17	.20	.24	.20
Neutral	.03	.18	.24	.18	.15	.23	.26

Figure 7.8. Two-Dimensional MDS Outcome for the Line Drawing Stimuli



and sadness and to some extent neutral were not easily separated from one another. The Kappa values are as follows: disgust with anger (K=0.08); disgust with sadness (K=0.16); disgust with neutral (K=0.16); anger with sadness (K=0.14); anger with neutral (K=0.28); and sadness with neutral (K=0.08).

The positioning of the emotional categories in the two-dimensional space supports the existence of a Pleasantness-Unpleasantness dimension with happiness and sadness at the opposite extremes. The second dimension appears very similar to that found in the previous experiment, i.e. a Facial Action dimension, with happiness, disgust and anger which feature the action of the mouth, at one end and fear and surprise, which are characterised by the involvement of the eyes and eyebrows, at the other.

7.4.3. Discussion

The third study was designed to replicate the methodology and statistical procedures of Study 2, with one important variation, i.e. in this case line drawing representations of photographs of facial expressions were used as stimuli. Judges were asked to categorise each line drawing into one of the six fundamental emotion groups. A neutral category was also provided. The results supported and extended the findings of Study 2. The resultant two-dimensional structure revealed polarisation of certain emotions such as happiness and surprise, as well as clustering of the negative emotions of sadness, anger and disgust.

Two differences emerged in comparing the configurational properties of the emotions in Studies 2 and 3. Firstly, in Study 2, fear was positioned between surprise and neutral, i.e. in the same quadrant as surprise, while neutral occupied a near pivot position. In the current study however, neutral and fear are found together, while surprise stands apart in a quadrant on its own. It is interesting to note that using only line drawings of expressions as stimuli, that surprise takes on a status previously reserved for happiness only, that is, a unique facial display, allowing it to be delineated from the other emotions. It could be that the eyes and eyebrows, important features in the judgement of surprise, are more clearly presented by the line drawings, as shadowing or other factors, e.g. glasses which are captured in a photograph and may impede judgement, are all avoided with a line drawing.

Secondly, and in contrast, sadness which was positioned alone and diagonally opposite from happiness in Study 2, when represented in the form of a line drawing, appears to be confused and grouped with other negative emotions, namely, anger and disgust. Although in the same quadrant as these two emotions, sadness has a co-ordinate which is very close to the horizontal axis, thus the middle spot on the vertical axis. The only other category which gravitates towards the centre on the vertical dimension is neutral, suggesting that these two expressions may have similar facial displays, which act as a middle ground for the vertical dimension.

The positioning of the emotions within the two-dimensional plane bears some resemblance to the classes derived from a numerical taxonomy analysis (in Study 1) applied to the facial distance measures associated with the stimuli (the measures are the same for the photographs and the line drawings). Two main classes emerged consisting of predominantly happiness and surprise expressions respectively, thus supporting the findings of the current study where happiness and surprise were not confused with other emotions, but stood apart as sole occupants of their own quadrants. There was also a third defined class which was characterised by the absence of any happiness expressions and in the main was composed of the negative emotions of sadness, anger, disgust and neutral. These negative emotions (with the exception of neutral) were found clustered together in this study also.

The two dimensions resulting from the judgements of line drawings supports the presence of a Pleasant-Unpleasant dichotomy with happiness and surprise at one extreme and fear, sadness, anger and disgust at the other. Similarly, the Facial Action dimension has also appeared revealing the presence of lower facial activity in the emotions of happiness, disgust and anger and upper facial activity in fear and surprise. This dimension has not been previously reported and as such needs further investigation. Future research should target the facial characteristics focussed upon by subjects in their judgements of expressions. For example, this study could be repeated with the essential features presented to the judges who are subsequently asked to rank those facial landmarks which aided in their judgement of the emotion. In this way and using the FAC.E.M. system, the spatial orientation of the emotions could be paired with the salient features of the face, in an attempt to elucidate which features are important in the judgement of the various emotional expressions. Alternatively, to test the hypothesis that the eyes are more clearly presented by a line drawing, upper and lower facial halves of line drawings and photographs of the emotions could be shown to judges.

7.5. Conclusion

The results of this chapter have revealed two important findings. Firstly, in keeping with the findings of Chapter 6, the mode of stimulus presentation, with reference to photographs or line drawings, produces a similar outcome in terms of the judgement of the facial expressions of emotion. This is borne out by the emergence of a two-dimensional structure consisting of a Pleasantness-Unpleasantness and Facial Action dimension respectively in Studies 2 and 3 and the similar configurations or clusters of emotions produced from the similarity ratings of photographs and line drawings in both studies. Furthermore, the results of this work extends the application of line drawings as a stimulus source, beyond the smiling and neutral expressions (which were the subject of Chapter 6), to the display of other emotions such as anger, fear, disgust, surprise and sadness. These results have suggested that the use of photographs and line drawing representations produced by the FAC.E.M. programme are interchangeable.

The second finding of this chapter concerns the resultant clustering patterns of the emotion categories. The most consistent and robust outcome across all studies has been the emergence of happiness and smiling as the most readily identified emotion and expression respectively. It is important to note that the primacy of happiness arises, regardless of the different methodological and statistical techniques applied to the data. For example, the outcome of the numerical taxonomy analysis applied to distance measures in the first study, produced three main classes representing happiness, surprise and the absence of happiness expressions respectively. Similar findings were obtained when a MDS technique was applied to the judgement data of raters in Studies 2 and 3. Two dimensions emerged and the location of the emotions on the perimeter of a circular structure closely resembled the clusters found in the first study. In other words, happiness occupied an isolated co-ordinative position in a quadrant, separated from both surprise and from a cluster of the negative emotions which were found in different quadrants.

PART 3

CHAPTER 8

A CONTROLLED QUANTITATIVE STUDY OF SMILING IN PARKINSON'S DISEASE AND DEPRESSION USING A MICROCOMPUTER-BASED APPROACH.

8.1. Introduction[1]

There are obviously a number of applications to which a model such as the FAC.E.M. system could be applied, in disciplines such as psychology, anthropology, psychiatry and neurology. In recent years, there has been an increase of interest in facial expression in clinical contexts particularly in psychiatry and neurology (Bellack, Mueser, Wade, Sayers & Morrison, 1992; Cramer, Bowen & O'Neill, 1992; Pilowsky & Bassett, 1980). Thus, a natural progression in testing the validity of the model further, is to apply it to a clinical issue.

A clinical problem of major importance concerns the nature of depression in Parkinson's disease (PD). With the advancing age of the general population, Parkinson's disease is more prevalent, and so a more precise delineation of depression in Parkinson's disease is of interest to clinicians in the disciplines of neurology and psychiatry, because of its implications for treatment.

Parkinson's disease, or the parkinsonian syndrome, is a common and disabling neurological condition which particularly affects old people. It was named after James Parkinson (1817) who referred to the illness as "*paralysis agitans*" (p. 1). Parkinson's disease is predominantly a disturbance of motor function and is characterised by bradykinesia (or slowness of voluntary movement), tremor (or trembling) and muscular rigidity (or stiffness of the muscles) (Hoehn & Yahr, 1967; Quinn & Hussain, 1989). Associated features of this syndrome include postural changes, shuffling gait, oculomotor abnormalities, excessive salivation, constipation and urinary complications. Thus, the physical and emotional difficulties associated with PD have major consequences in terms of individual suffering and family impact, in addition to implications for the provision of medical services.

The most common form of PD is "idiopathic parkinsonism", although some forms of medication and organic brain syndrome or diffuse brain damage may lead to a parkinsonian-like condition in those afflicted. A greater proportion of males

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1 An earlier version of this chapter has been published; Katsikitis, M., & Pilowsky, I. (1991). A controlled quantitative study of facial expression in Parkinson's disease and depression. *The Journal of Nervous and Mental Disease*, 179, 683-688 (see Appendix D.2.).

are affected than females and an occasional hereditary or familial pattern is reported (Hoehn & Yahr, 1967). Parkinson's disease is progressive, although the rate of deterioration is variable, and the mortality is estimated to be three times higher than that of the general population matched for age and sex (Lishman, 1978). In pathological terms, PD results through the loss of melanin pigment and degeneration of neurones in the substantia nigra (part of the extrapyramidal motor system) which is located in the midbrain. The level of the neurotransmitter dopamine and the subsequent number of dopaminergic fibres passing from the substantia nigra to the striatum (dopaminergic nigrostriatal tract) are severely reduced, thus creating a biochemical imbalance within the corpus striatum and associated regions of the brain (Hornykiewicz, 1981). The dopamine deficiency disorder is the characteristic feature of PD. However, a more recent discovery of the presence of certain toxic substances associated with nigral cell death may elucidate further the underlying cause of PD (Jenner, 1989). Currently, the disease is treated with dopaminergic medications (e.g. L-dopa) which serve to redress the balance of dopamine in the brain pathways associated with posture and movement control.

Although major advances have been made in understanding the neuropathology and pharmacotherapy of PD (Shaw, Lees & Stern, 1980), there remain certain important areas which have been relatively neglected in terms of research and treatment. Among these are firstly, the nature of depression which often occurs in PD. James Parkinson (1817), in his original description of the "*shaking palsy*" (p. 1) noted that the "*senses and ihe intellect*" (p. 34) were not affected by the disease process. However, researchers since that time have found that psychiatric disorders, in particular, depression and dementia, do occur amongst these patients (Todes, 1984). Indeed, the similarity between the facial expression of patients with Parkinson's disease and those with depression has not gone unnoticed. In particular the psychomotor retardation which includes the loss of facial movement, covaries with patients' self reports (Schwartz, Fair, Mandel, Salt, Mieske & Klerman, 1978). Furthermore, Trethowan (1979) has made an explicit comparison between the facial expression of Parkinson's disease sufferers and those with depression, noting that in depression,

> "*mobility of facial expression may be greatly reduced...almost Parkinsonian-like with eyes downcast, wearing a tonic expression of grief*" (p.175).

The occurrence of depression in patients with Parkinson's disease has also been reported (Mindham, 1970; Warburton, 1967). Indeed Parkinson (1817) himself cited a patient described by a Dr. Maty in the following way;

> "*A more melancholy object I never beheld. The patient, naturally a handsome, middle-sized, sanguine man, of a cheerful disposition, and active mind, appeared much emaciated, stooping, and dejected*" (p. 40).

More recently, Robins (1976) and Asnis (1977) showed that depression was marked in PD patients and that it was not necessarily related to the added impact of coping with a chronic physical disbility. On the other hand, Nissenbaum, Quinn, Brown, Toone, Gotham and Marsden (1987) related depression in PD to the "off" phase of the condition, i.e. the immobile phase which occurs with levodopa treatment. They also report that "on-off" mood swings occur in two-thirds of PD patients. Similarly, Katsikitis and Pilowsky (1988) found that depression was more marked in a PD group when compared with matched controls.

The second and to an extent related problem which is often reported but rarely explored to any particular extent is that of the gradual loss of facial mobility and the well known "mask-like" appearance so often found in PD patients. Indeed the extent of facial immobility, so often cited as a characteristic clinical feature of PD, has not been carefully researched and may be seen as a possible basis for depression in these patients. Social psychologists have provided considerable evidence which suggests that an appropriate use of the face is crucial to the quality of interpersonal relationships from the neonatal period onwards (Trevarthen, 1985; Wolff, 1963). Despite this, few attempts have been made to develop and evaluate techniques which target the problem of facial immobility. Indeed, the objective study of facial expression in Parkinson's disease has been difficult owing to the lack of a method for capturing and quantifying the relevant aspects of facial activity.

Katsikitis and Pilowsky (1988) have speculated that the presentation of an expressionless face may inhibit the facial expression and emotional state of others, thus contributing to the development of depression in patients with PD. Similarly, Brown (1982) noted that this is the case for depressed patients, where a display of "flat" affect may result in the avoidance of social contact, thus exacerbating feelings of loneliness and isolation, commonly experienced by depressed individuals.

Rinn (1984) noted that patients with PD are able to move their facial muscles voluntarily, but are unable to react with spontaneous expressive gestures. Similarly, Buck and Duffy (1980) found that PD patients were rated as significantly less expressive than an aphasic and a control group, on a task designed to assess spontaneous facial expression. Although the high incidence of depression found in PD patients may constitute a partial explanation for the psychomotor retardation and lack of spontaneity of facial expression, Rinn (1984) and Vogel (1982) have shown that these characteristics are not simply due to depression, but are also found in non-depressed parkinsonian patients.

On the basis of clinical evidence of this sort, and the response of both conditions to treatments such as ECT and tricyclic antidepressants, it has been suggested that they may share some common neuropathological abnormalities (Serby, 1980). In the light of such speculations it seems worthwhile to examine the nature of the relationship between PD and depressive disorders as closely as possible and from a wide variety of approaches.

In a previous study, Katsikitis and Pilowsky (1988) investigated the amount of facial activity displayed by a group of Parkinson's disease sufferers during a smile, compared to a group of matched normal controls. Using FAC.E.M., significant differences were found in the degree of mouth opening during a smile and also in the frequency of smiling between the two groups. Thus, the parkinsonian patients were found not to open their mouths by raising the upper lip to the same extent during a smile and furthermore, produced fewer smiles while viewing humorous cartoons. Depression scores on the Levine-Pilowsky Depression questionnaire (Pilowsky & Spalding, 1972) (see Appendix C.1.) were also obtained and a significant negative correlation was found between the depression score and inner eyebrow separation, indicating that drawing together of the eyebrows became greater as the depression score increased.

The present study was conducted in order to replicate and extend earlier findings (Katsikitis & Pilowsky, 1988) and to examine more directly the relationship between Parkinson's disease and depression. Using FAC.E.M., the facial activity of a parkinsonian group will be compared with "normal controls" and also with a clinically depressed group, with larger numbers than were involved in the Katsikitis and Pilowsky (1988) study, while following the same procedure.

8.2. Method

8.2.1. Subjects[2]

The group of twenty-one patients suffering from Parkinson's disease comprised ten males and eleven females. Five were inpatients of the Royal Adelaide Hospital's Geriatric Assessment Unit; eight were attending the Royal Adelaide Hospital's Parkinson's Review Clinic (where they were involved in an assessment and treatment programme, which included a neurological examination, occupational therapy and physiotherapy); seven were volunteers who were members of the Parkinson's Syndrome Society of South Australia (a community organisation providing support services for Parkinson's Syndrome sufferers and their families); and one patient was referred by a general practitioner.

The Depressed group included twenty patients, (14 males and 6 females) of comparable age to the Parkinson's disease group. All had been given a clinical diagnosis of Major Depression according to the Diagnostic and Statistical Manual of Mental Disorders Revised Third Edition (American Psychiatric Association, DSMIII-

2 I would like to acknowledge gratefully the co-operation of Drs. Don Burrow and Robert Penhall (Royal Adelaide Hospital), Drs. Linda McCarthy and David Ben-Tovim (Repatriation General Hospital), Drs. Steven McLean and Harry Hecht (Hillcrest Hospital), Heather Trenorden (Combined Neurological Resource Centre), for the referral of parkinsonian and depressed patients to this study, and Dr. Jeanette Linn (general practitioner), for a large number of the control subjects. I would also like to thank John Plenty and Terry O'Brien for their audiovisual expertise.

R, 1987) and were inpatients in three major teaching hospitals in Adelaide. Patients with dementia or pain were excluded from the study.

The Control group comprised seven males and twelve females of comparable age to the Parkinson and Depressed groups, who had no known physical or psychiatric illness.

8.2.2. Procedure

All patients and controls received an information sheet which provided a synopsis of the aims of the project as well as an explanation of their role as volunteers, and were asked to sign a consent form, approved by all relevant ethics committees (which allowed the researchers to videotape and subsequently use their facial expressions for the duration of the project). Each participant was seen individually and escorted to a room which contained a slide projector, screen and stopwatch. In one hospital the video cameras were built in, while in the other two, the subject sat in a chair facing a portable video camera equipped with video-recorder. Where portable cameras were used, the experimenter remained in the same room and operated the projector from a position which was not in the subject's view. Where the cameras were built in, subjects sat facing a wall-mounted camera while the recording was carried out in an adjoining room (separated by a large one way mirror) from which the camera could be operated by remote control.

Twelve humorous cartoon slides were each presented for fifteen seconds. When all slides had been viewed, they were presented again and each subject was asked to indicate whether they had found the cartoon amusing, by answering "YES" or "NO".

All patients and controls completed the Levine-Pilowsky Depression (Pilowsky & Spalding, 1972) (see Appendix C.1.) questionnaire which provides a Depression score between one and twenty, as well as classifying the respondent into one of three groups: "non-endogenously depressed", "endogenously depressed" and "non-depressive" (Pilowsky & Boulton, 1970; Pilowsky, Levine & Boulton, 1969).

Two judges with no previous training in the rating of facial expressions viewed the videotaped recordings of all sessions and after discussion, selected the most animated smile of each participant for microcomputer analysis. A hard copy, i.e. a still "photograph" of each person's smile was made from the videotape, using a video printer. These smiles were digitised according to a standard procedure (Katsikitis, Pilowsky & Innes, 1990; Pilowsky, Thornton & Stokes, 1985) and scores on twelve facial measures were obtained. The facial outlines produced by the computer using the mathematical model are shown in Appendix C (i.e. Appendix C.2., Appendix C.3. & Appendix C.4.)

8.3. Results

The length of the patients' awareness of illness in the Parkinson's disease group ranged from 1 to 20 years (mean=6.32, sd=4.75), with a mean age of 71.5 (sd=9.1) years. Current medication consisted of L-dopa in all cases, and in addition, Bromocriptine (Parlodel) (30%) and Amantadine (10%) had been prescribed. Antidepressants were used in 20% of cases. The majority of subjects had a morning appointment (85%), usually two or three hours after taking their medication. This was not convenient in three of the cases however, and these individuals were seen in the afternoon.

The length of the current episode of depression for the Depressed group ranged from 2 to 32 weeks (mean=11.1; sd=8.6) in eighteen patients, while one patient was recorded as having the illness for one year, i.e. since the death of a spouse, and one patient's data were missing. The mean age of the group was 69.4 (sd=5.8) years. All patients were taking antidepressants, in addition to antipsychotic agents (60%) and sedatives (25%).

The mean age of the Control group was 66.2 (sd=5.0) years. There were no significant age ($F(2,56)=2.89$, $p=0.064$) or sex ($\chi^2=4.5$, $df=2$, $p=0.10$) differences between the three groups. Table 8.1. presents the means (and standard deviations) of the face measures for the three groups.

Analysis of variance using each of the twelve face measures individually as the dependant variable revealed significant differences between the groups for End-Lip Measure ($F(2,57)=16.93$, $p<0.001$); Mid-Top-Lip Measure ($F(2,57)=6.11$, $p=0.004$) and Mid-Eyebrow Measure ($F(2,57)=10.06$, $p<0.001$).

Table 8.1. Means (and standard deviations) for the Twelve Facial Measures, Frequency of Smiling, and Depression Score in the Parkinsonian, Depression, and Control Groups[a]

Face Measures	Parkinsonian	Depression	Control
End-Lip Measure[b]	24.63 (9.38)	44.66 (18.01)	23.64 (9.21)
Mouth-Width Measure	56.05 (15.53)	51.27 (17.51)	62.42 (13.85)
Mouth-Opening Measure	41.28 (20.21)	32.19 (12.19)	41.75 (19.85)
Mid-Top-Lip Measure[b]	33.39 (15.38)	48.86 (23.32)	29.94 (14.35)
Mid-Lower-Lip Measure	24.23 (7.18)	30.78 (11.78)	25.43 (6.82)
Top-Lip Thickness Measure	35.79 (20.67)	24.10 (14.30)	33.22 (19.32)
Lower-Lip Thickness Measure	44.13 (16.13)	44.42 (13.25)	39.87 (16.60)
Eye-Opening Measure	33.92 (10.23)	38.42 (10.97)	30.69 (7.26)
Top-Eyelid/Iris Intersect Measure	73.80 (12.20)	70.67 (11.03)	69.34 (11.06)
Lower-Eyelid/Iris Intersect Measure	51.23 (11.39)	54.86 (9.28)	56.24 (12.57)
Inner-Eyebrow Separation Measure	95.24 (17.80)	111.46 (31.54)	102.02 (15.4)
Mid-Eyebrow Measure[b]	10.65 (13.84)	30.38 (19.13)	12.98 (11.73)
Frequency of Smiling[c]	3.93 (3.72)	2.76 (2.93)	6.64 (3.88)
Depression Score (LPD)[d]	5.85 (2.06)	12.05 (4.08)	3.00 (1.83)

a Significant difference across groups (ANOVA). pd=significant difference between groups with p=Parkinson's, d=Depression, c=Control.

b pd, dc

c pc, dc

d pd,pc, dc

Comparison of the group means using the Student Newman-Keuls procedure (SPSS, 1988) indicated significant group differences between the Parkinson's disease and Depressed groups with the latter group having higher scores for End-Lip Measure ($t=-4.98$, $df=57$, $p<0.001$), Mid-Top-Lip Measure ($t=-2.73$, $df=57$, $p=0.018$) and Mid-Eyebrow Measure ($t=-4.14$, $df=57$, $p=0.001$). Similarly, comparison of the Depressed and Control groups showed that the former had higher scores for End-Lip Measure ($t=5.09$, $df=57$, $p<0.001$), Mid-Top-Lip Measure ($t=3.26$, $df=57$, $p=0.004$) and Mid-Eyebrow Measure ($t=3.56$, $df=57$, $p=0.002$). It is interesting at this point to note that although a significant outcome was not achieved, there were trends towards differences between the groups for Mid-Lower-Lip Measure ($F(2,57)=3.11$, $p=0.052$) and Eye-Opening Measure ($F(2,57)=3.15$, $p=0.051$). Inspection of the means indicates that the Depressed group differed from the two others by having higher scores on both these face measures.

