

HOW PSYCHOLOGICAL TRAUMA AFFECTS COGNITIVE FUNCTIONS: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Abstract

Objective: Promising research has investigated the relationships between psychological trauma and cognitive impairments, resulting in deficits of information processing, attention or memory. From a clinical point of view, investigations regarding the potential associations between cognitive outcomes and trauma appear useful to draw informed clinical indications for practitioners. However, the current lack of systematization of the existing literature makes difficult to frame in a comprehensive perspective the results brought by empirical research.

Method: PRISMA principles were used to perform a systematic search on MEDLINE, PubMed, PsycINFO, PsycARTICLES, Scopus and Web of Science databases. Studies were screened and selected using inclusion/exclusion criteria defined in a PICOS format.

Results: The initial search identified 75.245 records and led to the final inclusion of 29 independent contributions assessing between-group differences considering differences according to trauma exposure or posttraumatic stress disorder diagnosis. After the extraction and codification of information and the computation of effect sizes, a series of meta-analyses were performed using a random effects model. Data confirm a significant impact of psychological trauma on cognitive domains, indicating that individuals who experienced traumas show worse cognitive functioning, particularly in the attention and executive functions domains. Moreover, meta-analyses reported that in the case of posttraumatic stress disorder, there are more cognitive domains impaired, including memory, processing speed, visuospatial processing, and global cognitive functioning.

Conclusions: The study confirms a direct association between trauma and cognitive functioning, suggesting the importance of further studies examining the characteristics of the traumatic experience to provide clear clinical guidelines.

Key words: psychological trauma, PTSD, cognitive function, meta-analysis

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OPEN ACCESS

Citation: Velotti, P., Rogier, G., Favieri, F., Forte, G., Zobel, S. B., Cataudella, S., Civilla, C., Velotti, A., Balladori, M., Capone, A., Salati, E., Salzillo, M., Monti, S., Blasi, M. T., Canevelli, M., Casagrande, M., Bruno, G. (2026). How Psychological Trauma Affects Cognitive Functions: a Systematic Review and Meta-Analysis. *Clinical Neuropsychiatry*, 23(2), 207-224.

doi.org/10.36131/cnfioritieditore20260208

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Funding: None.

Competing interests: None.

Supplementary material: in the article page.

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Introduction

Traumatic life experiences significantly impact mental health. It is widely demonstrated that traumatic experiences such as neglect and child maltreatment, starting from early life, are major risk factors for the onset of neuropsychiatric and psychopathological symptoms (Majer et al., 2010). Across the lifespan, the nature and centrality of traumas, rather than the effective number of negative events, may affect mental

health to different degrees, leading the occurrence of dysfunctional behaviors, depression, anxiety, and posttraumatic stress disorder (Cataudella et al., 2023; Desmarais et al., 2020; Prieto et al., 2023; Wamser-Nanney et al., 2018). For instance, the impact of adverse experiences on functioning is likely to differ according to the extent by which the individual perceived it as central to own life (Wamser-Nanney et al., 2018) or stressful (Graignic-Philippe et al., 2014), or according to the functional domain threatened by the adverse

event either physical, relational or sexual (Pace et al., 2024).

Animal models have reported structural and functional alterations in brain structures caused by early traumatic experiences, which may explain cognitive impairment in adulthood (Fenster et al., 2018; Nahum et al., 2022; Zoladz & Diamond, 2016). However, the variability in human studies and the scarce amount of longitudinal evidence underscore the need to analyze the impact of life events on cognitive functioning.

