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Executive functioning: Developmental consequences on adolescents with histories of maltreatment

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Abstract

Research suggests that children exposed to maltreatment have deficits in executive functioning (EF) but few studies have focused on the adolescent age group. We investigated whether maltreated adolescents had lower EF abilities compared to a group of non-maltreated adolescents. Forty adolescents with histories of child maltreatment, together with a comparison group of 40 non-maltreated adolescents matched for age, completed a comprehensive battery of EF tasks. Hierarchical multiple regression analyses, controlling for IQ, were carried out using each of the EF measures as dependent variables to examine group differences. Maltreated adolescents had significantly lower performance than non-maltreated adolescents on tasks assessing executive loaded working memory (ELWM), fluency, and inhibition, although switching was not impaired. Emotional and behavioural difficulties (EBD) were included in additional regression analyses to examine whether these variables would explain the group differences. The inclusion of EBD variables had some effect on group differences, as expected, but did not eliminate them. These findings support the theory that impairments in EF may be one underlying reason why adolescents with histories of maltreatment struggle to cope both inside and outside the classroom.

Introduction

Adolescence is generally regarded as a challenging time. It is a period of marked neurodevelopmental change, particularly in prefrontal regions, and it has been reported that stress exerts its maximal effects on the prefrontal cortex during adolescence (Andersen et al., 2008). During this period youngsters are in the process of acquiring higher-order, abstract cognitive skills, at the same time that their brains are maturing, and perhaps being permanently altered via myelination and synaptic pruning (Paus, Keshavan, & Giedd, 2008). The adolescent period is also characterised by increased independence and a greater exposure to peer influence, alongside the development and consolidation of more abstract and complex modes of thinking.

These naturally occurring neurodevelopmental changes during adolescence, particularly in the prefrontal cortex, may have an impact on Executive Functioning (EF) abilities. Although there are varying definitions, EF is generally regarded as encompassing the complex cognitive processes that serve on-going, goal-directed behaviours including goal setting and planning, organisation of behaviour over time, flexibility, attention and memory systems, and self-regulatory processes (Meltzer, 2007). A weakness in EF is associated not only with poor behavioural regulation but also poor cognitive achievements (Seguin, Nagin, Assaad, & Tremblay, 2004; St Clair-Thompson & Gathercole, 2006), and the fact that EF continues to develop into adolescence highlights the risks associated with executive dysfunction (Lee & Hoaken, 2007). Further, there is evidence that distinct profiles of EF impairment occur in individuals with a wide variety of developmental, psychiatric, and neurological disorders (e.g. Geurts, Verte, Oosterlaan, Roeyers, & Sergeant, 2004; Henry, Messer, & Nash, 2012).

Existing research suggests that EF may be impaired in adolescents with histories of maltreatment (see Kirke-Smith, Henry, & Messer, 2012, for a review), particularly if traumatic stressors or prior deficits in self-regulatory abilities manifest during adolescence (Cook et al., 2005). Uncertainties remain about the precise mechanisms by which this might occur, but there is likely to be a complex interaction between environmental experiences and an individual's genetic make-up. These factors influence neurobiological development across infancy and childhood, and in turn influence a child's psychological and emotional development (McCrory, De Brito, & Viding, 2010).

Although several studies have demonstrated that child abuse and neglect have relationships with later EF performance (e.g. De Bellis, Hooper, Spratt, & Wooley, 2009; De Prince, Weinzierl, & Combs, 2009; Mezzacappa, Kindlon, & Earls, 2001), research in this area is limited, particularly with regards to adolescents. Some studies have reported impairments in all aspects of EF skills in maltreated children (e.g. Lansdown, Burnell, & Allen, 2007), whereas others have been less conclusive and found impairments in only certain aspects of EF (e.g. Cromer, Stevens, De Prince, & Pears, 2006). This is further complicated by the fact that a variety of methodologies have been used and different aspects of EF have been investigated, making findings difficult to compare (e.g. Lansdown et al., 2007 used a rating scale of EF, whilst Cromer et al., 2006 used paper-and-pencil tasks).

