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Adaptive-skills after early-life adversity: A systematic review

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Abstract

The aim of this systematic review was to examine evidence for the presence of stress-adapted skills in people with a history of early-life adversity and to examine conditions under which these skills are manifested. The search was conducted in Web of Science and PsycINFO, including articles till October 23, 2023. The included articles study a non-clinical human population with a history of early-life adversity, and a comparison was made with a group/degree of early-life stress, or with a measurement condition mirroring the developmental environment of these children. For the included articles a quantitative and narrative description was given. The literature search identified 82 articles that were selected for further processing. Overall, different types of outcomes were found in the associations between early life stress and a variety of measures of functioning, including negative (74 articles), neutral (32 articles), and positive (12 articles) outcomes. In the included articles a variety of operationalisations for early-life stress was used. These types of early-life stress were found to have a positive and neutral association with diverse abilities. Besides, upon closer examination of the association between working memory and early-life stress, four articles found negative, four neutral, two positive, and six mixed results. Some of the positive and neutral outcomes were only manifested when the measurement condition mirrored the developmental environment. Overall, more empirical evidence is required for a thorough understanding of the factors influencing the emergence of these enhanced and intact abilities, and to pinpoint particular types of early-life stress contributing to such abilities.

Keywords: early-life adversity, enhanced abilities, cognition, working memory, developmental environment.

Adaptive-skills after early-life adversity: A systematic review

In 2017, approximately 3% of children in the Netherlands experienced at least one form of child maltreatment, as reported by healthcare professionals and 'Safe at Home' organizations (van Berkel et al., 2020). Globally the estimate is that 40% of children are exposed to some type of abuse or neglect (Stoltenborgh et al., 2014). Such child maltreatment is a frequently studied stressor during early childhood, next to violence, parental death, poverty, and illness, among others (Brown et al. 2009). A commonly used term for exposure to one or multiple of these adverse experiences before the age of 18 is early-life stress (Pechtel & Pizzagalli, 2011; Smith & Pollak, 2020). Child maltreatment influences developmental trajectories, with demonstrated consequences on education, social development, and both physical and mental health (World Health Organization, 2022). Specifically, children who have experienced early-life stress tend to score lower on diverse cognitive tasks, containing measures of cognition, memory, and attention (e.g. Lovallo et al., 2013; Rudd et al., 2021; Sepp et al., 2022; Schäfer et al., 2023). These findings support the deficits model, which is the most predominant model of consequences of early life stress. The deficit model emphasizes impairment in children coming from adverse environments, in contrast to their peers that have not experienced early-life stress.

Ellis et al. (2022) argue that deficit-based approaches to early-life adversity do not recognize that individuals who experienced early-life stress may also develop strengths beside weaknesses due to the presence of early-life adversity. Therefore, in deficit models, social and cognitive skills that develop in response to early-life stress are absent (Ellis et al., 2017; Frankenhuis & de Weerth, 2013). From an evolutionary developmental standpoint, stress has consistently been intertwined with the human experience. Consequently, adverse rearing conditions are expected to not merely hinder neurobiological systems but rather guide or regulate them toward functional patterns adaptive to stress (Belsky et al., 1991; Ellis & Del

Giudice, 2014, 2019). In the specialization hypothesis, Frankenhuis & de Weerth (2013) proposed that children from adverse environments might develop cognitive and perceptual skills that are important in their developmental context. Specifically, children who have experienced physical abuse tend to have specialized perceptual systems geared towards the detection and monitoring of threats (Pollak, 2008; Pollak et al., 2009). Furthermore, Frankenhuis et al. (2020) found that current involvement in violence was associated with better memory for dominance relations. In addition to the specialization hypothesis, Ellis et al. (2017) introduces the sensitization hypothesis, which assumes that cognitive advantages gained by individuals experiencing early-life stress manifest primarily in current stressful conditions. This hypothesis posits that current everyday experiences of stress-adapted individuals differ qualitatively, making standard laboratory conditions disadvantageous for assessing their abilities. Instead, evaluating them in contexts that mirror their developmental environment may reveal their enhanced abilities. Some empirical evidence supports this idea in studies on memory and attention. For example, negative, emotionally laden, or stressful information has the potential to enhance memory in maltreated individuals (for a review see, Goodman et al., 2010), and children who have experienced an unpredictable childhood show enhanced attention-shifting under current stressful conditions, but not under normal conditions (Mittal et al., 2015).

The abilities that develop in response to early-life stress are referred to as ‘hidden talents’ (Ellis et al., 2022). The primary aim of the hidden talents research program is to reveal a detailed map of skills that remain intact or may be enhanced under early-life adversity. This investigation encompasses understanding their development and expression in diverse contexts (Ellis et al., 2017; Frankenhuis & de Weerth, 2013). Even though some stress-adapted skills may be socially undesirable, the hidden talents model posits that there are

stress-adapted skills of practical value that can be utilized for positive purposes (Ellis et al., 2022).

The emphasis on the deficit models of development after early-life stress, shapes the perception of children originating from adverse environments by policymakers, educators, the general public, as well as how they see themselves. Awareness of hidden talents is important to facilitate ways for stress-adapted children to reach their full potential (Ellis et al., 2022). Furthermore, understanding how environmental conditions influence the performance of stress-adapted individuals can provide critical insights for designing effective interventions tailored to their unique skills (Ellis et al., 2017). The current study contributes to this by seeking evidence for hidden talents. This potentially reveals previously unrecognized abilities that individuals might possess after experiencing early-life stress.

In line with the deficits model, it is expected to find worse performance on different tasks in children who experienced early-life stress when compared to children who did not experience early-life stress. The goal of the hidden talents model is not to demonstrate the opposite of the deficit model, but to complement it in order to form a complete picture together (Ellis et al., 2022). Additionally, it is possible that due to the dominance of the deficit model, other contradictory findings may be more difficult to publish. For instance, the study by Franco et al. (2014) demonstrates that the most commonly published results are those that show strong outcomes in favor of the hypothesis (cf. Ioannidis et al., 2005). Furthermore, researchers might choose to publish only a portion of the results (Franco et al., 2016). Moreover, Rosenthal (1979) suggests that, in contrast to the published portion of the studies, it is also plausible to assume that many studies that did not support the outcomes are still in the file drawer. The current systematic review focuses on findings aligned with the hidden talents research program, which may have been previously overlooked. This does mean the aim of this paper is not for a proper evaluation or comparison of the evidence supporting the

hidden talents framework versus the support and effect sizes for studies into the deficit framework, as this lies beyond the scope of my master thesis and resources (i.e., time).

In order to contribute to the mapping of skills that remain intact or may be enhanced under early-life adversity (Ellis et al., 2017; Frankenhuis & de Weerth, 2013), the aim of the present review is to systematically examine evidence for the presence of any support for stress-adapted skills in people with a history of early-life adversity, and to examine under which conditions these stress-adapted skills are manifested. To my knowledge, no prior systematic review has been conducted on this subject. The terms that are used to operationalize early-life stress, in this systematic review, are broadly encompassing, to obtain an overview of the aspects of early-life stress in which hidden talents can be identified. Furthermore, a broad range of outcomes are considered to gain insight in which domains hidden talents might show.

Method

A systematic review is conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021).

Search strategy

The initial search was conducted in PsycINFO and Web of Science, which included articles up to October 23, 2023. A combination of search terms was used: (“Early-life adversity” or “adverse child* experiences” or “child* adversity” or “early-life stress” or “adversity-exposed youth” or “adverse child* environment” or “stressful child*”) AND (“hidden talents” or “enhanced skills” or “adapt* skills” or “adapt* behavior” or “attention” or “social skills” or “executive function*” or “cognition” or “cognitive control” or “memory” or “problem solving” or “learning” or “reasoning or “creativity”). These search terms were looked for in abstracts, keywords, and titles. Only academic journals were selected through filters in PsycINFO and Web of Science.

Inclusion and exclusion criteria

Articles were selected based on their inclusion of: a) at least one domain of interest should be measured; b) a comparison is made (e.g., group/degree of early-life stress or with a measurement condition mirroring the developmental environment of these children); c) non-clinical population; d) empirical and peer reviewed; e) measure of early-life stress; f) humans.

Articles were excluded based on: a) the article is not empirical and peer-reviewed, b) the population is clinical, c) not published in English or Dutch; d) systematic reviews; e) no measure of early-life stress; f) no measure of domain of interest; g) no comparison is made (e.g., group/degree of maltreatment or condition); h) treatment, therapy or intervention studies; i) animal studies.

