JOURNAL OF FORENSIC SCIENCES

J Forensic Sci, July 2011, Vol. 56, No. 4
doi: 10.1111/j.1556-4029.2011.01758.x
Available online at: onlinelibrary.wiley.com

PAPER

QUESTIONED DOCUMENTS

Abdulaziz Al-Musa Alkahtani,[1] *Ph.D. and Andrew W. G. Platt,*[1] *Ph.D.*

The Influence of Gender on Ability to Simulate Handwritten Signatures: A Study of Arabic Writers*

ABSTRACT: This study investigates whether a writer's gender can be determined from an inspection of simulated signatures written in the Arabic alphabet or Arabic abjad. It is generally believed that the penmanship of female writers is superior to male writers. There is also reason to expect that superiority in writing skill might contribute to success in simulating the signatures of other writers. Simulated signatures produced by a large population of male (414) and female (312) Arabic writers were graded, and the results were statistically analyzed. Women were found to have a marginal advantage simulating all elements of the signatures, but there was no statistically significant difference between the genders on any of the elements examined.

KEYWORDS: forensic science, Arabic signature simulation, statistical analysis

Although there are conjectures in the literature of forensic document examination about what types of people tend to be superior forgers (1–4), there has been little statistical comparison of the forging ability of people in different demographic categories. This study seeks to determine whether there is a correlation between gender and an Arabic writer's ability to simulate a signature written in the Arabic alphabet. There is some basis in the literature for expecting a difference between the genders: a variety of evidence, discussed below, suggests that women tend to have more skill in handwriting than men. There is also evidence that more skillful writers are better able to imitate handwriting. If skill at handwriting translates into skill at simulation of handwriting, then women might be expected to be more skilled at simulation and forgery than men.

Popular stereotypes elicited from studies of participants attempting to judge the gender of writers from their handwriting are that women's writing is more legible, neat, uniform, attractive, conventional in form, rounded, upright, ornate, made with lighter pen pressure, smaller in size, and displaying shorter ascenders and descenders than men's (5,6). The average rate of correct identification of gender in these studies is around 70%, which suggests that these stereotypes do have some validity, at least in the cultures (English-speaking, German, and Urdu) included in these studies (7–11). All of these studies report rates of correct identification above 50%, or chance.

The first five of these hypothesized feminine handwriting traits (legibility, neatness, uniformity, attractiveness, and conventionality in form) might indeed suggest greater skill, perhaps fine-motor control, on the part of women.

[1]Department of Forensic and Crime Science, Faculty of Sciences, Staffordshire University, College Road, Stoke-on-Trent, ST4 2DE, U.K.

*Financial support provided by the Counterfeiting and Forgery Department, Public Security, Ministry of Interior, Saudi Arabia.

Received 18 Jan. 2010; and in revised from 24 May 2010; accepted 19 June 2010.

Beech and Mackintosh (5) report a possible indication that women's handwriting style arises from innate characteristics. In a sample of women, they find that the degree to which handwriting is judged to be feminine (on a scale from *definitely a woman's writing* through *probably a woman's writing, uncertain,* and *probably a man's writing,* to *definitely a man's writing*) correlates with the ratios of the women's second-to-fourth finger lengths.

Direct studies of fine-motor skill are ambiguous or conflicting. Grade-school girls tend to excel in speed and accuracy of handwriting compared to boys, but this probably reflects their faster maturation, and boys tend to narrow the gap as they advance through puberty (12–16). Many, but not all, studies also find that adult women are superior to men in speed and/or accuracy of handwriting. However, in complex fine-motor tasks that do not seem to depend on finger size, but that require more central nervous system planning, such as handwriting and mirror drawing, women frequently do better than men (12,17–19). Thus, women may show superiority in handwriting, in many studies, because of an advantage in central planning rather than in fine-motor skill.

