Adolescents with Persistent History of Maltreatment Fail in Antisaccadic Task

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Abstract The antisaccadic task is sensitive to what is called frontal dysfunction, i.e. dysfunction of the frontal lobes of the cerebral cortex which are the basis for a wide range of symptoms. The present study examined saccadic eye movements in adolescents with persistent history of maltreatment. Participants included 17 female subjects with maltreatment history. The control group consisted of 54 typically developing female subjects. All participants were administered Child Behavior Checklist (CBCL) and saccadic eye movement tests. CBCL showed significant differences between the maltreated and control groups. The prosaccadic test revealed insignificant results between both groups. The antisaccadic test revealed a highly significant difference (longer latencies, more prosaccadic mistakes in the group of maltreated subjects). Antisaccadic eye movements may be regarded as a possible indicator of persistent maltreatment and following emotional and behavioral problems and may therefore enhance diagnostic methods.

Keywords Antisaccades · Disinhibition · Frontal dysfunction · Maltreatment · Out-of-home care

Child maltreatment is a multi-dimensional construct including (1) *abuse* or acts of commission, i.e. physical abuse, emotional abuse, and sexual abuse and (2) *neglect* or acts of omission, i.e. failure to meet a child's basic physical, emotional, medical/dental or educational needs (Child Welfare Information Gateway 2013).

Institutional care remains a major intervention in Czech Republic for children whose parents are not willing or able to care adequately for them. Despite the best intentions of those providing out-of-home care, many problems in these children tend to linger and continue up to adulthood. Balbernie (2010) speaks of cumulative trauma: the child grows up in a dysfunctional family which neglects the child emotionally or physically, and is then taken away from the family and placed into institutional care which is unable to provide for adequate basic emotional needs. McGrath-Lone et al. (2016) consider institutionally-reared children as a vulnerable group associated with multiple adverse outcomes including poorer health, problematic relationships with their peers, risky behavior (drinking, drug-taking, teenage pregnancy), and academic underachievement, as well as a higher probability of being unemployed, imprisoned, homeless, or a victim of violent crime. Humphreys et al. (2015) found that children who experienced institutional rearing as young children had significantly higher levels of callous-unemotional traits in early adolescence compared to children who were never institutionalized.

Negative emotional experiences in childhood shape the brain of an individual as the brain is highly plastic during this period (Anda et al. 2006; Hartmann 2009; Meares et al. 2011; Perry 2006; Sheridan et al. 2010; Schore 2000, 2009, 2011; Schore and Schore 2008). In deprived individuals, brain circuits which are supposed to form a substrate for empathy and for understanding the feelings of others are not formed. The principle of “use it or lose it” applies here.

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Schore (2000, 2009) assumes a significant structural defect of the orbitofrontal cortex which is responsible for self-regulation and contributes to the social and emotional problems of individuals. Similar arguments are presented for example in studies by Bick et al. (2015, 2017), Braun and Bock (2011), Kolb et al. (2012), McCrory et al. (2012), Mueller et al. (2010), and Slopen et al. (2012).

Antisaccadic Eye Movements Versus Maltreatment

In the prosaccadic task, the individual fixes their attention on a fixed point (circle) in the centre of a screen. A saccadic stimulus (triangle) then jumps in from the left or right. The individual is instructed to move their eyes as quickly as possible from the fixed point (circle) to the saccadic stimulus (triangle). The antisaccadic test also presents a visual cue on one side of the visual field but requires the examinee looks to the opposite side. The individual must first suppress their spontaneous saccadic reaction (so-called prosaccade) and focus their attention on the opposite side of the screen. This reaction is called an antisaccade. The average reaction time of antisaccades is longer than that of prosaccades (Fischer and Everling 1998). The saccadic stimulus causes a reflex reaction, in which the brain automatically begins to prepare a prosaccade and this must be suppressed by will. Only then is it possible to redirect saccades in the opposite direction. Therefore, antisaccades are the most time-consuming. Antisaccades contain a voluntary component, while prosaccades are controlled reflexively. Both types of saccades are controlled by different parts of the brain (Fischer and Everling 1998; Fischer and Weber 1992).

