

Childhood maltreatment and executive functions in adolescents

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Background: The aim of this study was to investigate differences in executive functions between adolescents exposed to different forms of single- and multitype childhood maltreatment. **Method:** The sample was composed of 83 adolescents, divided into three groups: single-type maltreatment ($n = 24$), multitype maltreatment ($n = 19$), and no history of maltreatment ($n = 40$), matched for education and sex. **Results:** The results showed that teenagers who suffered a single type of childhood maltreatment performed worse than the other two groups on tasks of cognitive flexibility and visual processing speed. Individuals who suffered multitype maltreatment had worse initiation and lower verbal processing speed than the other two groups. **Conclusions:** Childhood maltreatment may have a significant impact on executive functioning in adolescence.

Key Practitioner Message

- Adolescents exposed to childhood maltreatment may develop cognitive impairments
- Adolescents who suffered a single type of childhood maltreatment performed worse on cognitive flexibility tasks than adolescents exposed to multi-type maltreatment and adolescents with no history of victimization
- Adolescents who suffered a single type of childhood maltreatment performed worse on visual processing speed tasks than adolescents exposed to multi-type maltreatment and adolescents with no history of victimization
- Childhood maltreatment may have a significant impact on executive functioning in adolescence

Keywords: Maltreatment; executive functions; adolescents

Introduction

Studies have found a robust association between childhood maltreatment and cognitive functioning in adulthood (Cohen et al., 2006; Dannlowski et al., 2012; De Bellis, 2005; Grassi-Oliveira, Ashy, & Stein 2008; Grassi-Oliveira, Gomes, & Stein 2011; Lupien, McEwen, Gunnar, & Heim 2009; Navalta, Polcari, Webster, Boghossian, & Teicher 2006; Yates, Carlson, & Egeland 2008). According to some authors (Grassi-Oliveira et al., 2008; Hart & Rubia, 2012; Jaffee & Maikovich-Fong, 2011; Tanakaa, Wekerleb, Schmuckc, & Paglia-Boack 2011), childhood maltreatment can affect the development of brain structures such as the corpus callosum, the left neocortex, the hippocampus, and the amygdala. Exposure to maltreatment can also cause neurofunctional and neurohumoral alterations, increasing the excitability of limbic structures, and 'reprogramming' the hypothalamic–pituitary–adrenal (HPA) axis, leading to disturbances in the stress response (Frodl & O'Keane, 2013; Gowin et al., 2013).

The process of executive development follows an inverted U-shaped curve over the course of life, and can be divided into three developmental stages: simple planning and visual search abilities develop by the age of 6 years; context maintenance, hypothesis testing, and impulse control develop by age 10, while complex

planning, motor sequencing, and verbal fluency abilities develop during adolescence. Quantitative and qualitative changes in these functions, as well as the progressive acquisition of more complex abilities, culminate in adolescence (Séguin & Zelazo, 2005). As such, adolescence may be a sensitive period for the manifestation of the effects of exposure to childhood maltreatment on cognition, as this period is characterized by the rapid development and consolidation of more abstract and complex ways of thinking (Lee & Hoaken, 2007).

According to the literature, even when exposure to maltreatment is limited to childhood, its impact on memory (Grassi-Oliveira et al., 2011), language, attention, and executive functions (Chugani et al., 2001; De Bellis, Hooper, Spratt, & Woolley 2009) can extend into adulthood. Studies of the relationship between childhood maltreatment and executive functioning have produced a number of interesting findings. While some studies have reported significant associations between these two variables (De Bellis et al., 2009; Spann et al., 2012), others have found no relationship between them (Jacobs, Kennedy, & Meyer 1997; Veneziano, Veneziano, Legrand, & Richards 2004). Studies of children show that the executive components that appear to be most influenced by exposure to maltreatment are working memory, inhibition, verbal attention, processing speed,

problem solving, planning, and decision making (Beers & De Bellis, 2002; Fishbein et al., 2009). In adolescents, the impact of childhood maltreatment is more evident in tasks assessing cognitive flexibility, divided attention, working memory, and planning ability (Mezzacappa, Kindlon, & Earls 2001; Spann et al., 2012; Veneziano et al., 2004; Zou et al., 2013). Lastly, adult victims of childhood maltreatment tend to display impaired performance in assessments of inhibition, working memory, problem solving, cognitive flexibility, and attention (Brandes et al., 2002; Navalta et al., 2006; Stein, Kennedy, & Twamley 2002; Twamley, Hami, & Stein 2004).

