The Influence of Handedness in Face Detection

Submitted by

Fara Marina Di Noto

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Mentor: Dr. Dean G. Purcell, Professor of Psychology

Department of Psychology

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Abstract

The brain is contralaterally organized, meaning the right hemisphere controls the left side of the body and the left hemisphere controls the right side of the body (Carlson, 2011). Handedness is highly correlated with hemisphere dominance such that it can be predicted that a right-handed individual has a dominant left hemisphere (Levy & Reid, 1978). Face recognition occurs in the right hemisphere of the brain (Reynolds & Jeeves, 1978), while face perception tends to occur in the left hemisphere (Benton, 1980). Yet, there has been no determination as to which hemisphere is specialized for face detection. Handedness also predicts which half of an image, either the right or the left, will be identified easier by an individual (Shuren, Greer, & Heilman, 1996). By comparing how fast and accurate individuals are at detecting faces in the right and left visual field against their degree of handedness and subsequent hemisphere dominance, this study seeks to discover where face detection occurs in the brain.

The Influence of Handedness in Face Detection

Introduction

The contralateral organization of the brain allows for handedness to predict hemisphere dominance (Levy & Reid, 1978). That is, an individual with a dominant left hemisphere is very likely to be right-handed. Handedness, so often viewed as a binary variable of either right or left, is in reality measured on a spectrum (Levy & Reid, 1978). Individuals can have varying degrees of handedness ranging from strong right to strong left. In this study, handedness has been grouped into three categories: right-handed, mixed-handed, and left-handed (Levy & Reid, 1978). A strong left handed score correlates to right hemisphere dominance, and a strong degree of right handedness relates to left hemisphere dominance (Levy & Reid, 1978). An individual with mixed, or a definitive lack of strong handedness, predicts weak brain laterization or a lack of specialized functioning in each hemisphere (Levy & Reid, 1978).

Anatomical differences in brain structures with regard to handedness have been found in males (Amunts, Jäncke, Mohlberg, Steinmets, & Zilles, 2000). Strong right-handed males were found to have a deeper central sulcus on their left hemisphere; while a deeper central sulcus in the right hemisphere was found in strong left-handed males (Amunts, Jäncke, Mohlberg, Steinmets, & Zilles, 2000). No structural differences were shown for women (Amunts, Jäncke, Mohlberg, Steinmets, & Zilles, 2000). This physiological component supports the theory that handedness is correlated with hemispheric differences and dominance, as well as the notion that females have a higher tendency of decreased brain laterization.

Facial recognition is the process of recognizing who an individual is, whether it is a family member or an acquaintance, based off of their specific facial features (Benton, 1980). Facial perception is the method of identifying that a given combination of features is a face; usually based off of the eyes, nose, and mouth (Benton, 1980). Facial perception can occur when a caricature, part of a face, or a poorly rendered face is presented (Benton, 1980). Facial recognition can be hindered when the schema of a familiar face is disrupted by dramatic changes in appearance like the addition of a beard or drastic plastic surgery. These changes, however, would not affect the ability to perceive faces (Benton, 1980).

Detection is the process of identifying a change in space and location; it does not involve recognition, only the determination that a stimulus was presented (Purcell & Stewart, 1986). The *Face-detection Effect*, FDE, states that normally arranged upright faces are detected faster than inverted (upside-down) faces, and inverted faces are detected faster than faces with rearranged facial features (Purcell & Stewart, 1986). The detection of a face does not require that the participant determine that the stimulus is a face, only that a change in space has occurred. The FDE supports the theory that the brain is specifically designed to perceive faces since it found that the unconscious detection of faces is significant for upright normal faces as opposed to non-descript objects such as inverted and rearranged faces. Even though the participant does not know they are detecting a face, the FDE demonstrates that humans have an unconscious affinity for faces.

While the right hemisphere is specialized for facial recognition, there is evidence to propose that the left hemisphere is involved in facial perception (Benton, 1980). This suggests that both hemispheres have specialized face finding functions. Research to determine in which hemisphere facial detection occurs has not been definitive. Visual stimulation from the left visual field is processed in the right hemisphere. Stimulation from the right visual field is processed in the left hemisphere (Carlson, 2011). This is consistent with the processes of contralateral organization and will be used in this study to determine which hemisphere the face is perceived.