The antisaccadic task creates a conflict between voluntary and reflex reactions, thus allowing different variations to be tested. It is sensitive to what is called frontal dysfunction, i.e. dysfunction of the frontal lobes of the cerebral cortex which are the basis for a wide range of symptoms. Hence, the antisaccadic test is used by neurologists, psychiatrists, psychologists and other specialists to diagnose frontal dysfunction (Bittencourt et al. 2013 for review; Rommelse et al. 2008 for review). Failure in the antisaccadic test may in fact be significant for our study of the relationship between eye movements and maltreatment.

To our knowledge, Mueller et al.'s research (2012) is a unique study that explores the relationship between eye movements and maltreatment. The authors investigated whether maltreatment could affect the sensitivity of individuals towards rewards and punishments. Mueller et al. found that the number of directional errors in antisaccadic tasks was favorably influenced by incentives only in controls. Antisaccadic performance in a neutral condition (no incentive), however, was comparable in both groups, with

no significant difference. Mueller et al. tested individuals who had suffered maltreatment in early childhood. Then they grew up in functional families that reduced adverse maltreatment effects on their development. However, what will be the oculomotor image of individuals who are exposed to long-term effects of maltreatment? According to the neuropsychological and neuropsychiatric findings mentioned above, frontal dysfunction should be more significant; i.e. failure in the antisaccadic test may in fact be striking. For this reason, we decided to examine the relationship between eye movements and profound degree of maltreatment.

Method

Participants

The maltreated group consisted of 17 young women aged from 16 years and 4 months to 18 years and 1 month, $M = 17$ years and 3 months. Their parents maltreated them and had been themselves maltreated as children. Promiscuity and a tendency towards alcoholism or drugs were observed in parents of the subjects involved in the study. The parents of four of the individuals had been in prison, and one of these individuals had been sexually abused by her father. In many cases, social services had attempted to protect these families but were not always successful. Individuals that could not remain in the care of their families were placed in an institution from the age of about 11–12 years. Reasons for this included running away from home, wandering, neglect of school attendance, relationships with morally-impaired people and groups (pimps and criminally-oriented groups using girls as decoys), experimentation with drugs and their sale, alcoholism and smoking, the beginnings of prostitution and repeated petty theft. Contact with their parents was voluntary. If parents and their children expressed mutual interest, the subjects could visit their parents at home whenever they wanted, or parents could visit their daughters in the institution. Regular personal contact (with a frequency of once or twice per month) with at least one parent was maintained by eight subjects (i.e. 47% of the 17 subjects). Of these eight subjects, only one socialized with both parents. Most of the fathers exhibited no interest in contact with their daughters (in 15 out of 17 girls). The movement of subjects outside the institution had to be monitored—subjects often came home drunk or under the influence of drugs. One subject became pregnant twice during these trips away from the institution. A strong lack of restraint was observed in the subjects, with a focus on immediate satisfaction of their needs and wishes. If this did not occur, the subjects exhibited outbursts of anger combined with the destructive behavior (especially strong in 6 out of 17 subjects). A tendency towards self-harm manifested itself in 5 out of 17 subjects;

One of them attempted suicide repeatedly. In 10 out of the 17 subjects, there was repeated physical aggression directed towards other people (their peers and adults).

The control group consisted of female students of a Pedagogical Secondary School ranging in age from 16 years and 3 months to 17 years and 10 months ($M = 17$ years and 2 months); $N = 54$. None of them were suspected of having a long-term dysfunctional family environment. Their family environments could be described as stable and their families had not been registered with any social service. None of the subjects were observed as having tendencies towards the consumption of drugs or alcohol, or the smoking of cigarettes, or towards criminal activity, prostitution, bullying and aggressive behavior, suicidal attempts, running away from home or truancy.