The literature shows that comorbidity between different types of maltreatment is a common phenomenon, and that most children are simultaneously exposed to multiple forms of maltreatment (Pears, Kim, & Fisher 2008). According to some authors (Arata, Langhinrichsen-Rohling, Bowers, & O'Farrill-Swails 2005; Edwards, Holden, Felitti, & Anda 2003; Finkelhor, Ormrod, Turner, & Hamby 2005; Higgins & McCabe, 2001), exposure to multiple types of maltreatment may cause more damage than repeated exposure to a single type of maltreatment, even if the abuse in question is of a sexual nature. However, some studies do not support this hypothesis, and suggest that individuals exposed to a single type of severe maltreatment may suffer more damaging consequences than those exposed to multitype maltreatment (Finkelhor et al., 2005; Hildyard & Wolfe, 2002).

Although some studies of the impact of childhood maltreatment on cognition have investigated general intellectual ability, attention, working memory, processing speed, visual-spatial intelligence, language, and executive functioning (Lezak, Howieson, Loring, Hannay, & Fischer 2004), most studies focus on impairments in memory and learning (Hedges & Woon, 2011). Furthermore, in spite of the large number of studies of the relationship between maltreatment and cognitive impairment, the functional consequences of the stress resulting from childhood maltreatment and its influence on executive functioning are still poorly known (Fishbein et al., 2009; Spann et al., 2012; Stein, Koverola, Hanna, Torchia, & McClarty 1997).

The consequences of early exposure to traumatic life events in adolescents also remain largely unexplored, having only been investigated in a few studies (Fairchild et al., 2009; Spann et al., 2012; Veneziano et al., 2004). Lastly, no studies appear to have investigated the association between the number of types of maltreatment experienced in childhood and executive function performance in adolescence. In light of this information, we hypothesized that adolescents who suffered multitype childhood maltreatment would have worse executive performance than individuals who experienced single-type maltreatment and adolescents without a history of maltreatment. Therefore, the goal of the present study was to compare executive abilities between adolescents who suffered a single type of maltreatment, individuals who suffered multiple types of maltreatment, and a control group of adolescents with no history of childhood maltreatment.

Method

Design

The present study had a cross-sectional design.

Participants

The sample consisted of 83 adolescents aged between 12 and 18 years ($M = 14.03$; $SD = 1.48$). Participants were recruited from public schools in the city of Porto Alegre, Rio Grande do Sul, Brazil. Schools were selected as sampling units if they offered complete primary and secondary education. Participants were recruited from each institution through the random selection of one class from each grade between the sixth and the 11th grade.

Before the assessment, consent to participate in the study was obtained from parents or guardians and all participants. Data were collected through self-report instruments including a questionnaire used to collect data on sociodemographic variables, the Brazilian Criteria for Economic Classification (ABEP, 2008), which was used to assess participant socioeconomic status, and the Childhood Trauma Questionnaire – CTQ (Bernstein et al., 1994; adapted by Grassi-Oliveira, Stein, & Pezzi 2006) to assess the presence of child maltreatment. Participants were collectively assessed in their classrooms or in a specific location designated by the school.

After the initial assessment, participant scores were entered into a database, and individuals whose CTQ scores were indicative of childhood maltreatment were selected for the case group. Participants in the control group were selected by convenience sampling from research databases, and matched by sex and age with individuals in the case group.

The final sample was divided into two groups: $n = 43$ victims of childhood maltreatment (case group) and $n = 40$ nonvictims (control group). Inclusion criteria for the case group were: (a) history of maltreatment (sexual, physical, or emotional abuse, and emotional or physical neglect), as assessed by CTQ scores above the cut-offs of 13 to 15 for emotional abuse, 10 to 12 for physical abuse, 8 to 12 for sexual abuse, 15 to 17 for emotional neglect, and 10 to 12 points for physical neglect (Bernstein et al., 1994); (b) consent to participate in the study provided by participants as well as their parents or guardians, and (c) age between 12 and 18 years. The following criteria were used to select participants for the control group: (a) no history of childhood maltreatment; (b) consent to participate in the study was obtained from participants and provided by parents or guardians, and (c) age between 12 and 18 years. Individuals were paired by grade level and sex. The following exclusion criteria were applied: (a) symptoms of severe mental illness, such as psychosis or severe intellectual disability, detected during the interview with the participant. No individuals were excluded from participation in the study. The case group was divided into two subgroups: individuals who suffered a single type of maltreatment (sexual, physical, or emotional abuse, or physical or emotional neglect), and those concomitantly exposed to multiple types of maltreatment.