There was a significant relationship between group and LPD classification ($\chi^2=35.22$, $df=2$, $p<0.001$). The Depressed group were significantly more likely to be classified as endogenously or nonendogenously depressed on the LPD as compared to the Parkinson's disease and Control subjects, all of whom fell into the non-depressive category.

There was a significant group difference on the LPD Depression scores ($F(2,56)=51.44$, $p<0.001$). Table 8.1. displays the means (and standard deviations) of the depression score for each of the three groups. The Newman-Keuls test revealed that Depressed patients had higher depression scores than the Parkinson's disease group ($t=-6.86$, $df=56$, $p<0.001$); and Controls ($t=9.88$, $df=56$, $p<0.001$); and the Parkinsonian patients had significantly higher Depression scores than the Control group ($t=3.11$, $df=56$ $p=0.003$). The mean Depression scores for each group indicated that the Control group fell into the region of "mild" or "minimal" depression (mean=3.0, sd=1.8), the Parkinsonian group had "moderate" depression scores (mean=5.9, sd=2.0) and the Depressed group had "severe" depression scores (mean=12.1, sd=4.1) on a possible range from 1 to 20 on the LPD.

The Depression score was correlated with each of the 12 facial measures in the entire sample and significant correlations (Spearman rho) were found for End-Lip Measure (r=0.36, p=0.002); Mouth-Width Measure (r=-0.27, p=0.02); Mid-Top-Lip Measure (r=0.30, p=0.01); Eye-Opening Measure (r=0.27, p=0.02); and Mid-Eyebrow Measure (r=0.23, p=0.04). When each group was considered separately no significant correlations between depression scores and face measures within the Parkinsonian or Control groups were found, but a significant negative association emerged between Depression scores and Mid-Eyebrow Measure (r=-0.49, p=0.014) in the Depressed group[3].

Two judges scored the frequency of smiling in the three groups from the videotapes made during the cartoon viewing sessions. Table 8.1. presents the means (and standard deviations) of the frequency of smiling for the three groups. There were significant group differences (F(2,55)=5.83, p=0.005), and a comparison of the means revealed that both the Parkinsonian (t=-2.38, df=55, p=0.03) and Depressed groups (t=-3.33, df=55, p=0.002) smiled less frequently than the Control group. To ascertain whether the Control group found the cartoons more amusing than either the Parkinsonian group or the Depressed group, an item analysis was performed on the ratings of "funniness" which each subject had given for each cartoon. No significant differences emerged between the three groups across the twelve cartoons. The frequency of smiling and Depression score were correlated and a significant negative

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3 A scatterplot was performed which clearly demonstrated the between group variation in the correlation of Mid-Eyebrow Measure (MEM) and Depression score. Firstly, the Control group obtained scores in the "mild" range for depression and had low MEM scores (ranging from -5 to 36). Secondly, the Parkinson's disease group had scores in the "moderate" range for depression and similarly had low scores for MEM (ranging from -13 to 30). The Depression group had Depression scores in the "severe" range with MER scores ranging from 6 to 72. The scatterplot also revealed a strong negative correlation between MEM and Depression score within the Depressed group. The positive correlation obtained between MEM and Depression score in the sample as a whole may indeed be an artifact of the fact that both the Parkinson and Control groups had scores which tended to cluster at the moderate to low end for both variables and the Depression group showed high scores for MEM when the Depression score was moderate and low scores for MEM when the Depression score was high, thus presenting a plot which showed a modest positive linear relationship between these two variables (r=0.23, p=0.04). The smaller group of depressed subjects showed a clear negative correlation (r=-0.49, p=0.014) which was unequivocally significant.

correlation was found (rho=-0.34, p=0.005) indicating that the frequency of smiling decreases as the Depression score increases.

8.4. Discussion

The main aim of this study was to compare the facial activity of Parkinsonian patients and Depressed patients with a Control group by examining the facial characteristics displayed by each group during a smile. The focus on smiling as opposed to other expressions such as fear, anger or disgust (which may be associated with depression), seems justified by the frequency with which this expression is used in everyday interactions to regulate relationships and the fact that it is a response which lends itself particularly to the conduct of ethically acceptable experimental investigations involving emotions. In addition, of course, it is the obvious expression on which to focus in any study concerned with depressive affect.

The findings revealed significant differences between the groups in the degree of smiling activity, with the Depressed group having higher scores on three measures: End-Lip Measure, Mid-Top-Lip Measure and Mid-Eyebrow Measure. End-Lip Measure represents the averaged distance between the outer corner of the mouth and the outer canthus of the eye on the left and right sides of the face. Mid-Top-Lip Measure is the averaged distance between the centre of the top lip and the inner canthi of the eyes for the left and right sides of the face. Mid-Eyebrow Measure is the vertical distance of the midpoint between the nostrils and the midpoint of a line joining the highest points of the right and left eyebrows. The Depressed group had higher scores on each of these measures than both the Parkinsonian and Control group, reflecting what is often referred to colloquially as a "long face", presumably resulting from a loss of facial muscle tone around the mouth in depressive individuals (Ekman & Friesen, 1975). However, depression also appears to be associated with increased tone in some facial areas, e.g. the contraction of the corrugator and frontalis muscles in the drawing together and elevation of the brows (Hjortsjö, 1969; Schwartz, Fair, Mandel, Salt, Mieske & Klerman, 1978). This may reflect the not uncommon co-existence of anxiety and anger with depression. Katsikitis and Pilowsky (1988) previously suggested that the difference in smiling intensity between the Parkinsonian and Control groups was due to the unresponsiveness of the muscles around the mouth, specifically, the levator labii superioris and zygomaticus minor, which are involved in raising the upper lip. In this study we support and extend the findings to include the elevators of the outer corners of the mouth, viz, the zygomaticus major, caninus and upper buccinator muscles (Hjortsjö, 1969).

The findings also demonstrate differences in the frequency of smiling between the three groups with the Parkinsonian and Depressed groups smiling less frequently than the Control group. These results are in keeping with the earlier finding (Katsikitis & Pilowsky, 1988) that the frequency of smiling in patients with Parkinson's disease was considerably less than in the Control group. Similarly, in this study, the differences cannot be attributed to a diminished appreciation of the cartoons' humour, but must be considered a possible manifestation of the disease process. As previously suggested, this finding may have major implications for the ability of these patients to communicate effectively with family, friends and medical staff.

Not unexpectedly, Depressed patients had higher Depression scores on the LPD than the Parkinson's and Control groups, falling into the "severe" range on a scale from one to twenty. The patients suffering from Parkinson's disease, in turn, had significantly higher Depression scores (in the "moderate" range), than the Control group whose mean fell in the "minimal" range. This is in keeping with earlier findings (Katsikitis & Pilowsky, 1988). Interestingly the Parkinsonian patients were not classified as either form of depressive syndrome, (as were the depressed patients) suggesting that the "moderate" Depression scores did not indicate a depressive "syndrome" but rather an affective state.

Significant correlations emerged between the Depression score and End-Lip Measure, Mouth-Width Measure, Mid-Top-Lip Measure, Eye-Opening Measure, and Mid-Eyebrow Measure in the population as a whole, which indicate that as the Depression score increases, the corners of the mouth and the upper lip are lowered, the mouth narrows, the eyes are opened, and the middle of the eyebrows are raised. It may be argued that the positive correlation between Eye-Opening Measure and the

Depression score is the direct result of the positive correlation between Mid-Eyebrow Measure and the Depression score because eye opening may be a consequence of the elevation of the eyebrows. However, if this was the case one would expect that the Top-Eyelid/Iris Intersect Measure would also correlate positively with the Depression score, but this was not so.

While no significant correlations emerged between the Depression score and the face measures within the Parkinson's Disease or Control groups, a significant negative correlation was found between Mid-Eyebrow Measure and Depression score in the Depressed group. The lowering of the middle of the eyebrow in depression has not generally been recognised as a characteristic movement of the eyebrow in this group of patients, although it has not gone completely unnoticed. Thus, Hjortsjö (1969) noted the separate actions of the procerus and depressor supercillii muscles in depressing the middle part of the eyebrow during the display of "*sad, mournful and tormented*" expressions (p. 81.) On the other hand, the degree of inner eyebrow separation (i.e. Inner-Eyebrow Separation Measure) are commonly emphasised as consistent features of the brow in depression (Ekman & Friesen, 1975; Izard, 1971).

The fact that the patients in this study were not severely depressed or immobilised as a group, and indeed were able to co-operate in a research project and displayed spontaneous smiles, may in part explain why the results did not support earlier findings of corrugator muscle involvement in depression (Schwartz, Fair, Mandel, Salt, Mieske & Klerman, 1978). It should also be recalled however, that Schwartz and his colleagues (1978) reported greater corrugator activity on the basis of electromyographic measures of changes which need not have manifested in visible facial movement. No significant correlation was found between the Depression score and Inner-Eyebrow Separation in any of the groups as was previously reported (Katsikitis & Pilowsky, 1988). Currently, the model does not generate a measure reflecting inner eyebrow movements in the vertical plane.

It may be argued that as patients were aware of the purpose of the study, the operation of demand charactersitics may have influenced our findings. Rinn (1984) noted that while Parkinson's disease sufferers were unable to spontaneously display facial expressions they had no difficulty in producing posed smiles on request. If this was the case and demand characteristics lead to more posed smiles, then one might have predicted the frequency of smiling for the Parkinson's disease group would not differ from that of the Control group. However these findings have shown that the Parkinson's and Depressed groups did not smile as frequently as the Control subjects.

8.5. Conclusion

The findings of this study suggest that the depressive affect of patients with Parkinsonism lies somewhere between that of normal individuals and patients with "psychiatric" depression. It would, therefore, not seem justified to equate the depression of Parkinsonian patients with that of clinically depressed patients. Whether the differences are qualitative or quantitative remains an open question.

This study has also shown that a microcomputer-based model can be useful in the quantification of the psychomotor functioning of the face. This approach may have a role in the objective assessment of changes in the clinical state of patients following therapeutic intervention, which might be expected to influence facial expressions and mobility. In addition, the more detailed study of the "dynamics" of the onset, peaking and offset of smiling may also provide useful information.

CONCLUSION

This thesis had three main objectives. The first objective was to present a review of the extensive facial expression literature with a focus on the theoretical and methodological issues relevant to the description of the varying patterns of facial activity during an emotional episode. A second aim was to describe the history, reliability and validity of a working model of the face which was designed to quantify facial expression. Thirdly, an attempt was made to extend the application of the model (1) to include a range of different expressions, and (2) to explore the facial actions of people in whom the facial expression of emotion is difficult, as a consequence of an ongoing clinical condition.

In approaching the first objective of this thesis, it was decided to focus on three controversial issues in the facial expression literature as a framework within which the review could be structured. Part 1 of this thesis, incorporating Chapters 1, 2, 3, and 4, presents a comprehensive literature review encompassing the theories of emotion and expression, the social and biological determinants of facial expression, and the methodology and measurement techniques used in the judgement of facial expression. These issues will be examined in turn.

Chapter 1 notes that over one-hundred years of research from various scientific disciplines such as psychology, physiology, ethology and anatomy have contributed to the solid foundations which currently exist for the study of the nature and phenomenology of emotion and its expression. In this chapter, the distinction between the categorical and the dimensional approaches to the study of the facial expression of emotion is introduced. While the former is theoretically based, the latter, although without an overarching theory, nonetheless has produced consistent and robust findings across a number of studies. The different emphases of these approaches have made a major contribution to the formulation of some of the more contemporary theories of the facial expression of emotion. Indeed, it is generally accepted that the structure of emotion involves neurophysiological, expressive/motor and subjective/cognitive components in the production of the different emotional states. The question still remains as to the boundaries, if they exist, amongst the different emotional groupings.

Chapter 2 presents the evidence for the opposing views concerning the social and biological determinants of the facial expression of emotion, from the comparative, developmental, and cross-cultural perspectives. The comparative approach has repeatedly associated many facial and postural actions seen in animals, to the expression of emotion in humans, indicative of phylogenetic continuity. Comparative evidence of this sort supports the superiority of biological influences in the production of facial expressions. The developmental approach comprising innate, maturational and learning perspectives adds fuel to the controversy. Support for an innate influence on the expression of emotion is found in studies with infants and the congenitally blind. In direct opposition to this view is the position adopted by the learning theorists who propose that facial expressions are learned responses to environmental stimuli. Similarly, the cross-cultural research presents conflicting evidence with regard to the existence of discrete and universally recognised facial expressions. Supporters of the biological/innate viewpoint explain these contradictory findings in terms of the operation of "display rules" within cultures, which may inhibit the expressive display of an emotion in a given situation.

The two most commonly used methodologies for the study of the facial expressions of emotion, namely, the judgement and component approaches, are described in Chapters 3 and 4 respectively. Chapter 3 outlines the judgement approach, in which the design usually involves the presentation of a series of facial expressions to a group of observers who are asked to judge the expression shown. This approach has attracted a number of researchers, mainly due to the ease with which such an experiment can be conducted.

On the contrary, the component approach, presented in Chapter 4, involves the formulation of measurement systems designed to differentiate between the emotions by focussing on the facial features which move during a facial display of emotion. The most widely used and comprehensive measurement techniques are anatomically focussed and rely on the expressive features of the face. These measurement systems have the distinct aim of classifying the emotions on the basis of facial muscular action.

Part 2 of this thesis (Chapters 5 and 6) describes a microcomputer-based method for quantifying facial expression, based on a mathematical model of the face. Chapter 5 presents the history of the development of the model. The following characteristics of the model are emphasised:

1. The model is able to produce distance measures which represent the distance between selected facial landmarks, thus making possible the investigation of their relationship to individual facial expressions.
2. Line drawing representations can be produced from a photograph or still image of the face, thus rendering the stimulus source anonymous with regard to age, sex, culture and social class.
3. Information from both sides of the face can be obtained independently.
4. The methodology is non-intrusive.
5. Minimal training time is required in the digitisation of the face.
6. The model is capable of tracking the dynamics of any facial measure over time.
7. There is high reliability of quantification.

Two experiments are reported in Chapter 6. These were designed firstly, to validate further the computer model and secondly, to examine the relationship between the ratings made of a set of smiling and neutral expressions to the distance measures derived from them.

In the first study, judges were shown forty photographs of smile and neutral expressions and forty line drawings derived from these photographs. The judges were asked to rate the degree of smiling displayed by each face. In the second study, the line drawings of the faces were presented. Both studies revealed significant differences between the ratings made of the smile and the neutral expressions. Furthermore, both studies revealed similar results with regard to the facial measures which were significant in influencing observer judgement. When using the facial measures as separate covariates, five mouth measures and one eye measure were found to discriminate significantly between the ratings made on smiling and neutral expressions. When entered as simultaneous covariates, only four mouth measures, namely, End-Lip Measure, Mouth-Width Measure, Mouth-Opening Measure and Lower-Lip Thickness Measure contributed to the differences found in the expression ratings of the first experiment. In the second study, where only line drawings were used as stimuli, a fifth mouth measure, namely Mid-Top-Lip Measure, also contributed to the differences found in the ratings of smile and neutral expressions.

The findings of Study 2 also demonstrated the differences in judgement ratings during the evolution of the smiling and neutral expressions over time. These findings revealed a greater variation in ratings for the different stages of smiling than there was for the equivalent stages of the neutral expression. Furthermore, the judges' ratings as to the degree of smiling varied for the individual encoders, indicating that the judges were able to perceive differences in the encoding abilities of the individuals. The third finding from the results of Study 2 was that significant gender differences existed in the decoding skills of the judges. Females used the extreme of the rating scale more confidently to judge an expression as a smile and especially so when the smiling expression was reaching its peak. This was also the case for the judgement of neutral expressions where females used the lower end of the rating scale more often than the males. This finding accords well with previous evidence indicating female superiority in the decoding of nonverbal cues (Hall, 1979).

Two important conclusions can be drawn from the findings reported in Chapter 6. Firstly, the line drawing representations of smiling and neutral expressions produce the same responses in the judges as the photographs from which they were derived. This has implications regarding the need for photographic stimuli in studies involving the recognition of facial expression. In other words, it appears that the additional information perceived in a face such as hair, skin colour, makeup, age, etc, are not necessary cues in the recognition of these expressions. Indeed, experimenters may wish to examine separately the influence of these variables. These findings also have implications for the reporting of results in scientific journals where the presentation of photographs is not desirable.

A second important finding concerns the configuration of those features which represent activity of the mouth, which when taken together, were significantly more important than others in predicting the mean rating score of the judges. The findings of this study support those of others showing the salience of the mouth in the judgement of smiling (Bassili, 1979; Boucher & Ekman, 1975).

The third part of this thesis explores the utility of the model with regard to the quantification of a number of different expressions, as well as its use as a measurement tool to assess change in the facial expressiveness of patients who, due to parkinsonism or depression, have difficulty in moving their facial muscles.

Chapter 7 examines the issues concerning the structure of emotion from both a categorical and a dimensional perspective, as a contribution to the debate reviewed in Chapter 1. Three studies were presented which attempted to extend the application of the computer model.

The first of these studies examined the validity of conceptualising six emotions (i.e. happiness, surprise, fear, disgust, anger and sadness) as "fundamental" and pan-cultural (Darwin,1872; Ekman & Friesen, 1971; Ekman, Sorenson & Friesen, 1969). A numerical taxonomy programme was used to classify posed representations of each "fundamental" expression, including neutral, using only the distance measures obtained from each expression. The purpose was to find whether the taxonomy programme would classify the faces into groups corresponding to the six "fundamental" expressions.

The second study asked the question whether human judges, rating photographs of the same faces from which the distance measures were derived for presentation to the taxonomy programme in the first study, would categorise them into the six "fundamental" expression groups.

The third study used the capability of the model to produce line drawings of faces to examine whether human judges would categorise faces with a result comparable to that achieved by the numerical taxonomy programme. The three studies will be discussed in turn.

The first study investigated whether each of the six fundamental expressions of emotion (Ekman & Friesen, 1975) have configurational properties which would result in their being grouped into classes by a classification programme. Twenty-three actors posed the six fundamental emotions of happiness, surprise, fear, disgust, anger, sadness and a neutral expression. Still images of these videotaped expressions were digitised and distance measures between facial landmark points were obtained. These measures were subjected to a numerical taxonomy procedure (SNOB) which generated five classes. Class 1 contained almost 70% of the happiness expressions. In Class 2 the majority of expressions were of surprise. Each of classes 3, 4 and 5 consisted of mixtures of emotions. Class 5 however, was distinguished from all other classes by the complete absence of happiness expressions.

The second study was designed to validate the results produced using numerical taxonomy by presenting the photographs of the posed expressions to a group of judges. Each rater was given a list of emotion categories comprising the six fundamental emotions, (with neutral added as an extra category), and were asked to allocate the photographs to these categories. It was found that that the judges were unable to place "correctly" the photographs into the set of discrete categories, except in the case of happiness and to some extent surprise. As the emotions were not classified into mutually exclusive categories, the judgement data were analysed from a dimensional perspective, using a multidimensional scaling procedure, in a further attempt to investigate the underlying structure of these emotional groups. A circular model consisting of two pivotal dimensions with the fundamental emotions located on the perimeter was produced. It was argued that these dimensions represented a "Pleasant-Unpleasant" and a "Facial Action" dimension respectively. The Pleasant-Unpleasant dimension consisted of happiness and surprise at one extreme with sadness, disgust and anger at the opposite end. The Facial Action dimension was described in terms of the actions of the features in the upper and lower parts of the face. Specifically, the role of the eye and eyebrow region for the recognition of surprise, fear, and sadness as opposed to the predominance of the mouth region in the recognition of happiness and disgust (Bassili, 1979; Boucher & Ekman, 1975;

Ekman, 1979). The salience of the mouth was also an important finding in Chapter 6, since raters distinguished between the smile and neutral expressions in terms of the distance measures reflecting mouth movement.

The third study described in Chapter 7 was a replication of the second study, except in one regard, viz, that line drawings rather than the photographs of the posed expressions were presented to a new group of judges. The same list of expressions was provided and the judges were asked to place each line drawing into one of the categories of happiness, surprise, fear, disgust, anger, sadness and neutral. The findings supported those in Study 2 with the resultant two-dimensional structure constructed in the form of a Pleasant-Unpleasant and a Facial Action dimension respectively. This provides further evidence that line drawings are a viable alternative to photographs in facial expression research.

These findings indicate the primacy of happiness among the emotional expressions. The three studies described in Chapter 7 found that happiness was the most readily recognised emotion, firstly in terms of its facial components as represented by distance measures and secondly in terms of its overall configurational properties, as shown in the judgement studies using either photographs or line drawings as stimuli. These studies support many others in which the emotion of happiness has been found to be the most readily recognised. For example, the evidence presented in Chapters 3 and 4 highlighted that both judgement and component analyses of facial expression consistently show that happiness is the most easily recognised expression and has the most distinctive facial characteristics. In other words, both holistic and componential approaches to the face produce similar judgements in the case of happiness.

It was also argued that the results of these studies may have implications for our understanding of the brain's function in the early development of the human infant as a social organism. The clustering of emotion categories and the importance of the mouth for the encoding and decoding of the happiness expression may suggest that part of the process of recognising facial expressions requires the brain to carry out what is essentially a taxonomic activity. This is in keeping with Sergent's (1986) assumption that recurring facial configurations created by the excursion of the facial features during the expression of an emotion provide the brain with unique information.

