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Anthropological Review, 2012; 75(2):129-136

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Published version available at: <http://dx.doi.org/10.2478/v10044-012-0012-4>

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18 May 2016

<http://hdl.handle.net/2440/76995>

Writing with non-dominant hand: left-handers perform better with the right hand than right handers with the left

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ABSTRACT: Adult volunteers (7 females, 7 males) aged between 19 and 51 years, 7 right-handers and 7 left-handers, were asked to complete re-training writing tasks by using their non-dominant hand over 10 consecutive days. It is possible for adults to learn quickly to write legibly with their non-dominant hand. Left handers have a higher legibility score initially although right-handers improved with training more than left-handers. Individual's performance was unrelated to age and sex in the small sample studied.

KEY WORDS: handedness, males, females, re-training, Edinburgh Questionnaire

Although primates have been generally found to display an even 50–50 rate for unimanual tasks, humans have been an exception as they show a right hand preference of 70–95% (Chapman and Henneberg 1999). Given this prevalence, it has been (and often is) unacceptable to write with the left hand in many places around the world (Kim 2009; Zverev 2006). There is still environmental and cultural pressure against left handers. Vuoksima (2009) found that, in Finland, among older age groups, there were fewer left handers than in younger age groups, regardless of whether they were left handed all their life or switched to

the left hand in adulthood. It is possible that both hemispheres are involved in controlling complex manual tasks (Teixeira 2008). A study using 'converted' right handers and natural right handers shows that the sensorimotor area of the left hemisphere of the brain can be partly switched with training to the non-dominant hand (Klöppel 2007). Experiments in which adult individuals were retrained to write with the non-dominant hand, indicate that switch of handedness can be achieved in weeks, though no cortical activity was monitored in those studies (Chapman and Henneberg 1999; Walker and Henneberg 2007).

The Edinburgh Handedness Questionnaire is useful in determining the dominant hand among subjects. However, Büsch et al. (2010) found that there should be an increase in the number of questions asked to determine handedness, with emphasis on those questions that ask about unequivocally lateralized behaviour.

Previous studies on the retraining of individuals to write with a non-dominant hand (Chapman and Henneberg 1999; Walker and Henneberg 2007) used a majority of right handers and did not address a possible difference between left and right handers in the results of re-training. Such differences can be expected considering that hemispheric specialization for the visual control of action is independent of handedness (Gonzalez et al. 2006) and that even in consistent left-handers, the lateralization of language and praxis skills resembles that of right-handers in the vast majority of cases (Kroliczak et al. 2011). Our earlier studies suggested that re-training of adults does not depend on age. Bryden and Roy (2005) suggest that laterality evens out with an increase of age. However, their research was done on subjects between the age of 3 and 24 years. Kalisch (2006) also found that laterality moved towards a 50:50 ratio for left and right hand preference with increasing age. This complements a study by Doyen et al. (2008) as they found there was an increase in difference of the left and right hands in younger individuals.

The primary purpose of this study was to compare re-training to write with the non-dominant hand of adult right handers and left handers of both sexes and different ages.

Materials and methods

Participants

Participants were volunteers who gave informed consent to participate in this study. Their ages varied from 19 to 51 years. There were 7 males and 7 females participating.

Previous research papers used a majority of subjects who were dominantly right handed (Chapman and Henneberg 1999; Teixeira 2008; Walker and Henneberg 2007) or only right handers (Bryden and Roy 2005). Annett (2004) conducted a study with a sample of 2844 participants and found an average of 9.3% were left handers. In this study we aimed at having equal numbers of left- and right-handers. This was done by initial interviews with volunteers.

Participants' handedness was determined by completing a modified Edinburgh Questionnaire (Büsch et al. 2010). This questionnaire referred to 14 activities. Participants were asked to choose whether they preferred to perform a particular activity with the right hand, left hand or had no preference. An Edinburgh handedness score was determined from the questionnaire by giving a score of 1 to a left hand choice, 2 to a non-preferred choice and 3 to a right handed choice to coincide with previous studies. The total score was used to label a participant as left- or right-handed. In cases of ambiguity we considered the hand used for writing as deciding the handedness because this paper concentrates on writing tasks. Before answering the questionnaire each participant was given a set of rules and guidelines and was asked to answer the following question: "Have you sustained any injuries in the past to your hands

that may have affected your writing ability?" An injury may have influenced the participants' choice of their preferred writing hand during their lifetime. Only one participant had a broken arm at age 12 on the non-dominant side (left).