Procedure

All the obtained articles were transferred to Rayyan for deduplication and screening. The auto-resolver in Rayyan was used to detect and delete duplicates with 95% or more similarity. The remaining duplicates were manually deleted. Following this, 30 abstracts were read to decide whether inclusion and exclusion criteria should be added. No additional criteria were added after this. The initial screening was based on abstracts and titles, this was done by one person. After the initial screening the included articles were transferred into Excel. Within Excel, based on the findings reported in abstracts, studies were systematically documented using positive, neutral, and negative labels. Positive refers to articles that find better performance on a task when early-life stress is higher or in comparison to a group that did not experience early-life stress. Neutral refers to outcomes where no difference is observed in relation to the degree of early-life stress or between a group that did experience early-life stress and a group that did not. Negative refers to articles finding worse performance among individuals who experienced early-life stress in association with measured outcomes. Simultaneously, if information regarding the operationalization of concepts (as

operationalized by the author) or the results was missing, full-texts were consulted to determine whether to include or exclude these articles. Articles with positive and neutral findings were selected for further processing, while the total number of studies that presented negative outcomes were counted. Data were extracted from the articles with positive and neutral outcomes (in line with hidden talent approach) into a spreadsheet. The following information was extracted into the spreadsheet for the neutral outcomes: (1) type of early-life stress; (2) domain of interest; (3) study results. For the positive articles, the extracted data contained more detailed information, specifically: (1) sample characteristics, including sample size, gender and age; (2) type of early-life stress; (3) measure of early-life stress; (4) domain of interest; (5) measure of domain of interest; (6) study results. Finally, a quantitative and narrative description of the results followed.

Results

The literature search identified 2501 articles. After duplication removal 1348 articles remained. After the initial screening, based on abstracts and titles, 103 articles were selected. Following full-text screening 21 articles were excluded with reasons outlined in Figure 1. Of the 82 included articles 12 represent positive outcomes, in line with the “hidden talents” framework; in 32 articles neutral outcomes were reported; and the largest proportion of articles, 74 exhibited negative results. For the full overview of these results, see Appendix A. Of the articles, 41.5 percent revealed multiple results. In Figure 2, there is an overview illustrating the distribution of the identified outcomes.

Figure 1

PRISMA flow diagram of studies selected for the systematic review

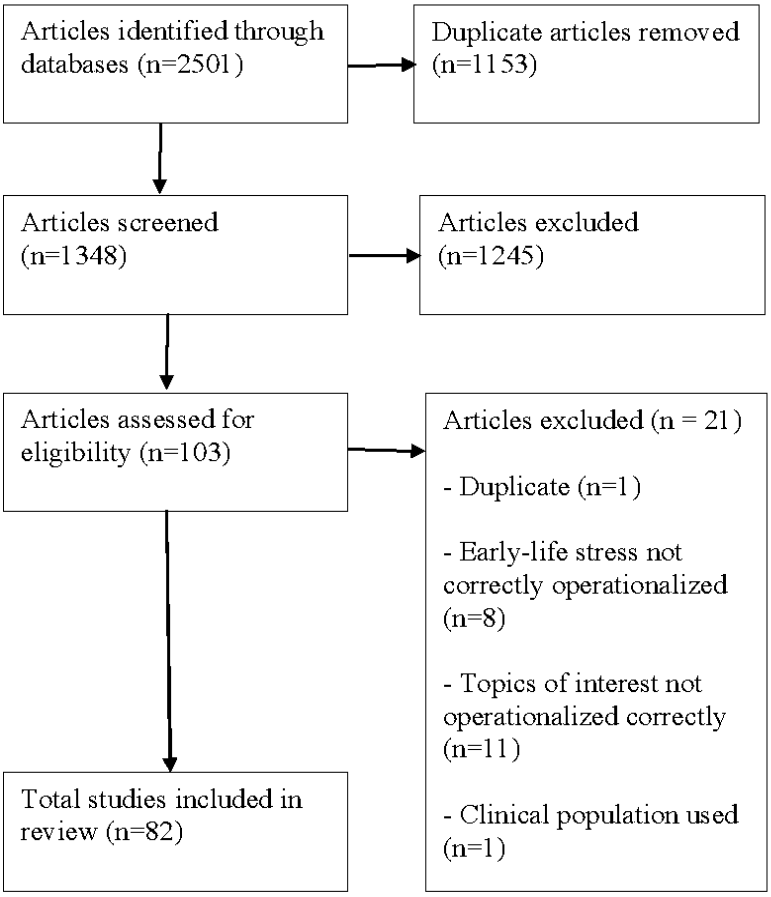
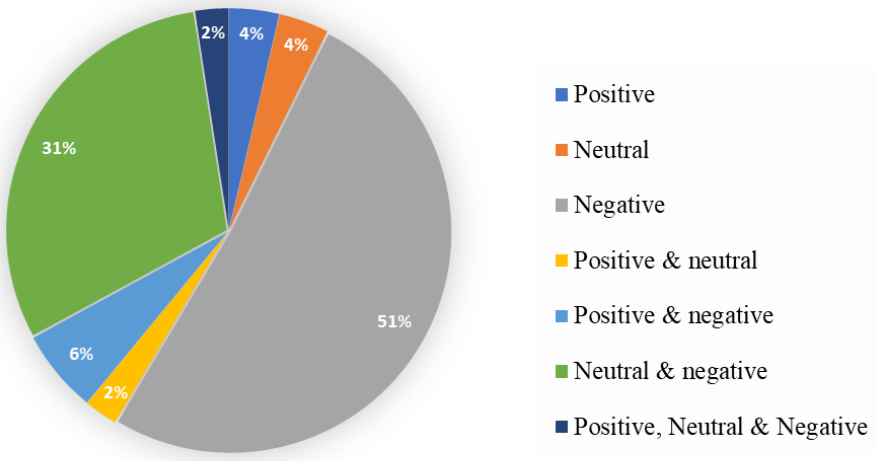


Figure 2

Distribution of study outcome.



The 12 studies that found positive outcomes (Table 1), were conducted in different countries: the United States, Germany, Ireland, China, Colombia, South Africa, and Nigeria. Likewise, the mean age of participants in the studies was also diverse, varying from 12.9 years to 69.1 years, and 28.4 years on average. In addition, most of the studies included male and female participants, few studies only studied male participants (Wu et al., 2021; Feeser et al., 2014) and in Feeney et al. (2013) the gender of the participants is not mentioned. Overall, the percentage of female participants range from 29.3% to 70%.

The 12 articles that reported positive findings used a variety of operationalizations for early-life stress. Six of the articles assessed early-life stress using a self-report measure for adverse childhood experiences or early-life stress (e.g. Childhood Trauma Questionnaire (Bernstein & Fink 1998); Adverse Childhood Experiences questionnaire (Anda et al., 2006)). However, how the studies used the outcome of the self-reports differed. Xie et al. (2022) used the total score, and others used the scores to create distinct groups (e.g. low early-life stress and high early-life stress; Thomsen & Jaque, 2018; Syal et al., 2014; Feeser et al., 2014; Metz et al., 2018). Furthermore, Wu et al. (2021) utilized both the total score and a score specific to threat- and deprivation-related early-life stress. Additionally, two articles used a self-report for unpredictable childhood as an operationalization of early-life stress (Mittal et al., 2015; Young et al., 2018) and two studies used the absence of upbringing by biological parents as an operationalization of early life stress (Nweze et al., 2021; Herzberg et al., 2018). Finally, other articles used a self-report that measures the amount of violence an individual experienced (Montoya-Arenas et al., 2022) and a self-report for sexual abuse (Feeney et al., 2013).

Positive outcomes related to early-life stress have been identified across an expanding array of measured constructs: memory, social skills, executive functioning, decision-making, cognitive control, creativity, and cognition. However, the majority of results have been

discovered in relation to memory. In six out of twelve articles, a positive association between early-life stress and various aspects of memory were identified. Four of these articles specifically focused on working memory. The results on working memory are discussed in detail below (see Working Memory). Positive results in other facets of memory were also noted. Enhanced visual memory was found when early-life stress was experienced in comparison to a control group. However, this enhanced visual memory was only found in men, and for women a similar trend was not identified (Syal et al., 2014). Lastly, better performance on an immediate word recall task in participants that experienced sexual abuse in comparison to participants that did not experience sexual abuse was found (Feeney et al., 2013). Besides finding enhanced memory, Fenney et al. (2013) also found better global cognitive functioning in the group that experienced sexual abuse, when compared to the control group.

Other areas that were found to be enhanced in association with early-life stress are executive function, attention, decision making, creativity and an aspect of social skills. Specifically, when examining the relationship between executive functions and sociopolitical violence, enhanced executive functioning is found in groups that have experienced displacement, extortion, and kidnapping in comparison to controls (Montoya-Arenas et al., 2022). Besides, a heightened degree of childhood adversity has demonstrated a positive correlation with augmented controlled attention (Wu et al., 2021). A tendency to make fewer risky decisions was found in youth who were adopted later in comparison with early adopted youth (Herzberg et al., 2018). Individuals reporting more than four adverse childhood experiences showcased an increased frequency of creative experiences (Thomsen & Jaque, 2018). Finally, individuals exposed to elevated levels of early-life stress exhibited an improved capacity for recognizing avoidance-related facial expressions when contrasted with those who experienced low early-life stress levels.