At the neurophysiological level, Perrett, Mistlin, Potter, Smith, Head, Chitty, Broennimann, Milner and Jeeves (1986) have reported the presence of specialised cells in the macaque temporal cortex whose function is to recognise faces. Furthermore they have isolated cells which recognise facial expression, regardless of identity and yet others which are sensitive to the mouth configuration. This supports Darwin's postulate as to the existence of unique and universal facial expressions, each of which is represented by a distinct facial configuration, the encoding and decoding of which may be subserved by innate neural processes. Thus classification may be regarded as the initial step in the process of recognising the expressive significance of facial configurations, providing the basis on which more refined processes for encoding and decoding emotional expression are developed in the course of maturation.

Chapter 8 demonstrates the use of the model in a clinical context. A study was conducted to compare the smiling behaviour of a group of Parkinson's disease sufferers, a group of patients with Major Depression, and a Control group of comparable age. Subjects were asked to view a series of amusing slides while their expressions were recorded. The most animated smile for each subject was chosen for analysis and the twelve distance measures were obtained. The Depressed group differed significantly from the other groups, with higher scores on End-Lip Measure, Mid-Top-Lip Measure and Mid-Eyebrow Measure. All subjects completed the Levine-Pilowsky Depression Questionnaire (Pilowsky, Levine & Boulton, 1969; Pilowsky & Spalding, 1972). The Depressed patients obtained higher Depression scores than the Parkinsonian group, who in turn had significantly higher Depression scores than the Control group. The Depression score was correlated with End-Lip Measure, Mouth-Width Measure Mid-Top-Lip Measure, Eye-Opening Measure, and Mid-Eyebrow Measure in the population as a whole. A significant negative correlation emerged between the Depression score and Mid-Eyebrow Measure in the Depressed group.

Both the Depressed group and the Parkinsonian group were found to smile significantly less often during the slide session when compared with the Control group. These results support earlier findings by Katsikitis and Pilowsky (1988) who used the model to quantify the smiling pattern of Parkinson's disease patients and found that this group differed from a Control group in the degree of movement of the muscles which open and close the mouth.

Given the salience of facial expressions, and in particular smiling, to the interpersonal communication of affect, the approach to the quantification of facial movement which has been described, may assist in the planning and monitoring of physiotherapeutic or rehabilitation programmes which are aimed at improving the patients' capacity to communicate emotional states more effectively. When it is considered that the presentation of an expressionless face may inhibit the facial expression and emotional state of others (Brown, 1982; Katsikitis & Pilowsky, 1988), it is not inconceivable that an improvement in this regard may offset at least one of the interpersonal variables which contribute to the development of depression in Parkinson's disease.

Pitcairn, Clemie, Gray and Pentland (1990) support the need for an objective method of assessing the relationship between a patient's mood, their facial expressions and body movement. They foresee one problem, however, with any programme designed to train the muscles of the face in patients with Parkinson's disease, because they note that such patients are able to pose voluntarily facial expressions on request. This suggests that any effective training programme must ensure that the neural process associated with non-spontaneous expressive gestures is not activated in preference to the previously neglected spontaneous pathways. The model described in this thesis would indeed be able to isolate those facial features which are indicative of posed expressions and thus be able to provide an objective assessment of spontaneous facial displays as they occur. In fact, one conceivable use of the model and the distance measures it produces, is to provide a clinical service to the neurology departments of general hospitals, as an objective assessment of clinical improvement in patients facing the variety of therapeutic interventions offered.

This thesis describes an approach to the quantification of facial expressions which shows considerable potential for use in a number of contexts. The following constitute a few possibilities:

1. The development and recognition of facial expression in children.
2. Exploration of the facial configurations of the less easily recognised negative emotions.
3. Establishing "cut-off" scores for the distance measures to indicate the likelihood of the presence of a particular expression.
4. Facial asymmetries.
5. Exploration of gender differences in the encoding and decoding of facial expression.
6. Effectiveness of substituting line drawings of facial expressions as stimuli presented to judges.
7. Facial expression in higher primates.
8. Evaluating the improvement in facial movement after neurological illnesses such as stroke or Bell's Palsy (paralysis of the facial nerve).
9. Monitoring brain activity (e.g. EEG patterns) of judges during a facial expression judgement task.
10. Monitoring brain activity during the display of facial expressions.
11. Assessing the emotional state in individuals unable to verbalise, for example, children.
12. Studying the dynamics of emotional displays, for example, smiling.
13. Evaluation of emotions in individuals unable to communicate adequately.

The study of the facial expression of emotion has long been concerned with capturing and quantifying the degree of movement in the face. This thesis describes a model which is capable of facilitating this process, so as to make the study of facial expression a more practicable exercise.

APPENDIX A

APPENDIX TO CHAPTER 6

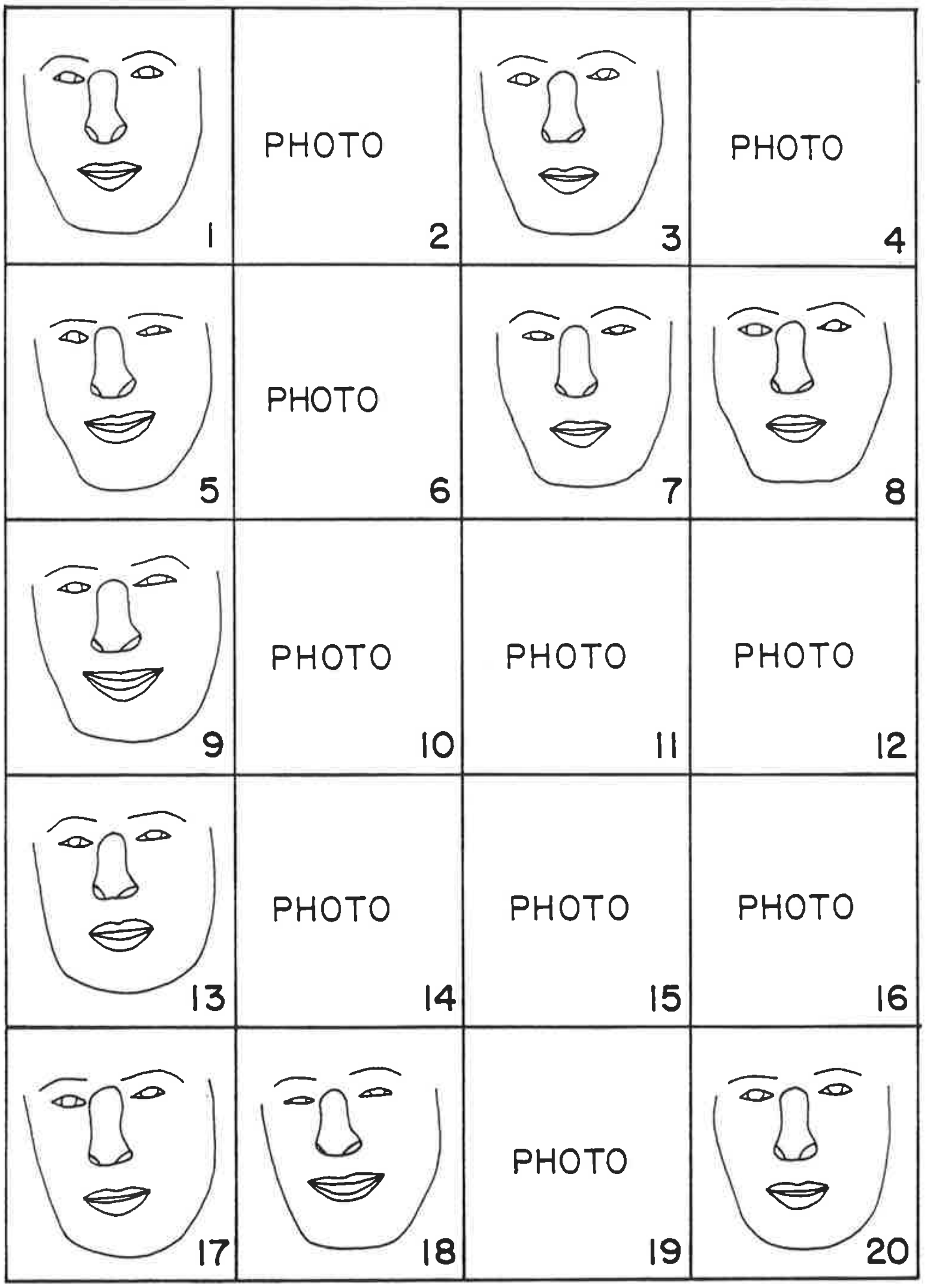
Appendix A.1: Random Ordering of Stimuli in Study 1

Slide Number	Encoder	Expression	Stage of Development	Mode of Presentation
1	1	neutral	1	line drawing
2	1	smile	2	photograph
3	1	neutral	5	line drawing
4	1	neutral	4	photograph
5	1	smile	4	line drawing
6	1	neutral	1	photograph
7	1	neutral	3	line drawing
8	1	neutral	2	line drawing
9	1	smile	3	line drawing
10	1	neutral	3	photograph
11	1	smile	4	photograph
12	1	neutral	2	photograph
13	1	smile	1	line drawing
14	1	smile	3	photograph
15	1	smile	5	photograph
16	1	smile	1	photograph
17	1	smile	5	line drawing
18	1	smile	2	line drawing
19	1	neutral	5	photograph
20	1	neutral	4	line drawing
21	2	smile	3	photograph
22	2	smile	5	photograph
23	2	smile	4	line drawing
24	2	neutral	2	photograph
25	2	neutral	5	line drawing
26	2	neutral	4	photograph
27	2	smile	3	line drawing
28	2	smile	4	photograph
29	2	neutral	3	photograph
30	2	neutral	1	photograph
31	2	neutral	3	line drawing
32	2	smile	5	line drawing
33	2	smile	1	photograph
34	2	neutral	1	line drawing
35	2	smile	1	line drawing
36	2	smile	2	line drawing
37	2	neutral	4	line drawing
38	2	smile	2	photograph
39	2	neutral	2	line drawing
40	2	neutral	5	photograph

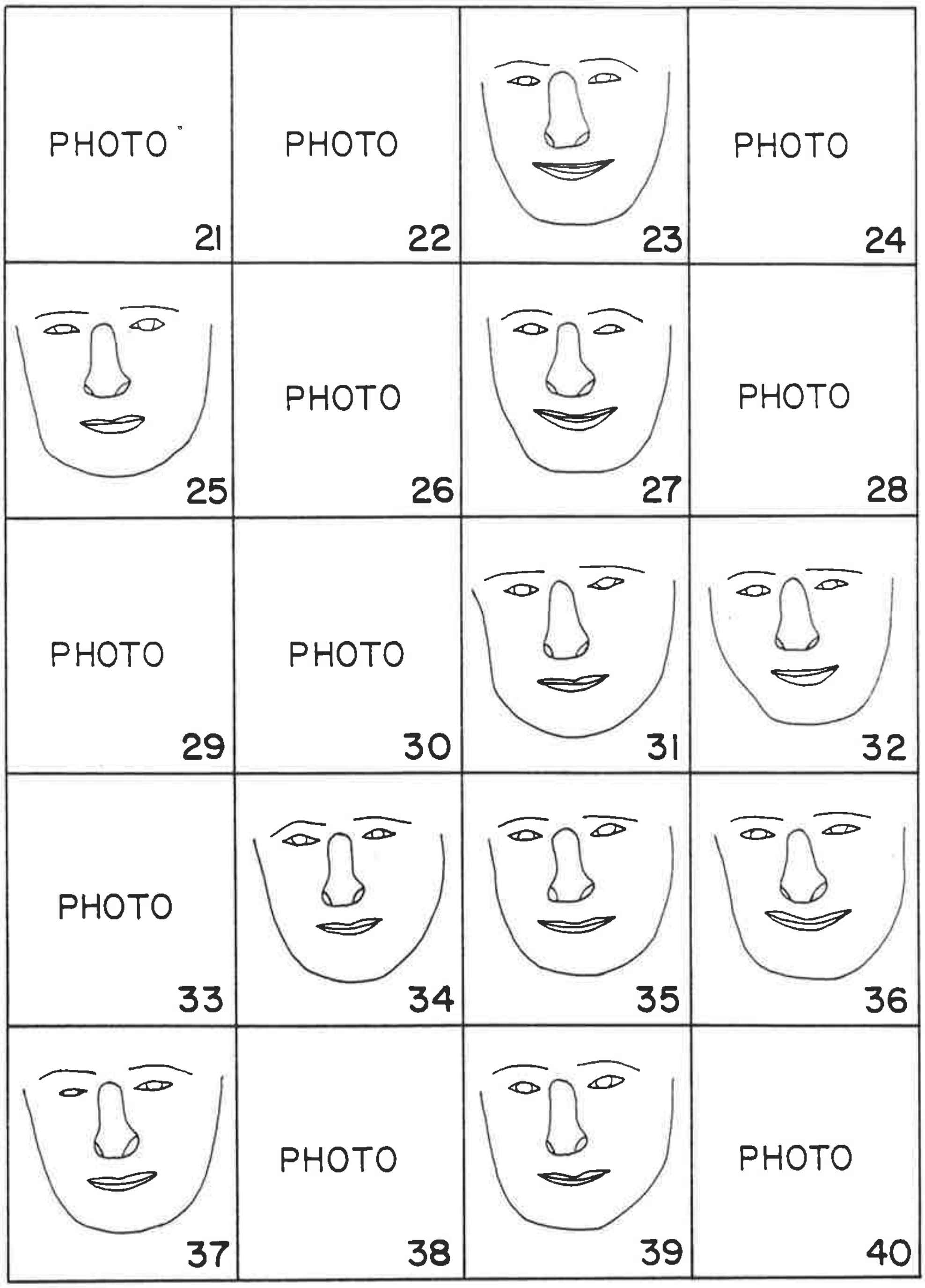
Appendix A.1: Continued..

41	3	smile	4	photograph
42	3	smile	3	photograph
43	3	neutral	1	line drawing
44	3	neutral	4	line drawing
45	3	neutral	5	photograph
46	3	smile	5	line drawing
47	3	neutral	4	photograph
48	3	smile	3	line drawing
49	3	neutral	1	photograph
50	3	neutral	2	line drawing
51	3	neutral	3	photograph
52	3	neutral	2	photograph
53	3	smile	4	line drawing
54	3	smile	2	photograph
55	3	smile	5	photograph
56	3	neutral	3	line drawing
57	3	smile	2	line drawing
58	3	smile	1	line drawing
59	3	smile	1	photograph
60	3	neutral	5	line drawing
61	4	neutral	3	photograph
62	4	neutral	2	photograph
63	4	smile	1	photograph
64	4	smile	5	line drawing
65	4	neutral	1	line drawing
66	4	smile	4	line drawing
67	4	smile	1	line drawing
68	4	smile	2	line drawing
69	4	neutral	5	line drawing
70	4	neutral	2	line drawing
71	4	neutral	5	photograph
72	4	smile	5	photograph
73	4	neutral	1	photograph
74	4	smile	3	photograph
75	4	smile	4	photograph
76	4	neutral	3	line drawing
77	4	smile	2	photograph
78	4	neutral	4	photograph
79	4	smile	3	line drawing
80	4	neutral	4	line drawing

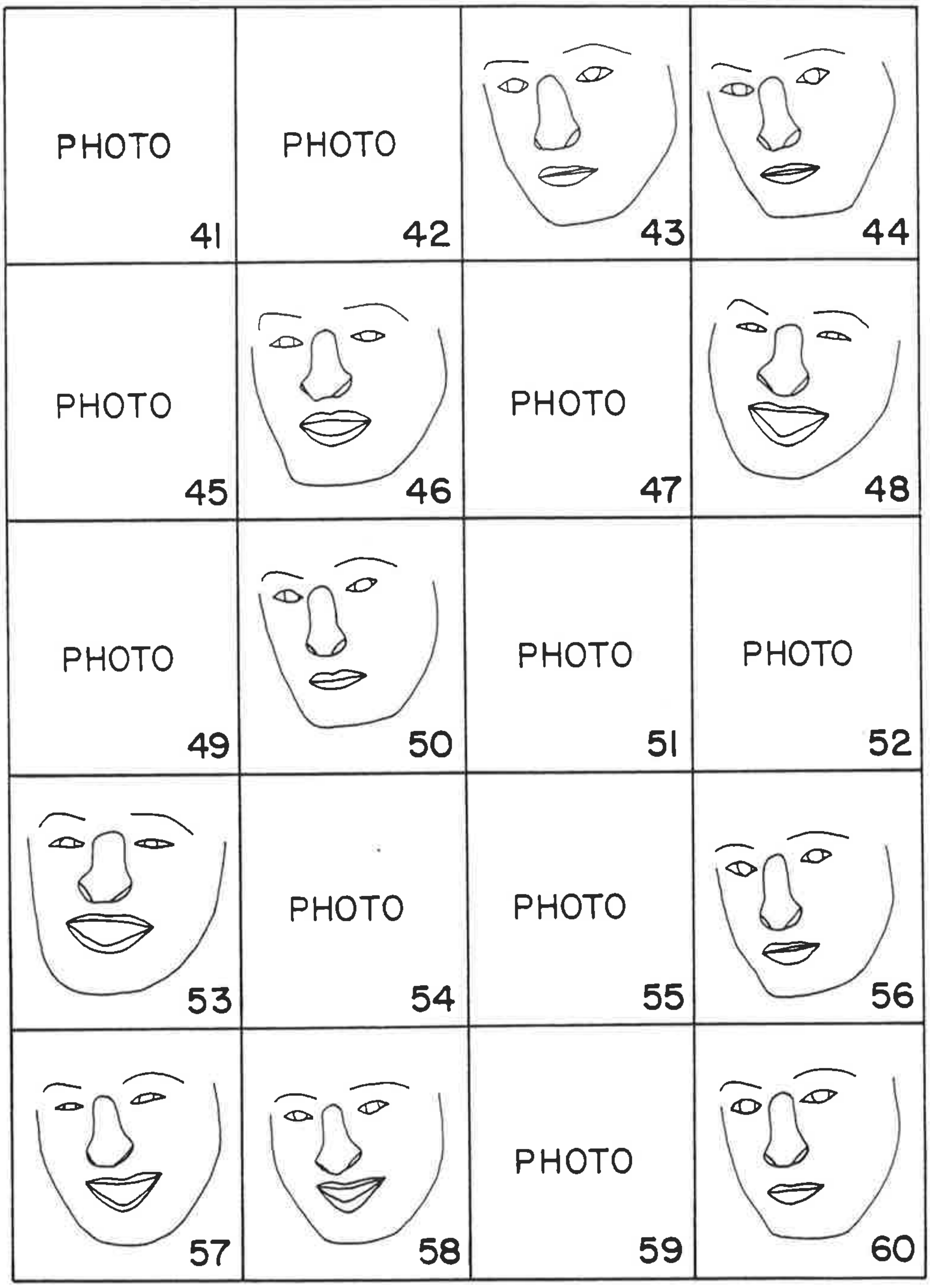
Appendix A.2: Stimuli as Presented to the Subjects in Study 1



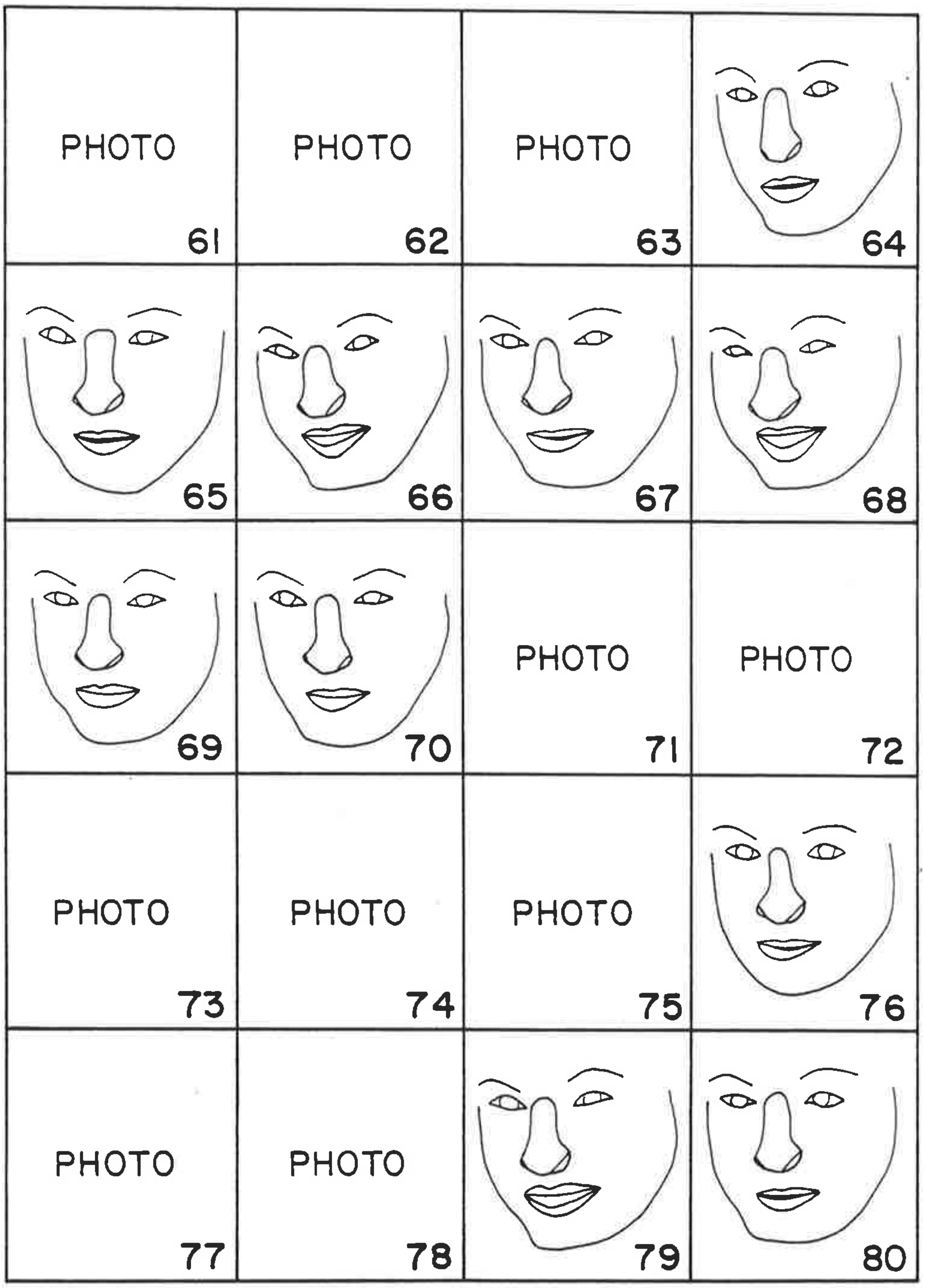
Appendix A.2. Continued..