Recent reviews attempted to summarize the evidence on the association between psychological trauma, cognitive functioning, and its decline. Schuitevoerder and colleagues (2013) found that in older adults, PTSD is associated with poorer cognitive performance across multiple cognitive domains, indicating impairments in executive functions, processing speed, and learning. Although Roelofs and Pasma (2016) did not confirm an exclusive connection between life events and cognitive decline, they proposed an integrated approach for assessing stressors and biological and cognitive systems to define the association between cognitive decay and traumatic experiences. In a recent meta-analysis, Vargas et al. (2019) found a negative correlation between childhood trauma and overall cognition, regardless of the psychiatric context. Specifically, for individuals with psychotic conditions, a negative association was found between overall cognition and childhood trauma (Vargas et al., 2019). Moreover, the systematic review of Desmarais and colleagues (2020) suggested a link between the occurrence of dementia and traumas in both early life (before 40 years) and mid-life (between 40 and 60 years). However, some aspects of this association remain ambiguous and require further examination of the relationship between traumatic experiences and cognitive functions. To cover the latest evidence and quantitatively summarize evidence about the association between traumatic life experiences (from childhood to adulthood) and cognitive functioning, we carried out a meta-analysis of empirical studies assessing this issue with a rigorous methodological framework. Our goal was to provide new evidence on the role and impact on cognitive functions of types of events that could cause traumatic experiences or lead to a diagnosis of PTSD. From this study, we aim to distinguish cognitive patterns associated with different types of traumatic experiences and analyze the factors that can impact the relationship between cognitive performance and experiences throughout an individual's lifespan.

Methods

Search strategy and selection criteria

The PRISMA 2020 Statement was used to perform a systematic search (Page et al., 2021). MEDLINE, PubMed, PsycINFO, PsycARTICLES, Scopus, and Web of Science databases were used to search literature, covering all articles up to 13/09/2023. Two concepts, namely trauma and cognitive impairment, were used to group search words. Following conventional formatting practices, the complete search filter is detailed in supplementary materials. Additionally, the researchers searched the grey literature by a) writing letters to the field's leading writers, requesting unpublished data on the issue, and b) looking for appropriate publications (using the same phrases and keywords) in Google Scholar (the first four pages) and the Database Dissertation Abstract International. Furthermore, the references list of the articles included in the quality assessment phase was

cross-checked to find additional research eligible for the meta-analysis.

The inclusion and exclusion criteria employed were the following:

- P (Population): Individuals across the lifespan (children, adults, elderly) who have experienced psychological trauma and/or suffer from PTSD. Trauma types include both personal (e.g., childhood/adult maltreatment, physical or psychological abuse) and collective (e.g., war, terrorism, natural disasters) events. Additionally, due to the high comorbidity of trauma-related distress with psychopathological conditions, ranging from mood alterations to diagnosis of psychosis and other psychiatric diseases, studies including both healthy and clinical populations were eligible.
- I (Intervention/Exposure): Measurement of cognitive functioning through validated cognitive tests, adopted in neuropsychological batteries or single assessments to evaluate and compare cognitive performances.
- C (Comparison): Between-group comparisons of individuals with vs. without trauma exposure and/or with vs without PTSD.
- O (Outcome): this meta-analysis included studies that reported raw means and standard deviations of cognitive outcomes associated with trauma-related categorization. When a publication stated that the authors evaluated both trauma and cognitive performance but no raw data (relating to the results or values of moderator variables) were published, the study's corresponding author was contacted to obtain such information. The studies lacking accessible quantitative data were excluded due to the inability to include them in the meta-analyses. For the outcome classification, considering the nature of the study, the heterogeneity in terms of instruments for assessing cognitive functions and, in some cases, the lack of the indication of the specific scale or task adopted to identify the raw results, highlighted by a pilot search, we referred to the indication of the authors of the primary study to classify each outcome in the specific domain

According to the PRISMA guidelines, data collection, selection and extraction were carried out independently by three authors (FF, GF, GR). Initially, the authors screened titles and abstracts to identify the most reliable studies. Disagreements in records selection were resolved by an external author (PV), who evaluated the fit of the studies with the inclusion and exclusion criteria. From the eligible and selected studies, information was extracted for descriptive outcomes (See **table 1** in the results section) considering:

- 1) publication characteristics (i.e., authors, year of publication, country);
- 2) sample characteristics (i.e., total sample size, classification, average age or age range, gender)
- 3) methods characteristics (i.e., instruments utilized to assess trauma and cognitive performance)
- 4) outcomes (i.e., cognitive domain assessed, trauma features, summary of the results on trauma-cognitive functions relationship)

To control possible effects of confounding variables and according to the aim of the study, relevant variables were coded for moderator analyses, subgroup analyses, and meta-regressions. Specifically, were considered:

- a) Gender, expressed as the proportion of men in the sample
- b) Age, expressed in years

- c) Type of trauma: childhood trauma (coded as 1), adult trauma (coded as 2), and generic lifespan trauma (coded as 3).
- d) Quality of the studies coded as Good versus Fair-Poor following the procedure described in the next paragraph.

Quality Assessment

To evaluate the quality of the included studies, the Newcastle-Ottawa quality assessment form for case-control studies was employed (Wells et al., 2009). In detail, each study was rated on three domains, Selection, Comparability and Exposure and a total score, potentially ranging from 0 to 9, was computed. Afterwards, the score was used to classify each study into three classes, indicating good, fair or poor quality.

Data Analysis

Effect sizes were computed using information regarding means and standard deviations obtained by individuals with trauma exposure and/or PTSD diagnosis and those obtained by comparison groups. Specifically, *r*-effect sizes were computed with a positive direction, meaning that individuals with trauma/PTSD obtained lower scores on measures of cognitive functioning compared to individuals without trauma/PTSD. Meta-analyses were conducted on studies investigating PTSD and those not investigating PTSD separately. Similarly, individual meta-analyses were conducted for each cognitive domain. Analyses were not performed when $k < 3$.

Meta-Analyses were performed in the Rstudio© software for Mac, using the *metafor* package (Viechtbauer, 2010). Before carrying out the analyses, effect sizes were transformed in *F* of Fisher (1925). A random-effects model was selected as this model considers the possibility that each observation has a different effect size drawn from different populations and is considered more conservative than the fixed-effect model (Cooper & Hedges, 1994).

If some observations were not independent because they were computed on the same sample, a three-level model was estimated and compared with a two-level effect. Specifically, when the LRT test was statistically significant ($p < .05$), the three-level model was preferred (Cheung, 2015).

After the estimation of the effect size, several analyses were performed to estimate and correct the impact of publication bias. Specifically, Egger's test was carried out and, when statistically significant, the Trim and Fill procedure was adopted to compute a corrected effect size (Duval & Tweedie, 2000). In three-level meta-analyses, the corrected effect size for publication bias was directly estimated using the *metabias* package for R (Mathur & VanderWeele, 2020).

Lastly, the *Q* index and its statistical significance were inspected to assess heterogeneity and provide indications on the possibility of testing the moderative role of several variables (Cochran, 1954). If this was statistically significant, hypotheses regarding the moderating role of variables were tested following two main strategies. Specifically, metaregressions were computed for continuous variables. Categorical variables were transformed into dummy variables using the most frequent value as a focal predictor, and moderation analyses were computed only in case each variable value counted at least two observations. In case several subdomains of cognitive functioning were

included, the nature of subdomain was considered as a categorical moderating variable. If these analyses led to statistically significant results, successive analyses were performed separately for each subdomain.

Results

Studies' Selection

The initial research yielded 75.245 articles. After removing duplicates, 30.646 unique records were screened for title and abstract, allowing the identification of 306 full texts examined for potential inclusion. Subsequently, 274 were excluded due to different reasons specifically reported in Figure 1. An agreement among authors resulted in the inclusion of 29 studies eligible for the quantitative synthesis. The flow chart in Figure 1 shows the overall search procedure. **table 1** reported the main characteristics of each study. Regarding quality assessment, 37.93%, 20.69% and 41.38% of the studies were respectively classified into the good, fair and poor categories (rating details are available in supplementary materials). Regarding the most frequent limitation of the studies, the lack of information regarding non-response rates was the rule rather than the exception.