Child Behavior Checklist (CBCL)

CBCL is a method developed by Achenbach (1991) to provide a standardized description of behavior. One possible cause of significant deviations of behavior may also be maltreatment. We are aware of the author's warning that high scores in his test cannot be automatically associated with a diagnosis. CBCL presents the assessor, whether this be an external assessor (parent, teacher) or the subject himself, with various statements to which are assigned frequency or intensity of occurrence. These statements are divided into nine groups: (1) withdrawn, (2) somatic complaints (complaints of headaches, stomach aches and sore eyes, skin problems, dizziness, unspecified physical problems), (3) anxiety/depression (anxious and depressive tendencies including feelings of inferiority and complaints of being misunderstood), (4) social problems (behavior inappropriate to age, gravitating towards older or younger friends; Not getting along well with peers, being a loner; Tendency to provoke), (5) thought problems (strange ideas and strange ways), (6) attention problems (chaotic, distracted, impulsive, gapes with a blank face), (7) delinquent behavior (lying, cheating, theft, running away from home or school, vandalism, physical violence, an inclination for tobacco, alcohol and drug consumption, behaving without remorse or self-control), (8) aggressive behavior (gossiping, hurting others, cruelty towards people or animals, answering back, threatening, provoking), (9) other problems (sexual problems, problems with excretion, self-harm, eating disorders, sleep disorders, onychophagia). We administered the CBCL–Teacher's/Parent's Report Form to the mothers of subjects in the control group and the female teachers of the subjects in institutional care. We administered the CBCL–Self Report Form to subjects in the control group and in the institutionalized group. CBCL has not yet been standardized in the Czech Republic. Therefore, we worked with the raw scores obtained from this test.

Eye Movements

Eye movements were registered with 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° in linear range $\pm 15^\circ$. The eye tracker captured monocular eye movements (from the left eye), and the measuring method was IROG (infrared oculography). The device contained a built-in saccadic test which administered horizontal prosaccades and horizontal antisaccades to the subjects. In the prosaccadic task, the subjects had to fix their gaze on a point in the centre of the screen. The foreperiod during which the central fixation target was displayed was constant at 1200 ms. After 200 ms, before the switching off of the central fixation target, a new saccadic stimulus lit up randomly left or right of the central fixation target on a horizontal plane and a distance of 4° from the target. The subjects were instructed to shift their 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 and a new trial began. In the antisaccadic task, the subject had to focus on the central fixation point which lasted 1000 ms, and after its disappearance there was a gap of 200 ms. After the gap, a new light appeared at a distance of 4° 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 at the opposite side of the screen. Targets were presented using laser projection on a light grey wall. No objects other than the projected light points were in the subject's field of vision. Assessment took place during the day in a quiet room.

Procedure

The subject was first instructed about the whole assessment process, including the viewing of any machines to be used. This was followed by calibration and 5–10 practice attempts at the prosaccadic test. The number of practice attempts varied. Some subjects completed the task straight away, while others required several attempts. The subject was always informed of the correctness of her saccadic response immediately after having produced it ("good, correct", "attention–error"). The instructions also included statements that it was natural to make mistakes, that everyone made mistakes and one should not allow oneself to become unsettled because of having made mistakes. These statements combined with feedback were aimed at producing the best oculomotor results from the subject. Practice tests were followed by new calibration and the subject was then administered the prosaccadic 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 min which was then followed by practice attempts at the antisaccadic test.

The antisaccadic 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 assessment including the practice attempts was no longer than 20 min per person.

Oculomotor Measures

We worked with the following measures: the mean reaction time of all correct saccades in the pro-overlap task; Standard deviation of the above mean value; Percentage of reflexive prosaccades in the anti-saccade task that were made mistakenly towards the target; Mean reaction time of those prosaccades; Standard deviation of the above mean value; Percentage of erroneous prosaccades that were corrected; Mean correction time measured from the end of the first saccade to the beginning of the second saccade; Mean reaction time of the correct antisaccades; Standard deviation of the above mean value. All times are displayed in milliseconds (ms), all other values in percentages (0 to 100).