Appendix A.2. Continued..



Appendix A.2. Continued..



Appendix A.3: Mean Ratings (and standard deviations) for Degree of Smiling on Four Encoders' Faces Presented in Two Modes for the Entire Group in Study 1 (N=354)

Expression	Mode	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1					
Stage 1	Line Dr.	4.36 (1.61)	7.33 (1.30)	7.91 (1.06)	6.59 (1.35)
Stage 2	Line Dr.	8.15 (1.02)	8.51 (1.15)	8.61 (0.83)	7.27 (1.33)
Stage 3	Line Dr.	8.53 (0.87)	8.36 (1.00)	8.63 (1.01)	7.89 (1.14)
Stage 4	Line Dr.	7.27 (1.30)	7.34 (1.29)	8.18 (1.14)	7.86 (1.13)
Stage 5	Line Dr.	5.45 (1.29)	7.13 (1.35)	6.90 (1.73)	7.47 (1.26
NEUTRAL 1					
Stage 1	Line Dr.	6.01 (1.42)	2.83 (1.53)	2.51 (1.38)	4.05 (1.67)
Stage 2	Line Dr.	4.64 (1.44)	2.72 (1.51)	1.93 (1.25)	3.58 (1.56)
Stage 3	Line Dr.	4.27 (1.49)	3.27 (1.46)	3.42 (1.36)	4.60 (1.68)
Stage 4	Line Dr.	3.01 (1.56)	3.18 (1.63)	2.52 (1.38)	4.08 (1.67)
Stage 5	Line Dr.	5.09 (1.49)	3.31 (1.49)	2.29 (1.35)	3.93 (1.51)
SMILE 2					
Stage 1	Real Face	4.40 (1.52)	7.91 (1.13)	7.93 (1.10)	6.58 (1.28)
Stage 2	Real Face	7.68 (1.34)	8.63 (1.02)	8.68 (0.88)	7.73 (1.19)
Stage 3	Real Face	8.58 (0.95)	8.16 (1.27)	8.89 (0.68)	8.04 (1.05)
Stage 4	Real Face	7.78 (1.21)	7.86 (1.17)	8.69 (0.82)	8.12 (1.07)
Stage 5	Real Face	4.29 (1.66)	7.30 (1.34)	6.72 (1.18)	8.11 (1.03)
NEUTRAL 2					
Stage 1	Real Face	4.40 (1.52)	3.09 (1.40)	2.19 (1.34)	5.02 (1.53)
Stage 2	Real Face	3.12 (1.51)	3.09 (1.49)	2.36 (1.32)	5.39 (1.44)
Stage 3	Real Face	3.48 (1.57)	2.87 (1.43)	2.59 (1.38)	5.43 (1.38)
Stage 4	Real Face	2.98 (1.57)	3.01 (1.46)	2.40 (1.49)	4.59 (1.62)
Stage 5	Real Face	2.44 (1.41)	2.96 (1.46)	2.46 (1.34)	5.03 (1.59)

Appendix A.4: Multivariate Analysis of Variance Showing the Significant Main and Interaction Effects for the Within-Subjects Factors in Study 1 (N=354)

FACTORS	F	SIGNIFICANCE OF F
ENCODER	203.02	0.00
MODE OF PRESENTATION	0.00	0.989
FACIAL EXPRESSION	5325.25	0.00
STAGE OF DEVELOPMENT	1010.36	0.00
ENCODER BY MODE OF PRESENTATION	273.15	0.00
ENCODER BY FACIAL EXPRESSION	1142.86	0.00
ENCODER BY STAGE OF DEVELOPMENT	185.69	0.00
MODE OF PRESENTATION BY FACIAL EXPRESSION	36.32	0.00
MODE OF PRESENTATION BY STAGE OF DEVELOPMENT	79.04	0.00
FACIAL EXPRESSION BY STAGE OF DEVELOPMENT	1222.17	0.00
ENCODER BY MODE OF PRESENTATION BY FACIAL EXPRESSION	167.48	0.00
ENCODER BY MODE OF PRESENTATION BY STAGE OF DEVELOPMENT	96.92	0.00
ENCODER BY FACIAL EXPRESSION BY STAGE OF DEVELOPMENT	510.13	0.00
MODE OF PRESENTATION BY FACIAL EXPRESSION BY STAGE OF DEVELOPMENT	32.46	0.00
ENCODER BY MODE OF PRESENTATION BY FACIAL EXPRESSION BY STAGE OF DEVELOPMENT	25.06	0.00

Appendix A.5: Random Ordering of Stimuli in Study 2*

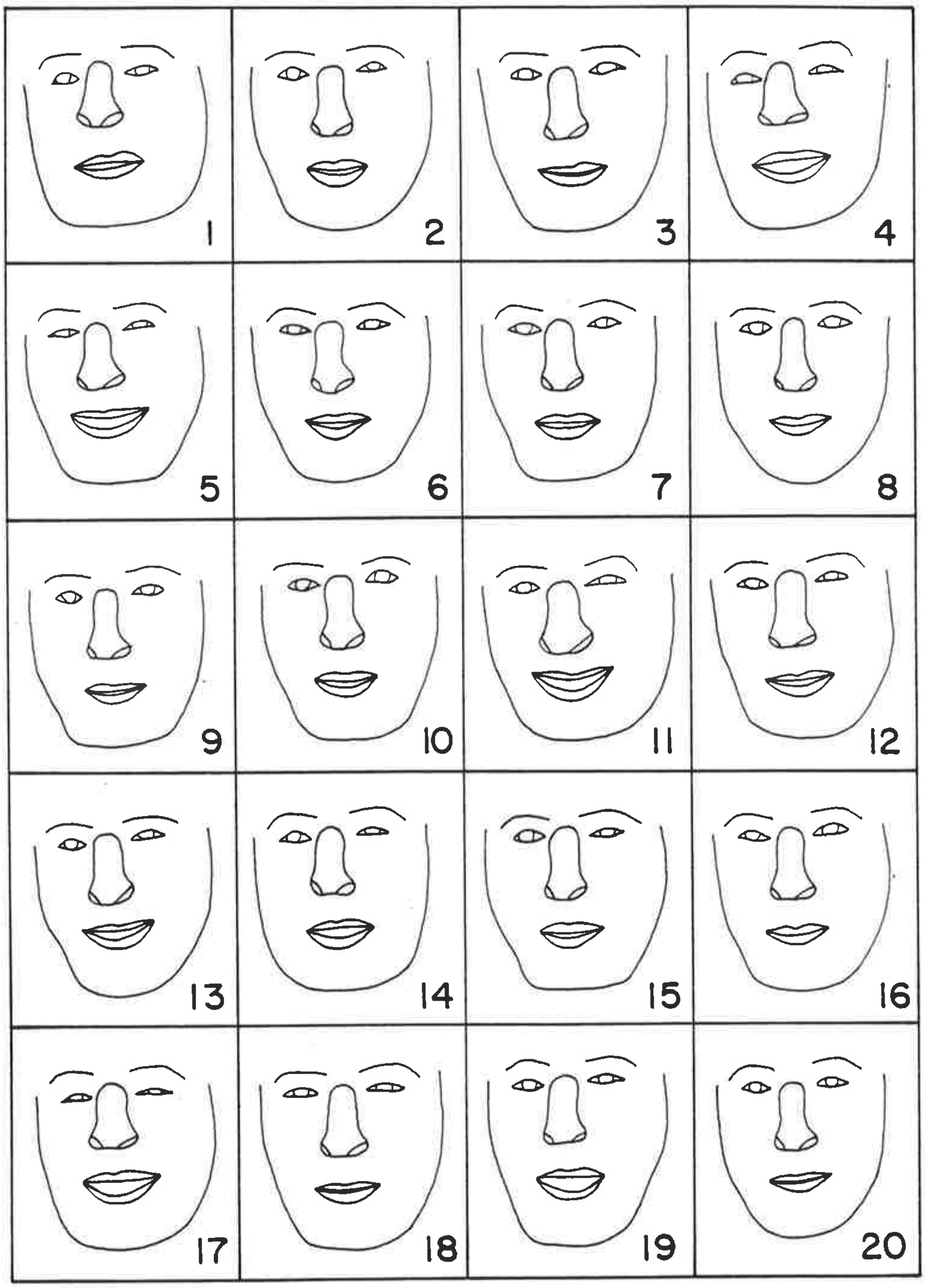
Slide Number	Encoder	Expression	Stage of Development
1	1	smile 2	5
2	1	neutral 1	5
3	1	smile 2	1
4	1	smile 2	4
5	1	smile 1	2
6	1	neutral 1	1
7	1	neutral 1	3
8	1	neutral 2	5
9	1	neutral 2	4
10	1	neutral 1	4
11	1	smile 1	3
12	1	smile 1	5
13	1	smile 1	4
14	1	smile 1	1
15	1	neutral 1	2
16	1	neutral 2	3
17	1	smile 2	3
18	1	neutral 2	1
19	1	smile 2	2
20	1	neutral 2	2
21	2	smile 2	4
22	2	smile 1	3
23	2	neutral 2	3
24	2	smile 2	1
25	2	neutral 1	2
26	2	neutral 1	1
27	2	neutral 1	4
28	2	smile 2	2
29	2	smile 2	3
30	2	smile 2	5
31	2	neutral 2	4
32	2	neutral 2	2
33	2	smile 1	4
34	2	neutral 1	3
35	2	neutral 2	5
36	2	smile 1	5
37	2	neutral 1	5
38	2	neutral 2	1
39	2	smile 1	2
40	2	smile 1	1

Appendix A.5: Continued..

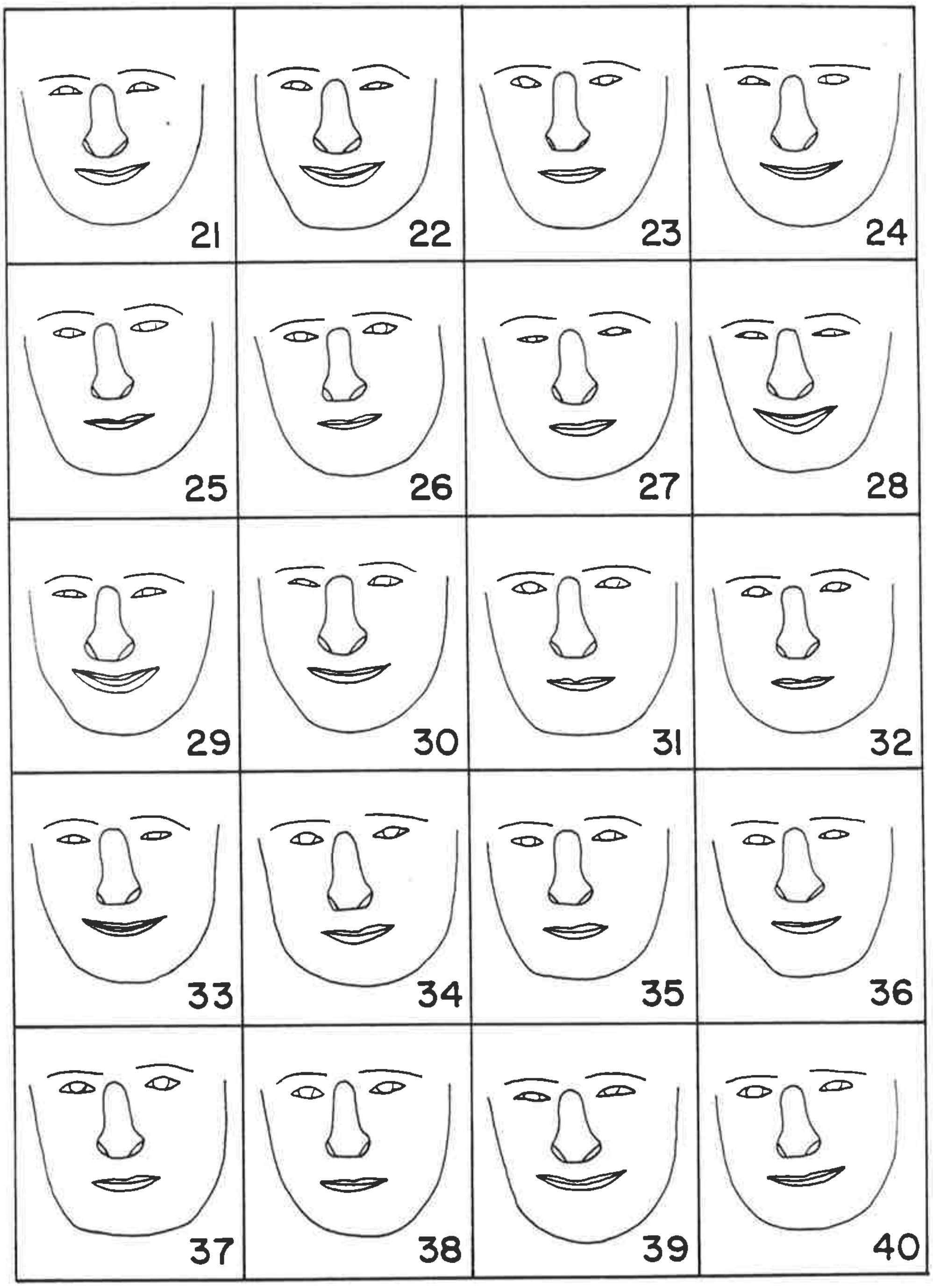
41	3	smile 1	1
42	3	smile 2	5
43	3	smile 2	2
44	3	smile 2	1
45	3	smile 1	2
46	3	neutral 2	3
47	3	neutral 1	3
48	3	neutral 2	4
49	3	smile 1	3
50	3	smile 2	3
51	3	neutral 1	2
52	3	neutral 1	5
53	3	neutral 2	2
54	3	smile 1	5
55	3	neutral 1	4
56	3	neutral 1	1
57	3	smile 1	4
58	3	neutral 2	1
59	3	neutral 2	5
60	3	smile 2	4
61	4	neutral 1	1
62	4	neutral 1	3
63	4	neutral 2	4
64	4	neutral 2	1
65	4	smile 2	4
66	4	smile 1	4
67	4	smile 2	3
68	4	neutral 1	5
69	4	smile 1	1
70	4	neutral 2	5
71	4	neutral 1	4
72	4	neutral 2	2
73	4	neutral 2	3
74	4	neutral 1	2
75	4	smile 2	5
76	4	smile 1	3
77	4	smile 1	2
78	4	smile 2	2
79	4	smile 1	5
80	4	smile 2	1

*Note: all stimuli are line drawings in Study 2.

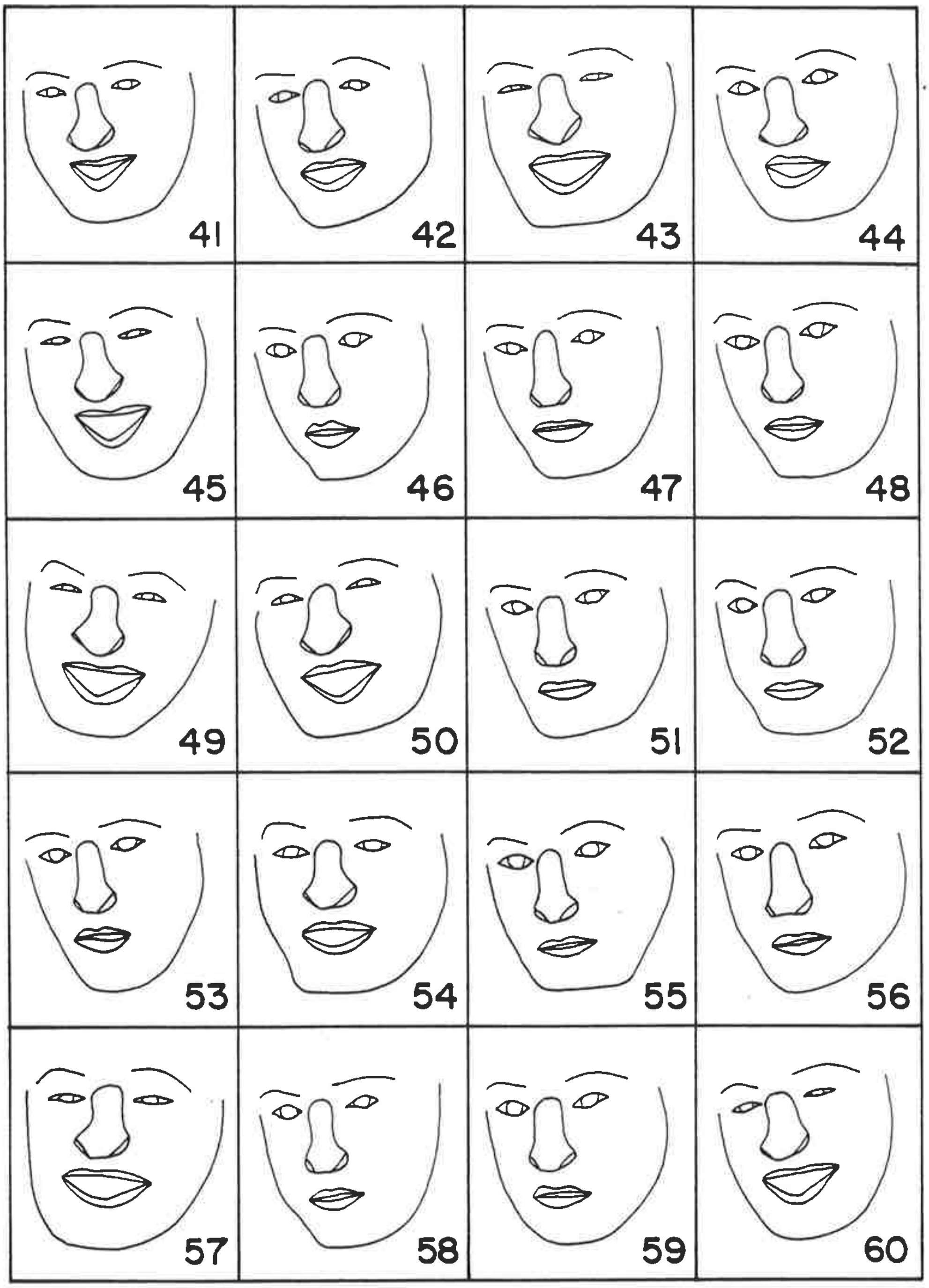
Appendix A.6: Stimuli as Presented to Subjects in Study 2



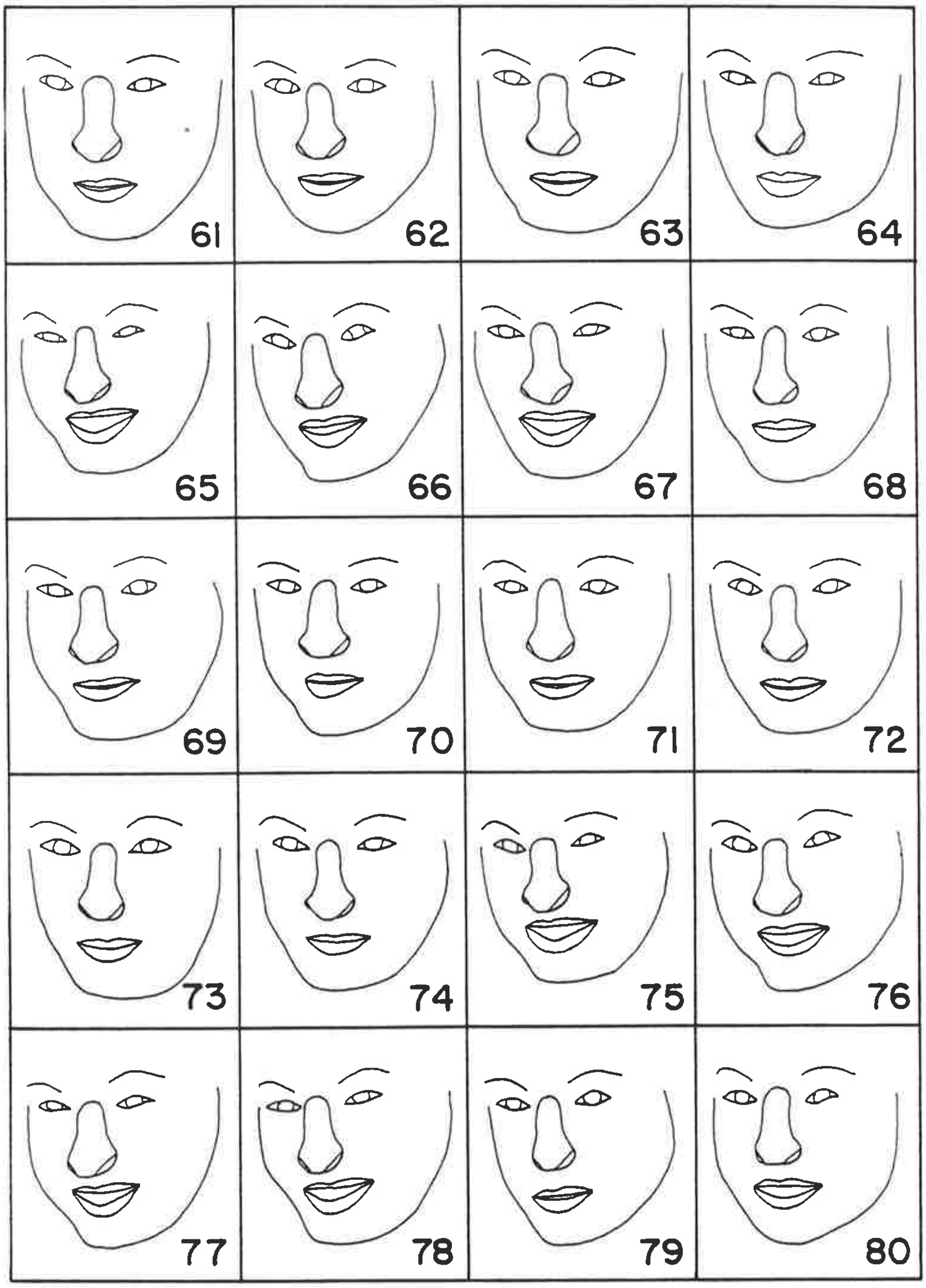
Appendix A.6. Continued..