The current study provided a thorough investigation of EF in adolescents with histories of maltreatment, comparing them to a group of non-maltreated adolescents. It was hypothesised that the maltreated group would have impairments in some aspects of EF, although which skills would be affected, and whether impairments in verbal and non-verbal domains would be apparent, was uncertain. A comprehensive battery of reliable tasks testing verbal and non-verbal EF abilities within the domains of ELWM, fluency, switching, and inhibition was utilised. These EF skills are widely postulated in the literature as important executive functions (e.g. Henry et al., 2012; Miyake et al., 2000), given there is good evidence for the 'fractionation' of EF in adults and children (Fisk & Sharp, 2004; Huizinga, Dolan, & van der

Molen, 2006). The tests were chosen to be simple measures of each construct, to minimise the contribution of other skills.

Whilst much research into cognitive skills in developmentally disordered populations has employed group comparison techniques such as *t*-tests and ANOVAs, these methods are usually underpinned by matching participants based on their scores on a measure of cognitive ability – frequently an IQ test. However, maltreated adolescents are likely to have lower IQ scores than non-maltreated adolescents (Saltzman, Weems, & Carrion, 2006). Consequently, individually matching groups of maltreated and non-maltreated adolescents would be challenging and potentially compromise the representativeness of both samples. Instead, all recruited participants were included in the analyses, with the obvious proviso that none of the comparison group had suffered from maltreatment or had any other form of learning or behavioural difficulty. Following Henry et al. (2012), hierarchical multiple regression analyses were used to examine group differences in EF after first controlling for IQ. If group differences remained after IQ was controlled, this would indicate that differences in performance were a result of a weakness in EF. Whilst an ANCOVA (controlling for IQ) could have been used as an alternative to multiple regression, the latter tends to be more robust and does not rely on predictor variables being normally distributed (Field, 2009).

Additionally, because maltreatment is associated with an increased risk of psychopathology (Black et al., 2002), with many maltreated youngsters demonstrating a range of internalising and/or externalising behaviour symptoms, a second set of analyses was carried out, including both IQ and emotional and behavioural difficulties (EBD). This assessed the potential effects of these important variables on EF performance and allowed the assessment of the effect of group differences after the removal of variance caused by IQ and EBD.

It was predicted that adolescents exposed to child maltreatment would show a range of EF difficulties. Further, we tentatively predicted that controlling for EBD might reduce, but not eliminate this disadvantage on EF tasks.

Methodology

Design

A cross-sectional design involving two groups was used, one of maltreated adolescents and a comparison group of non-maltreated adolescents. All participants completed a battery of tasks designed to assess EF skills in both verbal and non-verbal domains. They also completed three self-report questionnaires to examine EBD.

Participants

Forty adolescents of both genders who had suffered from maltreatment (either physical, emotional, sexual, neglect, or witnessing domestic violence), aged 11-18, were recruited from specialist schools for youngsters with EBD. A comparison group of 40 non-maltreated adolescents was recruited from mainstream secondary schools. The mean ages in each group were comparable and did not differ statistically: maltreated group 181.92 months; comparison group 181.10 months. As expected, differences were present in IQ scores (non-maltreated mean: 100.97 compared to the maltreated group mean of 87.37).

All maltreated participants had been subjected to Significant Harm as defined in the Children Act (Department of Health, England and Wales, 1989) which has been accepted as the threshold for recognition of child maltreatment. Background information was compiled by means of existing data taken from student records and teacher/tutor interviews and showed that (as defined by the Working Together to Safeguard Children government paper, 2010, 1.33-1.36): 30% of the maltreated youngsters had experienced physical abuse; 67.5% had experienced emotional abuse; 32.5% had experienced sexual abuse; 55% had experienced neglect; and 22.5% had witnessed domestic violence (N.B. these figures do not add up to 100% as many had experienced more than type of maltreatment). 55% of the sample first experienced abuse between the ages of 0-18 months; 10% between the ages of 18-36 months; 27.5% between the ages of 3-6 years; and 7.5% between the ages of 6-9 years.

Whilst some existing studies have focused specifically on children in care ('looked after children'), here we recruited participants with a variety of living arrangements. A large percentage were living with foster carers (45%), some were still living with a biological parent (32.5%), some were adopted (15%), and some were living with relatives (e.g. grandparents) (7.5%). Of the 30 youngsters who were not living with a biological parent: 16.6% were taken into care during the developmental period 0-18 months; 20% between 18-36 months; 26.6% between the ages of 3-6 years; 26.6% between the ages of 6-9 years; and 10% at the age of 9+ years. 3.3% had only been in one care placement whilst 63.3% had had 2-5 care placements and 6.6% had experienced 5+ placements.