Results

Tables 1 and 2 show the results of the CBCL, while Tables 3 and 4 show oculomotoric test results. In the institutionalized group, we tested 15 out of 17 young women who had completed the CBCL. The remaining two young women were not available at the time of testing; they had fled on their way home from school - police found them

Table 1 CBCL-self report

Aspect	Institutional- ized group <i>n</i> = 15 <i>M</i> (<i>SD</i>)	Control group <i>n</i> = 48 <i>M</i> (<i>SD</i>)	Wilcoxon's test	
			<i>W</i>	<i>p</i>
Total score	98.0 (40.7)	47.5 (15.1)	73.5	0.000
Withdrawn	6.0 (3.2)	3.4 (2.1)	194.0	0.003
Somatic complaints	6.5 (4.9)	3.1 (2.1)	212.5	0.008
Anxious/ depressed	16.9 (7.5)	7.9 (4.1)	112.5	0.000
Social problems	5.4 (2.7)	3.1 (1.8)	235.5	0.021
Thought problems	7.5 (3.1)	2.6 (1.7)	84.0	0.000
Attention problems	9.0 (4.4)	5.4 (2.7)	168.0	0.000
Delinquent behavior	10.3 (4.2)	2.6 (1.6)	11.0	0.000
Aggressive behavior	17.3 (7.7)	6.8 (3.4)	83.0	0.000
Other problems	17.5 (6.9)	8.1 (4.5)	100.5	0.000

The mean and standard deviation were calculated from raw test scores

Table 2 CBCL-teacher's (parent's) form

Aspect	Institutional- ized group <i>n</i> = 15 <i>M</i> (<i>SD</i>)	Control group <i>n</i> = 48 <i>M</i> (<i>SD</i>)	Wilcoxon's test	
			<i>W</i>	<i>p</i>
Total score	63.0 (38.0)	28.1 (18.7)	138.5	0.000
Withdrawn	4.7 (4.0)	3.4 (2.4)	263.0	0.207
Somatic complaints	2.8 (2.9)	2.4 (1.6)	315.0	0.565
Anxious/ depressed	8.5 (6.1)	5.7 (4.2)	225.5	0.062
Social problems	5.5 (3.1)	1.8 (1.4)	87.0	0.000
Thought problems	3.1 (2.2)	1.3 (1.5)	135.5	0.000
Attention problems	8.6 (4.7)	3.3 (2.7)	102.5	0.000
Delinquent behavior	9.9 (4.8)	1.9 (2.1)	29.0	0.000
Aggressive behavior	14.8 (11.8)	4.4 (4.3)	136.5	0.000
Other problems	6.6 (6.0)	4.3 (3.7)	250.5	0.145

The mean and standard deviation were calculated using raw test scores

later in a “drug den”. Hence, *N* = 15 in Tables 3 and 4. In the control group, 54 participants were tested. However, 6 of them refused to complete CBCL. Hence, *N* = 48 in Tables 1 and 2.

The results of the CBCL corresponded with anamnestic results and supported our initial notions about negative outcomes of maltreatment among subjects in the institutionalized group. Their CBCL-Self Report scores were significantly worse than in the control group (Table 1). Their teachers assessed them using the same CBCL-Teacher's Form less positively than mothers assessed their daughters in the control group (Table 2).

In the standard saccadic test, the institutionalized group reacted more slowly than the control group. However, the difference between the groups was not statistically significant. A noticeable difference appeared in the antisaccadic test. In comparison with the control group, the institutionalized group reacted much more slowly in producing correct antisaccadic reactions. They made more mistakes in the form of prosaccades. These mistakes were not corrected as often, but if they were corrected, this group reacted with much greater latency. These results indicate that basic saccadic generation circuitry is intact in the institutionalized group but it is the higher-order processes that are damaged. Results seem to support the idea that the antisaccadic test stimulates executive functions which are weaker in the institutionalized group.

Table 3 Prosaccadic test

Measure	Institutionalized group <i>n</i> = 17		Control group <i>n</i> = 54		Wilcoxon's test			
	<i>M</i> (<i>SD</i>)		<i>M</i> (<i>SD</i>)		Left		Right	
	Left	Right	Left	Right	<i>W</i>	<i>p</i>	<i>W</i>	<i>p</i>
Prosaccadic reaction time (ms)	215 (51.7)	213 (64.4)	191 (30.8)	198 (33.4)	321.0	0.064	422.0	0.622

