



Mediating effect of executive functioning between adverse childhood experiences and aggressive behavior: a systematic review

Bárbara Rodrigues

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Universidade do Minho
Escola de Psicologia

Bárbara Sofia Rebelo Rodrigues

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and Aggressive Behavior: a systematic
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Assinatura:

Barbara Sofia Rebelo Rodrigues

Efeito mediador do funcionamento executivo entre experiências adversas na infância e comportamento agressivo: uma revisão sistemática

Resumo

Experiências adversas na infância têm vindo a ser associadas ao aumento de risco para comportamento agressivo. Apesar de várias décadas de pesquisas destacando esta relação, pouco se sabe sobre o possível efeito mediador de défices no funcionamento executivo. Esta revisão sistemática teve como objetivo preencher esta lacuna e conhecer a literatura sobre o tema. Em dezembro de 2020, os estudos relevantes foram identificados através de consulta a cinco bases de dados eletrónicas, com a inclusão de estudos publicados desde sempre, escritos em português e inglês. Mil e sete estudos foram identificados, dos quais cinco foram considerados elegíveis. Só foram identificados estudos com bebés, crianças e adolescentes, que foram analisados e mostraram um efeito mediador das funções executivas entre experiências adversas prévias e comportamento agressivo. A escassez de estudos sobre a temática e a ausência de estudos com população adulta foi uma limitação para o conhecimento e seria relevante, no futuro, explorar este tema para uma melhor compreensão sobre esta relação, com o objetivo de prevenir tanto os maus-tratos a crianças como o comportamento agressivo associado.

Palavras-chave: experiências adversas na infância, funções executivas, comportamento agressivo, efeito mediador.

Mediating effect of executive functioning between adverse childhood experiences and aggressive behavior: a systematic review

Abstract

Adverse childhood experiences have been consistently linked to aggressive behavior. Despite several decades of research highlighting this relationship, little is known about the potential executive functioning deficits that are likely to mediate it. This systematic review aimed to fill this gap and understand what the literature tells us. In December of 2020, relevant studies were identified through five electronic databases for the inclusion of Portuguese or English quantitative published studies. 1007 studies were identified, which five were considered eligible. Studies with infants, children and adolescents were analyzed and showed a mediating effect of executive functions between adverse childhood experiences and aggressive behavior. The scarcity of studies included and the absence of studies with adult populations was a limitation and it would be relevant in the future to explore more about this topic to better understand this relationship with the aim of preventing both the mistreatment of children and the associated aggressive behavior.

Keywords: adverse childhood experiences, executive functions, aggressive behavior, mediating effect.

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Mediating effect of executive functioning between adverse childhood experiences and aggressive behavior: a systematic review

INTRODUCTION

Adverse childhood experiences (ACE) are potentially traumatic or highly stressful childhood events (i.e., sexual abuse, physical abuse, emotional abuse, neglect, contact with situations of violence, abuse of substances by an adult caregiver and other forms of household dysfunction) that occur during the first 18 years of life (Felitti et al., 1998). The prevalence of child maltreatment cannot be understated (Kessler et al., 2010). It is estimated that approximately 38.8% of the population would have suffered some ACE, of which 59.3 to 66.2% would have suffered multiple adversities, with an average of adversities of 2.5 to 2.9% (Kessler et al., 2010).

Research has been showing the existence of an association between ACE and aggressive behavior (Baglivio & Epps, 2015; Cuadra et al., 2014; Fox et al., 2015; Widom & Ames, 1994). Compared with general population youth, among youth offenders, there are higher rates of childhood trauma, particularly physical abuse (Zou et al., 2013). It is estimated that between 40% and 60% of offenders have been victimized at least once (Ford et al., 2007; Stahl, 2006). According to a report from the World Health Organization in 2020, violence is a global public health problem. Aggressive behavior is an evolutionarily highly conserved behavior directed toward another individual with the intent to cause harm. This behavior is widespread in the world (Bertsch et al., 2020) and is a common consequence of child maltreatment, observed through early childhood, adolescence (Pagani et al., 2004) and adulthood (Widom, 1989a). It includes a range of acts like physical fighting, to more severe sexual and physical abuse to homicide. Researchers have identified two major subtypes of aggression: reactive and proactive aggression. Reactive aggression refers to impulsive retaliatory act in response to a perceived threat. In contrast, proactive aggression refers to aggressive behaviors in search of a goal (Dodge & Coie, 1987).

Early adverse experiences and the risk of aggressive behavior have been consistently linked, but what remains to be delineated is how. Several cognitive processes may be mediating this relationship. In the first years of life, neuronal growth and neuroplasticity are rapid and extensive, and many brain regions are especially sensitive to stress and trauma (Brower & Price, 2001). Chronic stress can lead to dysregulation of the hypothalamic-pituitary-adrenal axis, which in turn may have side effects on the brain (Pechtel & Pizzagalli, 2013). Previous research has shown that ACE are associated with volume reduction