Table 1

Outcomes from the studies with positive results

Study	Country of study	Participants N (% female)	Age mean (SD)	Type of early-life stress	Measure of early-life stress	Domain of interest	Measure of domain	Study results
Xie et al. (2022)	US	120 (66.7%)	19.3 (2.1)	ACE	ACE questionnaire (Anda et al., 2006)	(Working) memory	Modified visual WM change detection task under induced negative arousal using audio clips from the IADS (Bradley & Lang, 2007)	Participants who have more ACEs show faster working memory consolidation speed under induced negative arousal, without affecting working memory storage capacity.
Feeney et al. (2013)	IE	6912	> 50	Childhood sexual abuse (CSA)	Two yes or no questions by questionnaire	Cognition; memory	Montreal Cognitive Assessment (Folstein et al., 1975); Mini-Mental State Exam (Nasreddine et al., 2005); 10-word-list recall task	Participants who have experienced CSA performed better on tests of global cognitive function and on an immediate word recall task, compared to participants who did not experience CSA.

Study	Country of study	Participants N (% female)	Age mean (SD)	Type of early-life stress	Measure of early-life stress	Domain of interest	Measure of domain	Study results
Thomsen & Jaque (2018)		234 (70%)	23.3	Number of ACEs (0; 1-3; ≥ 4)	ACE (Felitti and Anda, 2010)	Creativity	Experience of Creativity Questionnaire (Nelson & Rawlings, 2009)	Performing artists who experienced 4 or more ACEs experienced more intense creative and existential experiences compared to the group with 0 or 1-3 ACEs.
Wu et al. (2021)	China	60 (0%)	21.1 (0.8)	Total childhood stress; abuse (threat); neglect (deprivation)	CTQ (Bernstein & Fink, 1998)	Cognitive control	Go/NoGo task	Higher severity of childhood adversity was associated with more allocation of controlled attention.
Herzberg et al. (2018)	US	74 (67.6%)	12.9 (0.6)	Institutional care	Groups: PI-EA; PI-LA; non-adopted control group.	Decision-making	Balloon Analogue Risk Task (Lejuez et al., 2007)	PI-LA youth pressed the button fewer times than PI-EA and non-adopted youth. So, they made fewer risky decisions.

Study	Country of study	Participants N (% female)	Age mean (SD)	Type of early-life stress	Measure of early-life stress	Domain of interest	Measure of domain	Study results
Young et al. (2018)	US	372 (58.3%)	33.4 (13.5)	Childhood unpredictability	8 questions answered on a 7-point Likert Scale.	(Working) memory	Keep track task (Friedman et al., 2008; Yntema, 1963); continuous counters task (Unsworth & Engle, 2008)	Experiencing an unpredictable childhood environment was associated with improved working memory updating when people were assessed under uncertain conditions. In contrast, working memory updating diminished under an uncertainty condition for those who experienced predictable childhood environments.

Study	Country of study	Participants N (% female)	Age mean (SD)	Type of early-life stress	Measure of early-life stress	Domain of interest	Measure of domain	Study results
Mittal et al. (2015)	US	Exp 1: 103 (55.3%) Exp 2: 58 (29.3%) Exp 3: 181 (48.6%) Exp 4: 51 (47.1%)	Exp 1: 22.8 (8.0) Exp 2: 20.6 (1.6) Exp 3: 20.0 (1.2) Exp 4: =37	Unpredictable childhood exp 1, 2 & 3: self-report; exp 4: prospective measure (interview with mother)	Exp 1, 2 & 3: childhood unpredictability index; exp 4: Life Stress Inventory (Cochrane & Robertson, 1973)	Executive function	Color–shape task (Miyake et al., 2004) in a control or uncertainty condition (elicited by reading a news article).	Exp 1 and 3: in the uncertainty condition, experiencing greater unpredictability in childhood predicted better performance on shifting. Exp 2: contrary findings have been identified in comparison to exp 1. Exp 4: greater childhood unpredictability predicted better performance at shifting.
Montoya-Arenas et al. (2022)	CO	59 (42.4%)	69.1 (9.4)	Sociopolitical violence	CTSI (Bremner et al., 2007); ETI-SRCol (Posado et al., 2019)	Executive function	Tower of London-Drexel University Version (Culbertson & Zillmer, 2001)	The CTSIs for displacement and extortion, were associated with better performance in total initiation time score and total moves score, respectively. Kidnapping was linked to better performance in

Study	Country of study	Participants N (% female)	Age mean (SD)	Type of early-life stress	Measure of early-life stress	Domain of interest	Measure of domain	Study results
								total correct score, total moves score, and total execution time score on the Tower of London.
Syal et al. (2014)	ZA	Trauma: 27 (59.3%) Control: 28 (42.9%)	Trauma: 22.7 (0.8) Control: 21.9 (0.6)	Childhood trauma	CTQ -SF (Bernstein et al., 2003)	Memory	4 forced-choice visuospatial memory tasks (DMS; PAL; PRM; SRM) from the Cambridge Neuropsychological Test Automated Battery (Robbins et al. 1994)	Men in the trauma group achieved higher scores on the DMS than men in the control group. Also, men in the trauma group performed better than men in the control group on the PRM. In contrast, for women a similar trend did not exhibit.

Study	Country of study	Participants N (% female)	Age mean (SD)	Type of early-life stress	Measure of early-life stress	Domain of interest	Measure of domain	Study results
Nweze et al. (2021)	NG	104 (54.8%)	13.5 (1.9)	Parental deprivation	Groups: deprived (institutionalized or in foster care) and control group	(Working) memory	Digit Span Task (Mathot et al., 2011)	Deprived children performed better on the Digit Span Task than the control group, indicating better working memory capacity. They were able to memorize almost two additional digits.
Feeser et al. (2014)	DE	84 (0%)	27.9 (4.7)	Early-life stress (low ELS - high ELS)	CTQ (Bernstein & Fink 1998)	Social skills	Emotional facial recognition task with stimuli from the KDEF set (Lundqvist et al. 1998)	Participants with high ELS scores show increased emotion recognition for avoidance-related faces in comparison with participants with low ELS scores, measured by accuracy.

Study	Country of study	Participants N (% female)	Age mean (SD)	Type of early-life stress	Measure of early-life stress	Domain of interest	Measure of domain	Study results
Metz et al. (2018)	DE	31 (48.4%)	38.0 (11.7)	Early-life stress (no ELS group & ELS group)	CTQ (Klinitzke et al., 2012; Bernstein & Fink 1998)	(Working) memory	2-back task with emotional stimuli (as described by: Grimm et al., 2005). Stimuli: neutral, positive, and negative words from the Berlin Affective World List (Vo et al., 2009)	Participants with ELS showed increased working memory accuracy for negative targets when compared to positive targets. In comparison, such a difference was not found in the no ELS group.

Note. US = United States. IE = Ireland. CO = Colombia. ZA = South Africa. Ng = Nigeria. DE = Germany. PI = previously institutionalized. PI-EA = post-institutionalized early adopted (adopted prior to 12 months). PI-LA = post-institutionalized later adopted (adopted between 12 and 72 months). IADS = International Affective Digital Sounds. ACE = Adverse Childhood Experience. DMS = Delayed Matching to Sample task. PAL = Pattern Recognition Memory task. PRM = Pattern Recognition Memory task; SRM = Spatial Recognition Memory task. KDEF = Karolinska Directed Emotional Faces. ELS = early life stress. CTSI = Childhood Trauma Severity Index. CTQ = Childhood Trauma Questionnaire. CTQ - SF = Childhood Trauma Questionnaire Short Form. ETI-SRCol = Colombian version of the Early Trauma Inventory-Self Report. exp = experiment.

The 32 articles that found neutral outcomes (Table 2), also used a variety of operationalisations of early-life stress. Sixteen articles used diverse general terms for early life-stress, such as early-life adversity (D'Amico et al., 2022), childhood adversity (Kalla et al., 2021; Vogel et al., 2020), early-life stress (e.g. Feeser et al., 2014; Philip et al., 2016) and adverse childhood experiences (e.g. Ferrara & Panlilio, 2020; Gold et al., 2021). The measurement of these concepts was done using different self-report questionnaires (e.g. The ACE scale (Felitti et al., 1998); Childhood Trauma Questionnaire (Bernstein & Fink 1998)). Furthermore, eleven articles used subgroups for different forms of early-life adversity. The most used subgroups presented were threat- and deprivation-related adverse childhood experiences (e.g. Lin et al., 2022, Schäfer et al., 2023; Machlin et al., 2019). Another example is the use of different measures for adverse childhood experiences that distinguished abuse, household dysfunction, and separation from family in childhood (O'Shea et al., 2021). Additionally, a less common operationalisation for early-life stress is parental deprivation (e.g. Silvers et al., 2017; Nweze et al., 2021; Koss et al., 2020). Finally, Frankenhuis et al. (2020) operationalized early-life adversity as the exposure to violence in childhood, and Montoya-Arenas et al. (2022) as the experience of sociopolitical violence.