Thirty-five of the 40 participants in the maltreated group had medical diagnoses as follows: Attention Deficit Hyperactivity Disorder (ADHD) (45.71%); Obsessive Compulsive Disorder/Anxiety/Depression/PTSD (34.28%); Conduct Disorder/Oppositional Defiance Disorder (5.71%); and other (5.71%). 8.57% had more than one disorder. 15 participants were on medication: 7 for ADHD; 5 for depression/anxiety and 3 for other medical issues. The remaining five participants had no medical diagnoses.

For the comparison group of non-maltreated adolescents, as much care as possible was taken to ensure that they had not suffered from any type of maltreatment and that they did not have any medical diagnoses or learning difficulties. This included background information from the school and families, and assurances from the participants themselves.

Ethical considerations

The research was carried out in accordance with the Code of Ethics and Conduct of the British Psychological Society (BPS, 2006). Ethical clearance was obtained from the relevant UK Research Ethics Committee prior to commencing the study. Schools were approached via letter asking for their co-operation in this study, and help in identifying suitable students for the study. Once participants had been selected, a letter was sent to their families/caregivers explaining the purpose of the study and asking for their written consent. In the case of the 'children in care', Local Authority consent was also an essential pre-requisite.

Before commencing the testing, participants were given a short presentation detailing the general aims of the study, and informed of their right not to participate, to omit questions and withdraw their consent. They were given assurances of anonymity and confidentiality, and promised that no risks or deception would take place at any time. No reference was made directly to the student as to why they had been selected, in order to avoid any sensitive issues, and it was not obvious to their peers as to why they had been selected to prevent any unnecessary embarrassment. The researcher had enhanced CRB clearance, and extensive practical experience of working with youngsters with EBD in educational settings.

Measures

All the participants completed the following tasks:

1) EF measures.

a) Executive loaded working memory (ELWM): These tasks required concurrent processing and storage. Verbal ELWM was assessed using an adapted version of the Listening Recall task (Leather & Henry, 1994). The experimenter read a series of short sentences and the participant firstly judged whether each was true or false (processing), before being asked to recall the final word from each sentence in correct serial order (storage). Trials commenced with list lengths of one item and proceeded to longer lists up to a maximum of five. There were four trials for each list length and participants needed to get a minimum of 3 out of 4 trials correct before proceeding to the next level. Total trials correct (a maximum score of 20) were scored. Cronbach's alpha for reliability of this task was .78.

Non-verbal ELWM was assessed using The Odd-One-Out Task (Henry, 2001) which is a spatially-mediated test comparable to the Listening Span task described above. Participants were presented with a series of cards containing two identical visual items, and one similar but slightly different item. Participants were asked to point to the one which is different (processing), the card was then turned over, and a blank response board depicting the relevant number of 'empty' cards was then shown. The participant was then asked to recall the spatial location of the 'odd-one-out' by pointing to the response board (storage). Trials commenced with lists of one item and proceeded to lists of six items with four trials per list lengths. A minimum of 3 out of 4 trials correct was needed in order to proceed to the next level. Total trials correct were scored (a maximum score of 24). Cronbach's alpha for this task was .79 showing good reliability.

b) Fluency: Verbal fluency was measured using The Verbal Fluency Test, taken from the Delis-Kaplan Executive Functioning System (Delis, Kaplan, & Kramer, 2001). This involved two conditions: Letter Fluency, which taps the individual's ability to generate in 60 seconds as many words as they can in an effortful, phonemic format using individual letters from the alphabet (F, A and S); and Category Fluency, which requires the ability to generate words from designated semantic categories (animals and boys' names). Verbal fluency was the average raw score taken from all five tasks.

Similarly, non-verbal fluency was measured with The Design Fluency Test (Delis et al., 2001). This also comprised two conditions and used a response booklet containing patterns of dots in boxes. The participant had to draw as many different designs as possible in 60 seconds, each in a different box, by connecting the dots using four straight lines with no line drawn in isolation. Condition 1 contained only five filled dots; Condition 2 contained both filled and empty dots (5 of each) and the participant was instructed to connect only the empty dots. Design fluency was the average raw score from both these conditions. Test-retest reliabilities are reported as: letter (.67), category (.70), filled dots (.66) and empty dots (.43; Delis et al., 2001).

c) Switching: Verbal switching was measured using the Category Switching task in the D-KEFS Verbal Fluency Test. This evaluates the ability to generate words whilst simultaneously shifting between two different semantic categories (fruits and furniture) as quickly as possible in 60 seconds. Verbal switching 'cost' was the average raw score from the category fluency task, minus the raw score from the switching task. Test-retest reliability is reported as 0.53-0.65 (Delis et al., 2001).

