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Saccadic Eye Movements are Related to Personality Traits: A Comparison of Maltreated and Non- maltreated Young Women

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Abstract

Objective: The purpose of the study was to compare the relationship between the personality and eye movements of non-maltreated subjects and maltreated subjects.

Method: The control group consisted of 129 women with an average age of 18 years while the clinical group was made up of subjects with a long history of abuse or maltreatment. The prosaccade and antisaccade task and a BFI-44 which assesses the "Big Five" personality factors were administered to all of the participants. For the statistical analysis, linear modeling and discriminant analysis have been used.

Results: By controls we have found an association between eye movements and self-reported personality as indexed by the "Big Five" personality factors. In contrast, we noticed with maltreated subjects a dissociation between the oculomotor finding and personality. This dissociation may be regarded as a diagnostic marker of the maltreatment. Dissociative effects of maltreatment differed because of personality traits. The largest were by Agreeableness and Openness, where the reliability of the oculomotor test was weaker. Extraversion, Conscientiousness and Neuroticism, all associated with eye movements, are comparable with the members of the control group.

Conclusion: The role of antisaccade task can contribute to the diagnostics of the adverse impact of maltreatment on the personality of an individual.

Keywords: Saccade; Antisaccade; Big Five; Maltreatment; Personality

1. Introduction

In a study concerning the connection between maltreatment and saccadic eye movements Jost et al. [1], the authors reached the conclusion that the antisaccade task may be a contributor to a diagnosis of maltreatment. The antisaccade task has been used to investigate the higher-level decision-making processes. Neuropsychologically, the antisaccade task is sensitive to the malfunction of the frontal lobes of the cerebral cortex which form the basis for a wide range of symptoms. Hence, the antisaccade test is used by neurologists, psychiatrists, psychologists and other specialists to diagnose frontal dysfunction Bittencourt et al. [2] for a review). Its contribution to the antisaccade performance, however, may also be the result of the personality of the subject. Research has brought forth a growing body of evidence of the influence in which the personality of healthy individuals may exert on eye movements Bargary et al. [3-8]. The research has also gathered evidence that supports an association between maltreatment and personality functioning Carvalho et al. [9-13]. If we wish to better understand the antisaccade performance in maltreated subjects, we also must initially address the question of how the contribution of their personality relates to the antisaccade performance. It would help us to determine more precisely what a personality symptom is in the antisaccade performance and, on the other hand, what precisely constitutes a symptom of a dysfunction. Few if any studies have dealt with this problem, for we did not find such a study in any databases addressing this issue (PubMed, PsychINFO, ScienceDirect, Scopus, SpringerLink; key words: maltreatment, personality, eye movement, saccade). Therefore, we decided to compare the relationship between personality and eye movements in healthy subjects and maltreated subjects.

2. Method

2.1 Participants

The participants numbered 129 young women. The clinical part of the group consisted of 17 subjects (aged from 16 years and 4 months to 18 years and 1 month, M=17 years and 3 months) with a long history of maltreatment. Their parents were addicted to alcohol or drugs, they were promiscuous, and criminal behavior was evident. At least one girl had been sexually abused. After the age of 10, these girls were placed in out-of-home care by legal ruling of the local family court. The reason for the decision was a combination of behavioral problems including wandering away, home escapes, absence from compulsory school attendance, pre-criminal gang activity as well as experimentation with narcotics. In the out-of-home care, the girls began to attend the public elementary school regularly. No member of this group was mentally retarded. In late adolescence, sudden outbursts of anger occurred, accompanied by destructive behavior, child-like credulity, impulsive behavior, inclinations towards physical violence, or intentional self-harming. The control part of the group consisted of 112 typically developing subjects (ranging in age from 16 years and 6 months to 17 years and 11 months, M=17 years and 2 months) who are being raised in functional families and attending high school. They exhibited no behavioral and emotional difficulties, and moreover, these participants were prescreened to exclude anyone with a history of any kind of neurological disorder.

2.2 Questionnaire measure

We utilized the Czech version of BFI-44 which assesses the “Big Five” personality factors: Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism. Each response was rated on a five-point Likert scale and consisted of a total of 44 items. The Czech version of BFI-44 was standardized in 2014-15 Hrebickova et al. [14]. The internal consistency was estimated employing the Cronbach coefficient alfa with the following values: Extraversion 0.81;

Agreeableness 0.68; Conscientiousness 0.79; Neuroticism 0.83; Openness 0.75. According to Saad et al. [15] the criterion of reliability meets all the scales except for Agreeableness, which has a value less than 0.70. The lower consistency of the scale Agreeableness was nevertheless characteristic of the younger part of the sample; older women who belong to our participants, were satisfactory. The retest stability was determined with the assistance of the Pearson correlation coefficient. The retest was administrated two months later with the same sample of people. The results are as follows: Extraversion 0.86; Agreeableness 0.81; Conscientiousness 0.77; Neuroticism 0.82; Openness 0.67. The average for BFI-44 equals 0.79. The structure of BFI-44 items was developed from the factor analysis (Principal Component Analysis, Varimax rotation). Five factors with the average value of factor charges 0.55 were extracted. In conclusion, we deduce that the Czech version of the BFI-44 had acceptable psychometric traits, as represented by adequate scale reliability and corresponding retest reliability and the appropriate factor structure.