Participants in the control group obtained the following mean scores in the five CTQ subscales: Physical Neglect ($M = 5.35$; $SD = 1.27$), Emotional Neglect ($M = 6.45$; $SD = 1.96$), Sexual Abuse ($M = 5.03$; $SD = 0.53$), Physical Abuse ($M = 5.38$; $SD = 1.03$), and Emotional Abuse ($M = 6.13$; $SD = 1.82$). Control participants' scores ranged from 1 to 9 points in the physical neglect scale, 2 to 14 points for emotional neglect, 4 to 7 for sexual abuse, 3 to 8 for physical abuse, and 4 to 12 in the emotional abuse subscale.

Instruments

All instruments used in the present study had been previously adapted for use in Brazilian populations. The executive components assessed were selected based on previous literature indicating that these were the most sensitive components to the effects of childhood maltreatment.

Childhood trauma questionnaire (CTQ). The version of the CTQ used in the present study was adapted from its original version (Bernstein et al., 1994) to Brazilian Portuguese by Grassi-Oliveira et al. (2006). The questionnaire consists of a self-report instrument that assesses the occurrence of abuse or

neglect during childhood. The instrument contains five subscales: sexual, physical, or emotional abuse, and physical or emotional neglect.

The presence of one or more types of maltreatment was investigated through scores on CTQ subscales. Performance measures were then compared between the control group, who had no history of childhood maltreatment, and the two case groups, composed of individuals with history of maltreatment (sexual, physical, or emotional abuse, and emotional or physical neglect).

Arithmetic and digit span subtests of the Wechsler intelligence scale for children (WISC-III) or Wechsler adult intelligence scale (WAIS-III). Individuals aged between 12 years and 15 years and 11 months were assessed using the WISC-III (Nascimento, 2004; Wechsler, 1997), while participants aged 16 years and 11 months to 18 years were administered the WAIS-III (Nascimento, 2004). The Arithmetic subtest assesses mental calculation abilities, the comprehension of complex verbal material, and reasoning abilities. It also consists of a sensitive measure of working memory capacity (Groth-Marnat, 2000; Wechsler, 2004). The Digit Span subtest assesses working memory, and consists of number sequences which the participant must repeat in serial and in reverse order (Groth-Marnat, 2000; Wechsler, 2004).

FAS oral word association test. Assesses verbal fluency and is a sensitive measure of executive functioning (Strauss, Sherman, & Spreen 2006). For this task, the participant is given 60 seconds to elicit as many words as possible starting with the letters F, A, and S. Although normative data for this task are still scarce, reference values for comparison can be obtained from case-control studies published in the literature (Silveira, Passos, Santos, & Chiappetta 2009). The letter “F” was chosen due to its higher frequency in Brazilian Portuguese, along with the letters “C, P, M and L” (Schauelberger et al., 2005). In Brazil, there is a standardized instrument that assesses the letter F alone (Fonseca, Salles, & Parente 2008).

Trail making test (TMT). This task assesses attention, cognitive flexibility, visual processing speed, and praxis (Lezak et al., 2012). Normative values for this task are available for the Brazilian population Montiel and Seabra (2012).

Hayling test. This test assesses initiation, inhibition, verbal planning, and cognitive flexibility, as well as the speed of initiation and inhibition. The test was developed by Burgess and Shallice (1996, 1997), and in this study, a version of the Hayling Test which was adapted to the local population was used for participant assessment (Fonseca et al., 2010).

Block design and Vocabulary subtests of the WISC-III or the WAIS-III. A brief assessment of intelligence was conducted using the Block design and Vocabulary subtests of the WISC-III and the WAIS-III. This measure was used to control for the influence of intelligence on performance in other tests.