Table 4 Antisaccadic test

Measure	Institutionalized group <i>n</i> = 17		Control group <i>n</i> = 54		Wilcoxon's test			
	<i>M</i> (<i>SD</i>)		<i>M</i> (<i>SD</i>)		Left		Right	
	Left	Right	Left	Right	<i>W</i>	<i>p</i>	<i>W</i>	<i>p</i>
Antisaccadic reaction time (ms)	290 (78.2)	281 (83.4)	237 (46.9)	227 (41.4)	249.5	0.002	214.0	0.002
Percentage of prosaccadic mistakes	48.0 (23.5)	57.6 (27.3)	16.9 (16.0)	18.2 (14.5)	121.0	0.000	87.0	0.000
Percentage of corrections	66.2 (33.4)	51.7 (28.2)	86.8 (23.9)	88.4 (18.2)	552.5	0.004	730.0	0.000
Latency between mistake and correction (ms)	184 (88.9)	182 (63.3)	106 (40.9)	112 (37.7)	167.0	0.000	142.5	0.000

Discussion

Mueller et al.'s research (2012) is the unique and probably the only study to our knowledge that mentioned antisaccadic test in maltreated individuals. Mueller et al. were inspired with non-oculomotor studies where eye movements were not registered and a computerized two-choice decision-making task involving probabilistic monetary gains was used instead (e.g. Guyer et al. 2006). In these studies, maltreated individuals exhibited reduced sensitivity to rewards, unlike the control group. Mueller et al. innovatively used antisaccadic test on the sample of maltreated individuals. They primarily focused attention on the so-called incentive effect, i.e. whether the presence of incentives/rewards affects oculomotor performance of maltreated participants. Therefore, they compared pro- and antisaccadic performance in a neutral conditions (absence of incentives) versus conditions with incentives. The results supported their hypothesis, i.e. maltreated participants did not respond to incentives. Mueller et al. attributed this finding to the damage of the system which processes rewards. The cause of the damage was seen in maltreatment. However, the authors failed to distinguish both groups in terms of antisaccadic performance in neutral conditions. In our study, the participants went through the neutral conditions only on Mueller et al.'s terms. In these conditions, our findings are also partly comparable. In this partial accordance can be seen the support for the reliability of the findings. Mueller et al.'s maltreated individuals showed significantly longer latencies than controls, both in prosaccades and antisaccades. Our maltreated individuals also had longer latencies than controls. However, the difference was not significant in prosaccadic tasks—it reached

statistical significance in antisaccadic tasks, however. In Mueller et al. in a neutral condition of antisaccadic tasks the performance of maltreated individuals indexed by percentage of directional errors did not differ from controls. Percentage of directional errors was even higher in controls compared to maltreated individuals, although the difference did not reach statistical significance. In contrast, in our study maltreated individuals made significantly more directional errors than in controls. In addition, our maltreated individuals corrected significantly fewer errors, and if the errors were corrected, latencies of these corrections were significantly longer compared to controls. Unfortunately, Mueller et al. did not work with these parameters. A possible reason for these different findings could be the age of the participants—the effects of age and large differences in prosaccadic and antisaccadic performance in various stages of adolescence were shown by Fischer and Everling (1998).

In Mueller et al. the average age of subjects equaled about 11 years, while our participants were about 6 years older. During that time, the maturation of neural circuits which form the basis for prepotent reactions and executive function/inhibition could significantly progress. From this perspective, our maltreated participants were probably more mature and their prosaccadic performance was comparable to controls. The big difference can be observed in the personal history of maltreated participants in both studies, or in the degree of their maltreatment. Participants in the study of Mueller et al. were at the age of 2 years removed from their biological parents and placed in functional adoptive families with a good socio-economic status, reducing the potential adverse impact of the environment. In this quality family environment, participants lived for about 9 years (at

the age of 11 they were examined by Mueller et al.). Despite this, Mueller et al.'s individuals retain aberrant oculomotor responses, indicating the depth of the impact of adverse emotional experiences on the brain during early childhood, when children are highly sensitive to emotional stimuli. Our participants had probably more adverse personal history. They lived longer in dysfunctional families. At the time of removal from their families they had precriminal to criminal experience, experience with drugs, alcohol, and tobacco addiction. They roamed and lived in asocial and antisocial gangs—they simply lacked any order and love. They met regulations in institutional care, which of course could not give them the love and company of their peers. Their prosaccades were comparable to controls, indicating normal development in at least part of neuropsychiatric functions. Significant aberration remained in antisaccades reflecting higher order functions, i.e. self-regulation/disinhibition.