Different abilities lead to neutral outcomes in association with early-life adversity. The neutral outcomes were manifested in reasoning, attention, cognitive control, executive function, social skills, cognition, memory, and learning. Most of these neutral outcomes, nine, were found in association with memory (e.g. O'Shea et al., 2021; Young et al., 2022; Hawkins et al., 2021). Seven articles found neutral outcomes in association with different forms of cognition (e.g. Gold et al., 2021; Moliner et al., 2022), six in association with cognitive control (e.g. Machlin et al., 2019; Lambert et al., 2017), four in conjunction with attention (e.g. Silvers et al., 2017; Young et al., 2022), three with executive function (Montoya-Arenas et al., 2022; Kalla et al., 2021; Schäfer et al., 2023), three with social skills (Feeser et al.,

2014; Lipscomb et al., 2021; Holland et al., 2020), three with learning (Ferrara & Panlilio, 2020; Schelhaas et al., 2022; Patterson et al., 2013), and one in association with reasoning (Frankenhuis et al., 2020).

In studies utilizing various subgroups of early-life stress, neutral results are frequently observed in only one subgroup (or in multiple subgroups if more than two are utilized). For example, Lin et al. (2022) found no association between threat-related early-life adversity and later-life cognitive functioning, but they found a decline in cognitive functioning when associated with deprivation-related early-life adversity. However, with cognitive control both threat- and deprivation-related early-life adversity gave no significant effect (Wu et al., 2021). On the other hand, in the study of Lambert et al. (2017) deprivation was associated with poor cognitive control and threat was not.

Table 2

Outcomes from the studies with neutral results

Study	Type of early-life stress	Domain of interest	Study results
Frankenhuis et al. (2020)	Childhood violence (exposure)	Reasoning	More childhood violence was not associated with better/worse reasoning performance.
Silvers et al. (2017)	Institutional care	Attention	PI-youth had the same amount of attention for threatening stimuli as the comparison group.
Wu et al. (2021)	Threat (abuse)- and deprivation (neglect)-related ACEs	Cognitive control	Neither abuse nor neglect was significantly associated with an index of response inhibition.
Montoya-Arenas et al. (2022)	Sociopolitical violence (experience)	Executive function	Different aspects of the ETI-SRCol gave no significant difference with aspects of executive functioning.

Study	Type of early-life stress	Domain of interest	Study results
Nweze et al. (2021)	Parental deprivation	Cognitive control	Deprived children did not differ in performance from the control group on set-shifting and inhibition.
Feeser et al. (2014)	ELS	Social skills	For approach-related emotional faces no differences between the high and low ELS group were found in emotion recognition
Lakkireddy et al. (2022)	ACE	Cognition	All ACE sub-domains, except maltreatment, did not have a significant association with neurocognition.
Kalla et al. (2021)	CA	Executive function	When under stress, differences in executive functioning are no longer significant, when comparing different levels of CA.
Moseley et al. (2021)	ACE	Memory	No significant relation between ACE and memory was found.
Lipscomb et al. (2021)	ACE	Social skills	ACE was not related to social skills.
Lin et al. (2022)	Threat- and deprivation-related ACEs	Cognition	Threat-related ACEs were not associated with later-life cognitive function.
Schäfer et al. (2023)	Threat- and deprivation-related ACEs	Executive function; attention	Threat-related ACEs had no association with executive functioning and deprivation was not associated with attention orienting towards angry faces. Neither form of adversity was associated with attention bias over time.
D'Amico et al. (2022)	ELA	Memory	There is no association found between ELA and episodic memory.

Study	Type of early-life stress	Domain of interest	Study results
Vogel et al. (2020)	CA	Attention	The relationship between reaction time and response criterion on a continuous performance task of sustained attention in association with CA was not significant.
Nweze et al. (2023)	CA subgroups	Cognitive control; memory	The dysfunctional family, parental deprivation and global adversity groups did not score significantly lower on the inhibitory control task. The parental deprivation and family poverty groups score not significantly lower on working memory.
Ferrara & Panlilio (2020)	ACE	Learning	The relationship between ACE and academic metacognition is not significant.
Ding & He (2021)	CA subgroups	Memory	For other trauma than socioeconomic disadvantage, parental involved trauma, and maladaptive parental trauma in childhood no relationship was found with episodic memory.
Lambert et al. (2017)	Threat- and deprivation-related ACEs	Cognitive control	Violence (threat-related ACE) was not associated with cognitive control.
Philip et al. (2016)	ELS	Memory	Accuracy and response time did not show significant differences between the ELS and control group.

Study	Type of early-life stress	Domain of interest	Study results
O'Shea et al. (2021)	ACEs related to abuse, household dysfunction, and separation from family in childhood.	Memory	ACEs related to abuse and household dysfunction were not negatively or positively associated with memory.
Schelhaas et al. (2022)	ACE	Learning	Individuals with ACE demonstrated intact social threat and safety learning abilities.
Gold et al. (2021)	ACE	Cognition	Cumulative ACE was not associated with cognition in later life.
Moliner et al. (2022)	ACE	Cognition	Association between ACEs and cognitive change across a 10-year span was not statistically significant.
Hawkins et al. (2021)	ACE; threat-related and deprivation-related ACE	Memory	Threat-related ACEs showed intact working memory and cumulative ACEs intact immediate and delayed verbal memory.
Young et al. (2022)	environmental unpredictability, violence, and poverty	Attention; memory	Youth exposed to environmental unpredictability, poverty and violence scored the same as their peers on an attention-shifting task with abstract and ecological relevant stimuli. For working memory children exposed to violence and poverty scored the same as their peers when ecological relevant stimuli was used.

Study	Type of early-life stress	Domain of interest	Study results
Machlin et al. (2019)	threat- and deprivation-related ACEs	Cognitive control	Threat was not associated with the cognitive control task
Holland et al. (2020)	ELA subgroups	Social skills; cognition	Physical/emotional abuse and domestic violence were not associated with global cognition. None of these subgroups were associated with theory of mind.
Patterson et al. (2013)	ELS	Learning	Participants with ELS showed a slower rate of learning and reduced persistence in extension after partial reinforcement. However, after continuous reinforcement, the ELS-participants maintained response levels comparable to their peers without ELS.
Grainger et al. (2020)	ELS	Cognition	There were no differences in global cognition based on overall ELS experiences. Social cognitive function did not vary based on ELS experiences.
Xu et al. (2020)	ELS	Memory	ELS was not significantly associated with visual memory.
Koss et al. (2020)	institutional care	Cognitive control	PI-youth scored not significantly better or worse on most tasks of inhibitory control than their non-adopted peers.

Study	Type of early-life stress	Domain of interest	Study results
Seckfort et al. (2008)	ELS	Cognition	There was no significant association between ELS and one of the measures of cognitions (verbal memory, information processing speed, psychomotor speed, and cognitive flexibility).

Note. PI = previously institutionalized. ETI-SRCol = Colombian version of the Early Trauma Inventory-Self Report (Posado et al., 2019). ELS = early-life stress. ACE = adverse childhood experiences. CA = childhood adversity. ELA = early life adversity.

Working memory

Given that the majority of positive findings concern working memory, further focus is placed on examining this ability in more detail, in order to evaluate positive versus negative associations in the same knowledge domain, as this review suggests working memory seems the most fruitful domain to identify hidden talents. This involves considering negative, neutral, and positive findings to gain a better understanding of the magnitude of the positive results. Within the current study, sixteen articles analyzed working memory. Among these articles, six mentioned mixed results, four reported negative results, four mentioned neutral results, and two studies found positive results regarding working memory.

In the four articles that reported negative results regarding the association between working memory and early-life stress, three examined total early-life stress in relation to working memory (Nweze et al., 2023; Suntheimer & Wolf, 2020; Fuge et al., 2013), while one study utilized institutional care as an operationalization of early-life stress (Koss et al., 2020). Among the four studies that found neutral outcomes, three articles used total early-life stress as an operationalization (Ji & Wang, 2018; Moseley et al., 2021; Sharma et al., 2023), while one study measured different domains of early-life stress (Lakireddy et al., 2022).

Lakireddy et al. (2022) reported neutral results for all measured domains of early-life stress in relation to working memory. Among the two studies with positive findings, one utilized parental deprivation as an operationalization for early-life stress (Nweze et al., 2021), and the other measured total early-life stress (Xie et al., 2022). In the study by Xie et al. (2022), positive results were found while the participants were tested under induced negative arousal, reflecting the developmental environment of these participants.