2.3 Eye movements

Eye movements were registered with the eye tracker Express Eye manufactured by Optom in Freiburg, Germany. The eye tracker had a temporal resolution of 1 ms and a spatial resolution of 0.1 degree with a linear range of +/−15 degrees. The eye tracker captured monocular eye movements (from the left eye), and the measuring method applied was IROG (infrared occulography). This device contains a built-in saccade test which administered horizontal prosaccades and horizontal antisaccades to the subject. In the prosaccade task, the subject was required to fix her gaze on a point in the center of the screen. The preliminary period during which the central fixation target was displayed was constant at 1200 ms. After 200 ms, before switching off the central fixation target, a new saccadic stimulus lit up randomly left or right of the central fixation target at a horizontal plane at a distance of 4 degrees from the target. The subject was instructed to shift her focus as quickly as possible from the central fixation target to the saccadic stimulus which remained lit for 700 ms. This was followed by the appearance of the central fixation point at which time a new trial began. In the antisaccade task, the subject had to focus on the central fixation point which lasted 1000 ms, and after its disappearance, there was an interval or gap of 200 ms. After a pause, a new light appeared at a distance of 4 degrees randomly left or right of the central fixation target for a duration of 700 ms. The subject was instructed not to look at the light but rather at the opposite side of the screen. Targets were presented by means of a laser projection on a light grey wall. No objects other than the projected light points were within the subject's field of vision. The assessment took place during the day in a quiet room.

2.4 Procedure

The subject was first informed about the assessment process, including the viewing of any machines to be used. This was followed by calibration and 5-10 practice attempts at the prosaccade test. The number of practice attempts varied; some subjects completed the task on their first attempt while others required several attempts. The subject was always informed of the evaluation of her saccade performance immediately after having produced it (e.g. "good, correct"; "attention – error"). The instructions also included statements that it was natural to make some mistakes, that everyone makes mistakes and one should not become discouraged because of mistakes. These statements combined with positive feedback were aimed at producing the best oculomotor results from the subject. Practice tests were followed by a new calibration. Then the individual was administered the prosaccade test with 60 possible attempts. Targets to the left and right were randomly interleaved within a block. This was followed by a short pause of 2-3 minutes which was then followed by practice attempts of the antisaccade test. The antisaccade test was administered after calibration, again with 60 possible

attempts and with the same number of left-right randomly interleaved targets. The total length of the assessment including practice attempts took no longer than 20 minutes per person.

2.5 Oculomotor measures

We worked with the following measured parameters: the reaction time of all correct saccades in the prosaccade task for target direction moving left and right (milliseconds; *M, SD*); percentage of reflexive prosaccades in the antisaccade task that were made mistakenly towards the target (target direction: moving left and right); finally, the reaction time of the correct antisaccades for target direction moving left and right (milliseconds; *M, SD*).

2.6 Statistical analysis

From clinical experience it is known that in environment of deprivation, individuals resist the adversity of the environment and consequently do not end up being mistreated. Cicchetti, [10] To examine the "pure" adverse effects of maltreatment on the personality and to better understand the interaction between personality, maltreatment and eye movements, we first clustered the personality variables of the whole set (*N*=129, i.e. *n* for institutionalized subjects=17 + *n* for subjects growing up in the family=112). The personality variables were clustered by means of the Gaussian mixture model clustering method Scrucca et al. [16] which maximizes the BIC criterion in order to detect the optimal number of groups in the data. The estimated number of groups was 2 and the second group (*N*=10) consisted of some but not all of the institutionalized subjects yet no normally or typically developing subjects. The remaining seven subjects from the institutionalized group (whose personality profile met those of the typically developing group) we joined with the typically developing or non-maltreated control group. This combination resulted in the clinical group of subjects with a clearer observable effect of the maltreatment on their personality. We will continue to designate it a "maltreated group" and "maltreated subjects" while the second group we will refer to as a "control group," or "controls." In order to explain each of the personality traits, we have employed the linear modelling with explanatory variables containing all the eye movement variables and the cluster variable. We have also used the interaction of the cluster variable with all the eye movement variables in order to check the variations of dependence between the two clusters. The optimal model with respect to AIC was found by the stepwise analysis.