and functional impairment of the prefrontal cortex (PFC) (De Bellis et al., 2013). Given the role of the PFC in executive functions, PFC abnormalities after adverse childhood experiences may contribute to executive functioning deficits. (Poon, 2018). Executive functioning is the ability to exhibit higher order cognitive processing, planning or anticipating future events, reasoning, demonstrating flexibility, or completing tasks (Gioia et al., 2002). These are essential in preparing and executing goal-directed behavior (Diamond, 2013). Executive functioning can be divided into (a) “cold” executive functions (e.g., executive attention, working memory, problem-solving, planning, and shifting between mental tasks) which are conceptualized as being less integrated with affective and autonomic responses, and (b) “hot” executive functions (e.g., affect inhibition), modulating the emotional valence and intensity of responses and moderating behavioral responses (Poon, 2018). Most empirical neuropsychological research differentiates executive functions between three cores: inhibitory control, working memory, and cognitive flexibility. (Diamond, 2013; Miyake et al., 2000). Developmentally, the ability to flexibly switch between two different alternatives on a situation appears at approximately 5 years of age (Séguin & Zelazo, 2005 *cit in* Lee et al., 2007), whereas many cognitive tasks requiring the holding of information and the ability of inhibition appears between the ages of 3 and 7 (Diamond, 2002). Abstract reasoning and attentional set shifting steadily improve throughout adolescence, whereas inhibitory control tends to level off by early adolescence (Rosso et al., 2004). Although adult level performance on many EF is reached at approximately 12 years old, the development of more complex EF continues to develop into adulthood (Séguin & Zelazo, 2005 *cit in* Lee et al., 2007). Decision-making processes and the development of a metacognitive orientation, continue to be elaborated in adolescence (Byrnes, 2003 *cit in* Lee et al., 2007). The full impact of ACE may not be perceived until the child develops and engages in more serious relationships and develops more complex cognitive abilities (Lubit et al., 2003 *cit in* Lee et al., 2007). Thus, the impact of early trauma may not manifest itself until late adolescence or early adulthood. Although some cognitive functions appear at early age, the fact that executive functioning becomes more complex and continues to be developed into adolescence highlights the risk for executive deficits (Lubit et al., 2003 *cit in* Lee et al., 2007).

In support of these theories, studies have shown that individuals with histories of early trauma have been found to perform more poorly on tasks of EF compared with nonexposed controls (DePrince et al., 2009), and the frequency or severity of exposure to traumatic events in childhood has been negatively associated with EF task performance (Spann et al., 2012), which can lead to behavioral problems (Yoder et al., 2019). Early conceptualizations of this relationship have been largely informed by the nature of the maltreatment experience and social theory. (Dileo et al., 2016). For example, the

relationship between physical abuse and aggression is well supported via Bandura's (1978) social learning theory, which proposes that aggressive behavior is learned through life experiences (i.e., exposure to violence) and external reinforcement. However, in a large prospective study in the United States, Kotch et al. (2008) found that early neglect predicted aggressive behavior above other maltreatment experiences. Consequently, it is understood that children who are exposed to neglect are therefore denied of opportunities to unlearn maladaptive behaviors (Vitaro et al, 2006).

The emergence of neuroscience has encouraged an integrated neurodevelopmental view of how maltreatment may increase the risk of aggressive behavior. Through this lens, it can be hypothesized that the stress and fear-activating nature of traumatic events consolidate affective responses and stress functioning that are maladaptive in safe circumstances and increase the risk of aggressive behavior (Dileo et al., 2016). For example, a series of psychological studies has consistently reported that higher scores on report measures of emotion dysregulation mediate the relationship between child maltreatment and aggressive behavior (Fox et al., 2015; Garofalo & Velotti, 2017; Robertson et al., 2015).

There are some neuroscientific studies that illustrate the hypothesized neurophysiological changes in the limbic systems of maltreated children, suggesting that these may increase the risk of aggressive behavior. For example, structural neuroimaging studies have found relative amplification of the structures associated with affect regulation in maltreated children. With respect to an increased risk of aggressive behavior, Tupler and De Bellis (2006) found that increased hippocampal size in their study was associated with externalizing behaviors in maltreated children, suggesting that early trauma may stimulate growth in this region and increase this risk.

Therefore, there is evidence from psychological and neuroimaging studies to suggest that children may not only learn to behave aggressively when exposed to aggression in traumatic experiences (e.g., social learning theory), but also consolidate neuropsychological vulnerabilities that increase the risk. (Dileo et al., 2016). It is reasonable to presume that executive functions such as inhibition, flexibility, impulse control, and planning have possible relations with aggressive behavior. Prefrontal dysfunction theory explains this connection during adolescence. The theory says that the developing prefrontal cortex is overloaded by the early emergence of emotional and autonomy needs of early adolescence, leading to poor inhibitory control over aggressive impulses. People with properly developed executive skills of planning and inhibition are enabled to manage and inhibit their inappropriate behavior and impulses in defiant situations. In contrast, people with lower levels of EF may often face relational problems during

their interaction with others because of lack of inhibition of inappropriate offensive acts and words, resulting in aggressive outcomes (Fatima & Sheikh, 2016).

Kotch et al.'s (2008) study suggested that childhood neglect leads to compromised consolidation of higher-order cognitive functions that promote prosocial behavior and protect against aggressive behavior. In social cognitive literature, several studies have reported social information processing (SIP) deficits as a mediator of the relationship between child maltreatment and aggressive behavior (Dodge et al., 1990, 1997). In social-information-processing terms, these children may fail to develop appropriate attention to interpersonal interactions (e.g., bias to threatening cues) and may become hypervigilant toward hostile cues. Crittendon and Ainsworth noted that "such vigilance resulting from internal models of conflict and dominance could easily lead the abused child to misinterpret the behavior of others and to respond with aggression himself" (Dodge et al., 1990).

In sum, maltreatment of children is a chronic community problem that increases the risk of future aggressive behavior. Despite several decades of research highlighting this relationship, little is known about the potential executive functioning deficits that are likely to mediate it. This systematic review aimed to fill this gap and understand what the literature tells us. Therefore, the main objectives of this study were: 1) Analyze the mediating effect of FEs on the relationship between ACE and aggressive behavior; 2) Identify deficits in executive functions associated with ACE and aggressive behavior; and 3) Verify the potential existence of similar or different results regarding this mediating role in individuals with different age ranges. These objectives were defined based on the research question: "What is known in the literature about the mediating effect of executive functions between ACE and aggressive behavior?".