The incentive condition mentioned in Mueller et al. was more demanding for participants than the neutral condition mentioned in our study. In their decision-making process in prosaccadic and antisaccadic tasks, the participants had to incorporate incentive identification and handle its motivational value. An oculomotor test in Mueller et al. addressed multiple neuropsychiatric features and underlying brain regions; Not only executive functions/inhibition but also functions associated with processing rewards. Mueller et al.'s test therefore appears diagnostically more sensitive. Therefore, it may have identified the difference between the controls and maltreated individuals in the age of about 11 years, in antisaccadic task only in the incentive condition. We put a lower diagnostic sensitivity to our antisaccadic test application (with only neutral condition)—yet still we found a significant difference between the groups. The reason for this can be seen in more severe stage of maltreatment and the longer maltreatment effect on our participants group compared to Mueller et al.'s group.

Our study of maltreated subjects indicated significant oculomotor change, i.e. reduced ability to react in antisaccadic tests in their adolescence. In accordance with previous neuropsychiatric findings (Bick et al. 2015, 2017; Kolb et al. 2012; Braun and Bock 2011; Mueller et al. 2010) we assume that an important neural substrate of this change is the prefrontal cortex. Maltreated subjects were not as fortunate as the subjects in the control group and in their relationships with their parents they experienced rejection, scorn and ignorance—all characteristics of maltreatment. These negative experiences were encoded into the PFC due to its plasticity and metaplasticity, and formed it in a specific way. At the behavioral level, this manifested itself among others as lack of restraint, lowered self-control, and a decreased ability to inhibit reflexive prosaccades in the antisaccadic test, which could be explained by the fact that the PFC is connected to regions which control eye movements

at cortical level: frontal eye fields, supplementary eye fields and parietal eye fields (Leigh and Zee 2006; Munoz and Everling 2004).

The extent of the maltreatment disorder and possibilities of treatment remain unclear. Can the progress of the disorder be reversed or not? Have the subjects crossed a critical threshold? These questions stimulate a debate about the Pygmalion Effect. This term was taken from Ancient Greek myths about the beginning of sculpture and placed into pedagogical practice. As a precursor to sculpture, Pygmalion was aware of the beautiful, perfect shapes of natural, unshaped stone. He did not allow himself to be put off by the scepticism or jibes of his peers who did not possess his talent for observation, and he made his first stone statue. He continued to sculpt the statue using chisel and hammer until he breathed soul into it. The story of Pygmalion is essentially the content of daily work of all educators and parents. Every good parent believes they will bring humanity—speech, reason, love, conscience and willpower to their newborn who is formless and imperfect. All educators undergo difficult tests of optimism, i.e. their pygmalionism, in situations where a child's development is blocked and as a result the child is condemned. We believe that the educational reality in educational institutions for youth (out-of-home care) is probably the most difficult test of pygmalionism.

In these cases, the Pygmalion Effect can be reversed into its opposite pole, the so-called Golem Effect, which is the loss of faith in a remedy, or a loss of hope that demobilises educators and leads to burnout. The antisaccadic test does not resolve these issues. More precisely, we could not use this test to find solutions to these issues. However, the registration of ocular micro-movements which are invisible to the naked eye could contribute to progress, and could be used to determine the effectivity of treatment methods and efforts. However, this hypothesis deserves further investigation.

The Problem of Differential Diagnostics

The antisaccadic test is sensitive to frontal dysfunction which is the basis for a number of neurological and psychiatric syndromes.