Procedure

Data collection

The present study was approved by the Scientific and Research Ethics Committees of the Pontifical Catholic University of Rio Grande do Sul under protocol number 116400. The presence of childhood maltreatment was investigated in participants of a previous epidemiological study of the CTQ. Individuals who met criteria for the case and control groups were then invited to take part in the present study. Participants signed informed consent to participate in the study and their parents or guardians signed the free and informed consent. All participants were individually assessed in a single session

lasting approximately 90 min. Data were collected in seven public schools in the city of Porto Alegre, which provided facilities for the assessment of their students. Data were collected by researchers who were blind to participant groups. Participants were also assigned numbers, and protocols were identified by these numbers rather than by participant names.

At the end of the study, researchers contacted the schools and recommended the referral of individuals with a history of childhood maltreatment to specialized treatment programs. Participants were also provided a list of locations where free psychological treatment was provided for such cases, and referrals were made based on family income.

Data analysis

Instruments were administered and scored according to their respective manuals. Tests with no normative data for the Brazilian population were analyzed in terms of raw scores only. Raw scores on the Block Design and Vocabulary tests of the WAIS-III were converted to estimated IQ scores based on the tables provided by Jeyakumar, Warriner, Raval, and Ahmad (2004). WISC-III subtests used to assess intelligence were converted into estimated IQ using the tables found in the Compendium of Neuropsychological Tests (Strauss et al., 2006).

All data were entered into a database, and analyzed using the Statistical Package for the Social Sciences (SPSS) software for Windows, version 17.0 (SPSS Inc., 2008). Categorical variables were reported in terms of absolute and relative frequencies, while continuous ones were summarized in terms of means and standard deviations. One-way ANOVA were used for between-group comparisons of individuals who suffered multiple types of maltreatment (physical or emotional neglect, or emotional, physical, and sexual abuse), ones who suffered a single type of maltreatment, and the control group. The Chi-square test was used to investigate gender differences in the composition of each group. Results were considered significant at $p \leq .05$.

Results

Sample characteristics are presented in Table 1. The groups did not differ with regard to age, grade level, or estimated IQ. According to the chi-square test, gender distribution did not differ between groups. The most prevalent form of single-type maltreatment was emotional abuse (37.5%), followed by emotional neglect (33.3%), physical neglect (16.7%), physical abuse (8.3%), and sexual abuse (4.2%). In the multitype maltreatment group, emotional abuse was present in 17 of the cases, together with at least one other type of maltreatment. Emotional neglect and emotional abuse was the most frequent combination of maltreatment types reported by this group (26.2%), followed by emotional and physical abuse (15.8%), emotional abuse, and physical and emotional neglect (10.5%), emotional, physical and sexual abuse in combination with physical neglect, (10.5%), emotional, physical and sexual abuse (10.5%), emotional and sexual abuse (5.3%), emotional abuse and physical neglect (5.3%), emotional and physical abuse combined with emotional neglect (5.3%), physical and emotional neglect (5.3%), and emotional and physical neglect coupled with physical abuse (5.3%).

Table 2 displays the results of between-group comparisons on measures of executive function. Groups significantly differed on the time taken to complete part B of the TMT, with individuals who suffered a single type of maltreatment requiring more time to complete the task than those exposed to multitype maltreatment. The latter group also required a significantly longer time to complete part A of the Hayling test than the control group.

Discussion

The present study aimed to investigate executive functions in adolescents exposed to maltreatment (single type and multitype) and control individuals. The results showed that adolescents who suffered a single type of maltreatment had slower visual processing speed than individuals who suffered multitype maltreatment and controls. These findings did not corroborate previous studies, possibly because those investigations included participants with psychiatric disorders, whereas in the present study, this was set an exclusion criterion. Another possible explanation for this finding is the fact that exposure to a single type of severe abuse may be more damaging than exposure to multitype maltreatment (Hildyard & Wolfe, 2002). As the duration, intensity and frequency of each type of maltreatment were not controlled in the present study, it is possible that prolonged and intense exposure to a single type of abuse may cause greater cognitive impairment than the infrequent experience of multiple types of maltreatment.