The degree of handedness has an influence on facial recognition. Slight-left handers were determined to preform worse on facial recognition tests than strong left and strong right handers (Gilbert, 1973). This was said to be the result of decreased brain laterization, which may be inhibiting the recognition process (Gilbert, 1973). In addition, right handers have been found to respond to the right half of images (located in the right visual field) better than the half located in the left visual field (Shuren, Greer, & Heilman, 1996). Also, right handers are more likely to process images in the left hemisphere due to their contralateral brain organization (Shuren, Greer, & Heilman, 1996). This study seeks to uncover if there is specific hemispheric functioning for facial detection across all individuals or if it occurs in each individual's dominant hemisphere.

Methods

Subjects

75 undergraduate students from Oakland University participated in this study, 20 males and 55 females. The majority of participants were right handed. Sixty-nine percent of the scores were between the highest possible mixed-handed score of 3 and the highest possible right-handed score of 1. Subjects consented to participate and were not given monetary compensation. Two participants were excluded because their reaction times were either too fast, suggesting they responded before the stimulus could have been perceived, or they were below chance, suggesting that they were trying to produce a certain effect based on their perceived understanding of the hypothesis.

Measurements

The nature of the face that was presented is referred to as face type, and was either upright or inverted. An upright face is the typical presentation of a face where the eyes are the topmost feature, followed by the nose, then mouth. An inverted face is the same image as the upright face, except it was rotated 180 degrees so that the mouth is the topmost feature, followed by the nose, then eyes. The side of the computer screen where the face was presented is referred to as the face position, and was either the right or left side of fixation. Handedness was determined by Crovitz and Zener's Test for Handedness (1962), and has been prorated to a scale of 1-5. Scores ranging from 1.0-2.2 are right-handed scores (43 participants, 58.9%), 2.3-3.7 are mixed handed scores (14 participants, 19.2%), and 3.8-5.0 are left-handed scores (16 participants, 21.9%). The Interstimulus Interval, ISI, was the amount of time after the stimulus is presented until a patterned mask appears. The purpose of the patterned mask at different ISIs was to limit the amount of time that observers had to process the stimuli. In this experiment, ISIs are set to 0, 22, and 36 milliseconds. Reaction time was the amount of time from which the face was presented until the participant responds and was also measured in milliseconds. If the participant waited too long to respond no data was recorded.

Procedure

Each participant was first given a 14 query questionnaire to determine their degree of handedness. The participants were then instructed to complete the second part of the experiment, using the VScope computer program. The stimuli were faces displayed on a Macintosh eMac computer screen as black on white images using the computer program VScope 1.3. The visual angle is the standard way to measure an object's size on the retina. The ftL. is the measurement of light and refers to screen brightness. The screen illumination was 11.5 ftL. with a contrast ratio of .75 ftL. to 11.5 ftL. The masking stimulus was a rectangular pattern of overlapping letters (X and O). The mask was 13.7 cm in height (3.74° of visual angle) and 22.4 cm in width (6.15° of visual angle), covering the entire central field of view, including the two spatial locations at which the stimuli appeared. The illumination of the X and O mask was an average of 8 ftL. with just the black portion having an illumination of .75 ftL. The faces were 36 mm in height (0.98° of visual angle) by 39 mm in width (1.06° of visual angle). The single target face was presented randomly left and right of fixation at a distance of 56.5 mm (1.54° of visual angle).

Each presentation of a face is determined to be a "trial;" there are sixty trials per block and six blocks for every participant, for a total of 360 experimental trials per participant. There were 30 trials for every condition. Upright and inverted faces were presented an equal number of times in each visual field. The faces were presented with a patterned mask consisting of X's and O's at varying ISIs. Each ISI was used an equal number of times. Participants were asked to determine which side of the screen the face appeared by pressing either the 4 (for the left visual field) or the 6 (for the right visual field) on a number keypad. VScope recorded whether the participant selected the correct visual field and how fast they responded.

Participants controlled how long they waited between each trial and initiated each trial by pressing the 5 key with their middle finger. After the start of the trial, a fixation cross appeared in the center of the screen, then the cross was replaced by the stimuli and patterned mask. The fixation cross was set at 504 milliseconds and followed by 14.4 milliseconds of blank screen. Then the face was presented by itself for 14 milliseconds at varying ISIs followed by the mask. The mask was shown on the screen for 100.8 milliseconds.