3. Results

Personality traits of the participants are shown in Table 1. The maltreated group perceives itself as significantly less friendly, less conscientious, less open and more emotionally unstable. Only in the aspect of Extraversion is the difference insignificant. The finding is in line with the aforementioned results. Rogosch and Cicchetti [17] found that with six-year-old maltreated children a maladaptive personality organization (lower Agreeableness, Conscientiousness, and Openness to experience and higher Neuroticism). This maladaptive personality organization remained stable into early adolescence, up to age nine. In his review study, Cicchetti [10] strongly argues for the stability of personality organization in maltreated subjects. More recently, Van den Akker et al. [13], confirmed the continuity of normal and pathological personality traits in a longitudinal study, which began with subjects in childhood (at the age of 7) and ended in their late adolescence. David et al. [18] drew attention to the intergenerational transmission of the pathological traits of the personality in the so-called Prague Study. The results of the statistical analyses are presented in Tables 2 through 7.

Aspect	Maltreated group *n*=10 *Me*	Control group *n*=119 *Me*	Wilcoxon´s test	
			W	*p*
Extraversion	22	23	618.0	0.842
Agreeableness	-	44	0.0	0.000***
Conscientiousness	6.5	25	9.0	0.000***
Neuroticism	25	19	887.0	0.010*
Openness	9	19	78.0	0.000***

Note. The values are expressed in raw scores of the questionnaire BFI-44, the Czech version produced by Hrebickova et al. [14]. *p <0.05. . ***p < 0.001.

Table 1: Descriptive Statistics for Personality Traits.

Variable	Estimate	*p*
Intercept	22.36383	< 2e−16***
SRT/SD_{left}	−0.083	0.007**
SRT/SD_{right}	+0.074	0.021*

Note: $SRT/SD_{left,\ right}$=Standard deviation of saccadic reaction times of all correct saccades in the prosaccade task

Residual standard error: 5.641 on 126 degrees of freedom; Multiple *R*-squared: 0.06197, Adjusted *R*-squared: 0.04708; *F*-statistic: 4.162 on 2 and 126 *df*, *p*-value: 0.018. *p < 0.05. **p < 0.01. ***p < 0.001.

Table 2: Optimal Model for Extraversion.

The predictive variable for Extraversion consist in eye movements which are indexed by the variability of saccadic reaction times in the prosaccade task. The interaction of eye movements with cluster membership was not found. The prediction is sensitive to the asymmetry of the visual field on the left versus the right side. The value Estimate for saccadic reaction times variability in the left direction is negative (−0.083), i.e. with an increasing variability as Extraversion decreases. The value Estimate for variability SRT in the direction to the right has a positive sign (+0.074), i.e. with increasing variability, the Extraversion increases.

Variable	Estimate	*p*
Intercept	−40.569	0.434
Clust	89.271	0.083
SRT/M_{left}	0.150	0.145
SRT/M_{right}	1.291	0.008**
SRT/SD_{left}	−0.396	0.019*
SRT/SD_{right}	−1.337	0.052

Pr_{left}	−0.701	0.011*
Pr_{right}	0.684	0.052
antiSRT/M_{left}	0.575	0.019*
antiSRT/M_{right}	−0.884	0.008**
Clust: SRT/M_{left}	−0.141	0.140
Clust: SRT/M_{right}	−1.298	0.008**
Clust: SRT/SD_{left}	0.302	0.054
Clust: SRT/SD_{right}	1.421	0.038*
Clust: Pr_{left}	0.683	0.011*
Clust: Pr_{right}	−0.710	0.041*
Clust: antiSRT/M_{left}	−0.589	0.016*
Clust: antiSRT/M_{right}	0.880	0.008**

Note. Clust=Membership in a group; SRT/$M_{left,\ right=}$Mean of saccadic reaction times of all correct saccades in the prosaccade task; SRT/$SD_{left,\ right=}$Standard deviation of saccadic reaction times of all correct saccades in the prosaccade task; $Pr_{left,\ right=}$percentage of erroneous prosaccades in the antisaccade task; antiSRT/$M_{left,\ right=}$Mean of reaction times of the correct antisaccades; Clust: SRT/M …Clust: antiSRT/M=Interaction of oculomotor variable and group.

Residual standard error: 4.799 on 111 degrees of freedom; Multiple *R*-squared: 0.7304; Adjusted *R*-squared: 0.6891; *F*-statistic: .69 on and 111 *df*, *p*-value: < 2.2e−16. *$p < 0.05$. **$p < 0.01$.

Table 3: Optimal Model for Agreeableness.