Studies comparing individuals with and without trauma exposure

Attention. Two studies examined differences in the Attention domain among individuals with and without trauma exposure. These studies provided three observations conducted on 207 participants. The analyses evidenced that a two-level model offered the best fit for the data. The effect size was positive and statistically significant (Supplement 1_a), and no publication bias was revealed by the Egger's test. These results are detailed in **table 2**. The *Q* statistic was not statistically significant ($Q(2)=1.58; p > .05$); therefore, moderation analyses were not carried out.

Executive Functions. Nine studies examined the differences in the Executive Functions domain among individuals with and without trauma exposure. These studies included 29 observations from a sample of 2699 participants. The comparison between the two-level and a three-level models indicated that a three-model should be preferred (See **table 2**). As displayed in **table 2**, the main effect was positive and statistically significant (Supplement 1_b). The *Q* statistic was statistically significant, so moderation analyses were carried out. We first tested the hypothesis that the strength of effect size varied according to the subdomain of the executive functions investigated by the studies. Results indicate that the strength of the effect size did not statistically differ between studies investigating inhibition and those that did not ($\beta = -.03, p > .05$) as well as between those who investigated working memory and those that did not ($\beta = .21, p > .05$). However, we found that the strength of the effect size was significantly lower among studies that examined cognitive flexibility compared to those that did not ($\beta = -.17, p < .05$). Thus, separated analyses were carried out across subdomains.

Cognitive flexibility. Eight studies investigated differences in the cognitive flexibility between individuals with and without trauma exposure. These studies involved ten observations conducted on 1357 participants. The comparison between two-level and a three-level models indicated that a two-model should be preferred (See **table 2**). As displayed in