Performance on some tasks did not differ between individuals who suffered childhood maltreatment and control participants. A possible explanation for these findings is the fact that some cognitive processes are still undergoing development during adolescence (Séguin & Zelazo, 2005). Some examples of abilities that continue to develop throughout adolescence are abstract reasoning, future planning, and metacognition (Lee & Hoaken, 2007). To investigate whether the absence of differences in the present study may have been due to participant age, it is important to analyze the results of studies that compared executive functions between adult victims of childhood maltreatment and adult nonvictims.

A number of such studies have been identified in the literature, and many have found executive impairments in adults of various ages who were exposed to some form of childhood maltreatment (Brandes et al., 2002; Navalta et al., 2006; Stein et al., 2002; Twamley et al., 2004). Functional neuroimaging studies of adult victims of childhood maltreatment have also identified alterations in the neuroendocrine system (HPA axis), which influence cognitive processes such as language, memory, and executive functions (Carpenter, Shattuck, Tyrka, Gerac-

ioti, & Price 2011; Gowin et al., 2013; Mezzacappa et al., 2001). These individuals may also display impaired prefrontal cortex development (Glaser, 2000; Van der Kolk, 2003) and neurological maturation, disrupting neuronal growth and plasticity (Lee & Hoaken, 2007). Therefore, it is possible that the group differences found in the present study are due to the neurobiological and neurochemical alterations that result from exposure to childhood abuse and neglect.

Overall, findings in the literature suggest that adolescents exposed to maltreatment in childhood may develop a number of cognitive impairments (Gabowitz, Zucker, & Cook 2008; Hart & Rubia, 2012; Spann et al., 2012). Exposure to emotional or physical neglect, or to physical, sexual, and emotional abuse in childhood may lead to alterations in neurochemistry and in the structural development of the brain (Teicher et al., 2003), leading to changes in information assimilation and processing. Furthermore, early exposure to such adversity may influence the maturation of the frontal lobes, which are the last brain regions to fully develop, and the most important for executive functioning (Van Harmelen et al., 2010). The present findings regarding the lower visual and verbal processing speed in victims of maltreatment corroborate the claim that exposure to childhood abuse and neglect may influence executive functions well into adolescence (Heim et al., 2000, 2002; Kaufman et al., 1997).

Some authors suggest that, although single-type maltreatment is more commonly reported, multitype childhood maltreatment is also quite common (Allen, 2008; Higgins, 2004; Loue, 2005; Prino & Peyrot, 1994; Richmond, Elliott, Pierce, Aspelmeier, & Alexander 2009). Exposure to multiple types of abuse may lead to more pronounced cognitive impairment (Clemmons, Walsh, DiLillo, & Messman-Moore 2007; Richmond et al., 2009), and some studies suggest that certain types of maltreatment may have an especially significant impact on cognitive and emotional development, such as limited stress tolerance, anxiety, emotional instability, depression, suicidality, Post-Traumatic Stress Disorder (PTSD), substance abuse, Attention Deficit Hyperactivity Disorder (ADHD) and conduct disorder (CD; Arata et al., 2005; Finkelhor et al., 2005; Hart & Rubia, 2012).

However, in present study, individuals exposed to single- and multitype maltreatment displayed similar performance on almost all cognitive functions investigated. This may have occurred because participants in both groups provided similar severity ratings for the maltreatment to which they were exposed; that is, the consequences of maltreatment were independent of the amount and type of maltreatment experienced. The lack of differences between the cognitive performance of victims of single- and multitype maltreatment found in the

Table 1. Age, grade level, and estimated IQ of the groups studied

	Single type of maltreatment (N = 24)		Multitype maltreatment (N = 19)		Control (N = 40)		F	p
	Mean	SD	Mean	SD	Mean	SD		
Grade level	7.33	1.24	7.58	1.54	7.43	1.15	6.328	.337
Age	14.21	1.41	14.21	1.69	14.03	1.48	1.279	.857
Estimated IQ	87.50	12.52	93.00	15.16	92.10	12.66	1.196	.308

N = 83.