Non-verbal switching was also measured by using the switching condition of the D-KEFS Design Fluency Test. Again the participant was presented with a page of response boxes that contained both filled and unfilled dots (5 of each), but this time the participant had to switch between filled and empty dots (a measure of both design fluency and cognitive flexibility), completing as many as possible in 60 seconds. Non-verbal switching 'cost' was the average raw score between Conditions 1 and 2 minus the raw score from Condition 3. Test-retest reliability is reported as 0.13 (Delis et al., 2001).

d) Inhibition: A similar task to The Verbal Inhibition/Motor Inhibition task (VIMI) (Henry et al., 2012) was used to test for inhibition. In Condition 1 for the verbal task, the experimenter said the words either ‘day’ or ‘night’ out loud and participants had to copy by repeating the word. In Condition 2, the participants were told to inhibit this copying response by saying the opposite to the assessor. Each of the conditions had 20 trials, and the sequence was then repeated for both the Copy and Inhibit conditions (Conditions 3 and 4), making a total of 80 trials. The combined number of errors on each task represented the measure of inhibition. Cronbach’s alpha for this task was .91 showing high internal consistency.

The non-verbal motor task followed the same format (loosely based on Luria’s hand game (Luria, Pribram, & Homskaya, 1964), but words were replaced with actions. For Condition 1, participants were asked to copy the assessor by either making a pointed finger or a clenched fist, and then in Condition 2 do the opposite. Each of the conditions had 20 trials which were then repeated (Conditions 3 and 4). The combined number of errors on each task represented the measure of inhibition. Cronbach’s alpha for this task was .89 showing good reliability.

An additional task used to measure inhibition was the D-KEFS Color-Word Interference Test (Delis et al., 2001). To distinguish between the VIMI and this task, it will hereafter be referred to as Directed Attention. Based on the original Stroop test (Stroop, 1935), the primary executive function measured with this test concerns the examinee’s ability to inhibit an over-learned verbal response (i.e. reading printed words) in order to generate a conflicting response of naming the dissonant ink colours in which the words are printed. The D-KEFS test includes two baseline conditions: basic naming of colour patches (Condition 1) and basic reading of colour-words printed in black ink (Condition 2). Condition 3 is the traditional Stroop interference task in which the participant must inhibit reading the words in order to name the dissonant ink colours in which those words are printed. Participants were timed and scoring was based on completion times, and number of errors made. The ‘directed attention time cost’ was measured by subtracting the colour time (Condition 1) from the inhibition time

(Condition 3); and the 'directed attention error cost' was measured by subtracting the colour errors (Condition 1) from the inhibition errors (Condition 3). Internal consistency of this task is moderate to reasonably high (.62 - .79) with good to high test-retest reliability for children and adolescents (.77 - .90) (Delis et al., 2001).

2) Measure of IQ.

Participants also completed The Stanford Binet Abbreviated IQ test (ABIQ): Version 5 (Roid, 2006) comprising 2 subtests looking at both verbal and non-verbal intelligence. Standardised scores were used to give an overall measure of IQ. Corrected test-retest reliability coefficients are given as .84 for 6-20 year-olds (n=87). With regard to criterion validity, the overall correlation between ABIQ and full-battery IQ scores (FSIQ) is given as .87 for ages 6 and above.

3) Measure of strengths and difficulties.

All participants completed the Strengths and Difficulties Questionnaire (SDQ student-rated) (Goodman, 1997), a self-report questionnaire comprising 20 questions split into 4 subsets of 5 items each. Scores for each subset ranged from 0 – 10 and the Total Difficulties Score was generated by summing the scores from all the scales, with resultant scores ranging from 0 to 40. Chronbach's alpha is reported as .72 (Goodman, 1997).

4) Measures of anxiety and depression.