METHOD

Eligibility criteria

The inclusion criteria were: 1) Quantitative studies published in peer-reviewed journals; 2) Studies that evaluate the mediating effect of EF between ACE and aggressive behavior; 3) Study samples comprising participants assessed with EAI and CA; and 4) Studies written in Portuguese or English. Unpublished master's or doctoral theses, unpublished research reports, or chapters of books were not included. Articles were excluded if the participants had a history of head trauma or any diagnosis of schizophrenia disorder or bipolar disorder; and if they did not specifically assess aggressive behavior.

Information sources and search strategy

In December of 2020, relevant studies were identified through five electronic databases: Web of Science, PubMed, Scopus, PsycINFO and PsycARTICLES. The search equation used included the terms: ("adverse childhood experiences" OR "childhood Adversity" OR "abus*" OR "negligence" OR "maltreatment" OR "trauma" OR "ACE*") AND ("executive function*" OR "executive control*" OR "executive dysfunction*") AND ("offend*" OR "delinquen*" OR "violen*" OR "impulsiv*" OR "aggress*") AND NOT ("recidiv*"). Database searches were supplemented by a bibliographic review of identified articles, as well as consultation with experts on this topic. There was no time interval restriction during the search strategy.

Study extraction and selection

Identified studies were imported to the Rayyan platform and the duplicates were removed. A first screening of possible relevant articles was done through the title and abstract by two reviewers (BR and DM). Were identified articles to analyze in full, to ensure that the inclusion criteria were fulfilled. The references of the eligible articles were manually analyzed. All doubts were discussed between the two reviewers until a consensus was reached.

Data extraction

For each study, the name(s) of the author(s), the year of publication, the country and the study design were identified. Details of the sample size (N) and the main sociodemographic characteristics of the samples (mean age, education) were also collected. Then, the types of childhood adversity (e.g., abuse, neglect) and their prevalence, assessed by the included studies were identified. Details on which executive functions and aggressive behaviors were assessed within each study was also extracted. Finally,

the main results regarding the mediating effect of EF between ACE and aggressive behavior were described. Description of main sample features and study design are presented in Table 1, whereas description of type of childhood adversity, executive functions assessed, aggressive behavior, and main results of the eligible studies are presented in Table 2.

Data synthesis

Included articles were reviewed in a qualitative synthesis and the findings were summarized and highlighted their significance. Included articles were divided into three categories considering the age range of the samples: 1) Infants (12-38 months), 2) Children (6-12 years) and 3) Adolescents (12-20 years). Key findings are described in the Results section.

Risk of bias in individual studies

The risk of bias in individual studies was independently conducted by two reviewers (DM and BR). Was used the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies checklist of 14 items (National Institute of Health, 2016) for the assessment of quantitative studies. All items from the checklist were utilized, and each study was independently assigned an overall quality rating (“Good”, “Fair”, or “Poor”) (Table 3). Included studies with a rating of poor quality translates to a high risk of bias, whereas a rating of good quality translates to a low risk of bias. Potential risk of bias may include selection bias, information bias, measurement bias, or confounding (National Institute of Health, 2016). Quality ratings were not used to exclude studies but did serve to identify consistent weaknesses and risk of bias from eligible studies. Inter-rater agreement (or inter-rater reliability) was measured through Cohen’s kappa coefficient (κ), a robust statistic that measures the degree of agreement between two raters regarding the same qualitative (categorical) items, while considering chance agreement (McHugh, 2012). Cohen’s kappa magnitude can range from -1 to +1, where ≤ 0 represents no agreement; 0.01-0.20 represents none to slight agreement; 0.21-0.40 represents fair agreement; 0.41-0.60 represents moderate agreement; 0.61- 0.80 represents substantial agreement; and 0.81-0.99 represents almost perfect agreement, and 1 represents perfect agreement (McHugh, 2012). Inter-rater agreement analysis was performed using the IBM SPSS, version 25 for Windows (United States, New York, IBM Corporation).

RESULTS

Initially, 1007 studies were identified through electronic database searching. After the duplicates were removed (n = 432) a first screening of possible relevant articles was done through the title and abstract by two reviewers (BR and DM), where 530 articles were excluded. Were identified 45 articles to analyze in full, to ensure that the inclusion criteria were fulfilled. After a second screening of the 45 full articles, 40 were excluded: 21 for not testing the mediation effect of EFs between ACE and aggressive behavior, 11 for not concretely evaluating aggressive behavior, four for not being quantitative studies and four for being part of the “gray literature”. The references of the five eligible articles were manually analyzed, obtaining no additional results. In total, 1007 studies were identified in this systematic review, in which 5 were considered eligible (Demeusy et al., 2018; Dileo et al., 2016; Fatima & Sheikh, 2016; Harwood-Gross et al., 2020; Yoder et al., 2019) (Fig.1).

Characteristics of included studies and summary of the main findings

Year and country of publication

The total amplitude of included studies ranged between 2016 and 2020. The studies were carried out in different countries: Pakistan (Fatima & Sheikh, 2016), United States (Demeusy et al., 2018; Yoder et al., 2019), Australia (Dileo et al., 2016) and Israel (Harwood-Gross, 2020).

Sample characteristics

The sample sizes of the included studies ranged between 50 (Dileo et al., 2016) and 512 (Fatima & Sheikh, 2016). Sample characteristics showed that the mean age of samples ranged between 12 months and 17.19 years and the studies were divided into three categories considering the age range of the sample: 1) Infants (12-38 months) (Demeusy et al., 2018), 2) Children (6-12 years) (Dileo et al., 2016) and 3) Adolescents (12-20 years) (Fatima & Sheikh, 2016; Harwood-Gross et al., 2020; Yoder et al., 2019). The majority of the participant samples were enrolled between the last year of middle school all through high school. The socioeconomic level was identified by three studies (Demeusy et al., 2018; Dileo et al., 2016; Harwood-Gross et al., 2020) and was considered low.