Figure 1. Flow chart

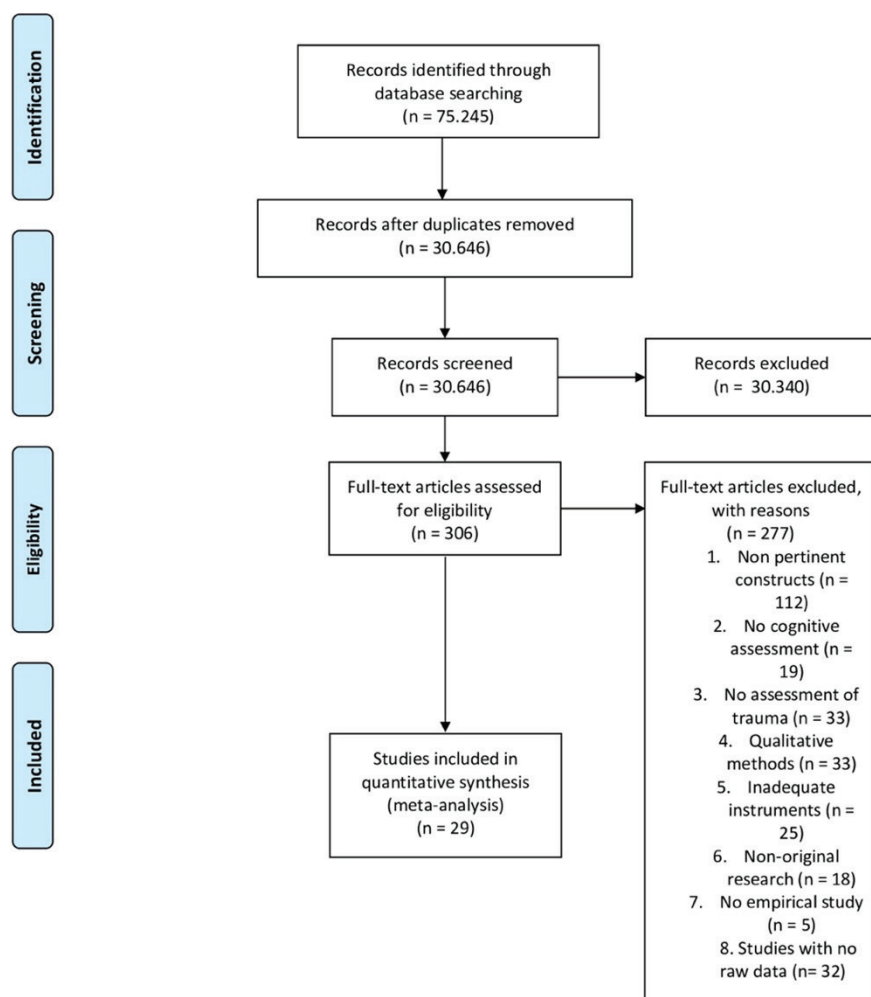


table 2, the main effect was positive and statistically significant (Supplement 1_c), and no publication bias was identified. The Q statistic was not statistically significant ($Q(7)=8.00, p>.05$), so moderation analyses were not carried out.

Inhibition function. Four studies investigated differences in the inhibition domain between individuals with and without trauma exposure. These studies provided five observations conducted on 330 participants. The comparison between a two-levels and a three-levels model indicated that a two-model should be preferred (See table 2). As displayed in table 2, the main effect was positive and statistically significant (Supplement 1_d), and no publication bias was identified. The Q statistic was not statistically significant ($Q(4)=6.40, p>.05$), so moderation analyses were not carried out.

Working memory. Six studies investigated differences in the Working Memory domain between individuals with and without trauma exposure. These studies provided eight observations conducted on 570 participants. The comparison between a two-levels and a three-levels model indicated that a two-model should be preferred (See table 2). As displayed in table 2, the main effect was positive and statistically significant (Supplement 1_e), and no publication bias was identified. As the Q statistic was statistically significant, moderation analyses were carried out using age, gender, age of trauma, methodological quality, and clinical composition of the sample as moderating variables. However, no statistically significant effect

was identified (See table 3).

Language. Five studies, conducted on 337 participants, investigated differences in the Language domain between individuals with and without trauma exposure. Because an equal number of observations were retrieved, a three-level meta-analysis was not performed. The effect size was positive and statistically significant (Supplement 1_f), and no publication bias was revealed by the Egger's test. These results are detailed in table 2. The Q statistic was statistically significant, so moderation analyses were carried out using age, gender, methodological quality, and clinical composition as moderators, none of which revealed a statistically significant effect (see table 3).

Memory. Seven studies investigated differences in the Memory domain between individuals with and without trauma exposure. These studies provided 18 observations conducted on 1702 participants. The comparison between two-level and a three-level models indicated that a three-model should be preferred (See table 2). As displayed in table 2, the main effect was positive but not statistically significant (Supplement 1_g), whereas the effect size corrected for publication bias was positive and statistically significant. The Q statistic was statistically significant, so moderation analyses were carried out. We first tested the hypothesis that the strength of effect size may differ between studies investigating long-term memory versus those that did not; however, no significant moderation effect was identified ($\beta=.01, p>.05$). Then, the moderating role of age, gender, methodological quality, and clinical

Table 1. Studies investigating the relationship between Trauma and Cognitive performance

Author (year)	Country	Stage of life of traumatic experience (Type of trauma)	Sample				Cognitive dimension investigated	Main Results	Association (Y;PY;N)
			N and nature	Gender (% males)	Age (years) M	PTSD Assessment			
(Augusti & Melinder, 2013)	Norway	Childhood (maltreatment)	43	35	9.49	PTSD assessed via Trauma Symptom Checklist for Young Children.	Executive Functions: Inhibition, Working Memory, Cognitive Flexibility	No Between-Differences in Inhibition and Cognitive Flexibility. Trauma, with high PTSD symptomatology, associated with low performance	PY
(Barrett et al., 1996)	USA	Adulthood (War Trauma)	2071 veterans	100	na	National Institute of Mental Health Diagnostic Interview Schedule	Memory: Long and Short Verbal Memory, Long and short Visual Memory Visuo-Spatial Ability Executive Functions: Cognitive Flexibility	Veterans with PTSD diagnosis showed generally worse performance in cognitive functions.	Y
(Beers & De Bellis, 2002)	USA	Childhood (mixed traumatic experiences)	29	55	11.78	Interview for PTSD diagnosis	Language Attention Executive Function: Cognitive Flexibility Memory: short and long verbal memory, Long visual memory Visuo-Spatial Ability Processing Speed	PTSD group showed worse performance in: language, attention, long memory verbal, visuospatial ability	PY
(Berthelot et al., 2015)	Canada	Childhood (mixed traumatic experiences)	66 high-risk offspring	49	17.2	-	Executive Functions: Working Memory Memory: long visual memory; long verbal memory	Maltreatment in childhood/adolescence negatively impacts cognitive domains.	Y