All participants completed the Beck Youth Inventories™ (Second Edition) (Beck, Beck, Jolly, & Steer, 2005) for Anxiety and Depression (BYI-A and BYI-D), comprising two self-report questionnaires of 20 questions each. The total raw score for each inventory is obtained by adding item scores, which may be 0, 1, 2, or 3, for all 20 items on the scale. The range of possible total raw scores on each of the inventories is 0 – 60. Chronbach's alpha ranges from

.86 to .96 indicating high internal consistency and test-retest reliability is reported as .74 to .94 on all scales (Beck et al., 2005).

Procedure

All participants were tested individually in a quiet room at school within the school day. Testing was carried out over several sessions to avoid fatigue. Before commencing, every effort was made to ensure that all the students were comfortable and relaxed, and the tasks were in a game-like format to ensure they were not too onerous.

The ABIQ test (Fluid Reasoning and Knowledge) was administered first, followed by the EF measures in the following sequence: ELWM, Fluency, Switching, Inhibition and Directed Attention, counterbalancing between verbal and non-verbal tasks apart from the Directed Attention task which did not allow for this. Before administering the Directed Attention task, participants' reading ability was checked to ensure that they could read the words 'red', 'green' and 'blue', and that they were not colour-blind. When all testing was completed, each participant's results were individually scored and entered into SPSS-PASW v18 by the researcher. Table 1 below gives details of sample characteristics including scores on each EF measure.

Table 1 about here

Results

Hierarchical multiple regression analyses were carried out to assess group differences in EF performance with each of the 10 EF measures as dependent variables in turn. Whilst some outliers were identified in the initial analyses, further key statistical checks (Durbin-Watson, tolerance/VIF statistics, Cook's/Mahalanobis distances, standardised DFbetas, plots of standardised residuals/predicted standardised values, standardised residuals, partial plots) suggested the absence of both multicollinearity and cases with undue influence, therefore these cases were included in the final analysis to maintain power (Field, 2009). For each regression, IQ was entered as a predictor variable at Step 1. Group (non-maltreated and maltreated) was entered at Step 2 to assess whether, after controlling for IQ, group differences in performance remained. The summary information in Table 2 includes total variance accounted for (total R^2), standardised beta-values for each predictor variable (Step 2), and changes in R^2 (Step 1 and Step 2). Significant values are indicated with an asterisk * where relevant.

Table 2 about here

Significant group differences (indicated by a significant change in R^2 at Step 2) were found for most EF measures: adolescents exposed to child maltreatment achieved lower scores on verbal and non-verbal ELWM, verbal and non-verbal fluency, verbal and non-verbal inhibition and directed attention (time cost and error cost). However, verbal and non-verbal switching did not appear to be impaired.

Further regression analyses were carried out including variables for anxiety, depression and behaviour difficulties in addition to IQ. This assessed whether the group differences found in the first analyses could be explained by co-morbidity of the maltreated group's EBD. Table 3 below shows a summary of means, SDs and ranges for the SDQ, BYI-D and BYI-A.

Table 3 about here

For each regression, IQ was entered as a predictor variable at Step 1. Scores from the BYI-A, BYI-D and SDQ were entered at Step 2, and Group (non-maltreated versus maltreated) was entered at Step 3 to assess whether, after controlling for IQ, and behaviour symptomatology, group differences in EF performance still remained. Tolerance/VIF statistics indicated an absence of multicollinearity in the data. The information in Table 4 includes total variance accounted for (total R^2), standardised beta-values for each predictor variable (Step 2), and changes in R^2 (Step 1, Step 2 and Step 3). Significant values are indicated with an asterisk * where relevant.

Table 4 about here

After including EBD variables, group differences remained on several EF variables: the maltreated group achieved lower scores on ELWM, Fluency, non-verbal Inhibition and Directed Attention error cost. However, verbal inhibition and Directed Attention time cost no longer showed a group difference. The change in R^2 at Step 2 gives an indication of which EF skills were affected by EBD: Table 4 shows that ELWM (verbal and non-verbal) and two measures of inhibition (verbal and directed attention cost) all showed a significant R^2 change when the EBD variables were entered at Step 2. Looking at the beta values at Step 3 gives some initial clues as to how EBD might impact on specific areas of EF. For example, higher levels of anxiety were associated with reduced verbal ELWM, verbal inhibition and directed attention (error cost).