Design

Only one study presented a longitudinal design (Demeusy et al., 2018). All other studies presented a cross-sectional design.

Procedures (recruitment)

Participants were recruited from schools for at-risk youth, Child Protection Agencies, houses in state Department of Youth Services and Child Protective Services.

Measures

To assess the type of adverse experiences in the childhood, the studies included instruments such as: Maltreatment Classification System (D. Barnett et al., 1993), Modified Maltreatment Classification System (MMCS) (English & Longscan, 1997), Parent–Child Relationship Scale (PCRS) (Rao, 2000), The Parental Bonding Instrument (PBI) (Parker et al., 1979), The Youth Self Report (Achenbach, 1991) and Childhood Trauma Questionnaire (CTQ) (Bernstein et al., 1994). To evaluate the executive functions, were used the following instruments: Three Boxes Scrambled (Diamond et al., 1997), Three Boxes Stationary (Diamond et al., 1997), Behavior Rating Inventory of Executive Function (BRIEF) (Gioia et al., 2000), Delis–Kaplan Executive Cognitive Functioning System (D-KEFS) (Delis et al., 2001) and The Cambridge Neuropsychological Test Automated Battery (CANTAB). Finally, to measure the aggressive behavior, one study asked youth whether they committed a sexual crime that could get them in trouble with the law, and the other studies included instruments such as: Child Behavior Checklist/2-3 (CBCL) (Achenbach, 1992), Reactive Proactive Aggression Questionnaire (RPAQ) (Raine et al., 2006) and The Aggression Scale (Mathur & Bhatnagar, 2004).

Mediating effect of EF between ACE and aggressive behavior

Infants (12-38 months)

Both spatial and nonspatial working memory were modeled as correlated mediators. Nonspatial working memory did not significantly predict aggression. However, results indicated a significant indirect effect of infancy neglect on toddler aggression via spatial working memory assessed at 26 months old. These results are indicative of partial mediation. The mediated effect was found to explain approximately 39% of the total effect of neglect on aggression at 38 months old (Demeusy et al., 2018).

Children (6-12 years)

Results showed that executive dysfunction represents a significant mediation pathway between early adversity and aggressive behavior by 62% in children aged between 6 and 12 years (Dileo et al., 2016).

Adolescents (12 to 20 years)

Partial mediation effect of EFs was evident between perception of low quality of parent–child relationship and aggression (Fatima & Sheikh, 2016). One study revealed that according to the organizing materials model, there is an indirect effect from sexual abuse to sexual violence where deficits in organizing materials mediates the relationship (Yoder et al., 2019). Different results were verified in one study, where there was no mediation effect demonstrated (Harwood-Gross et al., 2020). Results from indirect path from perceived maternal care to aggressive behaviors through executive functions were not significant (Harwood-Gross et al., 2020).

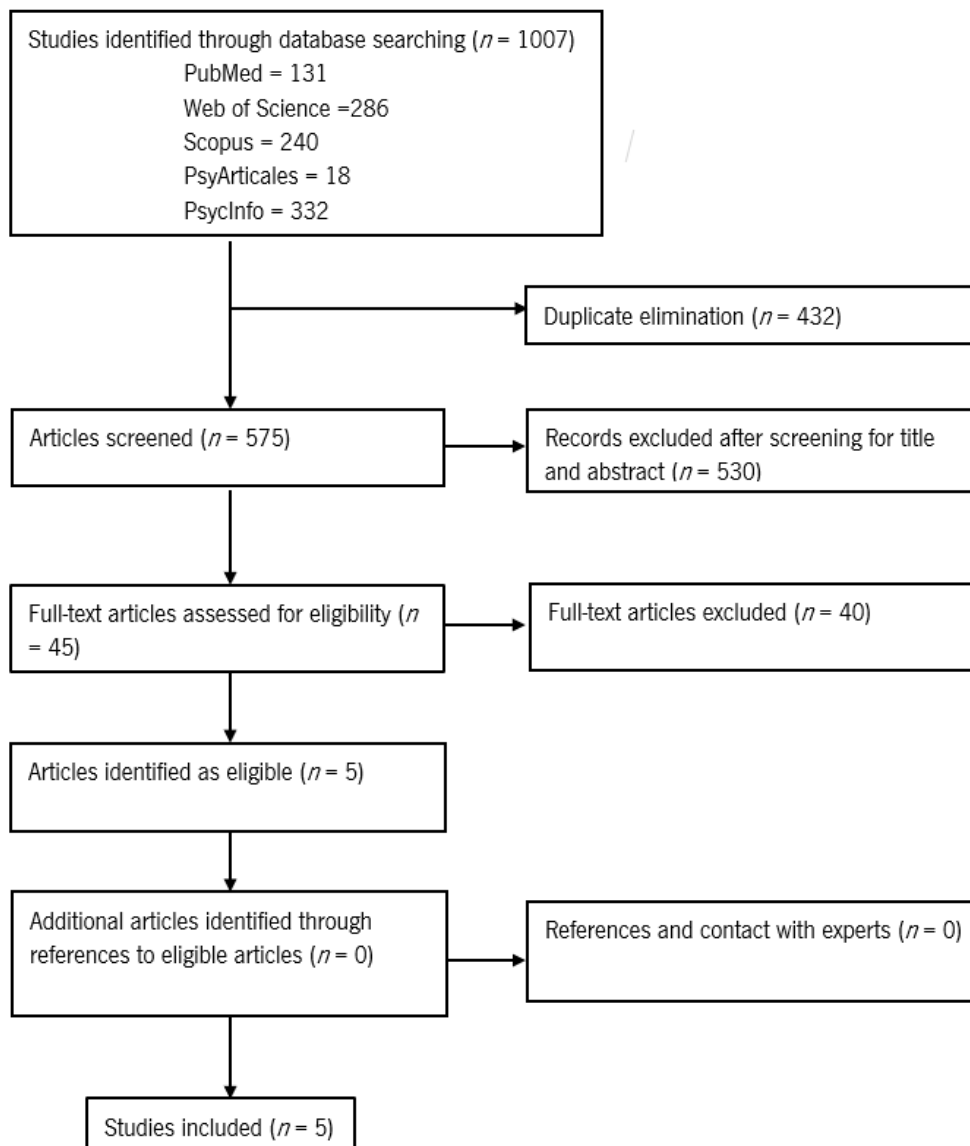


Figure 1. Flow diagram of the article selection.