The predictive variable for Agreeableness is indexed in the eye movements in the following ways: a) by saccadic reaction times in the prosaccade task, b) by the reaction times of the antisaccades, and c) by the percentage of direction errors in the antisaccade task. The prediction is influenced by the asymmetry of the visual field on the left vs. right side. With these oculomotor variables, we additionally observed their interaction with cluster variables. Unclustered values are related to the control group while the clustered values represent a mixture of both groups. By comparing Estimate values by interactions with non-clustered values, we have produced an Estimate of the clinical group, for example Clust: SRT/M_{right} + SRT/$M_{right=}$−1.298 + 1.291=−0.007. This value (i.e., the mean of saccadic reaction times of all correct saccades in the prosaccade task SRT/M_{right}) indicates a very low, negligible association between eye movements and Agreeableness in the subjects in the maltreated group. This oculomotor measure does not offer any forecast of Agreeableness in this group. Nevertheless, the predictive power of this oculomotor measure is strong in the control group; estimate=+1.291 shows that with the increasing value of SRT/M_{right}, the Agreeableness score also increases. The standard deviation of saccadic reaction times of all correct saccades in the prosaccade task (SRT/SD_{right}) predicts the measurement of Agreeableness at p=0.052, however its predictive value increases in group interaction (p=0.038). Hence by comparing the Estimate values of the interaction with non-clustered value, we acquire the Estimate of the maltreated group: Clust: SRT/SD_{right} + SRT/SD_{right}=1.421 + (–1.337)=+0.084. The predictive power of the oculomotor measure SRT/SD_{right} is again negligible in the maltreated group, whereas in the control group it is significant (–1.337). In the control group, the increasing value SRT/SD_{right} is associated with a decrease in Agreeableness. It is accordingly similar to other oculomotor measures: the standard deviation of saccadic reaction times of all correct saccades in the prosaccade task/left (SRT/SD_{left}) has the value

Estimate in the control group equal to –0.396, whereas for the clinical group it has been measured at –0.094. A percentage of the erroneous prosaccades in the antisaccade task (Pr_{left}) in the control group equals –0.701, and in the maltreated group –0.018, a percentage of erroneous prosaccades in the antisaccade task Pr_{right} in control group equals +0.684, in maltreated group –0.026. The mean of reaction times of the correct antisaccades anti SRT/M_{left} in the control group is equal to +0.575, in the maltreated group –0.014, the mean of reaction times of the correct antisaccades $antiSRT/M_{right}$ in the control group it is equal to –0.884 while in the maltreated group it has been measured at –0.004.

Variable	**Estimate**	***p***
Intercept	45.447	< 2e−16***
Clust	−14.514	1.42e−10***
SRT/SD_{left}	−0.091	0.002**
SRT/SD_{right}	0.071	0.025*
Pr_{right}	−0.049	0.038*
$antiSRT/M_{left}$	−0.019	0.095

Note: Clust=membership in a group; $SRT/SD_{left,\ right}$=Standard deviation of saccadic reaction times of all correct saccades in the prosaccade task; Pr_{right}=percentage of erroneous prosaccades in the antisaccade task; $antiSRT/M_{left}$= the mean of reaction times of the correct antisaccades. Residual standard error: 5.325 on 123 degrees of freedom; Multiple *R*-squared: 0.5142, Adjusted *R*-squared: 0.4945; *F*-statistic: 26.04 on 5 and 123 *df*, *p*-value: < 2.2e−16. *$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

Table 4: Optimal Model for Conscientiousness.

Belonging to a group significantly contributes to the total variance of Conscientiousness. Predictive oculomotor variables for Conscientiousness are the variability of the saccadic reaction times in the prosaccade task in the left and right direction ($SRT/\ SD_{left,\ right}$) and the percentage of erroneous prosaccades in the antisaccade task (Pr_{right}). In the antisaccade task, we note a strong prediction toward the right side, and the mean of reaction times of the correct antisaccades ($antiSRT/M_{left}$) became evident in the final model, though without achieving any statistical significance. The negative value Estimate in the percentage of erroneous prosaccades in the antisaccade task (Pr_{right}) means that with the decrease of the directional errors toward the right side, the Conscientiousness increases. Moreover, we can see an asymmetry in the left-to-right direction. The variability of the saccadic reaction times in the left direction shows a negative Estimate value, i.e. the decreasing variability in the leftward direction predicts an increase of Conscientiousness. Variability in the direction to the right has a positive value Estimate, i.e. the growth of variance on the right predicts an increase in Conscientiousness. However, the interaction of eye movements with cluster membership has not been found, i.e. merely belonging to the group does not affect the predictive ability of eye movements in relation to Conscientiousness.

Variable	**Estimate**	***p***
Intercept	4.048	0.366
Clust	5.076	0.042*
SRT/M_{right}	0.030	0.110

antiSRT/M_{left}	0.028	0.053
antiSRT/SD_{right}	−0.043	0.037*

Note: Clust=membership in a group; SRT/M_{right}=Mean of saccadic reaction times of all correct saccades in the prosaccade task; antiSRT/M_{left}=Mean of reaction times of the correct antisaccades; antiSRT/SD_{right}=Standard Deviation of reaction times of the correct antisaccades. Residual standard error: 6.869 on 124 degrees of freedom; Multiple *R*-squared: 0.1347, Adjusted *R*-squared: 0.1068; *F*-statistic: 4.826 on 4 and 124 *df*, *p*-value: 0.001189 *$p < 0.05$

Table 5: Optimal Model for Neuroticism.