After every trial participants, received feedback as to if they responded correctly. The feedback (either a + sign for a correct response, a – sign for an incorrect response, or an "o" for no response) was presented to the participant for 720 milliseconds after the selection was made. Before the start of the experimental trials, each participant completed one block of practice trials that were identical to the experimental trails expect for the ISIs. ISIs for the practice block were longer in order for the participants to become acclimated to the procedure.

Results

The data from two participants was removed because the results warranted their exclusion from the experiment. The ISI of 0 created a floor effect and was removed from the analysis. 611 trials were removed because the reaction time was under 250 milliseconds. A response under 250 milliseconds suggests that the participants responded before they could unconsciously determine where the stimulus was presented. A $\log_{10}$ transformation was performed on the reaction times to normalize the data. 18% of the reaction times for the remaining 22 and 36 ISIs were excluded because their t-values were above +4 or below -4. These values were determined to be outliers because they were extremely deviant from the population scores.

Correlations were performed to analyze the effects of the reaction time for inverted faces, the reaction time for normal faces, and the Face Detection Effect. The Face Detection Effect was figured by subtracting the reaction time for normal faces from the reaction time for inverted faces. A positive difference suggests the expected effect that individuals respond faster to normal faces, and a negative difference suggests that the individuals respond faster to inverted faces.

For right handers detecting faces in the right position there is a statistically significant correlation between the reaction time for inverted faces and the reaction time for normal faces ($r = 0.92$, $p < 0.01$). There is also a statistically significant correlation for the reaction time of inverted faces with FDE ($r = 0.32$, $p < 0.01$). As the reaction time for inverted faces increases, the magnitude of the FDE increases, meaning that the FDE is increased by poor performance on inverted faces. Although it is not as strong, right handers also experience this same effect between FDE and reaction time for inverted faces in the left position ($r = 0.25$, $p < 0.05$). For right handers detecting faces in the left position, there is a significant correlation between the reaction time for inverted faces and the reaction time for normal faces ($r = 0.89$, $p < 0.01$). There is also a statistically significant negative correlation between the reaction time of normal faces and FDE ($r = -0.22$, $p < 0.05$). This indicates that a faster reaction time increases the magnitude of the FDE. Meaning that the FDE increases because of a good performance on normal faces.

For mixed handers detecting faces in the right position, there is the predicted significant correlation between the reaction time for inverted faces and the reaction time for normal faces ($r = 0.95$, $p < 0.01$). There is no other statistically significant correlation for mixed handed individuals detecting faces presented in the right visual field. For mixed handers detecting faces in the left position, there is again the expected significant correlation between the reaction time for inverted faces and the reaction time for normal faces ($r = 0.95$, $p < 0.01$). There is also a significant negative correlation between the reaction time for normal faces with FDE ($r = -0.38$, $p < 0.05$). This indicates that a faster reaction time increases the magnitude of the FDE.

For left handers detecting faces in the right position, there is the predicted significant correlation between the reaction time for inverted faces and the reaction time for normal faces ($r = 0.86$, $p < 0.01$). There is also a statistically significant correlation between the reaction time for inverted faces and FDE ($r = 0.37$, $p < 0.05$). Meaning that the longer a participant waits to react increases the magnitude of the FDE. For left handers detecting faces in the left position, there is again the expected significant correlation between the reaction time for inverted faces and the reaction time for normal faces ($r = 0.84$, $p < 0.01$). There is also a significant negative correlation between the reaction time of normal faces with FDE ($r = -0.57$, $p < 0.01$).

Discussion

The correlations between the reaction times of inverted and normal faces are statistically significant for every group of handedness and in both the right and left visual field. The R^2 value for each of these correlations is 0.70 or greater. Left-handers have the strongest statistically significant correlation for detecting normal faces in the left visual field, with an R^2 of 0.32. Mixed-handers have the second highest statistically correlation for detecting normal faces in the left visual field with an R^2 of 0.14. Right-handers have a very small but statistically significant correlation for detecting normal faces in the left visual field. Every group of handedness has a significant correlational effect for detecting normal faces in the left visual field.

Right-handers have statistically significant correlations for detecting inverted faces in both the right and left visual field. There is also a statistically significant correlation for left handers to detect inverted faces in the right visual field. Right-handers do not have a statistically significant correlation for detecting normal faces in the right visual field.