Table 1. Description of main sample characteristics and study design.

Authors (Year), Country	Study design	Sample size (n)	Sample characteristics (Age; education level; socioeconomic status)
Demeusy et al. (2018) United States	Longitudinal.	45 Neglect infants. 44 Nonneglect infants. Their biological mothers.	Infants. Age: M= 12.7 months, SD= .68. Mothers. Age: M= 26.76; SD= 5.71. Education: NR. SES: Low.
Dileo et al. (2016) Australia	Cross-sectional.	Protective care group (n= 20). Community control group (n= 30).	PCG. Age: M= 9.4, SD=1.73. Education: NR. SES: M= median. CCG. M= 7.87, SD=1.67. Education: NR. SES: M= 64.56, SD= 19.06.
Fatima & Sheikh (2016) Pakistan	Cross-sectional.	512 Adolescents of South Asian ethnic background.	Age: M= 15.5, SD= 1.3. Education: Secondary and higher secondary. SES: NR.

Harwood-Gross et al. (2020) Israel	Cross-sectional.	71 At risk boys.	Age: M= 15.8, SD= 1.04. Education: from 9th to 12th grade. SES: Low.
Yoder et al. (2019) United States	Cross-sectional.	200 Adjudicated youth.	Age: M= 17.19, SD= 2.52. Education: M= 10th grade. SES: NR.

Note. NR= Not Reported; SES= Socioeconomic Status; PCG= Protective Care Group; CCG= Community control group.

Table 2. Description of type of childhood adversity, executive functions assessed, aggressive behavior, and main results of the eligible studies.

Authors (Year), Country	Type of childhood adversity (prevalence)	Executive functions assessed	Aggressive behavior	Main results
Demeusy et al. (2018) United States	Neglect (51%).	Working memory.	Physical aggression.	Working memory was modeled as a correlated mediator between neglect prior to baseline and aggression at 38 months, by approximately 39%.

Dileo et al. (2016) Australia	Physical violence (50%); Verbal abuse (50%); Neglect (50%); Being locked up (20%); Bullied (20%); An inappropriate sexual act (15%); Home accident (15%); Car accident (5%); Criminal act (5%)	Inhibitory control; shift; emotion control; working memory; planning organization; organization of materials; monitoring.	Reactive and proactive aggression.	Executive dysfunction represents a significant mediation effect between early adversity and aggression by 62%.
Fatima & Sheikh (2016) Pakistan	Perception of low quality of parent-child relationship.	Visual scanning; working memory; design fluency; inhibitory control; problem-solving.	Not specified aggression.	EF mediates the association between PCR and aggressive behavior, but the type of mediation is partial.
Harwood-Gross et al. (2020) Israel	Perception of low maternal care (66,2%).	Inhibitory control; selective attention; cognitive flexibility; planning ability; working memory.	Physical aggression.	No mediating role was found for EFs between perceived maternal care and aggressive behavior.
Yoder et al. (2019) United States	Domestic traumatic experience (85%); physical abuse (46%); sexual abuse (24.5%).	Working memory; planning and organizing; organizing materials; task completion.	Sexual violence.	There was a multi-mediational effect of organization of materials explaining the relation between sexual abuse and sexual violence.

Risk of bias of included studies

Quality appraisal of each criterion of the included studies is presented in detail in Table 3. The main sources of bias were: i) only one study presented a longitudinal design, and all other studies presented a cross-sectional design thus preventing determination of causality between variables; ii) few studies reported the participation rate (Demeusy et al., 2018; Fatima & sheikh, 2016). This increases the risk of bias because if fewer than 50% of eligible subjects participated in the studies, then there is concern that the studies population may not adequately represent the target population; iii) none of the studies presented any justification of sample size or power description, neither provided effect estimates or variance. This increases the risk of bias because it is not clear whether the studies had enough participants to detect an association if one truly existed. Furthermore, one study (Yoder et al., 2019) measured the outcome of sexual violence only by asking youth whether they committed a sexual crime that could get them in trouble with the law. There was great inter-rater agreement among the reviewers, $\kappa = .88$ (95% CI, .79 to .97), $p = .001$, and doubts were discussed until a consensus was reached. A final overall quality rating for each study is presented in Table 3.

Table 3. Risk of bias assessment of included studies.

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Asses sment
Demeusy et al. (2018)	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	NR	No	Yes	Good
Dileo et al. (2016)	Yes	Yes	NR	Yes	No	No	No	No	Yes	No	Yes	NR	NR	No	Fair
Fatima & Sheikh (2016)	Yes	Yes	Yes	Yes	No	No	No	No	Yes	No	Yes	NR	NR	No	Fair
Harwood-Gross et al. (2020)	Yes	Yes	NR	Yes	No	No	No	NA	Yes	No	Yes	NR	NR	No	Fair
Yoder et al. (2019)	Yes	Yes	NR	Yes	No	No	No	No	Yes	No	CD	NR	NR	No	Fair

Note. NR = Not Reported; Q1 = Was the research question or objective in this paper clearly stated?; Q2 = Was the study population clearly specified and defined?; Q3 = Was the participation rate of eligible persons at least 50%?; Q4 = Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?; Q5 = Was a sample size justification, power

description, or variance and effect estimates provided?; Q6 = For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?; Q7 = Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?; Q8 = For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome (e.g., categories of exposure, or exposure measured as continuous variable)?; Q9 = Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?; Q10 = Was the exposure(s) assessed more than once over time?; Q11 = Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants?; Q12 = Were the outcome assessors blinded to the exposure status of participants?; Q13 = Was loss to followup after baseline 20% or less?; Q14 = Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)?.