But in a conflicting study (12), it was found that postpubertal boys improve handwriting speed much faster than girls of the same age when both genders have the opportunity to practice the tasks and that other studies show better handwriting in men than in women when considerable practice is built into the research designs. They suggest that women tend to have more practice than men at handwriting, as a feature of their culture, and that when practice is equalized, the genders perform equally or with a slight advantage to men. These observations are consonant with evidence that young men develop faster nerve conduction and larger fast-twitch muscles than girls with puberty and that testosterone tends to enhance spatial cognition, motor performance, myelination, and neural growth. Thus, men's fine-motor task superiority and possible equality or superiority on complex fine-motor tasks, as well as their superiority in motor learning, may be because of the influence of testosterone at puberty (12,20–28). These lines of research suggest that women do not really possess superiority in handwriting ability, but they tend to have had greater culturally encouraged practice at it.

To summarize, the strongest causal explanations for differences in handwriting skill in men and women suggest that women have better central nervous system planning of language activities, including handwriting, and possibly cultural encouragement to excel in it, while men probably have superior motor control when they are motivated to practice handwriting, as a forger might well be. Results are still somewhat ambiguous, however. In this study, simulation ability was tested directly in men and women. The results are of interest to forensic document examiners (FDEs) and forensic investigators of suspected forgery, and they may also contribute interesting data to the unsolved questions surrounding gender differences in handwriting.

Methods and Materials

To look for correlations between simulation skill and gender, a large sample of 726 native speakers and writers of Arabic were asked to simulate the same two Arabic signatures under identical conditions. The simulations were then analyzed by three Arabic-literate FDEs, who assigned rankings of simulation quality to each participant for each of six handwriting elements in the signatures. These rankings were then compared between the two genders.

Data Collection

The subjects were recruited, mainly by group sampling from companies, schools, government organizations, and the like. The recruitment included a degree of quota sampling, as efforts were made to include fairly equal numbers of people with different levels of education, different levels of handwriting skill (as judged by the FDEs), different categories of occupation (classified by degree of use of handwriting in work), and different broad age groups. Each participant was questioned and examined by the investigator to exclude special disorders that might affect their handwriting. The participants were seated comfortably at tables or desks. Each was given a standard form attached to clipboards, providing the same writing surface to participants, and asked to complete the form using a fine-point, 0.7-mm, black or blue ballpoint pen.

The participants were allowed to study and practice simulating the target signatures for about 20 min and were then asked to make three freehand simulations of each signature.

The form was lined to provide horizontal baselines, against which alignment and slant of the simulations could be measured. Participants were asked to copy a small section of text in their normal handwriting to provide material for the FDEs to classify them into one of three levels of quality of handwriting.

The Model Signatures

The signatures provided for simulation include varied expressions of the six elements: form, line quality, size, slant, baseline, and spacing. The purpose of this is to maximize potential for simulation errors. This will be explained in more detail below under the definitions of the elements.

Form—This comprises the shapes of individual letters and of the connections between them. Before assigning an overall rank for form to each simulator, each judge ranked the individual's simulations for the subelements of gross form (including overall angularity versus roundedness and striking differences in shapes of letters), microform (including small differences in shapes and details such as the treatment of dots and of initial and final strokes in words), and shapes of connections. Differences in shapes of letters and connections are easily noticed, and so simulators working with the model signatures before them are likely to simulate form more accurately than the other elements.

Line quality—Refers to the smoothness and rhythmicity of pen pressure changes in the line of the cursive writing. Slow, careful copying of another's signature typically produces an uneven, wavering line, reflecting pauses and abrupt changes of direction, as the writer attempts to consciously draw the shapes of the writing. The fluency of good line quality develops unconsciously, as handwriting becomes practiced and habitual, rather than being consciously learned in school, as form is. Therefore, native simulators are unlikely to be aware of their line quality, and poor line quality is a well-known marker of forgery. In this study, the simulators are likely to attempt to draw the shapes accurately and slowly, ignoring the unnaturalness of the line they produce.

Size—Refers to the relative lengths and widths of parts of the writing, the sizes of letters relative to each other, and the absolute size of an entire signature. A variety of sizes are presented in the model signatures.

Slant—Refers to the relative degrees of slant of whole signature or parts of letters relative to writing baseline and also to the absolute degree of slant of different strokes, compared with the target signatures in which a variety of slants are present.