What produces this effect is not yet known because hemisphere dominance and face position interact. This effect could be produced by the degree of handedness, the position, or a combination of both. These finding suggest that facial detection for normal faces is highly correlated to occur in the right hemisphere or in the left position regardless of hemisphere dominance. Inverted faces are very difficult to detect, but there appears to be an effect for inverted faces for right-handers and an effect for inverted faces in the right visual field.

Further research using EEG scans of the brain while testing for face detection should be conducted in order to further understand these findings. Replication studies should be done to increase external validity. This study cannot definitively prove that face detection occurs in a specific hemisphere, but suggests that the effect is occurring. This study should be replicated and other studies need to be conducted in order to fully understand this phenomenon. This study is important as it investigates the earliest stages of perception. See Purcell and Stewart 1988 for theoretical implications.

Appendix

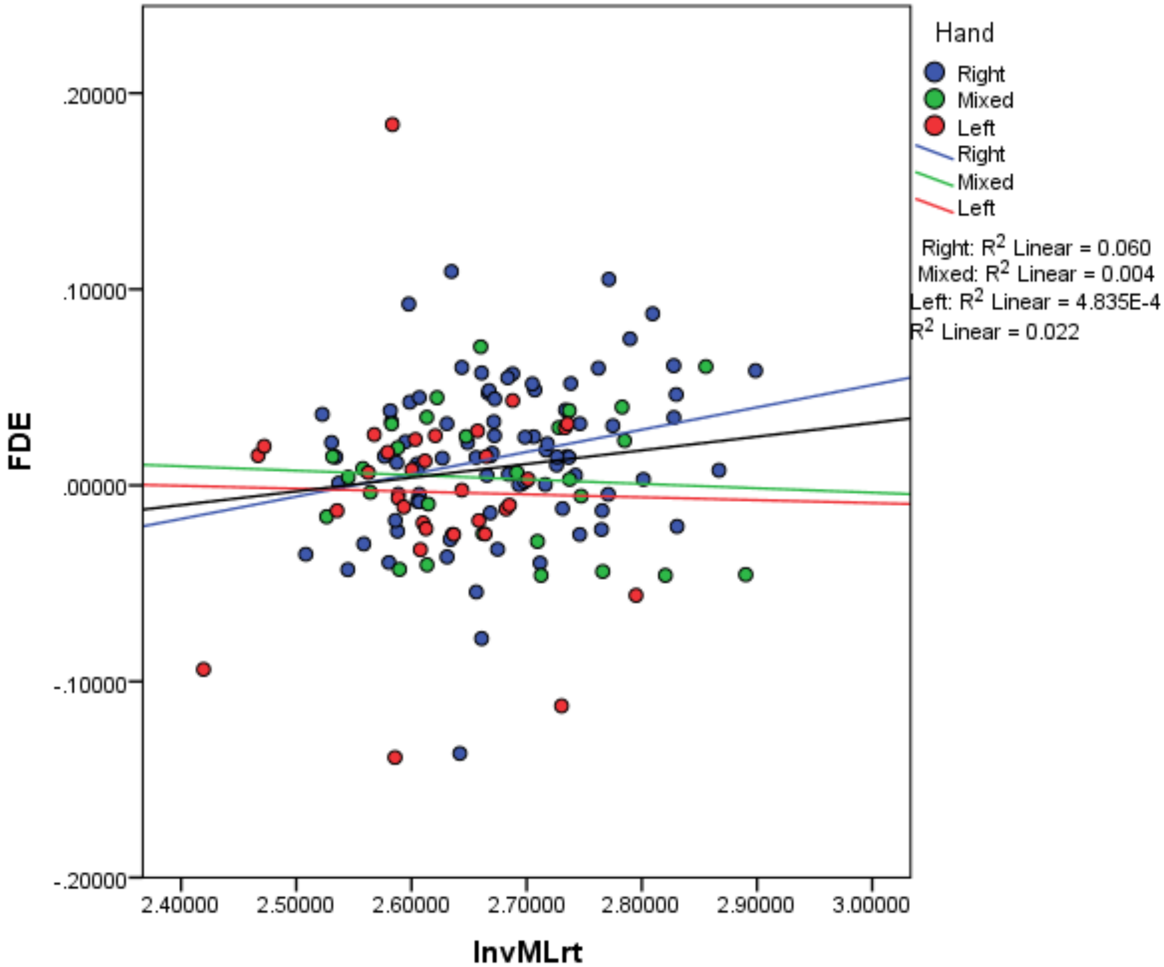

Figure 1.1: Reaction time for inverted faces in the left position and FDE across three hands.