DISCUSSION

To our knowledge, the present systematic review is the first that synthesizes relevant research on the mediating effect of executive functions in the relation between ACE and aggressive behavior. Despite that maltreatment of children is a chronic community problem that increases the risk of future aggression, little is known about the potential role of executive functioning deficits that are likely to mediate it. Thus, our main goals were to analyze the mediating effect of FEs on the relationship between ACE and aggressive behavior; to identify deficits in executive functions associated with ACE and aggressive behavior; and to verify the potential existence of similar or different results regarding this mediating role in individuals with different age ranges. A small number of studies were found in this review about the potential mediating effect of EFs in the relation between ACE and aggressive behavior. Thus, the literature still reveals a lack of knowledge regarding this topic. However, some noteworthy insights could be obtained and will be discussed in the following sections.

The majority of the included studies analyzed showed that there is a mediating or a partial mediating effect of EFs between ACE and aggressive behavior. Studies also showed that deficits in different EFs can mediate this relation, such as working memory, inhibitory control, shifting, problem-solving, visual scanning, planning and organizing, task completion, monitoring, design fluency and selective attention. It has been found that the development of the prefrontal cortex (PFC), which supports this wide range of EFs, is influenced by the environment during the first few years of life (Center on the

Developing Child at Harvard University, 2012; Schore, 1996). This is the same region of the brain that has been being associated with antisocial and aggressive behavior later in life (Demeusy et al., 2018). Prefrontal dysfunction theory of antisocial behavior explains this connection during adolescence. According to this theory, the late-developing prefrontal cortex is overloaded by the early emergence of social, emotional, and autonomy needs of early adolescence, leading to poor inhibitory control over aggressive impulses (Raine, 2002). EFs such as inhibitory control, flexibility, impulse control, and planning have possible relations with aggressive behavior because these regulatory abilities are likely to aid in inhibiting and controlling aggressive impulses, thinking of alternative explanations of behavior, and solving interpersonal conflicts. People with well-developed executive skills of planning and inhibitory control are able to inhibit their impulses in challenger situations. In contrast, people with lower levels of EFs may often face relational problems during their contact with others because of lack of control of inappropriate acts and words, resulting in aggressive outcomes. (Fatima & Sheikh, 2016). Thus, one proposed mechanism through which maltreatment may influence aggressive behavior is via deficits in cognitive development, particularly the development of executive functioning. Several studies have reported social information processing (SIP) deficits as a mediator of this relationship. SIP theory provides specific mechanisms through which cognitive errors may lead in the development of aggressive behavior and specifies at what stages in cognitive processing dysfunctions may occur (Dodge et al., 1990, 1997). According to this theory, in the absence of developmentally appropriate experiences, maltreated children may exhibit compromised attention (e.g., bias to threatening cues), appraisal (e.g., hostile attributional bias) and reasoning (e.g., positive outcome expectancies for aggression) processes that could thus lead the abused child to misinterpret the behavior of others and increase the risk of aggressive behavior (Dileo et al., 2016).

However, one included study (Harwood-Gross et al., 2020) did not find a mediating role of EFs between low perceived maternal care and aggressive behavior in adolescents. Instead, perceived maternal care predicted unique variance in both EFs and aggressive behavior. It is possible that other factors, such as parenting style and early educational experiences, not included in the present study, may underlie these relationships.

Only five studies with infants, children and adolescents were analyzed and, in general, all presented a significant mediating effect. This indicates that there may be consistency of results over time, however, due to the scarcity of studies, especially with adults, it was not possible to determine the differences between the different age groups. Thus, it could potentially be useful in future research, to

use adult populations to verify the existence of differences between individuals with different ages regarding this mediating role.

Implications for practice and research

Despite the scarcity of studies reviewed, some clinical and practical implications can be mentioned. This review highlights the importance of implementing early parenting interventions to boost later educational and social success in at-risk youth. This can be implemented through interventions, such as parenting programs or early interventions such as aggression prevention programs provided by trained professionals (Harwood-Gross et al., 2020). The results suggest that deficits in EFs might be important treatment focus for clinicians and the community working with maltreated children at risk of aggressive behavior. Therefore, clinicians could consider trialing intervention programs focused on EFs such as inhibitory control and emotion regulation that have been found to reduce aggression in community settings (Dileo et al., 2016). Further research should be done focusing on EFs that appear to be the greatest predictors of aggressive behavior, such as inhibitory control, shifting, problem-solving, planning and organizing in the sense of determine which interventions are most successful in improving executive function development and reducing the risk of aggressive behavior.

Strengths and limitations

To our knowledge, this is the first review that synthesizes relevant research on the mediating effect of EFs between ACE and aggressive behavior. This reveals to be the major strength of the present review. The inclusion of English and Portuguese language peer-reviewed journals, regardless of year of publication and study design, reveals to be another possible strength of the current review. The inclusion of data only from published studies can also be a strength, since it may allow the analysis of higher methodological quality studies compared with unpublished studies. It can also be a limitation thus the exclusion of gray literature may have been a limitation, since possible important studies may not have been analyzed, not allowing to obtain significant results. Efforts were made to capture all relevant studies through contact with subject matter experts and consulting the references from the eligible studies; however, it is possible that articles were overlooked, which can be a source of bias. The inclusion of only one study with a longitudinal design reveals to be another possible limitation of the present review thus preventing determination of causality between variables. The absence of studies with adult populations is also a limitation, which did not allow the analysis of differences between individuals with different age range regarding this mediating role. Finally, the major limitation of this study seems to be the scarcity of studies included, which did not allow the results to be representative to the normal population.