Differentially diagnostic studies of antisaccadic tests are probably rare. Many more studies have been done on the use of antisaccadic tests within one field, one single diagnosis or a syndrome. The problem with comparing antisaccadic findings are non-standardized procedures that do not allow simple comparison of results obtained from various studies (Antoniades et al. 2013; Bittencourt et al. 2013). The same oculomotor symptoms that we saw in our maltreated group (increased frequency of errors in the antisaccadic test and greater latency of corrective antisaccads) can be observed in other psychotic and non-psychotic disorders (Bittencourt et al. 2013; Gooding and Basso 2008; Pelak 2010). It is

likely that these symptoms have a common cause, weakened inhibition, which is common to several syndromes. Therefore, the antisaccadic test may not be a good tool for differential diagnostics. The sensitivity of the antisaccadic test is probably also bound to age. Biscaldi et al. (2000) found significant differences between dyslexics and a control group starting from approximately the 10th year of age: dyslexics made more prosaccadic errors and fewer corrections of these errors. However, at age 8 it was not possible to differentiate the two groups using the antisaccadic test. It is likely that effects of maltreatment are also related to age and the time children are exposed to maltreatment. It is therefore necessary to assess whether the antisaccadic test can differentiate maltreatment from, e.g. ADHD, schizophrenia or dyslexia, and when and in which developmental period.

Cause Versus Effect

Robust negative outcomes in the maltreated subjects probably developed in their families which were dysfunctional. The role of institutionalized care is unclear. There is no doubt that the institution helped them by rescuing them from a bad family environment. Maclean et al. (2016) found that out-of-home care might have a protective effect on education and at minimum no harmful effects. However, the authors admitted that children's outcomes might vary depending on many variables (placement type, duration of out-of-home care, and the number of placement changes). But can an institution stop the pathogenesis of a maltreatment? Subjects living in institutions experience peer relationships which are marked by the psychopathology of the subjects themselves, and can hardly provide a healing environment despite the greatest efforts of educators. Many studies have expressed scepticism about the effects of institutional care (e.g. Balbernie 2010; Chisholm 1998; McGrath-Lone et al. 2016; Sheridan et al. 2010). It seems that institutional care is useful only in the initial phase of resocialisation during which it is a temporary solution until the time the child or adolescent finds a suitable foster family. But even then, the problem may not be solved. Foster care may be weak and the family may not be able to cope with the child or adolescent, who must then return to institutional care. It may become a vicious cycle from which it is difficult to escape. The finding in antisaccadic test in our maltreated individuals reflecting massive frontal dysfunction supports concerns about the vicious circle.

Limitations

Our study was limited by a small number of participants in the maltreated group, as was the case in the study by Mueller et al. (2012). Our study was also limited by the degree and duration of maltreatment the participants were exposed

to. We chose a severe degree of maltreatment to increase the difference between maltreated individuals and controls. Fortunately, there were few cases of severe maltreatment. However, for scientific purposes it was necessary to significantly expand the sample. In terms of generalizability, similar results would have probably been obtained from other individuals who had experienced the same severe, long-term maltreatment as our clinical group. However, milder forms of maltreatment may not be reflected in antisaccadic tests of younger individuals, unlike more severe forms of maltreatment which were the subject of our study and the study by Mueller et al. A question for further research in this field could be formulated as follows: At which critical point in progressive maltreatment would results obtained from an antisaccadic test become a diagnostic marker?

Similarly limiting was the age of the tested individuals. Results of studies performed on healthy subjects (Fischer and Hartnegg 2008; Karatekin 2007) showed that age had a significant impact on oculomotor performance. Therefore, reliable comparisons could only be made on subjects from the same age group. From preschool age to early adolescence, results in the antisaccadic test were highly variable; and thus, less reliable. Fischer and Hartnegg (2008) compared antisaccadic performance in typically developing subjects and those with dyslexia, and found no significant differences between both groups until the period of early adolescence. Therefore, it may be assumed that the earliest possible time to test for maltreatment using the antisaccadic test would be adolescence - and definitely not preschool age.