Table 1. Continued

(Bremner et al., 1993)	USA	Adulthood (war trauma)	41	100	41	Mississippi Scale for Combat- Re- (WAIS-R): the arithmetic, vocabulary, picture arrange- ment, and block lated Post- traumatic Stress Disorder	Memory: <i>Short and long verbal memory, short and long visual memory.</i>	<i>PTSD condition is associated to worse memory condition.</i>	Y
(Bücker et al., 2012)	Brazil	Childhood (mixed traumatic experiences)	30 traumatized children 30 controls	66	8,77	-	Executive Functions: <i>Working Memory, Cognitive Flexibility</i> Attention Language Memory: <i>short verbal memory</i>	<i>Children with a history of trauma showed impairment in domains such as attention and working memory.</i>	Y
(Burri et al., 2013)	Switzerland	Sample1: Childhood (traumatic experiences) Sample 2: Adulthood (traumatic experiences)	S1: 41 adulthood trauma S2: 55 childhood trauma	S1: 70.73 S2: 52.73	S1: 75.9 S2: 78.81	7-item short screening scale for PTSD	Global Cognitive Functions Language	<i>Cognitive deficits in old age may be partly a consequence of PTSD or at least be aggravated by it.</i>	Y
(Carvalho et al., 2020)	Brazil	Childhood (maltreatment)	55	9,58	61,81	-	Executive Functions: <i>Inhibition, Working Memory, Cognitive Flexibility</i> Language Processing Speed	<i>History of maltreatment are associated to lower executive functioning.</i> <i>History of maltreatment are associated to higher processing speed</i>	Y
(Cohen et al., 2013)	USA	Adulthood (War trauma)	535 veterans (196 veterans with PTSD and 339 veterans without PTSD)	93.64	54.82	CAPS	Executive Functions: <i>cognitive flexibility</i> Memory: <i>short verbal memory.</i> Language Processing Speed.	<i>PTSD condition is associated with worse cognitive performance, particularly in speed processing, memory and executive functions.</i>	Y

Table 1. Continued

(Crowell et al., 2002)	USA	Adulthood (War trauma)	160	100	38	Clinical interview for PTSD (DSM-III)	Global Cognitive Functioning Executive Functions: cognitive flexibility Memory: short and long verbal memory; long visual memory. Visuo-Spatial ability Attention Language	No significant differences between veterans with PTSD and matched control group.	N
(Daugherty et al., 2019)	Spain	Adulthood Sample 1 (Physical Intimate Partner Violence) Sample 2: (Physical and Psychological Intimate partner violence)	S1: 84 S2: 63	S1:0 S2: 0	S1: 32.82 S2: 40.06	-	Executive Functions: inhibitory working memory, cognitive flexibility, decision making, planning. Attention Memory: short and long verbal memory; Short and long visual memory	Group with history of intimate partner violence, both psychologically and physically abused, showed worse attentive and executive functioning than control.	Y
(Geuze et al., 2009)	Germany	Adulthood (War trauma)	50	100	34.06	CAPS	Memory: short and long verbal memory; Short and long visual memory.	Groups with and without PTSD diagnosis significant differ in verbal memory performance (both short and long term) but not in visual memory.	PY
(Gil et al., 1990)	Israel	Not-specified (multiple traumatic experiences)	24	-	29.58		Attention Memory: long verbal memory; short visual memory. Language	PTSD condition is associated with worse performances in language fluency, but not differences in memory, and attention.	Y