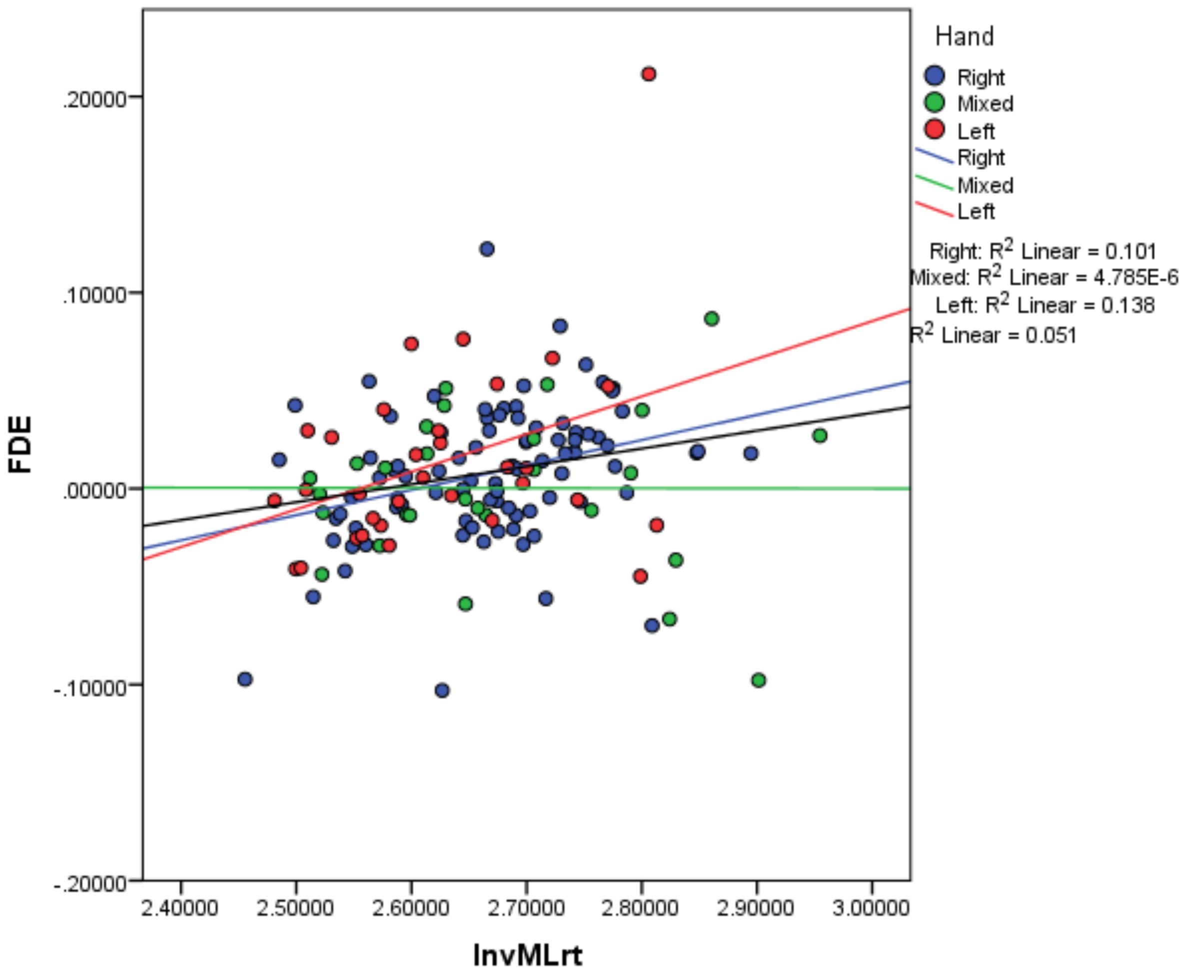

Figure 1.2: Reaction time for inverted faces in the right position and FDE across three hands.