Baseline—In this study it refers to the alignment of letters or of total handwriting relative to a ruled line. In many cases, the baseline of writing gradually rises higher above the ruled baseline over the course of the signature or, less often, gradually falls farther below it; both tendencies are presented in the model signatures in this study. Variations of this sort are present in the model signatures and maximize the opportunities for error in simulation of these elements.

Spacing—Refers both to the distance between letters within a word and also to the spaces between words. Absolute lengths of spaces are noted (compared to the lengths in the model signature) and also lengths relative to the lengths of other spaces within the simulation. Figure 1 shows that the spaces in Signature 1 are much smaller. There are no spaces between the ends of the last letters and beginnings of next between the names in this signature. The last letters of the words overlap with the first letters of the next words, although the cursive line is broken between words. The spaces between letters in Signature 1 are wide, with long connecting lines between letters. Signature 2, by contrast, has rather narrow, cramped letters separated by very short connecting lines.

FIG. 1—*The two target signatures.*

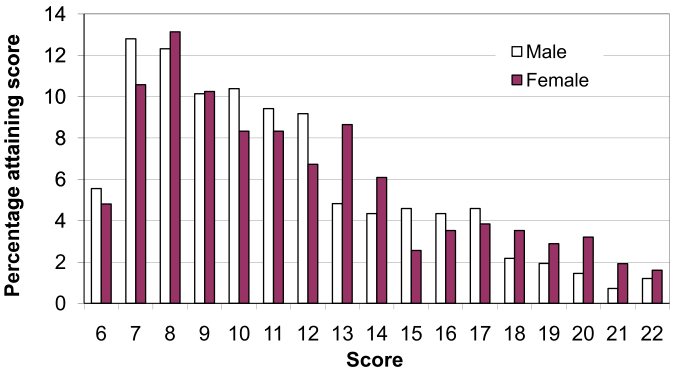

FIG. 2—*The percentages of male and female participants versus total score.*

The Ranking of Accuracy of the Simulations

The ranks of the quality of the simulations of the four elements for each individual were assigned by a panel of three certified Arabic-writing FDEs. The FDEs had between a 5- and 25-year experience of analysis of Arabic script in the government Department of Document Analysis in Saudi Arabia and were qualified to BSc level. Each gave a numerical rank from 1 to 4 to each of the subelements of form (gross form, microform, and connections), which were then averaged to give an overall ranking for that individual. Each FDE also ranked size, spacing, baseline, slant, and line quality. The ranks are defined as follows:

Rank 1: Completely different.
Rank 2: Significantly different.
Rank 3: Significantly alike.
Rank 4: Identical.

The ranking was carried out independently, and the FDE carried out the procedure without knowledge of the sex of the participants.

After the ranks were assigned, the data were analyzed using SPSS version 13.0 for significance of differences by the Mann–Whitney *U*-test with a Bonferroni adjusted significance level set at 0.05/6 = 0.008 for the multiple comparisons.

Results and Discussion

Overall, the quality of the simulations is rather low as judged by the sum of ranks for the six elements for each participant, with approximately 50% scoring totals of 10/24 or lower. To some extent, this may be expected because of the relatively short time available for study of the target signatures. Figure 2 shows the percentages of male and female participants achieving a given total score for the simulation of all six elements. Generally, the higher total rankings are achieved by women who outscore the men in the 18–24/24 region. The men are more highly represented at the lower scores between 6 and 12/24.

The results of the ranking process for the six individual handwriting elements are shown in Table 1. The simulation scores tend to be low. A rank of 1 (completely different, as if written by different people) is the most commonly awarded of the ranks to both men and women for line quality, spacing, and size, averaging close to 50% of ranks awarded for these elements. The most commonly awarded rank for form is rank 2 (significantly different, as if probably written by different people), averaging close to 60% of ranks awarded. About equal numbers of ranks 1 and 2 (about 33% of total ranks) are awarded for baseline and slant.

The generally low ranking of the simulations is not surprising, given the lack of expertise of the simulators, the short period they had to study the model signatures, the skill of the trained FDEs in detecting forgery, and the high bar set by the definitions of the higher ranks. That form would be the best simulated element by both genders confirms our previous findings for an Arabic language sample that partially overlaps with this one (27,28) and the work on a Chinese sample (29).