The sensation of belonging to a group contributes significantly to the total variance of Neuroticism. Predicting the oculomotor variable that achieved statistical significance is accomplished by measuring the variability of antisaccadic reaction times in the right (antiSRT/SD_{right}). Its growth is associated with the decline of Neuroticism (and its decline is accordingly associated with the growth of Neuroticism). On the very edge of statistical significance is the mean reaction times of the correct antisaccades for the left direction (antiSRT/M_{left}). The growth of this variable signals the growth of Neuroticism (and its decline accordingly indicates a reduction in Neuroticism). Individuals with low Neuroticism react more quickly to saccadic stimuli, particularly in the left direction. An interaction of eye movements with a relation toward the cluster was not found, i.e. merely belonging to the group does not affect the predictive ability of eye movements in relation to Neuroticism.

Variable	**Estimate**	***p***
Intercept	159.550	0.001**
Clust	−142.787	0.003**
SRT/M_{left}	−0.240	0.0 *
SRT/M_{right}	−1.088	0.014*
SRT/SD_{left}	0.163	0.225
SRT/SD_{right}	1.815	0.011*
Pr_{left}	0.468	0.035*
Pr_{right}	−0.531	0.065
antiSRT/M_{left}	−0.775	0.003**
antiSRT/M_{right}	0.754	0.010*
antiSRT/SD_{left}	0.438	0.013*
Clust: SRT/M_{left}	0.249	0.009**
Clust: SRT/M_{right}	1.096	0.013*
Clust: SRT/SD_{left}	−0.197	0.118
Clust: SRT/SD_{right}	−1.769	0.013*
Clust: Pr_{left}	−0.480	0.028*
Clust: Pr_{right}	0.532	0.061
Clust: antiSRT/M_{left}	0.777	0.003**

Clust: antiSRT/M_{right}	−0.761	0.009**
Clust: antiSRT/SD_{left}	−0.445	0.010*

Note: Clust=membership in a group; SRT/$M_{left,\ right=}$Mean of saccadic reaction times of all correct saccades in the prosaccade task; $Pr_{left,\ right=}$percentage of erroneous prosaccades in the antisaccade task; antiSRT/$M_{left,\ right=}$Mean of reaction times of the correct antisaccades; SRT/$SD_{left,\ right}$=Standard deviation of saccadic reaction times of all accurate saccades in the prosaccade task; Clust: SRT/M. Clust: antiSRT/SD=interaction of oculomotor variable and groups. Residual standard error: 3.722 on 109 degrees of freedom; Multiple *R*-squared: 0.4465, Adjusted *R*-squared: 0.35; *F*-statistic: 4.628 on 19 and 109 *df*, *p*-value: 1.257e−07. *$p < 0.05$. **$p < 0.01$.

Table 6: Optimal Model for Openness.

The predictive variable for Openness is indexed in the eye movements in the following ways: a) by the reaction times of the saccades in the prosaccade task; b) by the reaction times of the antisaccades and c) by the percentage of directional errors in the antisaccade task. The prediction is affected by the asymmetry of the visual field on the left versus right side. In all oculomotor variables, we have observed their interaction with the cluster variable, i.e. belonging to a group significantly affects the prediction of Openness according to the eye movements. Nonclustered values relate to the control group while clustered values constitute a mixture of both groups. By comparing the Estimate values by interaction with the nonclustered values, we find an Estimate of the maltreated group members for the oculomotor variable, for example: for SRT/$M_{left,\ ritht}$ we calculate: Clust: SRT/M_{left} + SRT/$M_{left=}$+0.249 + (−0.240)=+0.009. Similarly for the right direction: Clust: SRT/M_{right} + SRT/M_{right}=+1.096 + (−1.088)=+0.008. Next, the oculomotor variables for the maltreated group are the following: SRT/SD_{left}=−0.034; SRT/$SD_{right=}$+0.046; $Pr_{left=}$−0.012; Pr_{right}=+0.001; antiSRT/M_{left}=+0.002; antiSRT/M_{right}=−0.007; antiSRT/$SD_{left=}$−0.007. These values indicate a very low, negligible association between eye movements and Openness in the maltreated subjects. In contrast, in the control group, we observe rather strong associations of the eye movements with Openness.

Parameters		**Classification according to eye movements**	
		Normal personality (adapted personality)	**Maladapted personality (aberrant personality)**
Classification according to personality variables	Control group	118	1
	Maltreated group	6	4

Table 7: Discriminant Analysis of Participants According to Eye Movements.

Note: The personality variables were clustered by Gaussian mixture model clustering method Scrucca et al. [16] which maximize the BIC criterion in order to detect the optimal number of groups in the data. The estimated number of groups was 2 whereby the second group contained some but not all of the institutionalized subjects (*N*=10) with none of the control subjects. The remaining seven individuals from the out-of-home care group, (whose personality profiles fit to the typically-developing subjects) were classified by the aforementioned method to the control group. This has resulted in obtaining a clinical group of subjects with a clearer, more obvious, maltreatment effect on their personality. This table

shows two variables named “maltreated group” and “control group”. For classification, we used all variables of the eye movements (see the Oculomotor measures). The numbers in the table mean the number of subjects.