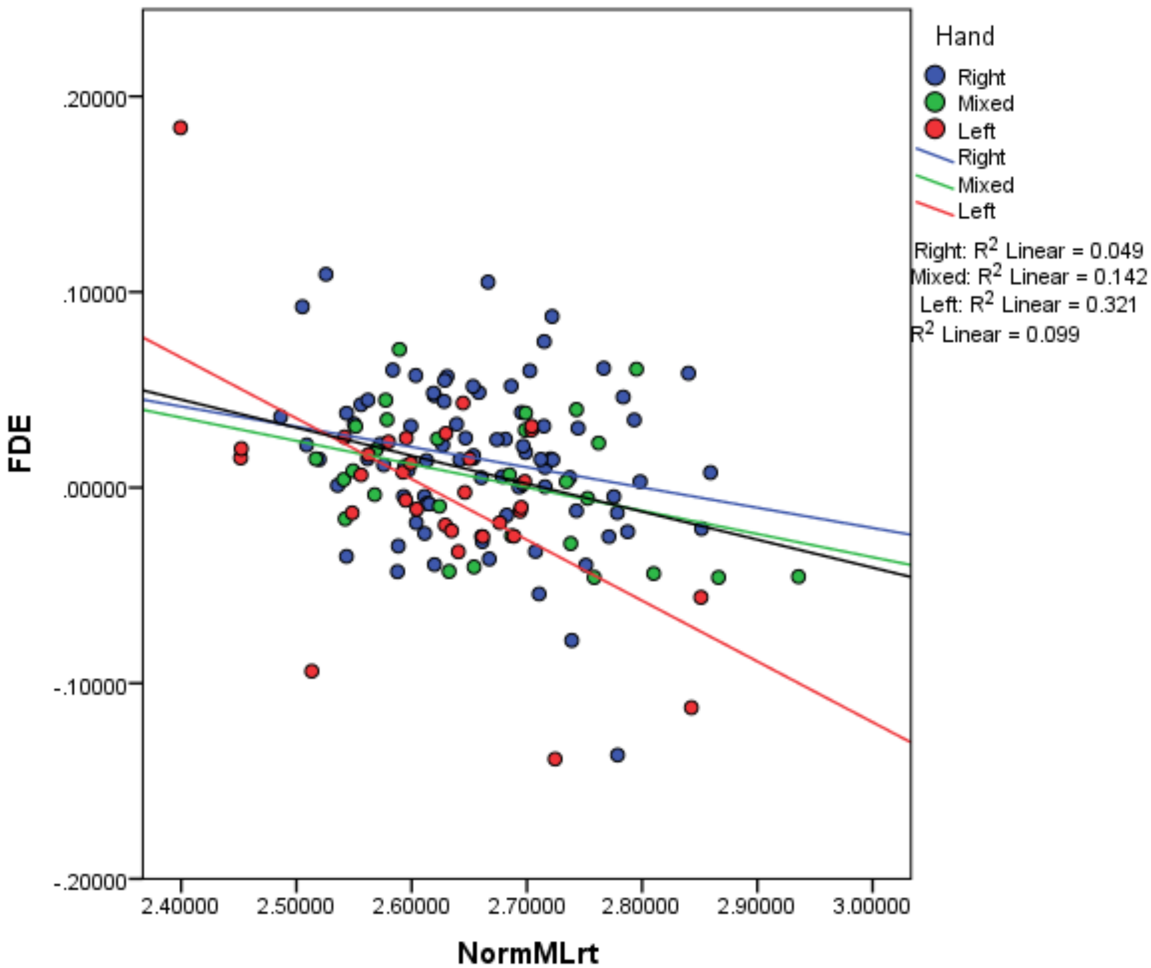

Figure 2.1: Reaction time for normal faces in the left position and FDE across three hands.