The method

We have followed here the procedure used in previous re-training studies (Chapman and Henneberg 1999; Walker and Henneberg, 2007). Each participant was given one A4 lined, binder book that contained 64 pages. Also, the same type of black pen was given to each participant; this was to eliminate any variables with different pen sizes, grips, etc., and also style of pages. Participants were asked to carry out the task at approximately the same time of the day, every day for 10 consecutive days, using the same pen and writing on the right side of the book. Also, writing in the same environment was desirable as different lighting, table or chair settings, etc., may influence the style of writing. Participants could write in cursive or print; however, they had to continue with the same modality throughout the task.

Participants were asked to give a sample of their dominant hand's writing before conducting the rest of the task. This was done by writing the phrase "The quick brown fox jumped over the lazy dog" twice, along with writing the alphabet in upper and lower case. The experimental task was to write with the participants' non-dominant hand the same phrase "The quick brown fox jumped over the lazy dog" twice, along with writing the alphabet in upper and lower case each day for a total of 10 consecutive days. This phrase was chosen to

complement a previous study completed by Walker and Henneberg (2007), and the alphabet in lower and upper case was chosen to complement a previous study completed by Chapman and Henneberg (1999). The task was kept simple to maintain high levels of compliance as the participants in the study were volunteers who received no compensation. At the end of the task participants were asked to provide any free-style comments they wished to make regarding their experience during the task. As such, these could not be analysed systematically, but provide some insight into the consistency of performance.

Analysis

Each booklet was analysed by assessing five main characteristics; letter slant, letter size, letter spacing, word spacing, shape and smoothness, as suggested by the previous study (Walker and Henneberg 2007). Results of each day were given a score between 1 and 10, 1 being furthest away from sample of dominant-handwriting and 10 being identical to sample handwriting. These scores were then used to compute a score 'gain'. This was done by using the score from the first day as the participants' standard and subtracting it from scores of following days (eg. Day 1=4, Day 2 score=5, therefore Day 2 gain=+1). This process was completed for all participants and a 'day average gain' was calculated. An unpaired t-test was used to show if there was any significant difference between averages of differently grouped participants. SPSS Statistics version 19.0.0 was used to calculate parametric and non-parametric correlations and assess their significance.

Results

Results of different participants varied (Table 1). Some, from very low initial scores, improved to high scores, others achieved relatively high scores initially and did not improve their results much during the 10-day period. Thus participants' gains also varied. All individual average scores differed significantly from one ($p < 0.05$, t-test). There were no ma-

ior differences in average age, handedness scores nor writing quality scores on various days between males and females (Table 2). Thus further analyses used jointly individuals of both sexes. Neither the initial scores, nor day 10 scores, nor gain scores correlated significantly with age, though a small sample size may be responsible. There was, however, a significant negative moment-product correlation between handedness score and day

Table 1. Scores for each individual for writing with non-dominant hand a test phrase and the alphabet. Scores out of 10 are derived by comparing non-dominant handwriting with the dominant hand written sample of the same phrase and the alphabet

Person	Sex	Writing quality score												
		Edinburgh		Days										Average
		Age	Score*	1	2	3	4	5	6	7	8	9	10	
Ch	F	39	36	5	6	6	5	5	5	6	6	6	7	5.7
Em	F	20	36	8	8	7	7	6	6	5	6	7	7	6.7
Fi	F	35	12	6	6	6	6	8	7	6	7	7	7	6.6
Jo	F	51	13	7	7	7	8	8	7	7	8	8	7	7.4
Mt	F	20	20	9	8	7	7	8	7	8	7	7	6	7.4
Ni	F	21	34	5	6	5	5	6	7	7	6	7	6	6.0
Zo	F	51	19	8	8	8	7	8	7	8	8	8	7	7.7
Ad	M	27	34	3	5	5	6	7	5	7	8	7	7	6.0
Br	M	20	17	9	9	8	9	8	8	7	8	7	7	8.0
Da	M	22	15	6	5	6	5	7	7	8	8	9	8	6.9
Ma	M	39	34	3	5	5	3	4	7	6	6	5	6	5.0
Mr	M	24	35	3	2	3	5	5	6	7	6	6	7	5.0
Mi	M	19	14	6	7	6	8	8	8	9	8	7	8	7.5
Pe	M	51	36	3	2	3	3	3	4	3	4	4	5	3.4