Table 5 provides details for each EF measure, about the percentage of maltreated adolescents who had scores that were greater than 1 *SD* and 2 *SD*s below the means for non-maltreated adolescents. Between 2 and 30 maltreated adolescents had scores that were greater than 1 *SD* below the mean of the comparison group and between 5 and 24 maltreated adolescents had scores that were greater than 2 *SD*s below the mean of the non-maltreated group.

Table 5 about here

Discussion

The aim of this study was to determine whether adolescents subjected to child maltreatment had impaired EF abilities. The findings indicated that after controlling for IQ, maltreated adolescents had impairments in a range of EF skills, including ELWM, fluency, and inhibition compared to an age- and gender-matched group of comparison adolescents. Both verbal and non-verbal domains were affected. However, switching (verbal and non-verbal) was not impaired, possibly because maltreated youngsters are adept at keeping vigilant for signs of danger, which may enhance or protect their ability to switch. These results support earlier findings on the effects of childhood maltreatment with younger samples (De Bellis et al., 2009).

A second set of analyses included variables related to EBD to examine the possibility that higher scores on these variables may have differentially affected EF performance in the maltreated adolescents. Anxiety, depression and behavioural difficulties were more common in the maltreated group, and accounted for significant portions of the variance in ELWM (verbal and non-verbal) and two of the four measures of inhibition (verbal inhibition and directed attention time cost), suggesting that some areas of EF are affected by these variables. However, group differences in ELWM, fluency, and two of the four measures of inhibition remained after the inclusion of EBD variables, providing evidence that EF is impaired in maltreated adolescents above and beyond behavioural/emotional symptomatology that may impact on performance. Nonetheless, the findings in relation to inhibition, where some measures no longer showed group differences once EBD had been included, suggest that inhibition might be mediated by EBD variables. Perhaps the ability to inhibit prepotent responses is linked to *current* emotional and behavioural symptomatology, rather than to underlying difficulties with this EF skill.

These findings support the theory that childhood maltreatment results in impairments in core capacities for self-regulation and interpersonal relatedness, which could be caused by alterations in the regulation of neuroendocrinological systems (Andersen & Teicher, 2009). In addition, they show that some areas of EF are affected by current emotional and behavioural difficulties. If stressors are protracted over time, there may be significant implications for the development of key cognitive functions, such as EF, especially during adolescence, an age when increasing autonomy makes these functions especially important (Mezzacappa et al., 2001). Whilst it is not possible to say definitely that this is because of maltreatment, there was an absence of multicollinearity in the data, which increases our confidence that the influences of IQ and EBD were independent from that of EF and consequently could be statistically controlled in the regression analyses.

Poor EF performance might occur in maltreated youngsters because they are more highly attuned to danger (McCrory et al., 2011; Pollak, 2008). Whilst in a state of hypervigilance, stress arousal and fear, it may be difficult to process verbal information, follow directions, or remember what is being said (Steele, 2002). Such tendencies could have a cascade of developmental influences (Thomas et al., 2009). For example, intense feelings can cause psychological and physical distress that challenge a youngster's ability to function effectively (Perry, 2002), and primary functions required for learning, such as focusing, attending, retaining, or recalling may be negatively affected (Steele, 2002). Furthermore, by the time adolescents reach secondary school, the complexity and volume of information can be overwhelming. For maltreated youngsters with weaknesses in EF, these challenges may become insurmountable and could explain why so many drop out of school and become involved in anti-social activities (McCrory & Viding, 2010).

It is important to note that not all children subjected to maltreatment show adverse effects, and it is estimated that between 12-22% of children/adults abused as children function well despite a history of maltreatment (McGloin & Widom, 2001). Luthar, Cicchetti, and Becker (2000) have pointed out that the majority of maltreated youngsters can function well in some domains, but not others, and show fluctuations over time. This is reinforced by the current findings: in each of the six areas of EF that showed significant group differences, between 50% and 75% of the maltreated sample demonstrated weaknesses. Why not all youngsters subjected to childhood maltreatment are adversely affected is not fully understood, however, some protective factors may include secure attachment patterns (Cook et al., 2005), resilience (Cicchetti & Rogosch, 1997), and a high IQ (Jaffee, Caspi, Moffitt, Polo-Tomas, & Taylor, 2007). Here, only 25% of the maltreated sample had IQs within the typical range, and 12.5% of these had IQs above the non-maltreated mean; in addition, IQ was a significant predictor of performance on several EF measures including ELWM, fluency, and directed attention (time cost) in the second set of regressions.