Conclusion

This review provides and adds more evidence about the potential mediating role of EFs on the relationship between ACE and aggressive behavior. Overall, results indicated that there is a mediating effect of EFs between ACE and aggressive behavior. Despite the relevant results found, understudied content areas still exist. Thus, it would be relevant in the future to explore more about this topic to better understand this relationship with the aim of preventing both the mistreatment of children and the associated aggressive behavior.

REFERENCES

Baglivio, T., & Epps, N. (2015). The Interrelatedness of Adverse Childhood Experiences Among HighRisk Juvenile Offenders. *Youth Violence and Juvenile Justice*, 14(3), 179–198. doi:10.1177/1541204014566286

Bandura, A. (1978). Social learning theory of aggression. *Journal of Communication*, 28(3), 12–29. doi:10.1111/jcom.1978.28.issue-3

Bertsch, K., Florange, J. & Herpertz, C. (2020). Understanding Brain Mechanisms of Reactive Aggression. *Curr Psychiatry Rep* 22, 81. doi:10.1007/s11920-020-01208-6

Brower, C., & Price, H. (2001). Neuropsychiatry of frontal lobe dysfunction in violent and criminal behaviour: a critical review. *Journal of Neurological Neurosurgery and Psychiatry*, 71, 720-726. doi:10.1136/jnnp.71.6.720

Center on the Developing Child at Harvard University. (2012). The science of neglect: The persistent absence of responsive care disrupts the developing brain: Working Paper No. 12. Retrieved from: <http://www.developingchild.harvard.edu>

Cicchetti, D., & Rogosch, A. (2001). The impact of child maltreatment and psychopathology on neuroendocrine functioning. *Development and Psychopathology*, 13(4), 783–804. doi: 10.1017/S0954579401004035

Crittendon, M., & Ainsworth, S. in Child Maltreatment, D. Cicchetti, Ed. (Cambridge Univ. Press, New York, 1989), pp. 432-463. doi: 10.1017/CB09780511665707.015

Cuadra, E., Jaffe, E., Thomas, R., & DiLillo, D. (2014). Child maltreatment and adult criminal behavior: Does criminal thinking explain the association? *Child Abuse and Neglect*, 38(8), 1399– 1408. doi:10.1016/j.chiabu.2014.02.005

Demeusy, M., Handley, D., Rogosch, A., Cicchetti, D., & Toth, L. (2018). Early Neglect and the Development of Aggression in Toddlerhood: The Role of Working Memory. *Child Maltreatment*, doi:10.1177/1077559518778814

De Bellis M., Hooper S., Spratt E., & Woolley D. (2009). Neuropsychological Findings in Childhood Neglect and their Relationships to Pediatric PTSD. *J Int Neuropsychol Soc.* doi:10.1017/S1355617709990464

DePrince, P., Weinzierl, M., & Combs, D. (2009). Executive function performance and trauma exposure in a community sample of children. *Child Abuse & Neglect, 33(6)*, 353–361. doi:10.1016/j.chiabu.2008.08.002

Diamond, A. (2002). Normal development of prefrontal cortex from birth to young adulthood: Cognitive functions, anatomy, and biochemistry. In D. T. Stuss & R. T. Knight (Eds.), *Principles of frontal lobe function* (pp. 466-503). Oxford, UK: Oxford University Press.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64*, 135–168. doi:10.1146/annurev-psych113011-143750

Dileo, F., Brewer, W., Northam, E., Yucel, M., & Anderson, V. (2016): Investigating the neurodevelopmental mediators of aggression in children with a history of child maltreatment: An exploratory field study. *Child Neuropsychology*. doi:10.1080/09297049.2016.1186159

Dodge, A., Bates, E., & Pettit, S. (1990). Mechanisms in the cycle of violence. *Science, 250 (4988)*, 1678–1683. doi:10.1126/science.2270481

Dodge, A., Lochman, E., Harnish, D., Bates, E., & Pettit, S. (1997). Reactive and proactive aggression in school children and psychiatrically impaired chronically assaultive youth. *Journal of Abnormal Psychology, 106(1)*, 37–51. doi:10.1037/0021-843x.106.1.37

Dodge, A., & Coie, J. D. (1987). Social-information processing factors in reactive and proactive aggression in children's peer groups. *Journal of Personality and Social Psychology, 53*, 1146-1158.

Fatima, S., & Sheikh, H. (2016). Adolescent Aggression as Predicted from Parent–Child Relationships and Executive Functions. *The American Journal of Psychology, 129(3)*, 283-294. doi:10.5406/amerjpsyc.129.3.0283

Felitti, V., Anda, R., Nordenberg, D., Williamson, D., Spitz, A., Edwards, V., Koss, M. & Marks, J. (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. *American Journal of Preventive Medicine, 14*, 245-258. doi: 10.1016/s0749-3797(98)00017-8

Ford, D., Chapman, J., Mack, M., & Pearson, G. (2006). Pathways from Traumatic Child Victimization to Delinquency: Implications for Juvenile and Permanency Court Proceedings and Decisions. *Juvenile and Family Court Journal*, *57*(1), 13–26. doi:10.1111/j.1755-6988.2006.tb00111.x

Fox, H., Perez, N., Cass, E., Baglivio, T., & Epps, N. (2015). Trauma changes everything: Examining the relationship between adverse childhood experiences and serious, violent and chronic juvenile offenders. *Child Abuse and Neglect*, *46*, 163–173. doi:10.1016/j.chiabu.2015.01.011