Conformity to the classification according to the results of the personality questionnaire and of the eye movements was found to be high in the control group, whereby only one subject was classified contrarily. This subject is a young woman growing up in institutional care. She perceives herself as a harmonious, normally-adapted personality, in contrast to the oculomotor finding, according to which she belongs to the group of maltreated subjects. The self-perception of her own personality as indexed by the Big Five seems to be exaggerated in terms of the oculomotor test. The probable cause may be some defensive mechanisms that protect her from distress. However, this is merely our hypothesis which would need to be verified through a properly detailed diagnosis. Among the members of the control group, six other young women were also being raised in out-of-home care; in all six cases they were found to be accordance with their own classification. Hypothetically, these women could be gifted with a resilience of an over-controlled personality organization which resists their maltreatment. Their percentage in the sample of the out-of-home care subjects equals to 35% (6/17 → 35%). In every one of the women being raised by their own family, we found a match in this classification. On the other hand, from the entire group of maltreated subjects, we found merely 4 subjects matching this classification. In six maltreated subjects, we observed a mismatch characterized by a reduced self-perception of their personality and by a normal oculomotor finding, predicting an adapted personality.

4. Discussion

The most substantial finding of our study is the dissociation between eye movements and personality in maltreated subjects in contrast to the control group. Consequently, this made it rather tricky to decode the relationship between personality and eye movements in maltreated subjects.

Reduced legibility of the maltreated subjects was also observed in a study, as manifestations of maltreated subjects in non-oculomotor measurements Jost et al. [19] .This study conducted research about how primary school teachers perceive the characteristics of their pupils who grew up in dysfunctional families and thereafter were placed in out-of-home care. To their teachers, family children appeared “more readable” than maltreated children. This readability was expressed by correlating the coefficients between the perception of teachers and the self-perception of the children. Cooperative agreements with teachers were noticeably higher in children raised by their own families. If a child from a stable family environment felt an above-average level of self-confidence or slightly below average, his/her teacher could more reliably estimate the level of self-esteem than by a maltreated child. It was a similar situation regarding the assessment of popularity and intelligence. The cause of the diminished readability is seen in maltreatment which adversely modified personality development and accordingly deteriorated the view of an individual of him or herself. Dytrych et al. [20] found social blindness in maltreated subjects. Social blindness is characterized by inadequacy which forms among maltreated subjects, in other words, a completely unrealistic picture of the world and a false image of themselves as well. This blindness is transmitted from one generation to the next, as the so-called Prague Study indicates David et al. [18]. In our study, this social blindness manifests itself as a major divergence between a self-reported personality and the oculomotor finding. Significant interactions of eye movements with cluster membership have divided personality traits into two distinct groups: (1) Agreeableness and Openness, whose prediction according to the eye movements was

distinctly influenced by membership in the cluster (maltreated group vs. controls) and (2) Extraversion, Conscientiousness and Neuroticism whose prediction according to the eye movements was not affected by cluster membership (see Tables 2 through 6). From these findings, we may conclude a differentiated impact of the environment on personality traits. Extraversion, Conscientiousness and Neuroticism seem relatively less influenced by maltreatment. Agreeableness and Openness, in contrast, appear to be increasingly sensitive. Through a factor analysis in healthy adults, De Young et al. [21] reached a conclusion regarding two factors of a higher order (the purported metatraits): the so-called Stability included Agreeableness, Conscientiousness and Neuroticism (emotional stability). Members of this group need to preserve stability in their personality in order to be consistent and "readable" for others and, as a consequence, to coexist socially and achieve different goals. The so-called Plasticity included Extraversion and Openness. The basis of Plasticity is exploration – the tendency to engage actively and flexibly with originality, because every individual evolves, and every environment within which the individual lives changes. This exploration has two basic manifestations: the social one, manifesting itself in Extraversion, and the cognitively one, manifesting itself in Openness. We may distinguish the main difference between ours and De Young et al.'s [21] classification in the participants: De Young et al. [21] operated with healthy individuals, while we have besides worked with seriously maltreated subjects. Our study has therefore attempted to capture the specific effects of maltreatment on personality development. Extraversion, which De Young et al. [21] judge as plastic, seems to us to be more stable, and on the other hand much less likely to be influenced by one's environment. Openness in both classifications appears to be both plastic and highly sensitive to the environmental influences. If there is a need to incorporate novel information into the personality organization common to both, Extraversion and Openness, as De Young et al. [21] surmise, then the need to explore social stimuli seems to us more fundamental than the need to explore cognitive stimuli. In both evaluated classifications, Conscientiousness and Neuroticism have proved to be stable personality traits, hence quite unlikely to be influenced even by a very different social environment. The Agreeableness is rated by De Young et al. [21] as stable. However, in our study, it has significantly interacted with cluster membership. In our study, Agreeableness together with Openness has been proven to be traits which are less resistant to maltreatment. Under ordinary circumstances, healthy individuals develop a balance of both personality metatraits, Stability and Plasticity, resulting in the functional adaptation to the social environment as well as to oneself. The healthy development of the personality, assumed in our control group, was associated with the development of eye movements, from which it was possible to forecast normality and personality traits in the control group. Maltreatment appears to us as a condition which devastates personality (balance of both metatraits, Stability and Plasticity and therefore makes it maladaptive) and dissociates the relationship between eye movements and personality. The symptom of this dissociative effect is the reduced readability of the personality by eye movements, precisely as we have observed in our study in maltreated subjects.