Appendix A.6. Continued..



Appendix A.6. Continued..



Appendix A.7: Mean Ratings (and standard deviations) for Degree of Smiling on Four Encoders' Faces Presented in Two Modes for the Entire Group in Study 2 (N=208)

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1				
Stage 1	4.99 (1.66)	6.96 (1.38)	7.78 (1.40)	5.41 (1.71)
Stage 2	8.30 (1.15)	7.68 (1.47)	7.44 (1.87)	7.91 (1.30)
Stage 3	8.60 (1.05)	7.41 (1.28)	8.25 (1.52)	7.51 (1.40)
Stage 4	6.93 (1.23)	6.44 (1.51)	7.64 (1.87)	7.54 (1.24)
Stage 5	5.94 (1.31)	5.26 (1.61)	7.31 (1.34)	3.89 (1.63)
SMILE 2				
Stage 1	4.85 (2.05)	6.85 (1.52)	6.90 (1.73)	6.49 (1.58)
Stage 2	5.71 (2.04)	8.10 (1.38)	7.48 (1.85)	8.01 (1.24)
Stage 3	8.07 (1.41)	8.03 (1.20)	7.80 (1.72)	8.16 (1.22)
Stage 4	7.64 (1.41)	7.12 (1.38)	7.90 (1.63)	8.23 (1.15)
Stage 5	4.24 (1.79)	6.66 (1.48)	6.10 (2.00)	4.14 (1.81)
NEUTRAL 1				
Stage 1	5.01 (1.55)	3.23 (1.56)	2.22 (1.19)	4.08 (1.54)
Stage 2	4.38 (1.56)	4.10 (1.71)	1.45 (0.88)	3.83 (1.55)
Stage 3	3.64 (1.64)	4.64 (1.60)	2.42 (1.49)	5.08 (1.55)
Stage 4	3.67 (1.60)	4.06 (1.80)	2.76 (1.46)	3.65 (1.70)
Stage 5	4.26 (1.73)	3.04 (1.53)	2.05 (1.20)	4.23 (1.64)
NEUTRAL 2				
Stage 1	3.68 (1.71)	2.83 (1.60)	2.29 (1.21)	4.38 (1.68)
Stage 2	5.22 (1.60)	3.50 (1.74)	2.98 (1.32)	2.88 (1.54)
Stage 3	3.41 (1.69)	4.11 (1.59)	2.35 (1.44)	3.72 (1.54)
Stage 4	3.87 (1.76)	3.09 (1.68)	2.16 (1.34)	4.97 (1.48)
Stage 5	4.01 (1.72)	3.58 (1.76)	2.95 (1.54)	3.15 (1.67)

Appendix A.8: Multivariate Analysis of Variance Showing the Main Effect of SEX and the Interaction Effects for the Between-Subjects and Within-Subjects Variance in Study 2

FACTORS	F	DF	SIGNIFICANCE OF F
Between-subjects			
main effect of SEX	0.17	1, 206	ns
Interaction effects			
SEX BY ENCODER	2.61	3, 618	ns
SEX BY FACIAL EXPRESSION	12.43	1, 206	p=0.001
SEX BY STAGE OF DEVELOPMENT	4.26	4, 824	p=0.002
SEX BY ENCODER BY FACIAL EXPRESSION	0.07	3, 618	ns
SEX BY ENCODER BY STAGE OF DEVELOPMENT	0.60	12, 2472	ns
SEX BY FACIAL EXPRESSION BY STAGE OF DEVELOPMENT	5.77	4, 824	p<0.001
SEX BY ENCODER BY FACIAL EXPRESSION BY STAGE OF DEVELOPMENT	1.81	12, 2472	p=0.041

Appendix A.9: Standardised Values for END-LIP MEASURE, Presented Separately for each Encoder, Expression and Developmental Stage of the Expression*

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1				
Stage 1	56.8	26.4	22.1	36.2
Stage 2	34.3	16.1	20.3	23.7
Stage 3	25.1	17.9	20.2	31.7
Stage 4	31.7	21.0	30.8	32.8
Stage 5	49.4	29.3	37.0	32.8
NEUTRAL 1				
Stage 1	46.6	33.7	45.9	39.3
Stage 2	46.0	34.6	45.0	36.6
Stage 3	50.6	31.3	43.6	35.8
Stage 4	44.4	30.3	44.5	36.9
Stage 5	48.1	38.1	39.6	38.4
SMILE 2				
Stage 1	46.1	19.8	35.4	38.7
Stage 2	52.2	17.2	28.1	25.8
Stage 3	48.1	15.3	31.0	28.9
Stage 4	63.6	16.6	23.3	27.8
Stage 5	69.8	19.3	29.1	27.4
NEUTRAL 2				
Stage 1	45.2	42.7	45.0	37.4
Stage 2	41.3	36.7	48.5	40.1
Stage 3	53.1	36.8	48.9	43.0
Stage 4	45.3	36.8	48.4	38.4
Stage 5	45.7	38.8	50.5	38.0

*Note: The facial measures have the same values in Study 1 and 2.

Appendix A.10: Averaged Standardised Smile and Neutral Scores for END-LIP MEASURE in Study 2 (N=208)

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	51.5	23.1	28.8	37.5
Stage 2	43.3	16.7	24.2	24.8
Stage 3	36.6	16.6	25.6	20.3
Stage 4	47.7	18.8	27.1	30.3
Stage 5	59.6	24.3	33.1	30.1
NEUTRAL				
Stage 1	45.9	38.2	45.5	38.4
Stage 2	43.7	35.7	46.8	38.4
Stage 3	51.9	34.1	46.3	39.4
Stage 4	44.9	33.6	46.5	37.7
Stage 5	46.9	38.5	45.1	38.2

Appendix A.11: Standardised Values for MOUTH-WIDTH MEASURE, Presented Separately for each Encoder, Expression and Developmental Stage of the Expression

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1				
Stage 1	43.9	61.7	58.6	35.2
Stage 2	68.3	74.9	65.0	44.7
Stage 3	60.8	74.9	65.3	48.5
Stage 4	59.3	70.8	65.8	45.1
Stage 5	41.8	51.7	49.2	45.1
NEUTRAL 1				
Stage 1	36.4	42.0	25.9	23.4
Stage 2	37.3	49.8	34.4	26.9
Stage 3	35.7	50.5	28.8	29.6
Stage 4	34.8	46.4	33.2	24.0
Stage 5	32.9	37.3	34.0	29.1
SMILE 2				
Stage 1	39.8	69.3	46.4	42.6
Stage 2	44.8	69.3	66.2	46.5
Stage 3	67.9	74.6	69.9	49.5
Stage 4	65.5	67.0	71.3	54.6
Stage 5	50.7	68.3	54.9	52.2
NEUTRAL 2				
Stage 1	30.7	41.8	32.1	24.0
Stage 2	40.8	41.4	33.2	30.2
Stage 3	38.3	44.1	29.6	23.3
Stage 4	35.6	40.2	28.5	29.8
Stage 5	31.2	39.3	28.3	23.5

Appendix A.12: Averaged Standardised Smile and Neutral Scores for MOUTH-WIDTH MEASURE in Study 2

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	41.9	65.5	52.5	38.9
Stage 2	56.6	72.1	65.6	45.6
Stage 3	64.4	74.8	67.6	49.0
Stage 4	62.4	68.9	68.6	49.9
Stage 5	46.3	60.0	52.1	48.7
NEUTRAL				
Stage 1	33.6	41.9	29.0	21.7
Stage 2	39.1	45.6	33.8	28.6
Stage 3	38.3	47.3	29.2	26.5
Stage 4	37.8	48.3	30.9	26.9
Stage 5	32.2	38.3	31.2	26.3

Appendix A.13: Standardised Values for MOUTH-OPENING MEASURE, Presented Separately for each Encoder, Expression and Developmental Stage of the Expression

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1				
Stage 1	26.8	02.3	45.9	03.6
Stage 2	36.9	01.1	71.6	45.5
Stage 3	30.9	06.8	75.9	36.9
Stage 4	28.9	07.2	70.9	31.4
Stage 5	19.8	02.3	49.2	31.4
NEUTRAL 1				
Stage 1	20.9	03.4	06.6	06.9
Stage 2	16.9	00.4	02.3	03.4
Stage 3	13.6	00.4	10.7	04.5
Stage 4	14.2	03.5	08.0	06.9
Stage 5	14.2	00.7	02.3	01.5
SMILE 2				
Stage 1	03.9	01.1	44.2	36.9
Stage 2	47.7	24.7	79.5	38.4
Stage 3	46.0	16.9	87.6	43.0
Stage 4	50.5	00.0	75.1	51.1
Stage 5	20.7	02.2	59.7	47.9
NEUTRAL 2				
Stage 1	03.3	00.8	12.3	02.3
Stage 2	03.9	03.5	17.6	04.5
Stage 3	01.1	03.4	15.9	02.2
Stage 4	04.7	03.4	14.0	03.5
Stage 5	01.1	03.4	12.1	04.7

Appendix A.14: Averaged Standardised Smile and Neutral Scores for MOUTH-OPENING MEASURE in Study 2

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	15.4	1.7	33.9	20.3
Stage 2	41.3	12.9	75.6	41.9
Stage 3	38.5	11.9	81.8	39.9
Stage 4	39.7	3.6	73.0	41.3
Stage 5	25.3	2.3	54.5	39.7
NEUTRAL				
Stage 1	12.1	2.1	9.5	4.6
Stage 2	10.4	2.0	10.0	3.9
Stage 3	7.4	1.9	13.3	3.4
Stage 4	9.5	3.5	11.0	5.2
Stage 5	7.7	2.1	7.2	3.1

Appendix A.15: Standardised Values for MID-TOP-LIP MEASURE, Presented Separately for each Encoder, Expression and Developmental Stage of the Expression

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1				
Stage 1	69.8	46.5	23.6	30.4
Stage 2	55.5	37.4	19.3	12.7
Stage 3	43.1	39.0	17.4	16.9
Stage 4	45.8	41.4	24.7	19.8
Stage 5	66.7	49.5	27.5	19.8
NEUTRAL 1				
Stage 1	55.5	46.8	39.5	34.1
Stage 2	53.2	51.9	37.6	30.6
Stage 3	61.6	46.5	32.4	33.1
Stage 4	54.5	44.2	38.5	34.2
Stage 5	60.9	51.9	32.2	32.8
SMILE 2				
Stage 1	65.1	41.5	20.7	25.2
Stage 2	66.3	40.0	20.5	12.8
Stage 3	69.9	35.5	21.6	12.9
Stage 4	93.3	33.9	19.4	10.7
Stage 5	91.0	31.5	19.2	13.5
NEUTRAL 2				
Stage 1	62.6	56.1	38.2	34.0
Stage 2	56.7	50.9	38.2	41.0
Stage 3	68.8	48.3	41.0	40.8
Stage 4	62.0	52.8	33.2	34.7
Stage 5	61.8	52.5	35.7	30.0

Appendix A.16: Averaged Standardised Smile and Neutral Scores for MID-TOP-LIP MEASURE in Study 2

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	68.0	44.0	22.2	27.8
Stage 2	60.9	38.7	19.9	12.3
Stage 3	56.5	37.3	19.5	14.9
Stage 4	69.6	37.7	22.2	15.3
Stage 5	78.8	40.5	23.4	16.7
NEUTRAL				
Stage 1	59.0	51.5	38.9	34.1
Stage 2	55.0	51.4	37.9	35.8
Stage 3	65.2	47.4	36.7	36.9
Stage 4	53.3	48.5	35.9	34.5
Stage 5	61.4	52.2	33.9	31.4

Appendix A.17: Standardised Values for MID-LOWER-LIP MEASURE, Presented Separately for each Encoder, Expression and Developmental Stage of the Expression

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1				
Stage 1	42.9	18.4	26.6	15.9
Stage 2	36.8	14.5	33.9	21.6
Stage 3	29.6	18.1	34.9	23.2
Stage 4	30.6	18.6	40.1	21.0
Stage 5	36.9	19.5	32.9	21.0
NEUTRAL 1				
Stage 1	33.7	19.1	23.0	18.8
Stage 2	33.4	19.1	20.4	17.3
Stage 3	34.9	17.9	21.0	18.5
Stage 4	31.7	18.9	21.7	19.6
Stage 5	34.4	20.2	18.2	18.1
SMILE 2				
Stage 1	30.5	15.7	29.6	26.4
Stage 2	46.7	23.6	38.8	20.8
Stage 3	51.5	19.3	42.2	23.2
Stage 4	61.9	12.9	34.8	23.7
Stage 5	51.0	12.5	29.1	23.9
NEUTRAL 2				
Stage 1	29.0	22.5	24.3	17.2
Stage 2	28.4	20.1	26.2	19.9
Stage 3	32.0	20.0	27.9	21.5
Stage 4	30.8	20.8	24.1	19.3
Stage 5	29.4	22.8	24.2	18.8

Appendix A.18: Averaged Standardised Smile and Neutral Scores for MID-LOWER-LIP MEASURE in Study 2

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	36.7	17.1	28.1	21.2
Stage 2	41.8	19.1	36.4	21.2
Stage 3	40.6	18.7	38.6	23.2
Stage 4	46.3	15.8	37.5	22.4
Stage 5	49.1	16.0	31.0	22.5
NEUTRAL				
Stage 1	31.4	20.8	28.7	18.0
Stage 2	30.9	19.6	23.3	16.6
Stage 3	33.5	18.9	24.5	20.0
Stage 4	31.3	19.9	22.9	19.5
Stage 5	31.9	21.5	21.2	18.5

Appendix A.19: Standardised Values for TOP-LIP THICKNESS MEASURE, Presented Separately for each Encoder, Expression and Developmental Stage of the Expression.

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1				
Stage 1	73.4	44.1	72.6	65.5
Stage 2	70.2	84.8	69.3	52.2
Stage 3	68.9	65.6	57.2	63.7
Stage 4	63.5	46.4	41.6	63.2
Stage 5	57.8	35.2	58.4	63.2
NEUTRAL 1				
Stage 1	65.0	41.1	36.6	48.5
Stage 2	70.2	42.2	48.7	55.0
Stage 3	65.9	44.1	33.7	61.1
Stage 4	76.6	40.9	33.7	55.5
Stage 5	75.1	32.1	36.6	64.1
SMILE 2				
Stage 1	67.5	60.7	49.1	44.5
Stage 2	61.4	52.2	52.1	59.7
Stage 3	78.8	60.3	52.4	59.4
Stage 4	69.4	55.5	42.8	56.9
Stage 5	80.8	42.1	30.4	57.3
NEUTRAL 2				
Stage 1	65.1	35.9	31.0	54.2
Stage 2	70.8	28.3	40.1	58.0
Stage 3	67.9	31.4	34.0	64.2
Stage 4	57.0	28.3	43.4	65.8
Stage 5	64.9	41.5	34.1	52.7

Appendix A.20: Averaged Standardised Smile and Neutral Scores for TOP-LIP-THICKNESS MEASURE in Study 2

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	70.5	52.4	60.9	55.0
Stage 2	65.8	68.5	60.7	55.9
Stage 3	73.9	62.9	54.8	61.6
Stage 4	61.5	50.9	42.2	60.0
Stage 5	69.3	38.7	44.4	60.3
NEUTRAL				
Stage 1	55.1	38.5	33.8	51.4
Stage 2	70.5	35.3	44.4	56.5
Stage 3	66.9	37.8	33.9	62.7
Stage 4	66.8	34.6	38.6	60.7
Stage 5	70.0	36.8	35.4	58.4

Appendix A.21: Standardised Values for LOWER-LIP THICKNESS MEASURE, Presented Separately for each Encoder, Expression and Developmental Stage of the Expression

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1				
Stage 1	67.9	28.4	52.7	68.8
Stage 2	41.4	30.5	39.3	54.2
Stage 3	48.6	41.2	43.5	46.3
Stage 4	48.5	30.4	34.9	53.9
Stage 5	61.2	37.8	48.9	53.9
NEUTRAL 1				
Stage 1	64.4	24.1	56.8	58.1
Stage 2	54.5	30.4	54.7	58.2
Stage 3	61.3	36.6	60.6	56.0
Stage 4	61.3	37.1	51.7	62.7
Stage 5	56.8	41.1	64.5	64.5
SMILE 2				
Stage 1	58.4	37.0	51.2	57.5
Stage 2	47.1	33.3	40.9	65.7
Stage 3	52.0	36.8	29.0	51.5
Stage 4	46.0	42.5	40.5	50.2
Stage 5	57.6	37.6	41.8	50.5
NEUTRAL 2				
Stage 1	50.8	41.7	46.9	70.2
Stage 2	48.3	30.2	75.2	63.7
Stage 3	63.1	39.6	68.0	73.0
Stage 4	55.2	35.2	61.8	65.1
Stage 5	54.5	28.8	54.6	69.7

Appendix A.22: Averaged Standardised Smile and Neutral Scores for LOWER-LIP-THICKNESS MEASURE in Study 2

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	63.7	32.7	51.9	61.5
Stage 2	44.3	31.9	40.1	59.9
Stage 3	50.3	39.0	36.3	46.9
Stage 4	47.3	36.5	37.7	52.1
Stage 5	59.4	37.7	45.4	52.2
NEUTRAL				
Stage 1	57.6	32.9	51.9	64.2
Stage 2	51.4	30.3	64.9	60.9
Stage 3	62.2	38.1	64.3	64.5
Stage 4	58.8	36.2	56.8	63.9
Stage 5	55.7	34.9	59.6	67.1

Appendix A.23: Standardised Values for EYE-OPENING MEASURE, Presented Separately for each Encoder, Expression and Developmental Stage of the Expression

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1				
Stage 1	52.6	50.4	50.3	52.3
Stage 2	39.2	37.3	34.4	49.3
Stage 3	43.2	41.7	27.6	60.3
Stage 4	42.5	34.4	39.6	61.7
Stage 5	48.7	43.9	47.2	61.7
NEUTRAL 1				
Stage 1	53.0	51.5	60.0	55.4
Stage 2	50.0	47.3	67.9	57.8
Stage 3	49.6	46.4	63.1	63.0
Stage 4	56.2	27.0	73.1	53.7
Stage 5	53.3	52.0	61.9	50.3
SMILE 2				
Stage 1	51.6	40.3	67.7	57.5
Stage 2	57.1	27.0	28.3	44.3
Stage 3	32.5	35.9	43.3	51.6
Stage 4	50.4	38.3	32.8	48.0
Stage 5	59.4	33.2	46.5	51.5
NEUTRAL 2				
Stage 1	47.5	48.0	69.2	58.1
Stage 2	49.9	55.3	67.6	62.0
Stage 3	59.7	50.0	68.6	60.9
Stage 4	55.1	53.6	68.6	58.1
Stage 5	57.5	48.2	68.4	53.2

Appendix A.24: Averaged Standardised Smile and Neutral Scores for EYE-OPENING MEASURE in Study 2

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	52.1	45.4	59.0	54.9
Stage 2	48.2	32.2	31.4	46.8
Stage 3	37.9	38.8	35.5	55.9
Stage 4	46.5	36.4	36.2	54.9
Stage 5	54.1	38.2	46.9	56.6
NEUTRAL				
Stage 1	50.3	49.8	64.6	56.8
Stage 2	50.0	51.3	67.8	59.9
Stage 3	54.7	48.2	70.9	61.9
Stage 4	55.7	40.3	65.3	55.9
Stage 5	55.4	50.1	68.8	51.8

Appendix A.25: Standardised Values for TOP-EYELID/IRIS INTERSECT MEASURE, Presented Separately for each Encoder, Expression and Developmental Stage of the Expression

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1				
Stage 1	81.7	81.5	81.9	89.2
Stage 2	90.9	74.2	71.4	88.3
Stage 3	81.9	79.2	62.3	85.4
Stage 4	75.3	78.2	57.1	82.4
Stage 5	77.7	83.2	79.9	82.4
NEUTRAL 1				
Stage 1	80.2	75.7	82.0	73.2
Stage 2	81.0	74.7	80.9	84.1
Stage 3	81.0	93.4	78.9	85.0
Stage 4	81.1	75.1	87.4	79.5
Stage 5	86.5	89.0	90.3	81.9
SMILE 2				
Stage 1	76.2	74.1	78.0	79.1
Stage 2	82.1	74.0	72.8	83.3
Stage 3	71.5	68.5	76.8	84.0
Stage 4	87.6	80.3	68.5	86.2
Stage 5	94.5	83.8	78.9	87.5
NEUTRAL 2				
Stage 1	76.9	77.3	99.2	83.5
Stage 2	74.6	93.8	99.8	81.6
Stage 3	79.2	90.9	86.5	76.1
Stage 4	81.2	85.9	81.3	83.3
Stage 5	79.7	81.0	90.0	86.5