Table 2. Performance on working memory, processing speed, cognitive flexibility, inhibition, attention, and initiation tests by group and function assessed

	Single-type maltreatment (N = 24)		Multitype maltreatment (N = 19)		Control (N = 40)		F	p
	Mean	SD	Mean	SD	Mean	SD		
Working memory								
Digit span - SO	3.96	1.57	4.89	1.15	4.25	1.37	2.491	.089
Digit span SO-RO	3.88	1.96	3.05	1.54	3.30	2.18	1.01	.366
Standardized arithmetic scores	7.71	3.03	9.00	3.32	7.23	3.03	2.121	.127
Processing speed								
TMT A time (s)	44.57	11.80	65.52	123.03	42.85	14.55	0.991	.376
TMT B time (s)	103.90*	36.12	76.78*	28.02	93.47	33.90	3.532	.034
Hayling A time (s)	23.98	9.58	28.98**	11.59	20.82**	9.71	4.031	.022
Hayling B time (s)	58.16	26.17	50.66	31.52	77.13	56.28	2.685	.075
Cognitive flexibility and inhibition								
TMT B errors	0.58	1.06	0.79	1.47	0.88	1.34	0.380	.685
TMT B time/A time (s)	2.40	1.14	2.34	0.677	2.19	0.606	0.520	.596
Hayling A errors	0.38	0.49	0.63	0.76	0.48	0.64	0.877	.420
Hayling B errors/15	6.43	3.75	4.50	2.87	6.50	3.55	2.266	.111
Hayling B errors/45	13.91	9.17	9.17	6.40	14.35	8.91	2.463	.092
FAS	29.17	9.17	27.11	5.23	28.43	8.72	0.339	.714
Attention and Initiation								
TMT A errors	0.25	0.44	0.00	0.00	0.15	0.36	2.771	.069

RO, Reverse order; SO, Serial order. A = Part A; B = Part B; A = Part A; B = Part B.

* $p = .029$; ** $p = .018$; *** $p = .012$; Bold values indicate significant differences.

present study could also be attributed to the fact that the consequences of each type of maltreatment were not separately assessed, as individuals were only categorized based on their experience of a single type versus multiple types of maltreatment. Therefore, it is important to consider the interaction between the number of types of maltreatment experienced and the consequences of each type of abuse or neglect, as these variables may influence their impact on the victim. Although neuroanatomical organization is genetically determined, the regions responsible for interpreting life experiences (the limbic system and the frontal lobes) develop gradually over the course of childhood and adolescence (Van der Kolk, 2003). Therefore, an adolescent victim of childhood maltreatment may suffer disruptions in the development of executive functions (Van der Kolk, 2003).

Although there is evidence that certain neurofunctional, behavioral, emotional, and cognitive alterations may occur as a result of childhood maltreatment, results are inconsistent as to which executive processes are more impaired in adolescents who suffered abuse or neglect in the first years of life (Spann et al., 2012). The lack of consensus between studies may be due to the diversity of constructs assessed, and to variations in the characteristics of the populations investigated. Hart and Rubia (2012), for instance, suggested that some of the limitations of studies of the association between maltreatment and cognition could be due to the inclusion of participants with psychiatric disorders, making it difficult to differentiate between the cognitive impact of the abuse itself, of the psychiatric condition, and of the interaction between these factors. The most common psychiatric illnesses diagnosed in victims of childhood maltreatment are PTSD (Borges & Dell'Aglio, 2009; De Bellis, Hooper, Woolley, & Shenk 2010; De Bellis et al., 2009; Thomas & De Bellis, 2004; Woon & Hedges, 2008), depression (Brietzke et al., 2012; Danielson, de Arellan-

o, Kilpatrick, Saunders, & Resnick 2005; Kendler, Kuhn, & Prescott 2004; Lopes et al., 2012), and bipolar disorder (Brietzke et al., 2012; Daruy-Filho, Brietzke, Lafer, & Grassi-Oliveira 2011).

In conclusion, the present study found significant associations between performance on measures of executive functions and exposure to childhood maltreatment. However, some limitations must be considered, such as the impossibility of verifying the effects of each different type of maltreatment due to the small sample size. The assessment instruments used may also have constituted a limitation, as they did not allow for the investigation of processes such as decision making and problem solving. In future studies, a more extensive assessment of "hot" executive functions should be carried out. However, the present findings make an important contribution to the literature, especially given the scarcity of studies of the relationship between executive functions and childhood maltreatment in adolescents. As a continuation of the present study, future investigations should compare executive abilities between individuals who suffered different types and combinations of maltreatment.

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