4.1 Executive functions and personality

The antisaccade task is regarded as an inhibition test Aichert et al. [22, 23]. In our regression models (see Tables 2 → 6), we found associations between the antisaccade task and most of the personality traits indexed by the Big Five (Agreeableness, Conscientiousness, Neuroticism and Openness), yet only in the case of the Extraversion did we fail to find this association. Hence, we conclude that personality significantly interacts with inhibition. An analogous conclusion has been published by von Hippel [24]. According to von Hippel, inhibition is implicated in two types of social inappropriateness: (1) in the ability to observe the goal-directed activity, to temper the omnipresent distracters, to follow

up on the same theme of conversation and (2) the ability not to express thoughts and opinions which are not tactful or considerate and so should not be uttered. The dissociation between knowledge regarding how to behave and the ability to keep this knowledge can be interpreted according to von Hippel as inhibitory losses. Von Hippel observed inhibitory losses in healthy, aging people. However, we may also see these losses in young people who have been exposed to long-term maltreatment – as our study clearly shows.

In their review study, Cyders and Coskunpinar [25] examined various aspects of impulsiveness as assessed by laboratory tasks and self-reported instruments. The authors found significant associations between prepotent response inhibition, measured by the antisaccade task. Additionally, the following aspects of impulsiveness were found: the lack of perseverance or an inability to stay focused on a task, a lack of planning, a negative urgency or a tendency to act rashly while experiencing negative affect and a lack of deliberation or a lack of premeditation or behaving without any regard to any awkward consequences. In line with these findings by Cyders and Coskunpinar are our own findings about the significant associations between antisaccade measures and Big Five factors, namely Agreeableness, Conscientiousness and Openness. Cyders and Coskunpinar found no significant association between the prepotent response inhibition and sensation-seeking or the tendency to enjoy exciting activities and being open to try new experiences. Sensation-seeking is a feature characteristic of the Extraversion. In line with this is also our finding about non-significant association of the antisaccade task with Extraversion.

However, Rauthmann et al. [8] found a significant association of the eye movements only with Extraversion, in contrast with our findings. The difference may be explained by the different nature of their oculomotor task. Rauthmann et al. [8] manipulated with various degrees of irritability of the occulomotoric tasks, which did not interfere with inhibition. Specifically, their Animation Red provoked extraverts to the frequent and typical reactions by which they differentiated from introverts (shorter dwelling time, higher number of fixations, shortening of the total browsing time). Rauthmann et al. [8] interpreted their findings by the characteristics of the Extraversion as a domain of liveliness, energy, and activation; stimulation, sensation, excitement, or activity-seeking. Therefore extraverts are associated with more frequent and faster oculomotor behavior and an increased interest in external stimuli. In contrast to the tasks of Rauthmann et al. [8] the saccade tasks that we have used appear to be extravertally neutral and without irritability. However, they are diagnostically less sensitive to this personality trait. Impulsivity may include several aspects such as thrill-seeking, the expressions of so-called non-planning impulsivity (first act and then think) and disinhibited behavior Cyders and Coskunpinar [25, 26]. BFI-44 captured primarily the aspect of unplanned impulsiveness. This aspect overlapped with the inhibition required in an antisaccade task. Rauthmann et al. [8] however found an association between their tasks and the Extraversion. Therefore we assume that their tasks were sensitive to thrill-seeking, which is the sign of the Extraversion.

In contrast to our findings, Fleming et al. [5] have chosen a three-factor model of the executive functions: inhibition – shifting – updating. One of their measures of inhibition was an antisaccade task. Fleming et al. [5] found that Conscientiousness is positively associated with cognitive flexibility rather than inhibition. This distinguished them from our findings. The administration of the task differed slightly from ours (Fleming et al. [5] chose the cue technique). Nevertheless, the difference was insignificant and it was not sufficient to explain their different findings from ours. However, participants of Fleming et al. [5] were only healthy subjects unlike in our study. We also see a significant difference in cultural factors. In the United States, being an extravert and displaying flexibility are much more appreciated

unlike in Czech society. The Czechs are more inclined to rigidity; self-control and tidiness are highly appreciated. These attributes also become a pedagogical objective of Czech school education. Our participants in the control group were future teachers, where these attributes become an element of their professional competence. Therefore, these features were probably also self-reported because BFI-44, as well as NEO, characterizes Conscientiousness by four aspects: order, self-discipline, dutifulness and ambition. The orientation on Conscientiousness in our controls and non-Conscientiousness in our maltreated subjects manifested itself through significant differences between the two groups, and these differences most likely contributed to a higher association between Conscientiousness and the performance in an antisaccade task. However, our finding of a significant association between inhibition and Conscientiousness does not vitiate the validity of the findings of Fleming et al. [5].