Appendix A.26: Averaged Standardised Smile and Neutral Scores for TOP-EYELID/IRIS INTERSECT MEASURE in Study 2

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	79.0	77.8	79.9	84.2
Stage 2	87.5	74.1	72.1	85.8
Stage 3	81.7	73.9	69.6	84.7
Stage 4	81.5	79.3	62.8	84.3
Stage 5	86.1	83.5	79.4	84.9
NEUTRAL				
Stage 1	78.6	76.5	90.6	78.4
Stage 2	77.8	84.3	90.4	82.9
Stage 3	80.1	92.2	82.7	80.6
Stage 4	81.2	80.5	84.4	81.4
Stage 5	83.1	85.0	90.2	84.2

Appendix A.27: Standardised Values for LOWER-EYELID/IRIS INTERSECT MEASURE, Presented Separately for each Encoder, Expression and Developmental Stage of the Expression

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1				
Stage 1	60.9	65.8	78.4	70.8
Stage 2	63.7	62.2	71.7	77.2
Stage 3	73.7	62.0	56.6	70.3
Stage 4	59.7	68.7	51.1	78.0
Stage 5	66.1	72.2	66.6	78.0
NEUTRAL 1				
Stage 1	57.5	64.2	42.1	56.8
Stage 2	72.9	65.2	61.4	57.5
Stage 3	47.2	63.1	53.1	68.1
Stage 4	50.5	44.8	57.8	57.4
Stage 5	41.6	57.7	58.6	49.5
SMILE 2				
Stage 1	62.8	79.3	64.5	70.1
Stage 2	65.3	76.9	53.4	78.4
Stage 3	57.1	66.8	66.2	60.5
Stage 4	78.5	71.7	66.1	75.4
Stage 5	65.8	77.8	79.6	77.2
NEUTRAL 2				
Stage 1	70.7	58.2	51.4	67.4
Stage 2	52.8	52.3	49.2	56.5
Stage 3	42.9	52.0	54.5	47.7
Stage 4	45.0	45.9	44.3	58.0
Stage 5	54.3	62.6	60.4	68.5

Appendix A.28: Averaged Standardised Smile and Neutral Scores for LOWER-EYELID/IRIS INTERSECT MEASURE in Study 2

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	61.8	72.6	71.5	70.5
Stage 2	64.5	69.6	62.6	77.8
Stage 3	65.4	64.4	61.4	65.4
Stage 4	69.1	70.2	56.6	76.7
Stage 5	66.0	75.0	73.1	77.6
NEUTRAL				
Stage 1	64.1	61.2	46.8	62.1
Stage 2	62.9	58.8	55.3	57.0
Stage 3	45.1	57.6	53.8	57.9
Stage 4	47.8	45.4	51.1	57.7
Stage 5	48.0	60.2	59.5	59.0

Appendix A.29: Standardised Values for INNER-EYEBROW SEPARATION MEASURE, Presented Separately for each Encoder, Expression and Developmental Stage of the Expression

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1				
Stage 1	45.4	35.0	57.1	74.7
Stage 2	54.6	16.7	63.2	82.5
Stage 3	38.9	37.1	68.2	77.9
Stage 4	37.1	33.2	80.5	76.6
Stage 5	50.0	33.3	78.2	76.6
NEUTRAL 1				
Stage 1	35.4	24.5	54.7	79.1
Stage 2	36.8	29.4	58.0	73.0
Stage 3	43.9	40.8	57.6	69.1
Stage 4	59.7	40.3	51.7	77.2
Stage 5	41.5	32.3	54.3	73.2
SMILE 2				
Stage 1	40.7	28.9	65.7	87.3
Stage 2	61.9	26.4	58.1	69.1
Stage 3	64.1	23.5	78.1	74.3
Stage 4	60.6	30.2	68.0	86.8
Stage 5	77.6	36.6	83.5	76.0
NEUTRAL 2				
Stage 1	38.2	35.2	53.3	87.5
Stage 2	68.9	28.0	49.1	69.3
Stage 3	51.3	35.0	45.7	69.1
Stage 4	56.2	18.6	70.7	69.0
Stage 5	40.3	28.4	69.4	80.9

Appendix A.30: Averaged Standardised Smile and Neutral Scores for INNER-EYEBROW SEPARATION MEASURE in Study 2

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	43.1	31.9	61.4	81.0
Stage 2	58.3	21.6	60.7	75.8
Stage 3	51.5	30.3	73.2	76.1
Stage 4	48.9	31.7	74.3	81.7
Stage 5	63.8	34.9	80.9	76.3
NEUTRAL				
Stage 1	36.8	29.8	54.0	83.3
Stage 2	52.8	28.7	53.6	71.2
Stage 3	47.6	37.9	51.7	69.1
Stage 4	58.0	29.5	61.2	73.1
Stage 5	40.9	30.4	61.9	77.1

Appendix A.31: Standardised Values for MID-EYEBROW MEASURE, Presented Separately for each Encoder, Expression and Developmental Stage of the Expression

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE 1				
Stage 1	46.4	10.0	37.4	40.1
Stage 2	38.1	15.0	35.5	33.7
Stage 3	31.6	20.1	43.7	41.3
Stage 4	19.0	16.3	51.7	42.9
Stage 5	36.5	13.4	60.4	42.9
NEUTRAL 1				
Stage 1	30.2	14.5	40.2	36.7
Stage 2	27.9	21.7	39.5	41.6
Stage 3	32.9	12.3	39.5	36.4
Stage 4	21.6	17.4	42.4	35.2
Stage 5	25.5	12.9	38.3	40.7
SMILE 2				
Stage 1	32.3	07.6	44.8	50.1
Stage 2	34.0	20.3	46.9	33.1
Stage 3	54.8	18.5	49.4	37.6
Stage 4	69.3	12.7	39.2	41.2
Stage 5	63.6	15.9	40.6	41.1
NEUTRAL 2				
Stage 1	29.8	19.7	36.3	37.3
Stage 2	30.9	14.2	33.7	40.1
Stage 3	35.3	16.9	37.4	43.7
Stage 4	31.7	13.3	45.0	39.1
Stage 5	26.2	18.6	44.7	31.3

Appendix A.32: Averaged Standardised Smile and Neutral Scores for MID-EYEBROW MEASURE in Study 2

Expression	Encoder 1	Encoder 2	Encoder 3	Encoder 4
SMILE				
Stage 1	39.9	8.8	41.1	45.1
Stage 2	36.2	17.2	41.2	33.4
Stage 3	43.2	19.3	46.6	39.5
Stage 4	44.2	14.5	45.5	42.1
Stage 5	50.1	14.7	50.5	42.0
NEUTRAL				
Stage 1	30.0	17.1	38.3	37.0
Stage 2	29.4	17.9	36.6	40.9
Stage 3	34.1	14.6	38.5	40.1
Stage 4	31.7	15.4	43.7	37.2
Stage 5	25.9	16.8	41.5	36.0

APPENDIX B

APPENDIX TO CHAPTER 7

Appendix B.1: Actor Membership to Classes Generated by the SNOB Programme*

Class Number	Class Membership
1 (n = 18)	110, 210, 310, 410, 610, 710, 810, 910, 1010, 1020, 1310, 1410, 1510, 1610, 1820, 1910, 2110, 2210
2 (n = 13)	220, 520, 720, 1120, 1260, 1420, 1810, 2020, 2220, 2310, 2320, 2330, 2340
3 (n = 13)	120, 130, 150, 160, 350, 510, 540, 1710, 2010, 2040, 2050, 2060, 2070
4 (n = 59)	230, 240, 250, 260, 270, 320, 330, 420, 430, 440, 450, 470, 530, 550, 620, 670, 730, 740, 750, 760, 770, 820, 830, 840, 860, 870, 920, 930, 950, 1030, 1110, 1130, 1140, 1160, 1170, 1210, 1220, 1230, 1240, 1250, 1270, 1360, 1520, 1530, 1620, 1630, 1640, 1650, 1660, 1670, 1830, 1920, 1930, 1960, 2120, 2230, 2240, 2250, 2370
5 (n = 57)	140, 170, 360, 370, 460, 560, 570, 630, 640, 650, 660, 850, 940, 960, 970, 1040, 1050, 1060, 1070, 1150, 1320, 1330, 1340, 1350, 1370, 1430, 1440, 1450, 1460, 1470, 1540, 1550, 1560, 1570, 1720, 1730, 1740, 1750, 1760, 1770, 1840, 1850, 1860, 1870, 1940, 1950, 1970, 2030, 2130, 2140, 2150, 2160, 2170, 2260, 2270, 2350, 2360

*Note: Class membership No.=110 denotes actor One's happiness expression; No.120=actor One's surprise; No.130=actor One's fear; No. 140=actor One's disgust; No. 150=actor One's anger; No. 160=actor One's sadness; No. 170=actor One's neutral etc..

Appendix B.2: Random Ordering of Actors' Expressions Used as Stimuli in Study 2 (Photographs) and Study 3 (Line Drawings)

Stimulus Number	Actor Number	Sex of Actor	Expression
1	11	male	happiness
2	22	female	disgust
3	5	female	surprise
4	9	female	surprise
5	3	male	happiness
6	12	male	anger
7	12	male	surprise
8	6	male	surprise
9	8	female	fear
10	16	female	neutral
11	9	female	neutral
12	13	male	surprise
13	5	female	disgust
14	9	female	sadness
15	12	male	fear
16	6	male	happiness
17	22	female	happiness
18	4	female	anger
19	11	male	anger
20	4	female	happiness
21	2	female	sadness
22	6	male	anger
23	13	male	anger
24	7	male	fear
25	20	male	happiness
26	10	female	fear
27	11	male	surprise
28	3	male	fear
29	7	male	disgust
30	10	female	sadness
31	4	female	fear
32	16	female	fear
33	6	male	neutral
34	3	male	sadness
35	2	female	disgust
36	4	female	surprise
37	7	male	sadness
38	8	female	sadness
39	2	female	fear
40	7	male	anger

Appendix B.2: Continued..

41	10	female	neutral
42	10	female	happiness
43	2	female	happiness
44	1	male	anger
45	3	male	anger
46	2	female	surprise
47	13	male	happiness
48	5	female	sadness
49	6	male	sadness
50	11	male	disgust
51	12	male	disgust
52	8	female	disgust
53	8	female	surprise
54	7	male	surprise
55	2	female	anger
56	6	male	disgust
57	1	male	fear
58	5	female	happiness
59	11	male	neutral
60	13	male	disgust
61	5	female	neutral
62	12	male	sadness
63	5	female	anger
64	2	female	neutral
65	9	female	happiness
66	1	male	sadness
67	19	male	neutral
68	4	female	sadness
69	8	female	neutral
70	4	female	disgust
71	8	female	anger
72	18	female	anger
73	10	female	surprise
74	11	male	sadness
75	19	male	happiness
76	23	female	neutral
77	5	female	fear
78	8	female	happiness
79	1	male	happiness
80	11	male	anger

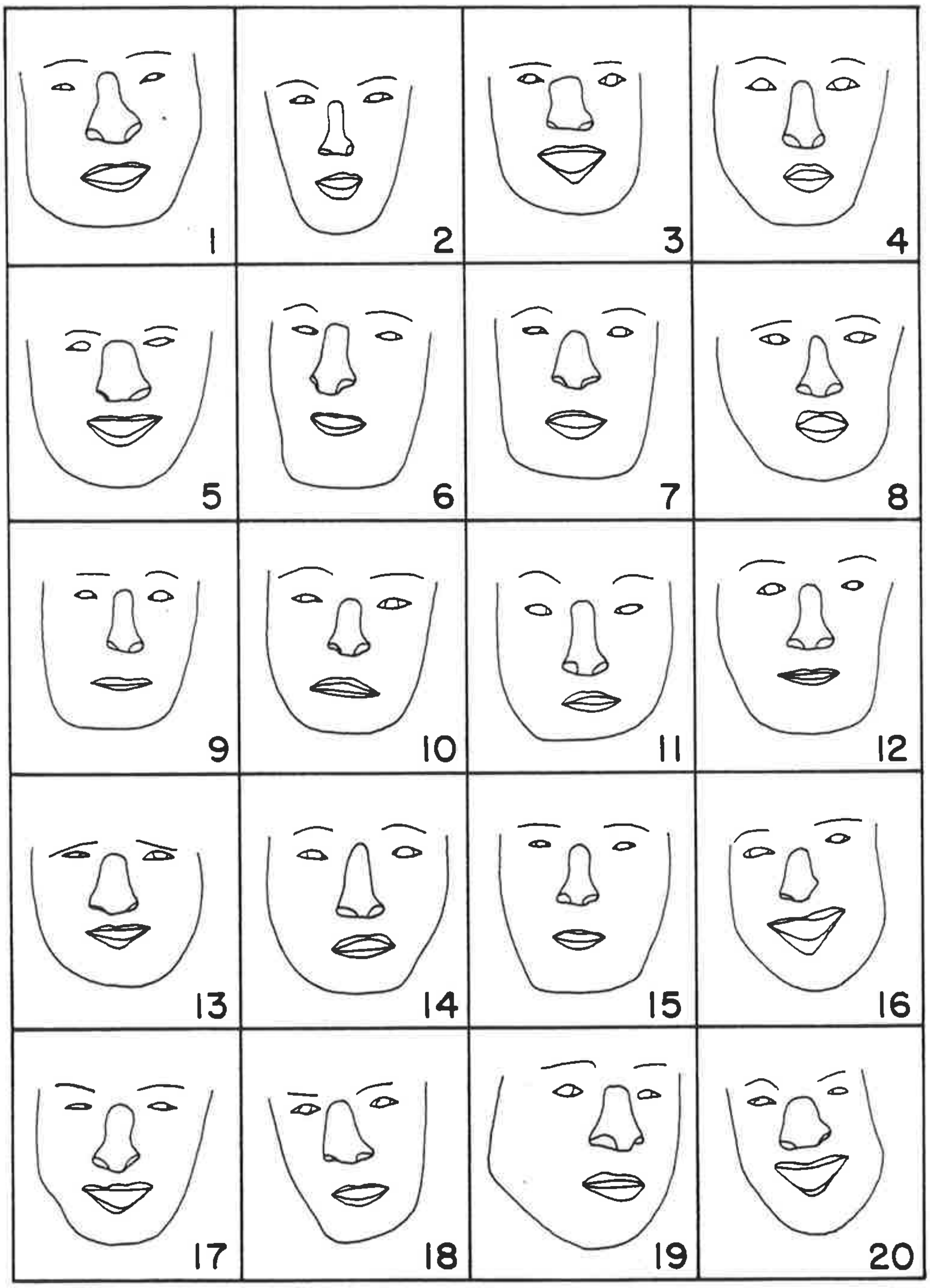
Appendix B.2: Continued..

81	9	female	disgust
82	6	male	fear
83	14	female	neutral
84	9	female	fear
85	4	female	neutral
86	12	male	neutral
87	7	male	happiness
88	3	male	disgust
89	7	male	neutral
90	1	male	surprise
91	3	male	neutral
92	3	male	surprise
93	12	male	happiness
94	10	female	anger
95	10	female	disgust
96	1	male	disgust
97	13	male	fear
98	9	female	anger
99	1	male	neutral
100	13	male	sadness
101	20	male	neutral
102	20	male	surprise
103	16	female	sadness
104	18	female	happiness
105	15	female	happiness
106	17	male	happiness
107	15	female	surprise
108	22	female	surprise
109	23	female	fear
110	17	male	sadness
111	22	female	sadness
112	19	male	disgust
113	18	female	neutral
114	21	female	disgust
115	20	male	fear
116	15	female	disgust
117	22	female	anger
118	20	male	disgust
119	19	male	surprise
120	13	male	neutral

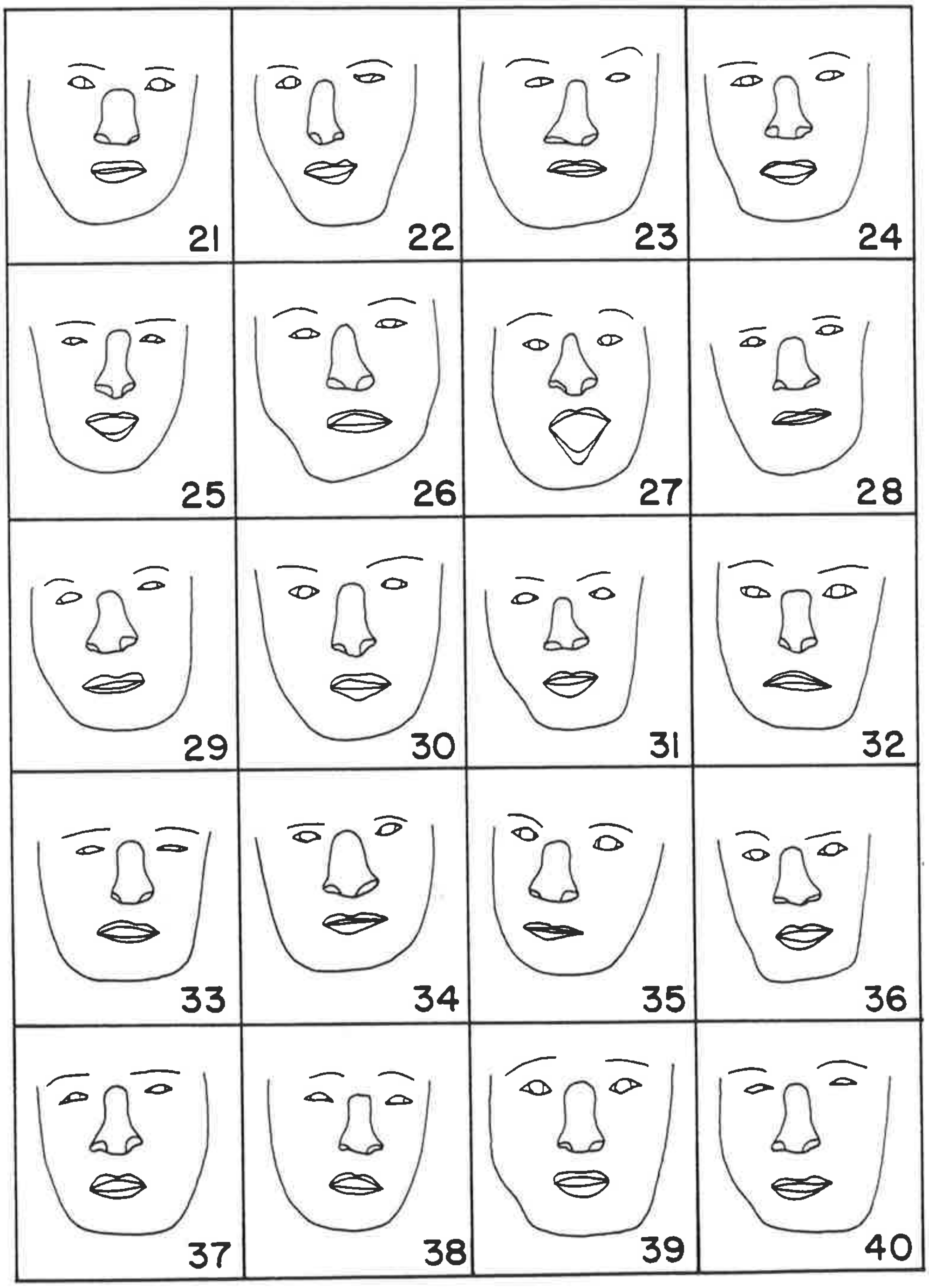
Appendix B.2: Continued..