Within the studies reporting mixed results, some also conducted tests under conditions mirroring the developmental environment of the participants, yielding different outcomes compared to tests conducted under normal conditions. Among the six articles reporting mixed results, three utilized different testing conditions. Metz et al. (2018) observed that children who experienced early-life stress performed lower on working memory tasks involving positive targets in an n-back task compared to children who did not experience early-life stress. However, they performed better on the tasks when it involved negative targets. Young et al. (2022) discovered that children exposed to violence and poverty exhibited lower working memory performance with abstract stimuli than their peers. On the contrary, no significant difference was found when stimuli relevant to their developmental environment were used. In a study by Young et al. (2018), it was found that children who experienced early-life stress exhibited poorer working memory than the control group. Nevertheless, when tested under conditions inducing uncertainty, children with early-life stress performed better than the control group. The other three studies that found mixed results did so for different reasons. In the study by Nweze et al. (2023), various domains of early-life stress were measured, with some resulting in neutral outcomes and others in negative outcomes for working memory. Pellizzoni et al. (2020) assessed working memory in two refugee groups compared to a control group. They found neutral outcomes for one refugee group but negative outcomes for another group exposed to more violence, when compared to the control group.

Phillip et al. (2016) measured working memory using 2-back and 0-back tasks, assessing both accuracy and speed. They found a negative association between early-life stress and accuracy in the 2-back task, while observing neutral associations with speed in the 2-back task, as well as with accuracy and speed in the 0-back task.

Sensitization hypothesis

As was observed in the case of working memory, some studies used testing conditions that mirror the developmental environment of children who encountered early-life stress. Here, the results related to other domains are presented. For instance, Mittal et al. (2015) identified enhanced executive functioning, specifically in terms of shifting, among children who experienced unpredictable childhoods, only when assessed under conditions characterized by heightened uncertainty. Another observation is that Kalla et al. (2021) found differences in executive functioning when comparing executive functioning with different levels of childhood adversity, however, when these participants were tested in a stressful condition these differences were no longer significant. Finally, Young et al. (2022) found a similar pattern, children that were exposed to violence and poverty scored lower on working memory when abstract stimuli were used. However, when stimuli that mirrored the developmental environment (creating a stressful condition) were used, these differences were no longer significant.

Discussion

The goal of the study was to systematically examine evidence for stress-adapted skills in people with a history of early-life adversity and to examine under which conditions these stress-adapted skills are manifested. The systematic review identified 83 articles associating early-life stress with an ability of interest. Within these articles some evidence for stress-adapted skills have been found. Specifically, 12 articles identified enhanced abilities in association with early-life stress and 32 articles represented intact abilities. The presence of

enhanced and intact abilities after the experience of early-life stress is in line with the hidden talents framework (Ellis et al., 2022). Besides the positive and neutral outcomes, the largest proportion of the articles identified negative results, this is in line with the deficits model of early-life stress, which highlights the impairments following the experience of early-life adversity. Nevertheless, the positive and neutral outcomes show that, as argued by Ellis et al. (2022), alongside these impairments, intact and enhanced abilities should also be recognized.

Some support for stress-adapted skills in people with a history of early-life stress was found for a wide range of operationalizations of early-life stress (e.g. adverse childhood experiences, institutionalization, violence, trauma) and for diverse domains of interest (e.g. memory, attention, creativity, learning, cognitive control). Although no clear pattern could be identified for which type of early-life stress and domain of interest the positive and neutral findings are most common, among the positive findings, memory, especially working memory, presented the most evidence for enhanced skills in comparison to other skills. It is worth noting that this may be due to the larger number of studies conducted and published on working memory compared to other domains (e.g. executive functioning, attention, creativity).

When considering all the studies on working memory, no definitive conclusion could be drawn regarding whether this particular skill is enhanced following early-life stress. The studies included in the review exhibited varied outcomes regarding working memory. Four studies reported impaired working memory after early-life stress (Nweze et al., 2023; Suntheimer & Wolf, 2020; Fuge et al., 2013; Koss et al., 2020), while four different studies found no significant relation between early-life stress and working memory (Ji & Wang, 2018; Moseley et al., 2021; Sharma et al., 2023; Lakireddy et al., 202). However, two studies indicated enhanced working memory (Nweze et al., 2021; Xie et al., 2022). Moreover, when examining the six mixed results, among the three studies that included testing conditions

mirroring the developmental environment of individuals who experienced early-life stress, two studies found enhanced working memory (Metz et al., 2018; Young et al. 2018) and one found intact working memory (Young et al. 2022). Overall, when considering testing conditions mirroring the developmental environment some evidence is found for intact or enhanced working memory.

Interestingly is the finding that when testing conditions mirrored the developmental environment of children that experienced early-life stress, the evidence for enhanced or intact working memory was more salient (Metz et al., 2018; Young et al. 2022; Young et al. 2018; Xie et al., 2022), which is in line with the sensitization hypothesis (Ellis et al., 2017). This discrepancy, where enhanced and intact abilities are observed only under testing conditions that mirror the developmental context of these children, may be attributed to their unique day-to-day experiences in which these children developed their skills. Standard laboratory conditions may fail to capture these experiences, thereby limiting their ability to fully demonstrate their potential (Ellis et al., 2017). This was also shown in different domains than working memory. Despite only a minority of studies examining the abilities of the participants in a context that mirrored their developmental environment, all these articles confirmed that the abilities were only found to be enhanced or intact in the test condition that reflected their developmental surroundings (Metz et al., 2018; Young et al. 2022; Young et al. 2018; Mittal et al., 2015; Kalla et al., 2021).

The differences in design and methodology presented challenges in comparing the results of the studies. For instance, different measurement instruments are used to assess working memory, leading to a variety of outcomes. Nweze et al. (2021) used the Digit Span Task, Sharma et al. (2023) used the Corsi Block Tapping Backwards Task, Pellizonni et al. (2020) used the Backward Word Span Task, and multiple studies used an n-back task (e.g. Metz et al., 2018; Fuge et al., 2014; Philip et al., 2016) to assess working memory. In

addition, within the same task, different studies take different aspects into account, leading to varying results. For example, Phillip et al. (2016) demonstrated that negative results were only found for one aspect of the n-back task, while the other aspects yielded neutral results.

An additional factor contributing to discrepancies in findings, whether regarding working memory or other cognitive skills, may stem from variations in the operationalizations employed for early-life stress. For example, Wu et al. (2021) found cognitive control to be enhanced in association with early-life stress, while Lambert et al. (2017) found cognitive control to be intact when measured in association with threat-related adverse childhood experiences and impaired when measured in association with deprivation-related adverse childhood experiences. Besides, most articles that used different subgroups of early-life adversity (e.g. Machlin et al., 2019; Nweze et al., 2023; Ding & He, 2021) found different results for different forms of early-life stress. Which could indicate that these children only develop the skill if it is useful in their environment, as proposed by the specialization hypothesis (Frankenhuis & de Weerth, 2013). For instance, Schäfer et al. (2023) found a neutral outcome for threat-related experiences in association with executive functioning, but a negative association for deprivation-related experiences. Contrary, in the same study deprivation-related experiences had no association with attention orienting towards angry faces, however threat-related experiences did.

When considering the overall findings across all domains evaluated, most of the studies are in line with the deficit approach. However, in the search for the evidence for hidden talents, it is important to consider in which particular skills the effects of adaptation to stress can be expressed. The results of this review suggest that working memory could be a skill that is enhanced in individuals growing up under conditions of early life stress. Moreover, such enhanced skill may be obscured in standard laboratory conditions (Ellis et al., 2017) as observed in studies on working memory with negative findings that evaluated the

skill only in standardized laboratory tasks. Therefore it is important to assess a particular skill in a situation that mirrors the developmental environment the individual grew up in.

Strengths and limitations

The current review presented an overview of a wide range of possible abilities that might be enhanced or intact in association with early-life stress, in particular working memory. This contributes to the goal of the hidden talents research program to reveal a detailed map of the intact and enhanced skills under early-life adversity (Ellis et al., 2017; Frankenhuis & de Weerth, 2013). Additionally, to my knowledge it is the first systematic review on this topic. This can provide direction for further research and offer an initial indication of potential skills to be investigated for their intactness or improvement (e.g., working memory).

However, various limitations can be identified in the current systematic review. The reliability is diminished due to the fact that the screening was conducted by a single individual (Wang et al., 2020). In screening the articles, it is recommended to utilize at least two examiners (Liberati et al., 2009), to reduce the chance of rejecting articles that are relevant (Edwards et al., 2020). In addition, categorizing the results of studies into positive, neutral, and negative categories based solely on abstracts is not ideal for comprehensive analysis. Abstracts often provide an overview of the study results rather than detailed findings of the analyses. Consequently, there may be more positive, neutral, or negative results than those mentioned in the current study, which results in an incomplete picture of the findings in this review. It would have been preferable to base the categorization on full-text screening for a more complete assessment. A noteworthy example is the study by Sharma et al. (2023), which was categorized as a study with negative findings in the current review based on the negative association between childhood adversity and cognitive development mentioned in the abstract (see abstract “Childhood adversity had a negative influence on cognitive

development.", Sharma et al., 2023). However, upon closer examination of the results of this study, enhanced emotion recognition was found in participants with higher scores on childhood adversity (see "Childhood adversity was a negative determinant of set shifting and faux pas recognition, but had a positive influence on emotion recognition (Table 2 and Fig. 5)." p. 5, Sharma et al., 2023)[1], which clearly illustrates the reporting bias.