* 12–15=strongly left handed, 16–19=moderately left handed, 20–23=weakly left handed, 24=ambidextrous, 25–28=weakly right handed, 29–32=moderately right handed, 33 and more – strongly right handed

Table 2. Comparing male with female participants: age, Edinburgh questionnaire score and average non-dominant handwriting scores (10 means the same quality as the dominant handwriting)

	Females (n=7)		Males (n=7)	
	Average	SD	Average	SD
Exact age (years)	33.9	13.9	28.9	11.9
Edinburgh score	23.9	11.4	26.4	10.4
Writing quality score:				
Day 1	6.9	1.6	4.7	2.4
Day 5	7.0	1.3	6.0	2.0
Day 10	6.7	0.5	6.9	1.1

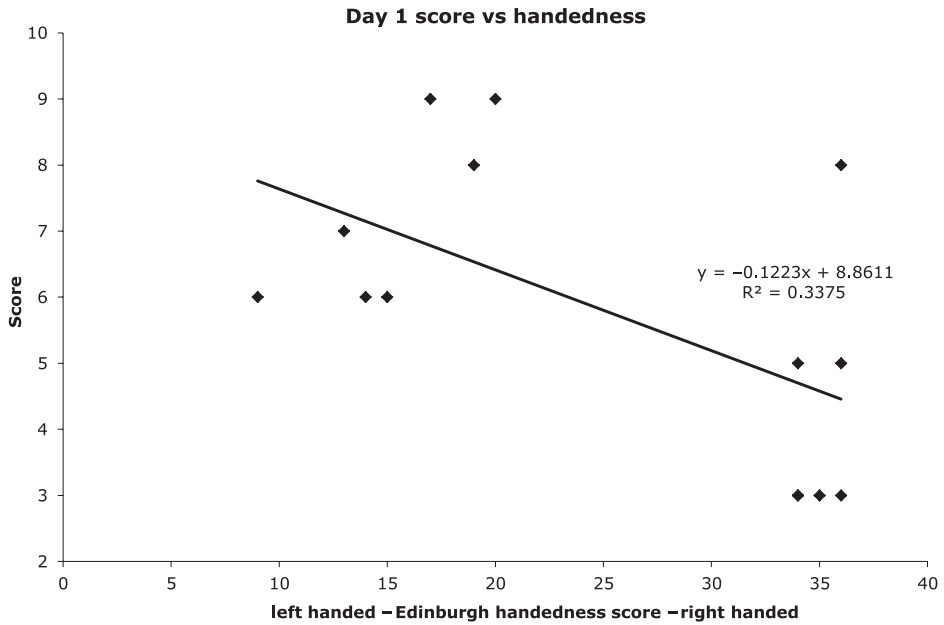


Fig. 1. Day 1 score of the non-dominant handwriting quality compared to the dominant handwriting (score 10), by the degree of handedness as measured by the Edinburgh Questionnaire score