Another limiting factor was sex homogeneity. Studies focused on the development of eye movements in healthy individuals (Fischer and Hartnegg 2008; Karatekin 2007) do not mention the impact of sex and did not study the effect of sex on eye movements. In contrast, Bonnet et al. (2013) included sex in their collection of variables affecting eye movements. Bonnet et al. studied horizontal and vertical prosaccadic, antisaccadic and smooth pursuits in healthy individuals aged 19–82 years. The variable which had a decisive influence on eye movements was age. Neither sex nor education level affected oculomotor performance. These results contrasted with those of Bargary et al. (2017), who studied prosaccadic and antisaccadic eye movements and smooth pursuits in healthy individuals aged 16–20; mostly students from Cambridge University. Their main-sequence measure (the relationship between the amplitude and the peak velocity of a saccade) did not exhibit significant sex difference. However, men had significantly shorter prosaccadic and antisaccadic reaction times. In the antisaccadic task, men made significantly fewer directional mistakes. Bargary et al. were critical of these differences between sexes and cast doubt over whether their sample, in the present study and others, was sufficiently representative in terms of men and women. Few people now doubt differences between

sexes in the clinical sense. Girls reach school maturity earlier; girls are calmer and more focused than boys, in whom we often see a greater amount of liveliness; girls are better readers than boys, who tend to have dyslexic problems; girls' performance is more harmonious. When exposed to maltreatment, girls tend to be more resistant—as observed by the pioneer of Czech care for healthy child development, neuropsychiatrist Matejcek (1992). A difficult-to-control variable is the degree of maltreatment. Clinical experience show that severe maltreatment has a similar effect on both sexes. Women become comparable to men in disinhibited behavior. They are equally impulsive, uncontrollable, explosive, and highly aggressive. So, the impact of sex on oculomotor performance would then be neutral. However, this hypothesis would need to be tested, perhaps in future studies.

Another limiting factor was the absence of CBCL standard score. The raw score did not consider the impact of age on CBCL. So, this impact was checked by assessing age balance in both groups, clinical and control. Standard score, in contrast to raw score, allows comparison of test results with population norms to reach a conclusion: whether the specific finding is normal or subnormal. The maltreated group was found to be subnormal CBCL level based on personal and family history, and current behavioral patterns, see Methods, subchapter Participants. Both groups, clinical and control, were chosen in such a way as to maximize the extremes of the continuum *full adaptation - maladaptation*. Differences in raw score had statistical significance. Thus, raw score was not likely to have influenced CBCL. It was safe to assume that standard score - had it been available - would have probably confirmed the subnormal level of the clinical group. The same theory applies to the normal level of the control group.

A final limiting factor was the absence of other kinds of eye movements, e.g. smooth pursuits or vergences, and other types of oculomotor tasks. The various diagnoses included in our study, as well as in that of Mueller et al. (2012), would be unlikely to contribute to the differential diagnostics. The antisaccadic test would not be able to differentiate maltreatment from other disorders, psychotic and non-psychotic. To resolve differential diagnostics, an expansion of oculomotor tests on other kinds of eye movements and oculomotor tasks would be a suitable solution. Biscaldi et al. (2000) experimented with two types of saccadic sequential tasks. Participants were monitored passively while observing a point on the screen moving from left to right. During active monitoring, their eyes jumped in a row of dots arranged horizontally and they determined the speed of “reading” these dots. This dot task gave the subject greater freedom in decision-making, thus perhaps enticing him/her to greater voluntary activity—making him/her an active player, rather than a passive viewer. Both tasks tested saccades, but they also contributed to the total score from a different aspect,

and the participation of both increased incremental validity of oculomotor tests.

Conclusion

Registration of eye micro-movements is time undemanding and non-invasive. It offers comfort to the individual investigated with only minimal discomfort. It offers expansion and diversification of findings. The antisaccadic test may be one of the markers of maltreatment and may therefore enhance diagnostic methods. However, we did not find differentially diagnostic value in the antisaccadic test. For this, further studies exploring other types of eye movements and oculomotor tasks will be required.

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Compliance with Ethical Standards

Conflict of Interest Jiri Jost and Helena Havlisova have received research grant Nr. 100/2013/S from the Grant Agency of the South Bohemia University, Ceske Budejovice, Czech Republic. The funding agency had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication. Zuzana Bilkova, Zuzana Stefankova, and Ludmila Zemkova declare that they have no conflicts to report.

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 revised in 2000. Informed consent was obtained from all patients for being included in the study.

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