Additionally, the present study employed only general terms for early-life stress. However, there are numerous possible operationalizations of early-life stress (e.g. poverty, child maltreatment, violence). Due to the scope of the current study, it was not feasible to conduct a comprehensive investigation encompassing all possibilities. Consequently, the study outcomes are limited to articles that employ either a broad operationalization of early-life stress (e.g. adverse childhood experiences) or more specific operationalizations that explicitly make a link with early-life stress (e.g. violence; sexual abuse). For instance, while the present study discovered only one outcome suggesting improved abilities associated with sexual abuse, operationalized as early life stress, other potential findings related to sexual abuse, not operationalized as early life stress by the authors, were omitted from the search. In addition, various abilities were included in the current review to be examined in relation to early-life stress (e.g. memory, creativity, reasoning, cognition), leading to considerable heterogeneity in the included studies. Hence, for certain measured abilities in relation to early-life stress, only one positive or neutral outcome was identified. For example, intact reasoning was found in one article (Frankenhuis et al., 2020) and enhanced creativity also was detected in one study (Thomsen & Jaque, 2018). It is conceivable that other results were overlooked because a different operationalization of early-life stress was utilized that was not included in

[1] Also note that in Sharma et al. (2023) 18 neutral findings (non significant associations) between childhood adversity and cognitive skills were not discussed, and the conclusions by authors were based on two negative significant associations.

the search terms. On a positive note, the heterogeneity observed in the articles suggest that intact and enhanced abilities could be distributed across various domains.

Because of the heterogeneity of the outcomes, the results can, at most, guide further exploration of enhanced and intact abilities and indicate potential types of early-life adversity within which to investigate. Furthermore, the present review provides a different perspective on the development and abilities of individuals who have experienced early-life stress, in addition to the deficit model that focuses on the impairments of these individuals. This might help these individuals see their own strengths besides weaknesses and therefore feel empowered (Ellis et al. 2022). Moreover, it could alter the perception of policymakers, educators, and the general public regarding children who have experienced early-life adversity - not solely focusing on what these children cannot do, but also acknowledging their abilities.

Future studies

Future studies should explore the enhanced abilities and intact skills that are identified when different operationalizations of early-life stress are used. To illustrate, future studies can focus on forms of interpersonal early-life stress (e.g. psychological abuse, sexual abuse, neglect) as operationalization of early life stress, or non-interpersonal early-life stress (e.g. neighborhood violence, poverty, food deprivation). Additionally, focus can be directed towards identifying which forms of early-life stress (e.g. threat- and deprivation-related early-life adversity, see McLaughlin et al., 2014; McLaughlin & Sheridan, 2016) contribute to improvements in specific measured concepts. Considering that different forms of early-life stress may lead to distinct enhanced or intact abilities useful in their environment. Finally, when conducting future research, it is important to keep in mind that studies that included conditions mirroring the developmental environment found intact or enhanced skills that were

not identified through the normal testing condition. Further studies should include stimuli or conditions aligned with the type of early-life stress that is measured in those studies.

Conclusion

In the current study some empirical evidence was found for stress-adapted skills in individuals with a history of early-life stress, which can be observed especially when tested under conditions mirroring their developmental environment. Working memory was found as a domain most predominantly supporting the hidden talents framework. Moreover, potential enhancements in abilities may be identified in other domains, such as cognition, creativity, cognitive control, decision-making, executive functioning, and social skills. Likewise, possible intact skills have been observed across various domains, including reasoning, attention, cognitive control, executive function, social skills, cognition, memory, and learning. Some of these stress-adapted skills often manifest only under conditions that mirror the developmental context of the individual, however only a minority of the studies tested these skills under ecologically valid conditions. More empirical evidence is required for a thorough understanding of the factors influencing the emergence of these enhanced skills and to pinpoint particular types of early-life stress contributing to such improvements.

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Appendix A

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
Working for the future: parentally deprived Nigerian Children have enhanced working memory ability	Nweze, T and Nwoke, MB and Nwufo, JI and Aniekwu, RI and Lange, F	2021	1	1	0
Vigilance, the Amygdala, and Anxiety in Youths with a History of Institutional Care	Silvers, JA and Goff, B and Gabard-Durnam, LJ and Gee, DG and Fareri, DS and Caldera, C and Tottenham, N	2017	1	1	0
Threat and deprivation are associated with distinct aspects of cognition, emotional processing, and psychopathology in children and adolescents	Schäfer, JL and McLaughlin, KA and Manfro, GG and Pan, P and Rohde, LA and Miguel, EC and Simioni, A and Hoffmann, MS and Salum, GA	2023	0	1	1
The role of metacognition in explaining the relationship between early adversity and reading comprehension	Ferrara, AM and Panlilio, CC	2020	0	1	1
The role of childhood trauma, HPA axis reactivity and FKBP5 genotype on cognition in healthy individuals	Ferrer, Alex and Soria, Virginia and Salvat-Pujol, Neus and Martorell, Lourdes and Armario, Antonio and Urretavizcaya, Mikel and Gutiérrez-Zotes, Alfonso and Monreal, José Antonio and Crespo, José Manuel and Massaneda, Clara and Vilella, Elisabet and Palao, Diego and Menchón, José Manuel and Labad, Javier	2021	0	0	1

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
The relationship between childhood stress and distinct stages of dynamic behavior monitoring in adults: neural and behavioral correlates	Wu, JH and Liu, YT and Fang, HH and Qin, SZ and Kohn, N and Duan, HX	2021	1	1	1
The Mediating Role of Cardiometabolic Dysregulation on the Relation Between Adverse Childhood Experiences and Adult Cognition	Moliner, S and Quinn, JM and Sheffler, J	2022	0	1	1
The mediating role of allostatic load in the relationship between early life adversity and cognitive function across the adult lifespan	D'Amico, D and Amestoy, ME and Fiocco, AJ	2022	0	1	1
The influence of early life stress on the integration of emotion and working memory	Metz, S and Aust, S and Fan, Y and Bönke, L and Harki, Z and Gärtner, M and Bajbouj, M and Grimm, S	2018	1	0	1
The enduring effects of abuse and related adverse experiences in childhood: A convergence of evidence from neurobiology and epidemiology	Anda, Robert F. and Felitti, Vincent J. and Bremner, J. Douglas and Walker, John D. and Whitfield, Charles and Perry, Bruce D. and Dube, Shanta R. and Giles, Wayne H.	2006	0	0	1

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
The effect of parental loss on cognitive and affective interference in adolescent boys from a post-conflict region	Mueller, SC and Baudoncq, R and De Schryver, M	2015	0	0	1
The Effect of Early-Life Stress on Memory Systems Supporting Instrumental Behavior	Patterson, TK and Craske, MG and Knowlton, BJ	2013	0	1	1
The Effect of Early Life Stress on Memory is Mediated by Anterior Hippocampal Network	Xu, JJ and Guan, XJ and Li, H and Zhang, MM and Xu, XJ	2020	0	1	1
The effect of childhood trauma on spatial cognition in adults: A possible role of sex	Syal, Supriya and Ipser, Jonathan and Phillips, Nicole and Thomas, Kevin G. F. and van der Honk, Jack and Stein, Dan J.	2014	1	0	1
The divergent impact of catechol-o-methyltransferase (COMT) Val^{158}Met genetic polymorphisms on executive function in adolescents with discrete patterns of childhood adversity	Zhang, Huihui and Li, Jie and Yang, Bei and Ji, Tao and Long, Zhouting and Xing, Qiquan and Shao, Di and Bai, Huayu and Sun, Jiwei and Cao, Fenglin	2018	0	0	1
The beneficial effect of oxytocin on avoidance-related facial emotion recognition depends on early life stress experience	Feeser, M and Fan, Y and Weigand, A and Hahn, A and Gärtner, M and Aust, S and Böker, H and Bajbouj, M and Grimm, S	2014	1	1	0