One limitation of this study was the fact that the groups differed on diagnostic status and educational experience. Consequently, an additional control group drawn from the same EBD schools as the maltreated group would be useful to include in future research investigations. Similarly, adjustments for socio-economic status (SES), which has been suggested to affect the development of EF skills (Noble, Norman, & Farah, 2005), and for variables such as the severity, frequency, type, and developmental period of abuse would be useful because our maltreated participants from specialist schools may represent the more severe end of the spectrum. It should also be noted that some of the maltreated participants disliked psychological tests, possibly due to extensive previous psychological assessments, and may not have performed to the best of their abilities despite the tasks being presented in a game-like format and every effort being made to ensure that they felt comfortable and relaxed. Finally, inclusion of a formal assessment of the characteristics and history of the non-maltreated group in future research would increase confidence about group allocation.

Nonetheless, the findings from this study should be valuable in helping to create better support for maltreated adolescents inside and outside the classroom. Deficits in EF not only have consequences for the regulatory systems that will affect behaviour such as inhibition and poor attention skills, but could also lead to impairments in information processing systems, which could cause impaired functioning in the classroom and other situations.

Conclusion

The current findings extend earlier work and demonstrate that adolescents exposed to childhood maltreatment have significant impairments in EF in comparison to non-maltreated adolescents after controlling for IQ. These weaknesses include ELWM, fluency, and inhibition in both the verbal and non-verbal domains, and may help explain why maltreated youngsters struggle to cope inside and outside the classroom. After controlling for EBD, several EF skills (fluency, ELWM, non-verbal inhibition and directed attention (error cost) remained impaired. We suggest that targeting these key abilities could aid maltreated youngsters in their everyday activities and help them regulate stress.

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Table 1 Summary of means/SDs/ranges for descriptive/EF variables

Variable/Group	Non-maltreated group (n = 40; 23 males, 17 females)	Maltreated group (n = 40; 26 males, 14 females)
Age (months)	181.10 (22.79) 132 – 216	181.92 (22.77) 135 – 221
IQ Stanford-Binet abbreviated version	100.97 (8.08) 85 – 118	87.37 (12.58) 70 – 121
ELWM (verbal) [a]	13.85 (2.28) 9 – 20	10.66 (2.33) 4 – 15
ELWM (non-verbal) [a]	22.25 (2.12) 17 – 24	17.11 (4.60) 7 – 24
Fluency (verbal) [b]	16.82 (2.55) 11.8 – 23.2	12.74 (4.24) 2.2 – 18.2
Fluency (non-verbal) [b]	11.34 (2.71) 7 – 17.5	7.88 (3.39) 3 – 16
Switching cost (verbal) [c]	7.00 (2.52) 2.5 -13.5	6.09 (3.70) -.5 - 13
Switching cost (non-verbal) [c]	2.53 (3.48) -7 – 10.5	3.09 (2.90) – 1.5 - 11
Inhibition (verbal) [d]	1.20 (1.50) 0 – 5	5.47 (5.88) 0 – 24
Inhibition (non-verbal) [d]	0.50 (1.01) 0 – 4	2.47 (3.60) 0 – 13
Directed attention time cost [e]	21.37 (7.98) 8 – 41	34.00 (19.98) 11 – 115
Directed attention errors [d]	0.90 (1.3) -1.00 – 4	3.21 (3.47) -2 – 16

[a] = trials correct; [b] = items generated per minute; [c] = category fluency average score minus switching fluency score; [d] = number of errors; [e] = time taken

Table 2 Summary details of regressions predicting performance on each EF measure (note that for brevity, information is included only for step 2 of the models for each EF measure).