In general, the data suggest that there is a trend for women to be better than men at simulating all of the elements.

Thus, the percentage of women scoring 4 in any given category is higher, while at the poor ranking end of the scale, the proportion of men scoring 1 is always higher than women.

Table 2 shows the sum of ranks of men and women for simulation of form, line quality, size, spacing, baseline, and slant, generated by the Mann–Whitney *U*-test. The Mann–Whitney *U*-test is the nonparametric equivalent of an unpaired *t*-test, which analyzes for the significance of differences in the median values of ranked data. The generally accepted criteria for determining significance are a *p*-value of 0.05. However, with multiple comparisons, there is an increased possibility of Type 1 errors occurring, and to guard against this, a Bonferroni adjustment of the significance level was made. The resulting alpha level was set at 0.05/6 = 0.008.

Table 2 also contains the *Z* scores and *p*-values for each element, which show that the tendency toward superior accuracy of women's simulations does not reach significance for the elements analyzed. However, there is a nonsignificant trend toward superior simulation by women throughout the elements, with the exception of line quality.

No significant differences exist between the rankings of how well men and women simulate the elements of the target signatures. In this context, it is worth noting that the unadjusted *p*-value for the difference in size would be significant although with a very small size effect (30). This leads us to conclude that this difference is unlikely to be of importance in the forensic analysis of forged Arabic signatures, but may well be an area to focus further research on these aspects in other types of script.

Conclusions

The results of this study do not suggest that gender is a good predictor for forging ability. However, there is a nonsignificant

TABLE 1—*The percentages of male and female scores for each element of the signatures.*

	Line Quality		Form		Size		Spacing		Baseline		Slant	
Score	M	F	M	F	M	F	M	F	M	F	M	F%
1	49.8	50.0	21.7	20.5	59.9	54.8	48.8	42.3	35.7	34.0	28.3	27.6
2	45.9	46.2	56.5	58.7	27.3	25.0	31.9	33.7	37.4	32.4	34.8	32.4
3	4.3	3.8	19.1	15.4	9.9	14.1	12.6	16.0	16.7	16.0	20.0	18.6
4	0.0	0.0	2.7	5.4	2.9	6.1	6.8	8.0	10.1	17.6	16.9	21.5

TABLE 2—*Summary of statistical analysis of rankings generated by the Mann–Whitney* U-*test.*

	Gender*	Sum of Mean Rank	*Z*	$p^{\dagger}$
Line quality	M	364.25	−0.216	0.899
	F	362.50		
Form	M	362.12	−0.288	0.819
	F	365.33		
Size	M	351.69	−1.977	0.048
	F	379.17		
Spacing	M	351.64	−1.897	0.060
	F	379.17		
Baseline	M	352.57	−1.699	0.089
	F	378.0		
Slant	M	357.52	−0.919	0.358
	F	371.43		
Total of freehand simulation	M	353.08	−1.548	0.122
	F	377.33		

*Data for 414 male and 312 female participants.
†The significance level was reduced by Bonferroni adjustment to 0.008 for these comparisons.

trend for women to simulate the six elements better than men. Of these elements, the difference in simulation of size approaches significance, and this may be an area for the focus of future studies. These data also offer very little support to the notion that women may be more skilled than men in handwriting. More research is needed to extend these findings to other languages.

Acknowledgments

We are grateful to the following FDEs for their time and effort in analyzing the simulated signatures: Ahmad Assiry, Mohammad Al-Oyoni, Jubran Qushaish, and Bandar Al-Hokbani.