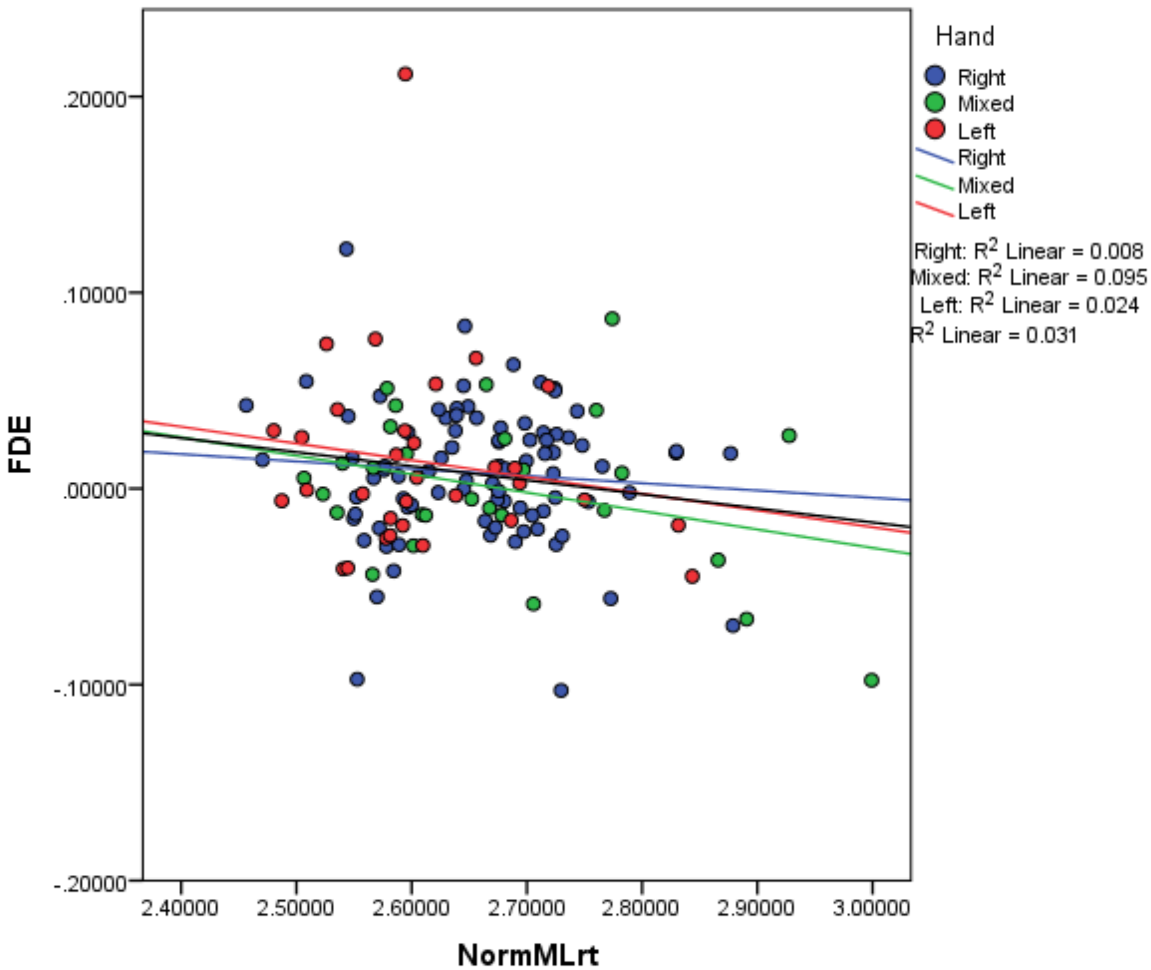

Figure 2.2: Reaction time for normal faces in the right position and FDE across three hands.

Table 1: Correlations for faces in the right position from right-handers.

Correlations

		InvMLrt	NormMLrt	FDE
InvMLrt	Pearson Correlation	1	.916**	.318**
	Sig. (2-tailed)		.000	.003
	N	86	86	86
NormMLrt	Pearson Correlation	.916**	1	-.088
	Sig. (2-tailed)	.000		.421
	N	86	86	86
FDE	Pearson Correlation	.318**	-.088	1
	Sig. (2-tailed)	.003	.421	
	N	86	86	86

**. Correlation is significant at the 0.01 level (2-tailed).

Table 2: Correlations for faces in the right position from mixed-handers.

Correlations

		InvMLrt	NormMLrt	FDE
InvMLrt	Pearson Correlation	1	.952**	-.002
	Sig. (2-tailed)		.000	.991
	N	28	28	28
NormMLrt	Pearson Correlation	.952**	1	-.308
	Sig. (2-tailed)	.000		.111
	N	28	28	28
FDE	Pearson Correlation	-.002	-.308	1
	Sig. (2-tailed)	.991	.111	
	N	28	28	28

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3: Correlations for faces in the right position from left-handers.

Correlations

		InvMLrt	NormMLrt	FDE
InvMLrt	Pearson Correlation	1	.860**	.371*
	Sig. (2-tailed)		.000	.036
	N	32	32	32
NormMLrt	Pearson Correlation	.860**	1	-.155
	Sig. (2-tailed)	.000		.397
	N	32	32	32
FDE	Pearson Correlation	.371*	-.155	1
	Sig. (2-tailed)	.036	.397	
	N	32	32	32

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 4: Correlations for faces in the left position from right-handers.