Table 1. Continued

(Goodman et al., 2007)	Israel	Not-specified (Holocaust)	28	46	67.92	PDS	Global Cognitive Functioning Executive Functions: working memory, cognitive Flexibility. Attention Memory: long visual and long verbal memory. Processing speed.	Elderly with schizophrenia and PTSD associated to holocaust showed general worse cognitive performances compared to patients with schizophrenia exposed to holocaust but with no PTSD.	Y
(Hart Jr et al., 2008)	USA	Adulthood (War trauma)	25	100	80	CAPS	Executive Functions: Inhibition, Working memory, Cognitive Flexibility. Language Memory: short verbal memory. Processing Speed.	PTSD are associated with worse attention performances, but no other differences emerged.	py
(Kirke-Smith et al., 2014)	United Kingdom	Childhood (maltreatment)	80	39	15		Executive Functions: inhibition, working memory, cognitive flexibility. Language		
(Litcher et al., 2000)	Ukraina	Childhood (Chernobyl nuclear disaster)	600	60	10.7	-	Memory: short visual memory Processing speed.	The evacuee children were not significantly different from their classmates on the objective measures or on most of the subjective measures of cognitive functioning	N
(Loughan & Perna, 2014)	USA	Childhood (mixed traumatic experiences)	45	40	11.8	-	Executive Functions: cognitive flexibility. Memory: short and long verbal memory; Short and long visual memory.	No significant differences between who experienced traumas and control.	N
(Lu et al., 2017)	China	Childhood (mixed traumatic experiences)	48	37	21.5	-	Executive Function: inhibition, working memory, cognitive flexibility. Processing Speed.	Subjects with childhood trauma exhibited impaired cognitive flexibility. No other differences were reported	py

Table 1. Continued

(Lynch & Widom, 2022)	USA	Childhood (mixed traumatic experiences)	1196	51	29.2	-	Global Cognitive Functioning. Executive Functions: <i>inhibition, cognitive flexibility.</i>	Worse cognitive performances in who experienced traumas.	Y
(Trentini et al., 2009)	Brasil	Adulthood (Spouses death)	60	30	74.15	-	Global cognitive functioning Language Memory.	There were no significant differences between the means of cognitive performance of widowed or married elders	N
(Narita-Ohtaki et al., 2018)	Japan	Adulthood (traumatic experiences)	108	0	37.7	IES-R	Global cognitive functioning Executive Functions Memory: <i>short and long verbal memory.</i>	PTSD patients performed poorly in all cognitive domains examined.	Y
(Nikulina & Widom, 2013)	USA	Childhood (maltreatment)	792		51	-	Visuo-Spatial ability Executive functions: <i>cognitive flexibility</i> Processing Speed	Trauma is associated to worse performance.	Y
(Stein et al., 1999)	Canada	Childhood (sexual abuse)	42	0	30.5	CAPS	Memory: <i>short and long verbal memory.</i>	No significant differences between PTSD and non-PTSD conditions.	N
(Twamley et al., 2009)	USA	Adulthood (Intimate Partner Violence)	75	0	35.9	CAPS	Executive Functions: <i>inhibition, cognitive flexibility.</i> Memory: <i>short and long verbal memory.</i> Processing speed. Executive Functions: <i>working memory, cognitive flexibility</i>	PTSD group did not report significant differences in cognitive performances.	N
(Vasilevski & Tucker, 2016)	Australia	Childhood (maltreatment)	82	-	14.54	-	Language Processing Speed Memory: <i>long memory</i> Visuo-Spatial ability	The maltreated group showed significant impairments on measures of executive function and attention, working memory, learning, visuospatial function and visual processing speed.	Y