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
Social threat and safety learning in individuals with adverse childhood experiences: electrocortical evidence on face processing, recognition, and working memory	Schellhaas, S and Schmahl, C and Bublatzky, F	2022	0	1	1
Risk taking, decision-making, and brain volume in youth adopted internationally from institutional care	Herzberg, Max P. and Hodel, Amanda S. and Cowell, Raquel A. and Hunt, Ruskin H. and Gunnar, Megan R. and Thomas, Kathleen M.	2018	1	0	1
Resting mononuclear cell NR3C1 and SKA2 expression levels predict blunted cortisol reactivity to combat training stress among elite army cadets exposed to childhood adversity	Kalla, Carmel and Goltser-Dubner, Tanya and Pevzner, Dalya and Canetti, Laura and Mirman, Aron and Ben-Yehuda, Ariel and Itzhar, Noa and Benarroch, Fortu and Shalev, Amit and Giesser, Ruth and Fruchter, Eyal and Vashdi, Inon and Oz, Osnat and Haber, Roni and Saloner, Chen and Lotan, Amit and Galili-Weisstub, Esti and Bonne, Omer and Segman, Ronen	2021	0	1	1
Relationship between adverse childhood experiences, social-emotional competencies, and problem behaviors among elementary-aged children	Ray, Dee C. and Angus, Emily and Robinson, Hannah and Kram, Kirsten and Tucker, Sarah and Haas, Sara and McClintock, Damian	2020	0	0	1

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
Neurocognition and its association with adverse childhood experiences and familial risk of mental illness	Lakkireddy, Sai Priya and Balachander, Srinivas and Dayalamurthy, Pavithra and Bhattacharya, Mahashweta and Joseph, Mino Susan and Kumar, Pramod and Kannampuzha, Anand Jose and Mallappagari, Sreenivasulu and Narayana, Shruthi and Alexander, Alen Chandy and Muthukumaran, Moorthy and Sheth, Sweta and Puzhakkal, Joan C. and Ramesh, Vinutha and Thatikonda, Navya Spurthi and Selvaraj, Sowmya and Ithal, Dhruva and Sreeraj, Vanteemar S. and Mahadevan, Jayant and Holla, Bharath and Venkatasubramanian, Ganesan and John, John P. and Murthy, Pratima and Benegal, Vivek and Reddy, Y. C. Janardhan and Jain, Sanjeev and Viswanath, Biju	2022	0	1	1
Multi-sample assessment of stress reactivity as a mediator between childhood adversity and mid- to late-life outcomes	Sheffler, J and Meyer, C and Puga, F	2022		0	1

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
Investigation of reward learning and feedback sensitivity in non-clinical participants with a history of early life stress	Wilkinson, MP and Slaney, CL and Mellor, JR and Robinson, ESJ	2021	0	0	1
Interaction of Early Life Stress and Corticotropin-Releasing Hormone Receptor Gene: Effects on Working Memory	Fuge, P and Aust, S and Fan, Y and Weigand, A and Gärtner, M and Feeser, M and Bajbouj, M and Grimm, S	2014	0	0	1
Instrumental learning and cognitive flexibility processes are impaired in children exposed to early life stress	Harms, MB and Bowen, KES and Hanson, JL and Pollak, SD	2018	0	0	1
Instrumental learning and cognitive flexibility processes are impaired in children exposed to early life stress	Harms, Madeline B. and Bowen, Katherine E. Shannon and Hanson, Jamie L. and Pollak, Seth D.	2018	0	0	1
Induced negative arousal modulates the speed of visual working memory consolidation	Xie, Weizhen and Lu Sing, JC Lynne and Martinez-Flores, Ana and Zhang, Weiwei	2022	1	0	0
Individuals with adverse childhood experiences explore less and underweight reward feedback	Lloyd, A and McKay, RT and Furl, N	2022	0	0	1
Individual differences in the encoding of contextual details following acute stress: An explorative study	Sep, Milou S. C. and Joëls, Marian and Geuze, Elbert	2022	0	0	1

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
Impact of childhood adversity on network reconfiguration dynamics during working memory in hypogonadal women	Shanmugan, S and Cao, W and Satterthwaite, TD and Sammel, MD and Ashourvan, A and Bassett, DS and Ruparel, K and Gur, RC and Epperson, CN and Loughead, J	2020	0	0	1
Hidden talents in harsh conditions? A preregistered study of memory and reasoning about social dominance	Frankenhuis, Willem E. and de Vries, Sarah A. and Bianchi, JeanMarie and Ellis, Bruce J.	2020	0	1	1
Hidden talents in context: Cognitive performance with abstract versus ecological stimuli among adversity-exposed youth	Young, ES and Frankenhuis, WE and DelPriore, DJ and Ellis, BJ	2022	0	1	1
Growth trajectories for executive and social cognitive abilities in an Indian population sample: Impact of demographic and psychosocial determinants	Sharma, Eesha and Ravi, G. S. and Kumar, Keshav and Thennarasu, Kandavel and Heron, Jon and Hickman, Matthew and Vaidya, Nilakshi and Holla, Bharath and Rangaswamy, Madhavi and Mehta, Urvakhsh Meherwan and Krishna, Murali and Chakrabarti, Amit and Basu, Debashish and Nanjayya, Subodh Bhagyalakshmi and Singh, Rajkumar Lenin and Lourembam, Roshan and Kumaran, Kalyanaraman and Kuriyan, Rebecca and Kurpad, Sunita Simon and Kartik, Kamakshi	2023	0	0	1

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
	and Kalyanram, Kartik and Desrivieres, Sylvane and Barker, Gareth and Orfanos, Dimitri Papadopoulos and Toledano, Mireille and Purushottam, Meera and Bharath, Rose Dawn and Murthy, Pratima and Jain, Sanjeev and Schumann, Gunter and Benegal, Vivek				
Growth trajectories for executive and social cognitive abilities in an Indian population sample: Impact of demographic and psychosocial determinants	Sharma, E and Ravi, GS and Kumar, K and Thennarasu, K and Heron, J and Hickman, M and Vaidya, N and Holla, B and Rangaswamy, M and Mehta, UM and Krishna, M and Chakrabarti, A and Basu, D and Nanjayya, SB and Singh, RL and Lourembam, R and Kumaran, K and Kuriyan, R and Kurpad, SS and Kartik, K and Kalyanram, K and Desrivieres, S and Barker, G and Orfanos, DP and Toledano, M and Purushottam, M and Bharath, RD and Murthy, P and Jain, S and Schumann, G and Benegal, V and CVEDA Consortium	2023	0	0	1

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
Exposure to childhood trauma is associated with altered n-back activation and performance in healthy adults: Implications for a commonly used working memory task	Philip, Noah S. and Sweet, Lawrence H. and Tyrka, Audrey R. and Carpenter, S. Louisa and Albright, Sarah E. and Price, Lawrence H. and Carpenter, Linda L.	2016	0	1	1
Exploring EFs and Math Abilities in Highly Deprived Contexts	Pellizzoni, S and Apuzzo, GM and De Vita, C and Agostini, T and Ambrosini, M and Passolunghi, MC	2020	0	0	1
Executive function after risk-reducing salpingo-oophorectomy in BRCA1 and BRCA2 mutation carriers: does current mood and early life adversity matter?	Shanmugan, S and Sammel, MD and Loughead, J and Ruparel, K and Gur, RC and Brown, TE and Faust, J and Domchek, S and Epperson, CN	2020	0	0	1
Enhanced Avoidance Habits in Relation to History of Early-Life Stress	Patterson, TK and Craske, MG and Knowlton, BJ	2019	0	0	1
Emotion regulation strategies modulate the effect of adverse childhood experiences on perceived chronic stress with implications for cognitive flexibility	Kalia, V and Knauft, K	2020	0	0	1

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
Effects of early life adversity on immune function and cognitive performance: results from the ALSPAC cohort	Holland, JF and Khandaker, GM and Dauvermann, MR and Morris, D and Zammit, S and Donohoe, G	2020	0	1	1
Effect of Exposure to Socio-Political Violence and Abuse During Childhood on Executive Planning in Adult Life	Montoya-Arenas, DA and Londono-Guzman, D and Franco, JG and Gaviria, AM	2022	1	1	1
Early-life stress is associated with impairment in cognitive control in adolescence: An fMRI study	Mueller, SC and Maheu, FS and Dozier, M and Peloso, E and Mandell, D and Leibenluft, E and Pine, DS and Ernst, M	2010	0	0	1
Early-life stress is associated with a preponderance of habitual responding in a novel instrumental avoidance learning paradigm	Gordon, AL and Patterson, TK and Knowlton, BJ	2020	0	0	1
Early life stress, FK506 binding protein 5 gene (FKBP5) methylation, and inhibition-related prefrontal function: A prospective longitudinal study	Harms, MB and Birn, R and Provencal, N and Wiechmann, T and Binder, EB and Giakas, SW and Roeber, BJ and Pollak, SD	2017	0	0	1
Early Life Stress on Brain Structure and Function Across the Lifespan: A Preliminary Study	Seckfort, DL and Paul, R and Grieve, SM and Vandenberg, B and Bryant, RA and Williams, LM and Clark, CR and Cohen, RA and Bruce, S and Gordon, E	2008	0	1	0