Correlations

		InvMLrt	NormMLrt	FDE
InvMLrt	Pearson Correlation	1	.891**	.245*
	Sig. (2-tailed)		.000	.023
	N	86	86	86
NormMLrt	Pearson Correlation	.891**	1	-.221*
	Sig. (2-tailed)	.000		.040
	N	86	86	86
FDE	Pearson Correlation	.245*	-.221*	1
	Sig. (2-tailed)	.023	.040	
	N	86	86	86

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 5: Correlations for faces in the left position from mixed-handers.

Correlations

		InvMLrt	NormMLrt	FDE
InvMLrt	Pearson Correlation	1	.949**	-.066
	Sig. (2-tailed)		.000	.739
	N	28	28	28
NormMLrt	Pearson Correlation	.949**	1	-.377*
	Sig. (2-tailed)	.000		.048
	N	28	28	28
FDE	Pearson Correlation	-.066	-.377*	1
	Sig. (2-tailed)	.739	.048	
	N	28	28	28

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 6: Correlations for faces in the left position from left-handers.

Correlations

		InvMLrt	NormMLrt	FDE
InvMLrt	Pearson Correlation	1	.836**	-.022
	Sig. (2-tailed)		.000	.905
	N	32	32	32
NormMLrt	Pearson Correlation	.836**	1	-.566**
	Sig. (2-tailed)	.000		.001
	N	32	32	32
FDE	Pearson Correlation	-.022	-.566**	1
	Sig. (2-tailed)	.905	.001	
	N	32	32	32

**. Correlation is significant at the 0.01 level (2-tailed).

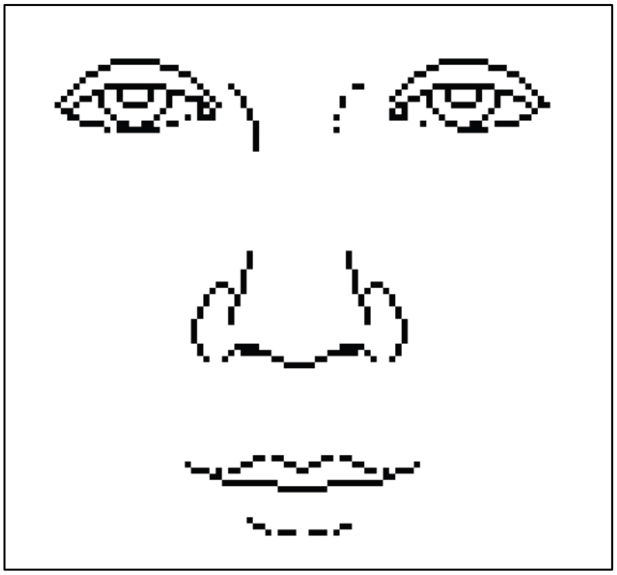

Figure 3.1: Normal Face (stimulus was presented with out the square outline)

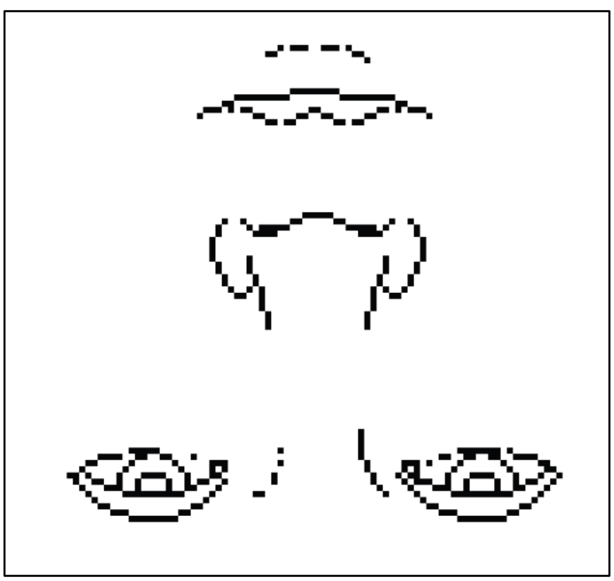

Figure 3.2: Inverted Face (stimulus was presented with out the square outline)

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