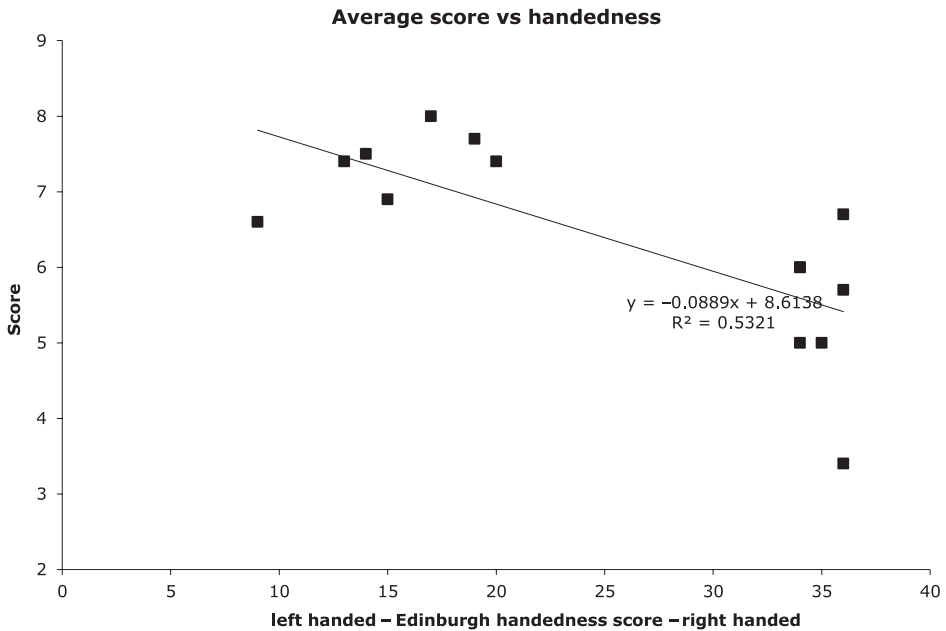


Fig. 2. Average score of the non-dominant handwriting quality of each participant compared to the dominant handwriting (score 10), by the degree of handedness as measured by the Edinburgh Questionnaire score

1 score: Pearson's $r = -0.581$, $p = 0.029$, but Spearman's " ρ " $= -0.438$, $p = 0.117$ (Fig. 1). This means that left-handers achieved higher initial quality of writing with their right hands than right-handers with their left hands. This relationship persisted throughout the entire exercise, and average scores clearly correlated negatively with Edinburgh handedness scores: Pearson's $r = -0.729$, $p = 0.003$, and Spearman's " ρ " $= -0.659$, $p = 0.010$ (Fig. 2). As expected from these observations, the gain scores showed positive correlation with handedness scores ($r = 0.413$, " ρ " $= 0.281$), indicating that right-handers achieved greater improvement of their left hand writing over the 10 days. This correlation, however, was not significant. Left handers, starting with high scores, had less room for improvement.

Discussion

All our participants achieved scores significantly different from one (1), indicating that they could write legibly with their non-dominant hand even with minimal training. While analyzing the participants' handwriting, their comments during the task were noted and it shows that the level of improvement may come down to various factors. Letters may have been formed differently due to how tired the person was at the time of the task or how tired they were during the writing exercises. Some participants found their arm and/or hand cramped or hurt during the task. Some participants noted that they had tried to write a bit slower than usual to improve their non-dominant handwriting. It was also noted that if the participants wrote faster, their non-dominant handwriting became less legible. Some participants deliberately changed the way

they held their pen or shaped some letters in the hope that it would improve their non-dominant handwriting. Also, one participant mentioned that writing with smaller letters made it easier to write with the non-dominant hand. All these comments could suggest that participants were not improving the same style of writing as they had with their dominant hand, but rather starting to learn how to write anew. Participant "Zo" was interesting to analyze as she was weakly left-handed, but she chose the right hand to write with. This shows that there was less chance of improvement as the writing with both hands was very similar and could have skewed the results.

Some participants found that they were writing particular letters back-to-front compared to their dominant hand or the way they performed their letters: i.e., the letter 'o' formed clockwise or anti-clockwise. Participants found it hard to decide whether their forearm or just their hand, or neither, was supposed to rest on the table/book to write their tasks.

Some participants commented that as the task continued they felt their writing was easier to complete with their non-dominant hand. However, this was not reflected in the improvement of quality of their writing when comparing it to their dominant (sample) writing.

As previously shown (Chapman and Henneberg 1999; Walker and Henneberg 2007), it is possible for adults to learn to write legibly with the non-dominant hand. Left handers are better at this task initially while right handers achieve greater improvements over time. The difference between left handers and right handers in initial results may be related to the fact that in left-handers lateralisation of language and practical skills is still similar to that of right-handers (Kro-

liczak et al. 2011). This situation may be a reflection of the fact that left-handers, living in a right-handed world, are exposed to more right-handed actions in their everyday lives than right handers are exposed to left-handed actions. When, however, exposed to an artificial left-hand use regime, right handers quickly improve their non-dominant hand proficiency.

This strongly argues for the fact that most human actions, considered as an expression of general handedness, can be easily transferred to the other hand, producing proficient use of that hand. Whether the hand preference has deeper causes remains to be seen, but at the level of the action (writing) that is most commonly used to define handedness there is no reason to consider a qualitative difference between left and right hand. The difference seems to be habitual, learned action rather than an action with deeply predetermined causes.

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