EF Measure	**Total R^2 accounted for by the model**	**Change in R^2 Step 1**	**Change in R^2 Step 2**	***β* IQ Step 2**	***β* Group Step 2**	***F* Change Step 2**
ELWM (verbal)	.469	.381***	.087***	.420***	-.356***	12.66***
ELWM (non-verbal)	.453	.340***	.113***	.358**	-.404***	15.91***
Fluency (verbal)	.330	.245***	.084**	.301**	-.349**	9.69**
Fluency (non-verbal)	.295	.205***	.090**	.253*	-.360**	9.81**
Switching cost (verbal)	.033	.000	.033	-.135	-.220	2.65
Switching cost (non-verbal)	.008	.003	.005	-.005	.086	.394
Inhibition (verbal) +	.225	.118**	.108**	-.123	.395**	10.71**
Inhibition (non-verbal) +	.196	.055*	.141***	.016	.451***	13.48***
Directed attention time cost +	.194	.147**	.047*	-.242	.258*	4.33*
Directed attention error cost +	.195	.130**	.065*	-.191	.306**	6.11*

+ Outliers not excluded as they were all < 1 on Cook's distance and < 15 on Mahalanobis' distance suggesting that they did not carry undue influence. *p < .05; ** p < .01; ***p < .001

Table 3 Summary of means, SDs and ranges for the SDQ, BYI-D and BYI-A

Group	SDQ Total Difficulties	BYI-D	BYI-A
Typical	9.50 (4.31) 2 - 24	49.43 (5.90) 39 - 65	45.53 (7.12) 35 - 69
Maltreated	18.35 (5.10) 6 - 35	56.56 (12.16) 36 - 84	51.72 (11.4) 32 - 84

Table 4 Summary details of regressions controlling for EBD on each EF measure (note that for brevity, information is included only for Step 3 of the models for each EF measure).

EF Measure	Total R^2 accounted for by the model (Step 3)	Change in R^2 Step 1	Change in R^2 Step 2	Change in R^2 Step 3	β IQ Step 3	β SDQ Step 3	β BYID Step 3	β BYIA Step 3	β Group Step 3	F Change Step 3
ELWM (verbal)+	.509	.380***	.065*	.064**	.444***	.076	.276	-.330*	-.390**	9.44**
ELWM (non-verbal)	.468	.337***	.072*	.059*	.377***	-.035	.200	-.207	-.3768*	8.09**
Fluency (verbal)+	.359	.239***	.071	.049*	.297*	-.121	.080	.162	-.344*	5.62*
Fluency (non-verbal)	.292	.199***	.022	.071**	.241*	.090	-.075	-.052	-.413**	7.34**
Switching cost(verbal)	.042	.001	-.010	.031	-.143	.054	.115	-.038	-.273	2.38
Switching cost(non-verbal)	.022	.003	.014	.005	.007	-.012	.169	-.187	.105	.345

EF Measure	Total R^2 accounted for by the model (Step 3)	Change in R^2 Step 1	Change in R^2 Step 2	Change in R^2 Step 3	*β* IQ Step 3	*β* SDQ Step 3	*β* BYID Step 3	*β* BYIA Step 3	*β* Group Step 3	*F* Change Step 3
Inhibition (verbal) +	.357	.111**	.238***	.008	-.105	.462**	.248	-.460**	.138	.90
Inhibition (non-verbal) +	.216	.052*	.108*	.057*	.028	.166	.118	-.229	.369*	5.29*
Directed attention time cost +	.234	.145**	.074*	.015	-.266*	.098	-.305	.304	.189	1.41
Directed attention error cost +	.249	.124**	.087	.039*	-.216	-.018	-.410*	.370*	.300*	3.64*

+ Outliers not excluded as they were all < 1 on Cook's distance and < 15 on Mahalanobis' distance suggesting they did not carry undue influence.
* $p < .05$; ** $p < .01$; *** $p < .001$

Table 5 Percentages and numbers of maltreated adolescents showing impairments on each EF measure (performance >1 SD and >2 SD below the mean scores for the comparison group)

Variable	**>1 SD**	**>2 SD**
IQ	75% (30)	45% (18)
ELWM verbal	60% (24)	30% (12)
ELWM non-verbal	75% (30)	60% (24)
Fluency verbal	60% (24)	35% (14)
Fluency non-verbal	60% (24)	35% (14)
Switching cost verbal	27.5% (11)	12.5% (5)
Switching cost non-verbal	5% (2)	0% (0)
Inhibition verbal	62.5% (25)	42.5% (17)
Inhibition non-verbal	55% (22)	47.5% (19)
Directed attention (time cost)	50% (19)	31.58% (12)
Directed attention (error cost)	52.63% (20)	34.21% (13)

(N.B. Directed attention cost and errors only had 38 maltreated participants)