Garofalo, C., & Velotti, P. (2017). Negative emotionality and aggression in violent offenders: The moderating role of emotion dysregulation. *Journal of Criminal Justice*, *51*(April), 9–16. doi:10.1016/j.jcrimjus.2017.05.015

Gioia, A, Isquith, K., Kenworthy, L., & Barton, M. (2002). Profiles of everyday executive function in acquired and developmental disorders. *Child Neuropsychology*, *8*, 121–137. doi:10.1076/chin.8.2.121.8727

Harwood-Gross, A., Lambez, B., Feldman, R. & Rassovsky, Y. (2020) Perception of Caregiving During Childhood Is Related to Later Executive Functions and Antisocial Behavior in At-Risk Boys. *Front. Psychiatry* 11:37. doi:10.3389/fpsyt.2020.00037

Kessler, C., McLaughlin, A., Green, G., Gruber, J., Sampson, A., Zaslavsky, M., & Williams, R., (2010). Childhood adversities and adult psychopathology in the WHO world mental health surveys. *British Journal of Psychiatry*, *197*(5), 378–385. doi:10.1192/bjp.bp.110.080499

Kotch, B., Lewis, T., Hussey, M., English, D., Thompson, R., Litrownik, J. & Dubowitz, H. (2008). Importance of early neglect for childhood aggression. *Pediatrics*, *121*(4), 725–731. doi:10.1542/peds.2006-3622

Lee, V., & Hoaken, S. (2007). Cognition, Emotion, and Neurobiological Development: Mediating the Relation Between Maltreatment and Aggression. *Child Maltreatment*, *12*(3), 281–298. doi:10.1177/1077559507303778

McHugh, L. (2012). Interrater reliability: The kappa statistic. *Biochemia Medica*, *22*, 276-282. doi:10.11613/BM.2012.031

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, H., Howerter, A., & Wager, D. (2000). The unity and diversity of executive functions and their contributions to complex “Frontal Lobe” tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49–100. doi:10.1006/cogp.1999.0734

National Institutes of Health (2016). *National Institutes of Health Quality Assessment tool for Observational Cohort and Cross-Sectional Studies*. Available online at: <http://www.nhlbi.nih.gov/health-pro/guidelines/in-develop/cardiovascular-risk-reduction/tools/cohort> (Accessed 18 April, 2021).

Pagani, L., Tremblay, R., Nagin, D., Zoccolillo, M., Vitaro, F., & McDuff, P. (2004). Risk factor models for adolescent verbal and physical aggression toward mothers. *International Journal of Behavioral Development, 28*(6), 528–537. doi:10.1080/01650250444000243

Poon, K. (2018). Hot and cool executive functions in adolescence: development and contributions to important developmental outcomes. *Front. Psychol.* doi:10.3389/fpsyg.2017.02311

Raine, A. (2002). Annotation: The role of prefrontal deficits, low autonomic arousal, and early health factors in the development of antisocial and aggressive behavior in children. *Journal of Child Psychology and Psychiatry, 43*, 417–434. doi: 10.1111/1469-7610.00034

Roberton, T., Daffern, M., & Bucks, S. (2015). Beyond anger control: Difficulty attending to emotions also predicts aggression in offenders. *Psychology of Violence, 5*(1), 74–83. doi:10.1037/a0037214

Spann, N., Mayes, C., Kalmar, H., Guiney, J., Womer, Y., Pittman, B., Blumberg, P. (2012). Childhood abuse and neglect and cognitive flexibility in adolescents. *Child Neuropsychology/europsychology, 18*(2), 182–189. doi:10.1080/09297049.2011.595400

Stahl, L. (2006). *Delinquency cases in juvenile court, 2002*. Washington, DC: Office of Juvenile Justice and Delinquency Prevention, U.S. Department of Justice. Retrieved from: <http://www.ncjrs.gov/pdffiles1/ojjdp/fs200602.pdf>

Tupler, A., & De Bellis, D. (2006). Segmented hippocampal volume in children and adolescents with posttraumatic stress disorder. *Biological Psychiatry, 59*(6), 523–529. doi:10.1016/j.biopsych.2005.08.007

Vitaro, F., Brendgen, M., & Barker, D. (2006). Subtypes of aggressive behaviors: A developmental perspective. *International Journal of Behavioral Development, 30*(1), 12–19. doi:10.1177/0165025406059968

Widom, S. (1989a). The cycle of violence. *Science, 244*(4901), 160–166. doi:10.1126/science.2704995

Widom, S., & Ames, A. (1994). Criminal consequences of childhood sexual victimization. *Child Abuse and Neglect*, 18(4), 303–318. doi:10.1016/0145-2134(94)90033-7

World Health Organization (2016) Youth Violence. *Fact Sheet on Youth Violence Providing Key Facts and Information on the Scope of the Problem, Risk Factors, Prevention, WHO response*. World Health Organization. Available at: <http://www.who.int/mediacentre/factsheets/fs356/en/#.W0vDI-vBcok.mendeley&title=Youthviolence&description=WHO>

Yoder, J., Grady, M. & Precht, M. (2019) Relationships between Early Life Victimization, Antisocial Traits, and Sexual Violence: Executive Functioning as a Mediator, *Journal of Child Sexual Abuse*, 28:6, 667-689. doi:10.1080/10538712.2019.1588819

Zou, Z., Meng, H., Ma, Z., Deng, W., Du, L., Wang, H., & Hu, H. (2013). Executive functioning deficits and childhood trauma in juvenile violent offenders in China. *Psychiatry Research*, 207(3), 218–224. doi:10.1016/j.psychres.2012.09.013