References

1. Huber A, Headrick AM. Handwriting identification: facts and fundamentals. London and New York: CRC Press, 1999.
2. Muehlberger RJ. Identifying simulations: practical considerations. J Forensic Sci 1990;35(2):368–74.
3. Puri DKS. Study of a copied forgery. J Sec Admin 1980;3:79–87.
4. Conway JVP. Evidential documents. Springfield, IL: Charles C. Thomas, 1959.
5. Beech JR, Mackintosh IC. Do differences in sex hormones affect handwriting style? Personality Individ Differ 2005;39(2):459–68.
6. Huber A, Headrick AM. Handwriting identification: facts and fundamentals. London and New York: CRC Press, 1999.
7. Hamid S, Loewenthal KM. Inferring gender from handwriting in Urdu and English. J Soc Psychol 1996;136:778–82.
8. MacInnis SE. Adolescent handwriting—native versus nonnative. Can Soc Forensic Sci J 1994;27(1):5–14.
9. Masson JF. A study of the handwriting of adolescents. J Forensic Sci 1988;33(1):167–75.
10. Cusack CT, Hargett JW. A comparison study of the handwriting of adolescents. Forensic Sci Int 1989;42:239–48.
11. Osborn AS. Questioned documents, 2nd edn. Chicago, IL: Nelson Hall Co., 1939.
12. Dorfberger S, Adi-Japha E, Karni A. Sex differences in motor performance and motor learning in children and adolescents: an increasing male advantage in motor learning and consolidation phase gains. Behav Brain Res 2009;198(1):165–71.
13. Cohen MR. Individual and sex differences in speed of handwriting among high school students. Percept Mot Skills 1997;84(3 Pt 2):1428–30.
14. Ziviani J, Elkins J. An evaluation of handwriting performance. Educ Rev 1984;36(3):249–61.
15. Tenwolde H. More on sex differences in handwriting. J Appl Psychol 1934;18S:705–10.
16. Starch D. The measurement of handwriting. J Educ Psychol 1913; 4:445–64.
17. Berninger VW, Nielsen KH, Abbott RD, Wijsman E, Raskind W. Gender differences in severity of writing and reading disabilities. J Sch Psychol 2008;46(2):151–72.
18. Weintraub N, Drory-Asayag A, Dekel R, Jakobovits H, Parush S. Developmental trends in handwriting performance among middle school children. OTJR: Occupation, Participation, and Health 2007;27(3):104–12.
19. Kennedy KM, Raz N. Age, sex, and regional brain volumes predict perceptual-motor skill acquisition. Cortex 2005;41(4):560–9.
20. Falter CM, Arroyo M, Davis GJ. Testosterone: activation or organization of spatial cognition? Biol Psychol 2006;73(2):132–40.
21. Sisk CL, Zehr JL. Pubertal hormones organize the adolescent brain and behavior. Front Neuroendocrinol 2005;26(3-4):163–74.
22. Reed TE, Vernon PA, Johnson AM. Sex difference in brain nerve conduction velocity in normal humans. Neuropsychologia 2004;42(12): 709–14.
23. Korman M, Raz N, Flash T, Karni A. Multiple shifts in the representation of motor sequence during the acquisition of skilled performance. Proc Natl Acad Sci USA 2003;100:12492–7.
24. DeBellis MD, Keshavan MS, Beers SR, Hall J, Frustaci K, Masalehdan A. Sex differences in brain maturation during childhood and adolescence. Cortex 2001;11(6):552–7.
25. Prayer D, Roberts T, Barkovich AJ, Prayer L, Kucharczyk J, Moseley M, et al. Diffusion-weighted MRI of myelination in the rat brain following treatment with gonadal hormones. Neuroradiology 1997;39(5):320–5.
26. Thomas JR, French KE. Gender differences across age in motor performance: a meta-analysis. Psychol Bull 1985;98:260–82.
27. Alkahtani AA, Platt AWG. A statistical study of the relative difficulty of freehand simulation of form, proportion, and line quality in Arabic signatures. Sci Justice 2010;50:72–6.
28. Alkahtani AA, Platt AWG. Relative difficulty of freehand simulation of four proportional elements in Arabic signatures. J Am Soc Quest Doc Exam 2009;12(2):69–75.
29. Leung SC, Cheng YS, Fung HT, Poon N. Forgery1-simulation. J Forensic Sci 1993;38(2):402–12.
30. Cohen J. Statistical power analysis for the behavioral sciences, 2nd edn. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc., 1988.

Additional information and reprint requests:
Andrew W. G. Platt, Ph.D.
Department of Forensic and Crime Science
Faculty of Sciences
Staffordshire University
College Road
Stoke-on-Trent, ST4 2DE
U.K.
E-mail: a.platt@staffs.ac.uk