121	17	male	disgust
122	18	female	fear
123	16	female	disgust
124	14	female	sadness
125	23	female	surprise
126	16	female	anger
127	21	female	anger
128	20	male	sadness
129	18	female	surprise
130	23	female	disgust
131	21	female	surprise
132	17	male	neutral
133	23	female	anger
134	15	female	fear
135	22	female	neutral
136	18	female	sadness
137	18	female	disgust
138	14	female	surprise
139	19	male	anger
140	14	female	happiness
141	15	female	neutral
142	22	female	fear
143	19	male	sadness
144	14	female	anger
145	21	female	fear
146	21	female	sadness
147	17	male	fear
148	14	female	fear
149	15	female	sadness
150	21	female	neutral
151	17	male	surprise
152	23	female	sadness
153	16	female	happiness
154	20	male	anger
155	14	female	disgust
156	21	female	happiness
157	17	male	anger
158	23	female	happiness
159	19	male	fear
160	15	female	anger
161	16	female	surprise

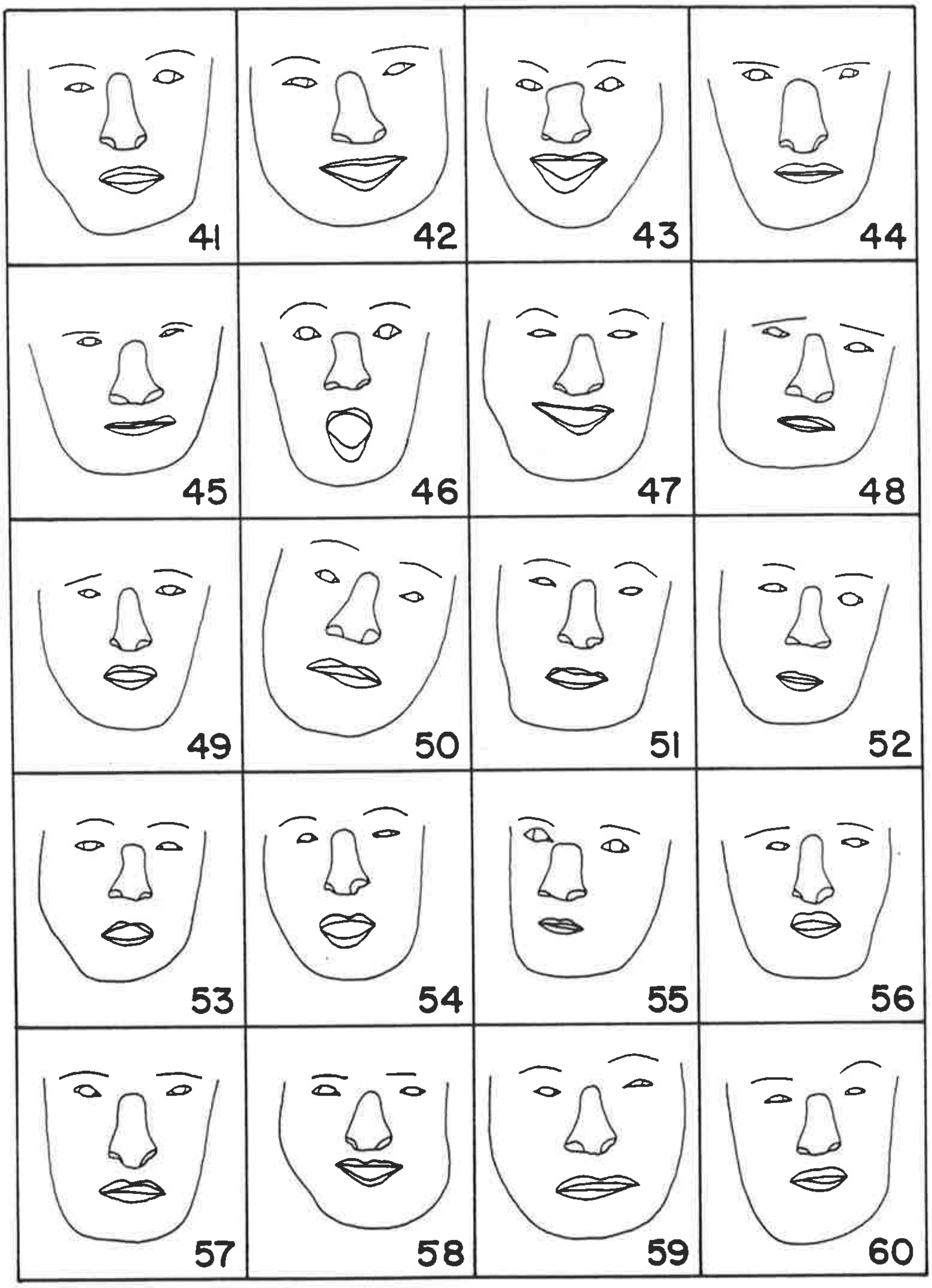
Appendix B.3: Stimuli as Presented to Judges



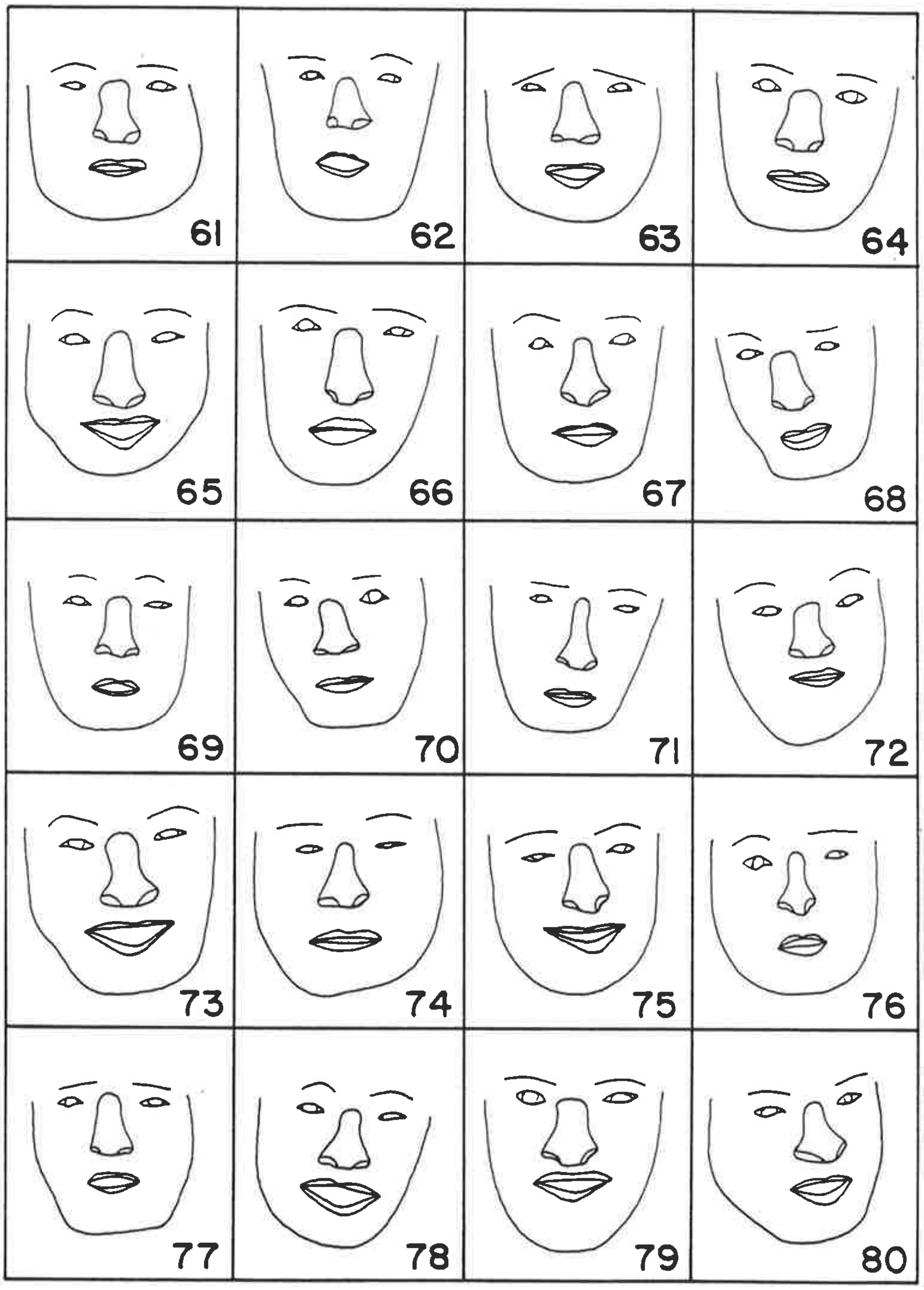
Appendix B.3. Continued..



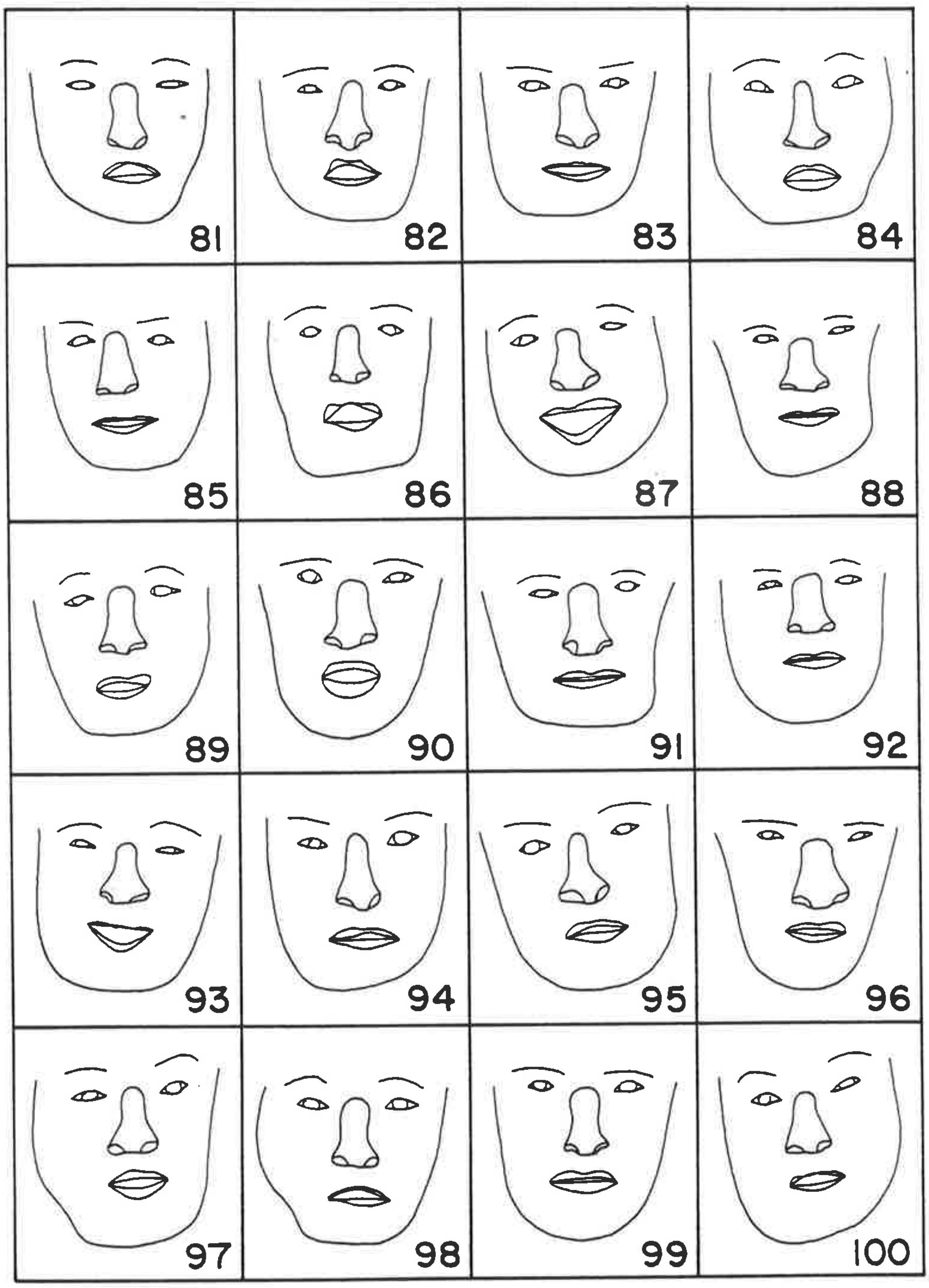
Appendix B.3. Continued..



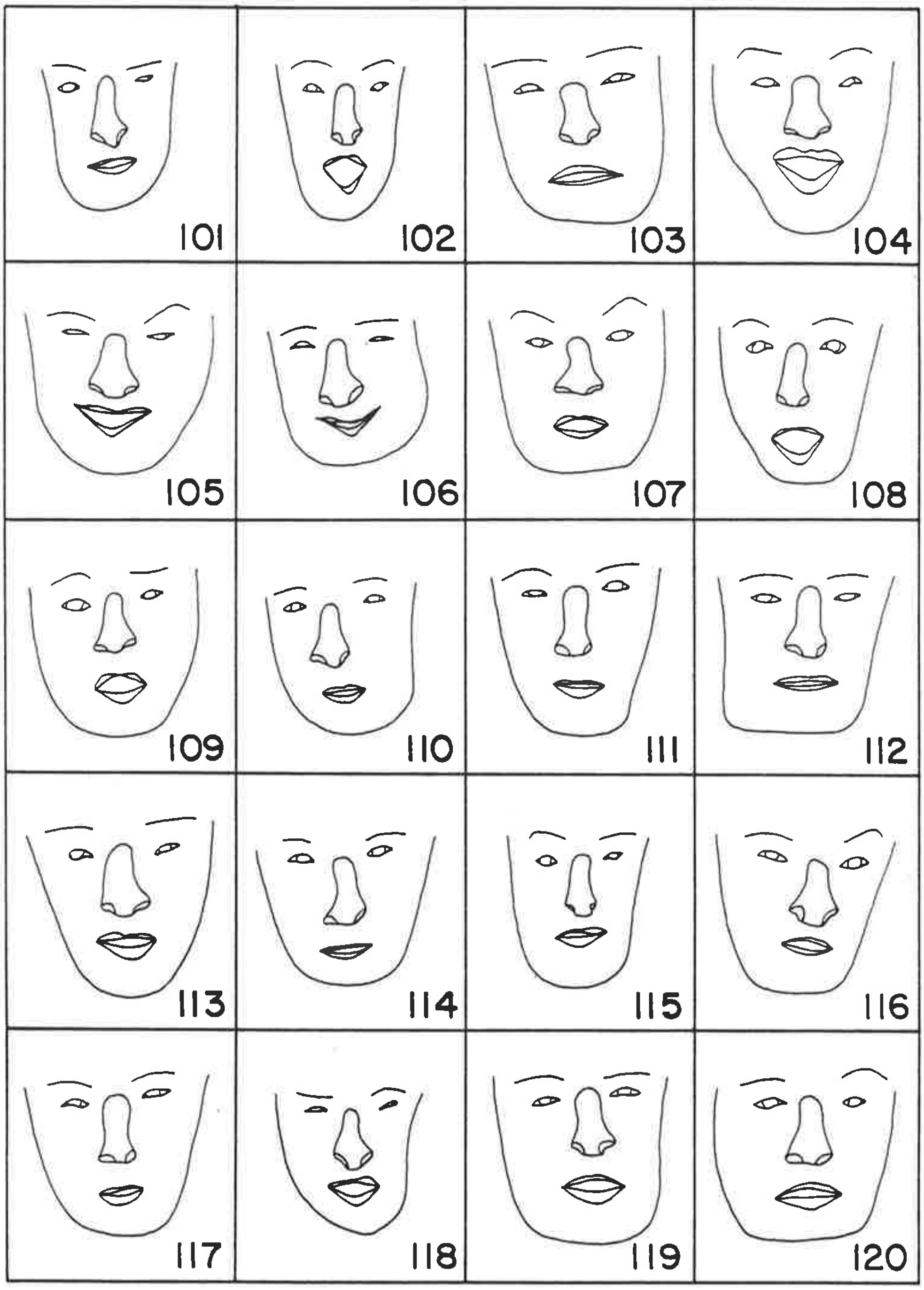
Appendix B.3. Continued..



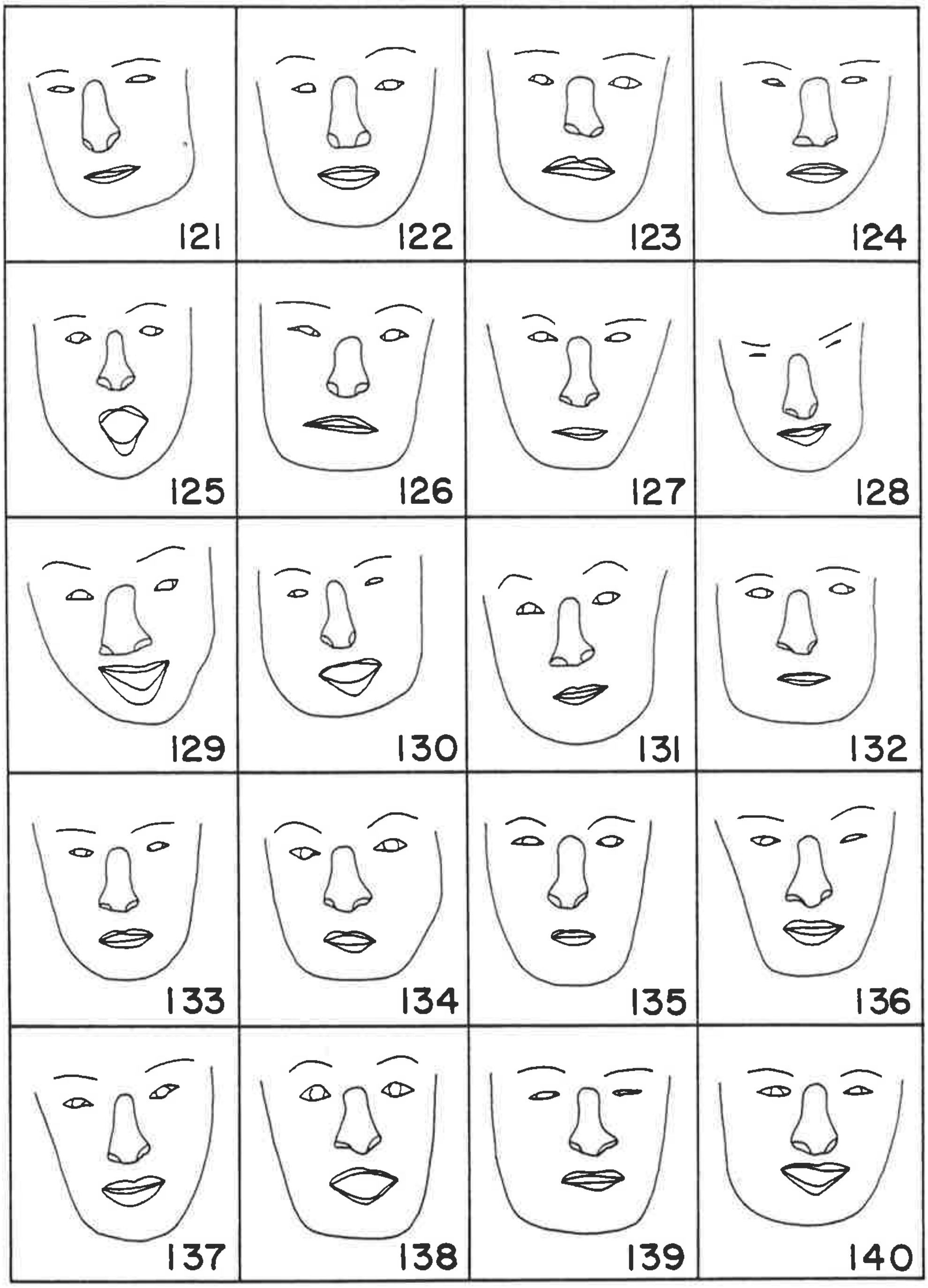
Appendix B.3. Continued..



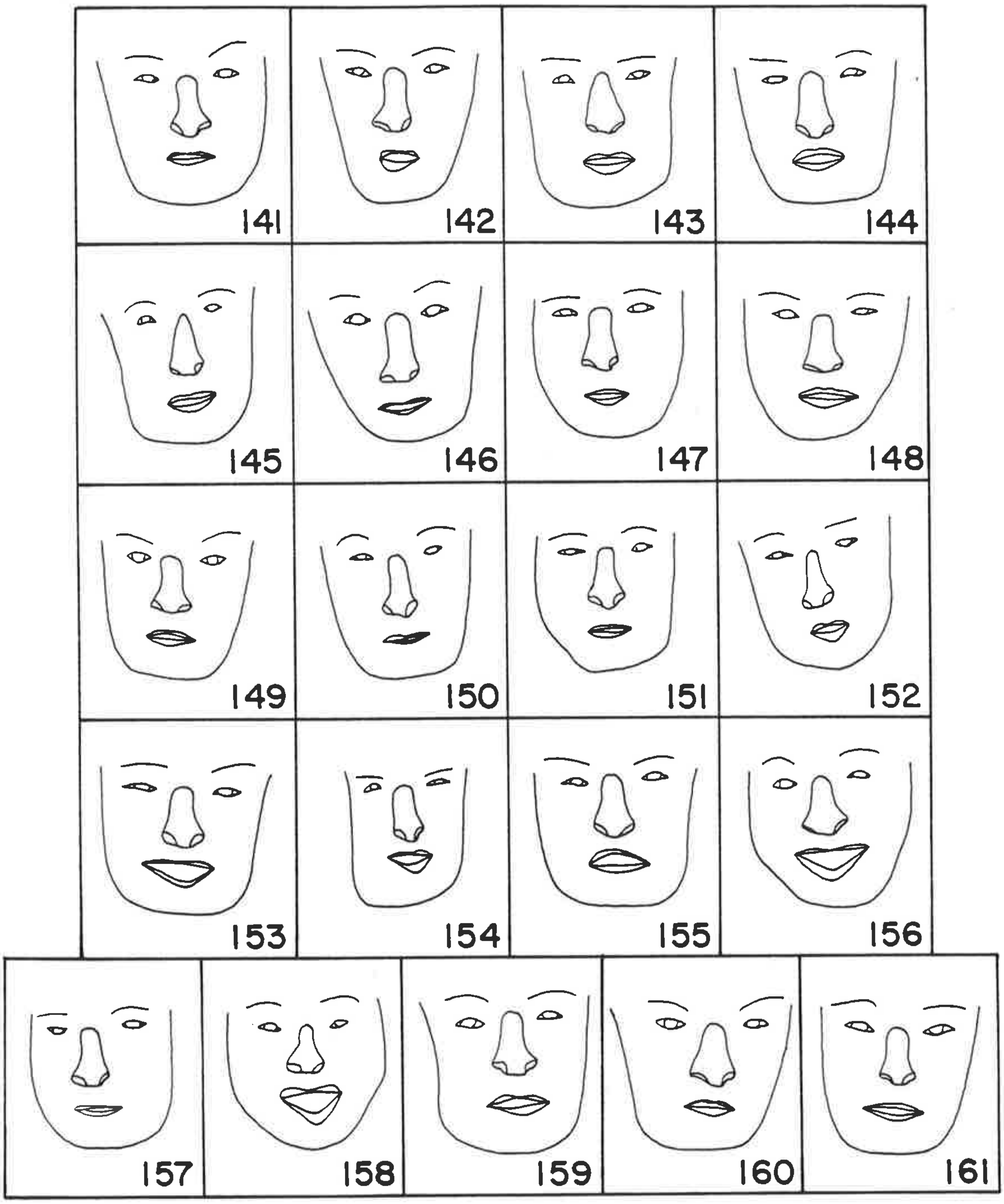
Appendix B.3. Continued..