Aichert et al. [22] investigated the relationship between self-reported impulsiveness among other antisaccade task. The authors found a significant correlation ($r=0.134$; $p=0.004$). However, self-reported impulsivity explained merely 12% of the variance measured impulsivity in the antisaccade way. Aichert et al. [22] drew attention to two different techniques in measuring impulsiveness (self-reported measures and behavioral lab tasks), which may have contributed to these different findings. The antisaccade is one of the laboratory methods of measuring impulsiveness, specifically the prepotent response inhibition. The consequences resulting from a reduction of inhibition in daily life are much more serious than in a laboratory where "it does not matter" while impulsiveness in everyday life is much more likely to be condemned or even punished. The questionnaire is therefore burdened by social desirability, unlike the antisaccade task. However, according to Aichert et al. [22] the diagnostic value of the antisaccade task is not rendered useless. Instead, it shows us the "basal" degree of impulsivity, which is evaluated differently in the social and cultural context of a particular individual – as socially tolerable or intolerable according to the individual. The oculomotor tasks submitted to the subject and the eye movements registered are more neutral than questionaires with respect to identification of personality; they do not provoke the subject to knowingly or unknowingly misrepresent the data about themselves. Coskunpinar and Cyders [27] reach this very conclusion in their meta-analytical overview study concerning the relationship between impulsiveness and substance-related attentional bias. Both measures, self-reported impulsivity and the lab task, assess different aspects of impulsiveness and actually have little overlap. Coskunpinar and Cyders [27] concluded that in comparison with questionnaire-measured impulsivity, laboratory-measured impulsiveness is a better predictor of behavior known as substance-related attentional biases.

4.2 Asymmetry of the visual field in the left-right direction

In our study, we observed asymmetry or differences in the occulomotor behavior of the subjects in the direction left – right. The differences were always characteristic for just one occulomotor variable and manifested itself by the opposite sign of the Estimate value by the respective variable. For example, the variability of the saccadic reaction times predicting Extraversion showed an Estimate value for the left direction of –0.083 (that means its growth was signaled by a decrease of the Extraversion) and for right direction +0.074 (that also means its growth signaled the growth of Extraversion). This asymmetry may be explicated by the functional specialization of the two brain hemispheres. The left visual field in the prosaccade task is coordinated by the right hemisphere which is normally specializing in visual-spacial functions and visual-motor aspects of saccade. The right visual field in the prosaccade task is controlled by the left hemisphere which is customarily the site of voluntary control Cameron et al. [28, 29]. Visual attention therefore operates in the left visual field

at a lower level than in the right visual field, whereby conscious voluntary functions enter the game. Asymmetry is in fact a normal sign in healthy subjects. For our controlled subjects, the asymmetry of the visual field manifests itself in all five personality traits (Extraversion, Agreeableness, Conscientiousness, Neuroticism, Openness) while in the maltreated group it was limited to just Extraversion, Conscientiousness and Neuroticism. We conclude that the cause of the difference is the weakened voluntary component and under-controlled personality organization among the maltreated subjects. From this point of view, the dissociative effect of maltreatment in the diagnosis of personality traits according to the eye movements manifested itself especially in Agreeableness and Openness in our maltreated subjects.

4.3 Limits

The limitation of this research consists in the small number of maltreated subjects that does not allow for major overarching generalizations. From an alternative point of view, it is a blessing that there is a very limited number of severely maltreated subjects among us. Another limit is the lack of a developmental aspect. A developmental study could indicate when eye movements may be already associated with a personality, when it is possible to detect the onset of dissociation and accordingly to consider the possible effects of maltreatment. Individual differences regarding resilience and gender in relation to the different degrees of maltreatment are also unclear from our research.

5. Conclusion

The eye movements are likely to contain information about personality, indexed by the Big Five, and the oculomotor test can therefore enrich the personality diagnosis. By typically developing subjects, we found an association between eye movements and a self-reported personality as indexed by the Big Five. Conversely, we have observed in maltreated subjects dissociation between the oculomotor finding and personality. This dissociation could be considered as a diagnostic marker of maltreatment. The dissociative effects of maltreatment differentiated according to personality traits. The most striking dissociation we have observed are narrowed to Agreeableness and Openness, whereby it vitiated the reliability of the oculomotor test while in Extraversion, Conscientiousness and Neuroticism, dissociation seemed less noticeable. As a consequence, we have reached the conclusion that Agreeableness and Openness are more sensitive to maltreatment in relation with other traits. The present study indicates the asymmetry of the visual field in the left-right direction by the occulomotor tasks we employed. In maltreated subjects, in contrast to typically developing subjects, this asymmetry limited itself to some personality traits. We see a potential cause in the weakened voluntary component in maltreated subjects, because an antisaccade task is considered to be the test of inhibition.

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Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Standards and Informed Consent

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revized in 2000. Informed consent was obtained from all subjects for being included in the study.

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