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
Early life socioeconomic adversity is associated in adult life with chronic inflammation, carotid atherosclerosis, poorer lung function and decreased cognitive performance: a cross-sectional, population-based study	Packard, CJ and Bezlyak, V and McLean, JS and Batty, GD and Ford, I and Burns, H and Cavanagh, J and Deans, KA and Henderson, M and McGinty, A and Millar, K and Sattar, N and Shiels, PG and Velupillai, YN and Tannahill, C	2011	0	0	1
Early life adversity contributes to impaired cognition and impulsive behavior: Studies from the Oklahoma Family Health Patterns Project	Lovallo, William R. and Farag, Noha H. and Sorocco, Kristen H. and Acheson, Ashley and Cohoon, Andrew J. and Vincent, Andrea S.	2013	0	0	1
Early adversity and children's regulatory deficits: Does postadoption parenting facilitate recovery in postinstitutionalized children?	Koss, KJ and Lawler, JM and Gunnar, MR	2020	0	1	1
Early Adverse Childhood Experiences and Social Skills Among Youth in Fragile Families	Pierce, H and Jones, MS and Holcombe, EA	2022	0	0	1
Disparities by Gender and Race/Ethnicity in Child Maltreatment and Memory Performance	Brown, MJ and Jiang, YP and Hung, PY and Haider, MR and Crouch, E	2022	0	0	1
Differential associations of threat and deprivation with emotion regulation and cognitive control in adolescence	Lambert, Hilary K. and King, Kevin M. and Monahan, Kathryn C. and McLaughlin, Katie A.	2017	0	1	1

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
Differential Associations of Deprivation and Threat With Cognitive Control and Fear Conditioning in Early Childhood	Machlin, L and Miller, AB and Snyder, J and McLaughlin, KA and Sheridan, MA	2019	0	1	1
Differential Associations of Adversity Profiles with Adolescent Cognitive Control and Psychopathology	Brieant, A and Clinchard, C and Deater-Deckard, K and Lee, J and King-Casas, B and Kim-Spoon, J	2022	0	0	1
Developmental consequences of early life stress on risk for psychopathology: Longitudinal associations with children's multisystem physiological regulation and executive functioning	Rudd, KL and Roubinov, DS and Jones-Mason, K and Alkon, A and Bush, NR	2021	0	0	1
Deprivation and threat as developmental mediators in the relation between early life socioeconomic status and executive functioning outcomes in early childhood	Vogel, SC and Perry, RE and Brandes-Aitken, A and Braren, S and Blair, C	2021	0	0	1
Cumulative risk, teacher-child closeness, executive function and early academic skills in kindergarten children	Suntheimer, NM and Wolf, S	2020	0	0	1
Correlates of hallucinatory experiences in the general population: An international multisite replication study	Moseley, Peter and Aleman, André and Allen, Paul and Bell, Vaughan and Bless, Josef and	2021	0	1	0

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
	Bortolon, Catherine and Cella, Matteo and Garrison, Jane and Hugdahl, Kenneth and Kozáková, Eva and Larøi, Frank and Moffatt, Jamie and Say, Nicolas and Smailes, David and Suzuki, Mimi and Toh, Wei Lin and Woodward, Todd and Zaytseva, Yuliya and Rossell, Susan and Fernyhough, Charles				
Cognitive variations following exposure to childhood adversity: evidence from a pre-registered, longitudinal study	Nweze, T and Ezenwa, M and Ajaelu, C and Hanson, JL and Okoye, C	2023	0	1	1
Cognitive function is preserved in older adults with a reported history of childhood sexual abuse	Feeney, Joanne and Kamiya, Yumiko and Robertson, Ian H. and Kenny, Rose Anne	2013	1	0	0
Cognitive adaptations to stressful environments: When childhood adversity enhances adult executive function	Mittal, Chiraag and Griskevicius, Vladas and Simpson, Jeffry A. and Sung, Sooyeon and Young, Ethan S.	2015	1	0	1
Childhood mental health difficulties mediate the long-term association between early-life adversity at age 3 and poorer cognitive functioning at ages 11 and 14	Nweze, T and Ezenwa, M and Ajaelu, C and Okoye, C	2023	0	0	1

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
Childhood Adversity, Reward Processing, and Health During the COVID-19 Outbreak: The Mediating Role of Reward Learning	Oltean, LE and Soflau, R	2022	0	0	1
Childhood Adversity and the Creative Experience in Adult Professional Performing Artists	Thomson, P and Jaque, SV	2018	1	0	0
Childhood Adversity and Dimensional Variations in Adult Sustained Attention	Vogel, SC and Esterman, M and DeGutis, J and Wilmer, JB and Ressler, KJ and Germine, LT	2020	0	1	1
Characterizing the dimensional structure of early-life adversity in the Adolescent Brain Cognitive Development (ABCD) Study	Brieant, A and Vannucci, A and Nakua, H and Harris, J and Lovell, J and Brundavanam, D and Tottenham, N and Gee, DG	2023	0	0	1
Can an Unpredictable Childhood Environment Enhance Working Memory? Testing the Sensitized-Specialization Hypothesis	Young, ES and Griskevicius, V and Simpson, JA and Waters, TEA and Mittal, C	2018	1	0	1
Associations between childhood adversities and late-life cognitive function: Potential mechanisms	Ding, RX and He, P	2021	0	1	1
Association of Adverse Childhood Experiences and Social Isolation With Later-Life Cognitive Function Among Adults in China	Lin, L and Cao, B and Chen, WQ and Li, JH and Zhang, YY and Guo, VY	2022	0	1	1

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
Are adverse childhood experiences associated with late-life cognitive performance across racial/ethnic groups: results from the Kaiser Healthy Aging and Diverse Life Experiences study baseline	Gold, AL and Meza, E and Ackley, SF and Mungas, DM and Whitmer, RA and Mayeda, ER and Miles, S and Eng, CW and Gilsanz, P and Glymour, MM	2021	0	1	1
An investigation into early-life stress and cognitive function in older age	Grainger, SA and Crawford, JD and Kochan, NA and Mather, KA and Chander, RJ and Draper, B and Brodaty, H and Sachdev, PS and Henry, JD	2020	0	1	1
Altered development of hippocampus-dependent associative learning following early-life adversity	Lambert, HK and Peverill, M and Sambrook, KA and Rosen, ML and Sheridan, MA and McLaughlin, KA	2019	0	0	1
Adverse Experiences in Early Childhood and Kindergarten Outcomes	Jimenez, ME and Wade, R and Lin, Y and Morrow, LM and Reichman, NE	2016	0	0	1
Adverse childhood experiences from family and society contribute to increased risk of depressive symptoms and cognitive impairment: a cross-sectional study	Ren, ZY and Luo, YA and Zheng, XY and Liu, JF	2023	0	0	1
Adverse childhood experiences and their impacts on subsequent depression and cognitive impairment in Chinese adults: A nationwide multi-center study	Zhang, TT and Kan, LA and Jin, CB and Shi, WM	2023	0	0	1

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
Adverse Childhood Experiences and Rate of Memory Decline From Mid to Later Life: Evidence From the English Longitudinal Study of Ageing	O'Shea, BQ and Demakakos, P and Cadar, D and Kobayashi, LC	2021	0	1	1
Adverse childhood experiences and children's development in early care and education programs	Lipscomb, Shannon T. and Hatfield, Bridget and Lewis, Hillary and Goka-Dubose, Emiko and Abshire, Caitlyn	2021	0	1	1
Adverse childhood experiences and childhood autobiographical memory disturbance	Brown, DW and Anda, RF and Edwards, VJ and Felitti, VJ and Dube, SR and Giles, WH	2007	0	0	1
Adverse childhood experiences and child development outcomes in Ceará, Brazil: A population-based study	Rocha, Hermano A. L. and Sudfeld, Christopher R. and Leite, Álvaro J. M. and Rocha, Sabrina G. M. O. and Machado, Márcia M. T. and Campos, Jocileide S. and e Silva, Anamaria C. and Correia, Luciano L.	2021	0	0	1
Adverse childhood experiences (ACEs) associated with reduced cognitive flexibility in both college and community samples	Kalia, V and Knauft, K and Hayatbini, N	2021	0	0	1

Title	Authors	Year	Positive outcome	Neutral outcome	Negative outcome
Adverse childhood experience categories and subjective cognitive decline in adulthood: an analysis of the Behavioral Risk Factor Surveillance System	Terry, RM and Schiffmacher, SE and Dutcher, AA and Croff, JM and Jelley, MJ and Hartwell, ML	2023	0	0	1
Adverse childhood events and cognitive function among young adults: Prospective results from the national longitudinal study of adolescent to adult health	Hawkins, MAW and Layman, HM and Ganson, KT and Tabler, J and Ciciolla, L and Tsotsoros, CE and Nagata, JM	2021	0	1	1
A study of the relationship between adverse childhood experiences, life events, and executive function among college students in China	Ji, Shanling and Wang, Huiping	2018	0	0	1
	Total		13	32	74

Appendix A. Study outcomes: positive, neutral, and negative.