Appendix B.3. Continued..



Appendix B.3. Continued..



Appendix B.4: Kappa Tables for Study 2: The Judgement of Photographs

$$K = P_o - P_e / 1 - P_e$$

Stimulus

Response	Happiness	Not Happiness	**Total**
Happiness	377	76	453
Not Happiness	14	2270	2284
Total	391	2346	2737

K=0.89

Stimulus

Response	Surprise	Not Surprise	**Total**
Surprise	198	126	324
Not Surprise	193	2220	2423
Total	391	2346	2737

K=0.45

Stimulus

Response	Fear	Not Fear	**Total**
Fear	108	89	197
Not Fear	283	2257	2540
Total	391	2346	2737

K=0.36

Stimulus

Response	Disgust	Not Disgust	**Total**
Disgust	128	143	271
Not Disgust	263	2203	2466
Total	391	2346	2737

K=0.32

Appendix B.4: Continued..

Stimulus

Response	Anger	Not Anger	**Total**
Anger	181	245	426
Not Anger	210	2101	2311
Total	391	2346	2737

K=0.38

Stimulus

Response	Sadness	Not Sadness	**Total**
Sadness	146	235	381
Not Sadness	245	2111	2356
Total	391	2346	2737

K=0.25

Stimulus

Response	Neutral	Not Neutral	**Total**
Neutral	241	444	685
Not Neutral	150	1902	2052
Total	391	2346	2737

K=0.29

Stimulus

Response	Happiness	Surprise	**Total**
Happiness	377	46	423
Surprise	3	198	201
Total	380	244	624

K=0.83

Appendix B.4: Continued..

Stimulus

Response	Happiness	Fear	**Total**
Happiness	377	1	378
Fear	1	108	109
Total	378	109	487

K=0.97

Stimulus

Response	Happiness	Disgust	**Total**
Happiness	377	17	394
Disgust	3	128	131
Total	380	145	525

K=0.89

Stimulus

Response	Happiness	Anger	**Total**
Happiness	377	6	383
Anger	3	181	184
Total	380	187	567

K=0.95

Stimulus

Response	Happiness	Sadness	**Total**
Happiness	377	0	377
Sadness	0	146	146
Total	377	146	523

K=1.0

Appendix B.4. Continued..

Stimulus

Response	Happiness	Neutral	**Total**
Happiness	377	6	383
Neutral	4	241	245
Total	381	247	628

K=0.96

Stimulus

Response	Surprise	Fear	**Total**
Surprise	198	68	266
Fear	41	108	149
Total	239	176	415

K=0.46

Stimulus

Response	Surprise	Disgust	**Total**
Surprise	198	9	207
Disgust	9	128	137
Total	207	137	344

K=0.89

Stimulus

Response	Surprise	Anger	**Total**
Surprise	198	9	207
Anger	3	181	184
Total	201	190	391

K=0.94

Appendix B.4: Continued..

Stimulus

Response	Surprise	Sadness	**Total**
Surprise	198	16	214
Sadness	10	146	156
Total	208	162	370

K=0.86

Stimulus

Response	Surprise	Neutral	**Total**
Surprise	198	21	219
Neutral	76	241	317
Total	274	262	536

K=0.65

Stimulus

Response	Fear	Disgust	**Total**
Fear	108	6	114
Disgust	17	128	145
Total	125	134	259

K=0.82

Stimulus

Response	Fear	Anger	**Total**
Fear	108	12	120
Anger	55	181	236
Total	163	193	356

K=0.60

Appendix B.4: Continued..

Stimulus

Response	Fear	Sadness	**Total**
Fear	108	16	124
Sadness	47	146	193
Total	155	162	317

K=0.60

Stimulus

Response	Fear	Neutral	**Total**
Fear	108	13	121
Neutral	95	241	336
Total	203	254	457

K=0.52

Stimulus

Response	Disgust	Anger	**Total**
Disgust	128	68	196
Anger	89	181	270
Total	217	181	270

K=0.31

Stimulus

Response	Disgust	Sadness	**Total**
Disgust	128	33	161
Sadness	48	146	194
Total	176	179	355

K=0.54

Appendix B.4: Continued..

Stimulus

Response	Disgust	Neutral	**Total**
Disgust	128	13	141
Neutral	94	241	335
Total	222	254	476

K=0.56

Stimulus

Response	Anger	Sadness	**Total**
Anger	181	58	239
Sadness	62	146	208
Total	243	204	447

K=0.45

Stimulus

Response	Anger	Neutral	**Total**
Anger	181	29	210
Neutral	53	241	294
Total	234	270	504

K=0.68

Stimulus

Response	Sadness	Neutral	**Total**
Sadness	146	68	214
Neutral	122	241	363
Total	268	309	577

K=0.33

Appendix B.5: Kappa Tables for Study 3: The Judgement of Line Drawings.

$K=P_o-P_e/\underline{1-P_e}$

Stimulus

Response	Happiness	Not Happiness	**Total**
Happiness	316	238	554
Not Happiness	98	2246	2344
Total	414	2484	2898

K=0.96

Stimulus

Response	Surprise	Not Surprise	**Total**
Surprise	136	218	354
Not Surprise	278	2266	2544
Total	414	2484	2898

K=0.26

Stimulus

Response	Fear	Not Fear	**Total**
Fear	74	248	322
Not Fear	340	2236	2576
Total	414	2484	2898

K=0.09

Stimulus

Response	Disgust	Not Disgust	**Total**
Disgust	70	259	329
Not Disgust	344	2225	2569
Total	414	2484	2898

K=0.05

Appendix B.5: Continued..

Stimulus

Response	Anger	Not Anger	**Total**
Anger	101	287	388
Not Anger	313	2197	2510
Total	414	2484	2898

K=0.09

Stimulus

Response	Sadness	Not Sadness	**Total**
Sadness	100	323	423
Not Sadness	314	2161	2475
Total	414	2484	2898

K=0.12

Stimulus

Response	Neutral	Not Neutral	**Total**
Neutral	107	421	528
Not Neutral	307	2063	2370
Total	414	2484	2898

K=0.04

Stimulus

Response	Happiness	Surprise	**Total**
Happiness	316	87	403
Surprise	45	136	181
Total	361	223	584

K=0.49

Appendix B.5: Continued..

Stimulus

Response	Happiness	Fear	**Total**
Happiness	316	25	341
Fear	8	74	82
Total	324	99	423

K=0.76

Stimulus

Response	Happiness	Disgust	**Total**
Happiness	316	50	366
Disgust	13	70	83
Total	329	120	449

K=0.60

Stimulus

Response	Happiness	Anger	**Total**
Happiness	316	42	358
Anger	16	101	117
Total	332	143	475

K=0.69

Stimulus

Response	Happiness	Sadness	**Total**
Happiness	316	21	337
Sadness	3	100	103
Total	319	121	440

K=0.87

Appendix B.5: Continued..

Stimulus

Response	Happiness	Neutral	**Total**
Happiness	316	13	329
Neutral	13	107	120
Total	329	120	449

K=0.85

Stimulus

Response	Surprise	Fear	**Total**
Surprise	136	60	196
Fear	50	74	124
Total	186	134	320

K=0.31

Stimulus

Response	Surprise	Disgust	**Total**
Surprise	136	29	165
Disgust	20	70	90
Total	156	99	255

K=0.57

Stimulus

Response	Surprise	Anger	**Total**
Surprise	136	23	159
Anger	23	101	124
Total	159	124	283

K=0.68

Appendix B.5: Continued..

Stimulus

Response	Surprise	Sadness	**Total**
Surprise	136	29	165
Sadness	24	100	124
Total	160	129	289

K=0.64

Stimulus

Response	Surprise	Neutral	**Total**
Surprise	136	32	168
Neutral	74	107	181
Total	210	139	349

K=0.40

Stimulus

Response	Fear	Disgust	**Total**
Fear	74	42	116
Disgust	47	70	117
Total	121	112	233

K=0.24

Stimulus

Response	Fear	Anger	**Total**
Fear	74	39	113
Anger	43	101	144
Total	117	140	257

K=0.36

Appendix B.5: Continued..

Stimulus

Response	Fear	Sadness	**Total**
Fear	74	43	117
Sadness	64	100	164
Total	138	143	281

K=0.22

Stimulus

Response	Fear	Neutral	**Total**
Fear	74	66	140
Neutral	101	107	208
Total	175	173	348

K=0.04

Stimulus

Response	Disgust	Anger	**Total**
Disgust	70	67	137
Anger	77	101	178
Total	147	168	315

K=0.08

Stimulus

Response	Disgust	Sadness	**Total**
Disgust	70	56	126
Sadness	70	100	170
Total	140	156	296

K=0.16

Appendix B.5: Continued..

Stimulus

Response	Disgust	Neutral	**Total**
Disgust	70	56	126
Neutral	76	107	183
Total	146	163	309

K=0.16

Stimulus

Response	Anger	Sadness	**Total**
Anger	101	69	170
Sadness	81	100	181
Total	182	169	351

K=0.14

Stimulus

Response	Anger	Neutral	**Total**
Anger	101	59	160
Neutral	61	107	168
Total	162	166	328

K=0.28

Stimulus

Response	Sadness	Neutral	**Total**
Sadness	100	81	181
Neutral	96	107	203
Total	196	188	384

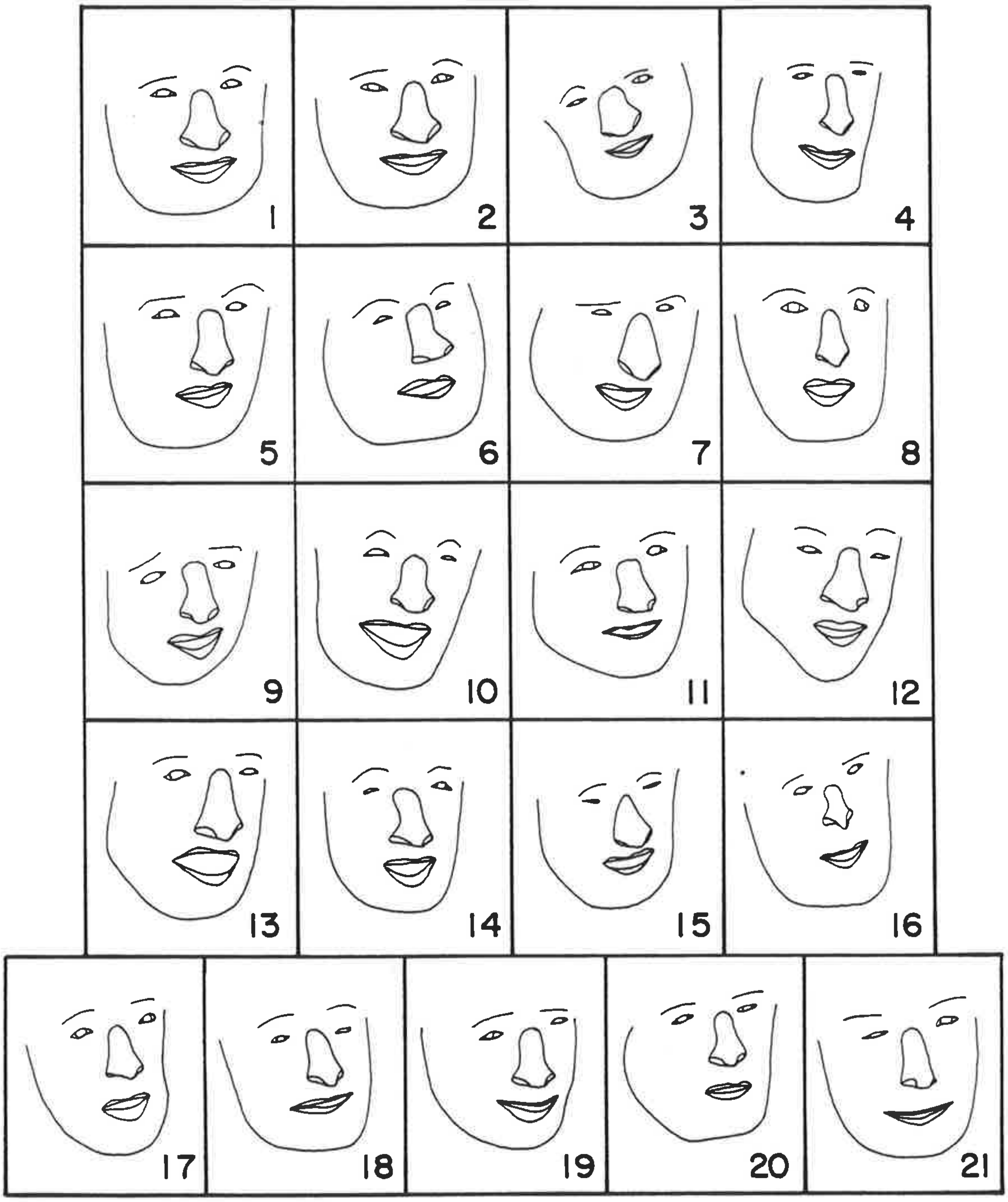
K=0.08

APPENDIX C

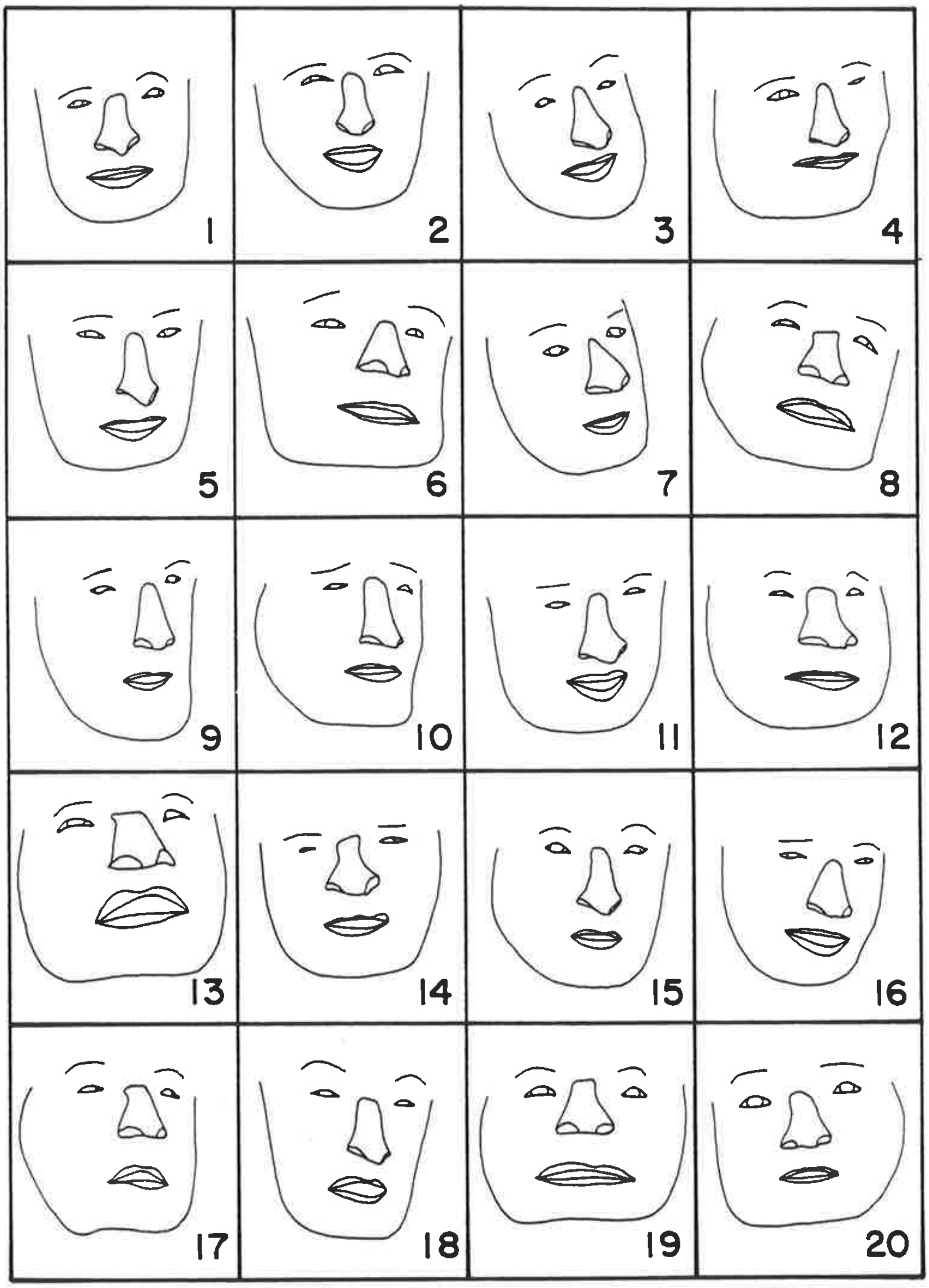
APPENDIX TO CHAPTER 8

Appendix C.1: LEVINE-PILOWSKY DEPRESSION QUESTIONNAIRE

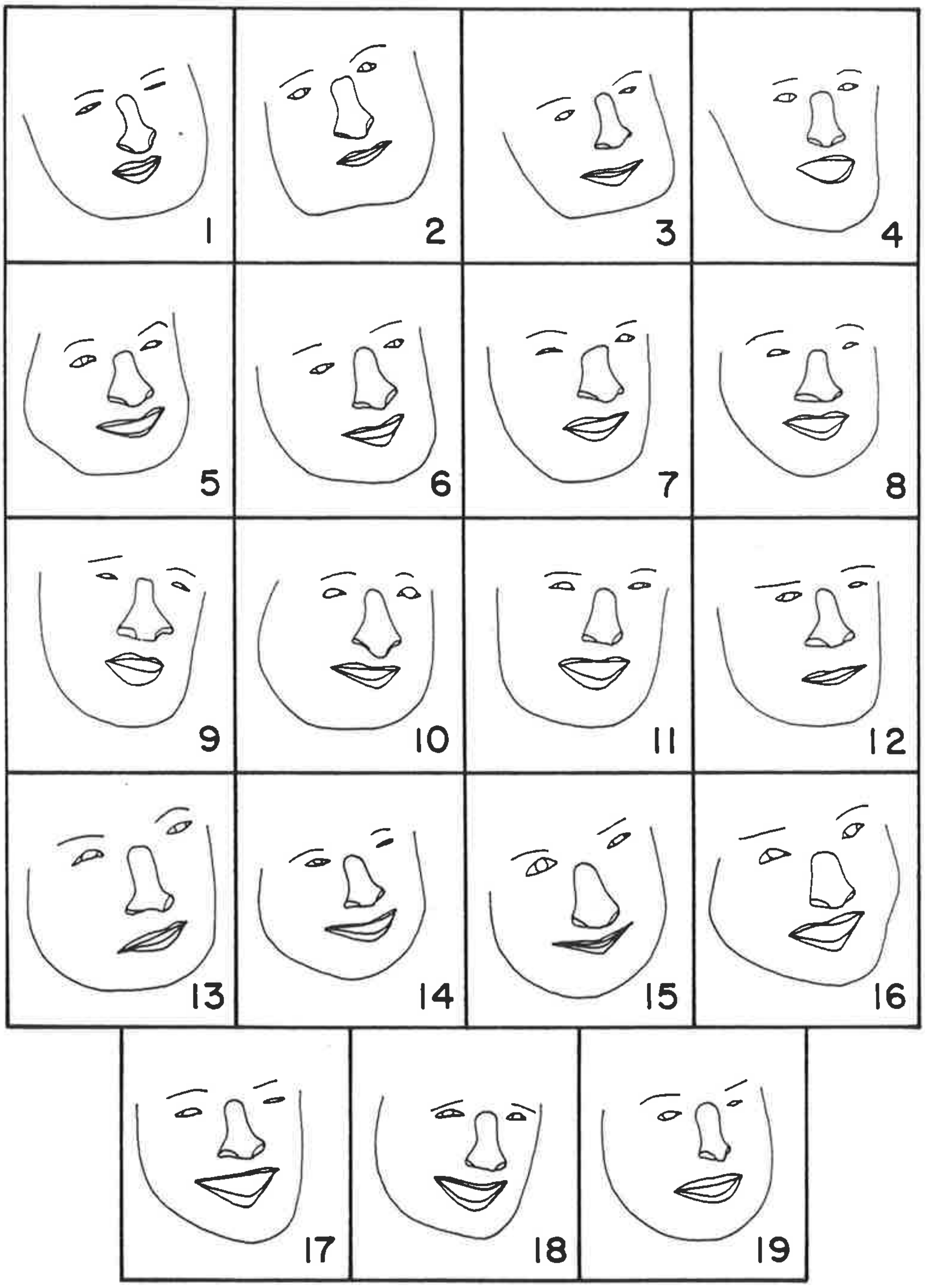
Appendix C.2: Line Drawing Representations of the Expressions in the Parkinsonian Group



Appendix C.3: Line Drawing Representations of the Expressions in the Depressed Group



Appendix C.4: Line Drawing Representations of the Expressions in the Control Group



APPENDIX D

THESIS PUBLICATIONS

Katsikitis, M., Pilowsky, I., Innes, J.M. (1990) The quantification of smiling using a microcomputer-based approach.
Journal of Nonverbal Behavior, *v. 14 (1) pp. 3-17*

Katsikitis, M., Pilowsky, I. (1991) A controlled quantitative study of facial expression in parkinson's disease and depression.
Journal of Nervous and Mental Disease, *v. 179 (11), pp. 683-688*

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