Table 1. Continued

(Vasterling et al., 1998)	USA	Adulthood (war trauma)	43	78	35.5	SCID interview	Executive Functions: inhibition, cognitive flexibility Memory: short and long verbal memory; Short and long visual memory. Attention	PTSD showed worse condition in memory performance. No significant differences in Executive Function and Attention.	py
(Yasik et al., 2007)	USA	Childhood (abuse)	S1: 69 S2: 91	S1: 47 S2: 60	S1: 13 S2: 13	SCID interview	Memory: short visual and verbal memory.	PTSD condition associated with worse performance than trauma exposure with no PTSD	Y
(Yehuda et al., 2004)	USA	Not specified (Holocaust)	S1: 76 S2: 66	38	69.3	CAPS	Memory: long memory.	PTSD is associated with impairments in memory performances compared to non-PTSD exposed individuals. Survivors without posttraumatic stress disorder did not reported impairment compared to control.	py

Table 2. Summary of samples' sizes, main meta-analytic effects, levels' analyses and publication bias analyses for studies investigating differences across individuals with and without trauma exposure in cognitive functioning

Domain	Number of observed statistics	Number of studies	N	ES 90% CI	τ2level3	τ2level2	LRT (sig.)	Egger test sig.	Corrected ES 90% CI
Attention	3	2	207	.27 [-.034 .521]	<.01	<.01	.04 (.845)	.460	-
Functions	29	9	2699	.34 [.100 .544]	.12	.03	11.51 (.001)	-	-
Cognitive flexibility	10	8	1357	.16 [.097 .226]	<.01	<.01	<.01 (1)	.368	-
Inhibition	5	4	330	.28 [.090 .454]	<.01	.01	<.01 (1)	.095	-
Working memory	8	6	570	.44 [.276 .579]	.04	<.01	2.88 (.090)	.891	-
Language	5	5	337	.25 [-.105 .543]	-	.07	-	.991	-
Memory	18	7	1702	.28 [-.044 .551]	.40	.04	125.06 (<.001)	-	.25 [.066 .425]
Speed	4	4	1495	.08 [-.123 .273]	-	.01	-	.71	-

Note: LRT= Likelihood Ratio Test; sig.= p value; CI=Confidence Interval.

Table 3. Summary of heterogeneity and moderation analyses on studies investigating differences across individuals with and without trauma exposure in cognitive functioning

	Q	Intercept	Age	Gender	Clinical composition ^a	Age of Trauma ^b	Quality ^c
Functions	78.55*	.38*	-	-	-	-	-
Functions Working memory	24.25*	.38*	<.01	<.01	-.25	.24	.01
Language	21.05*	.33*	<-.01	<-.01	-.18	-	.13
Memory	162.84*	.28	<-.01	-.01	-	-.32	-.32
Speed	12.156*	.08	-.01	.01	-	-	.16*

Note: * p value <.05; -= not tested; ^a= focal predictor: Mixed sample; ^b= focal predictor: Adulthood; ^c=focal predictor: Good.

composition was tested, leading to non-statistically significant results (See **table 3**).

Processing Speed. Four studies, conducted on 1495 participants, investigated differences in the Speed domain between individuals with and without trauma exposure. Because an equal number of observations were retrieved, the three-level meta-analysis was not performed. The effect size was positive but not statistically significant (Supplement 1 h), and no publication bias was revealed by the Egger's test. These results are detailed in **table 2**. The Q statistic was statistically significant, so moderation analyses were carried out using age, gender and methodological quality as moderating variables. We found that this last variable significantly and positively moderated the main effect (see **table 3**).

Studies comparing individuals with and without PTSD

Global Cognitive Functioning. Five studies investigated differences in global cognitive functioning between individuals with and without PTSD. These studies provided six observations conducted on 1588

participants. The comparison between two-level and a three-level models indicated that these did not statistically differ, so a two-level meta-analysis was performed (See **table 4**). As displayed in **table 4**, the main effect was positive and statistically significant (Supplement 2 a), and no publication bias was identified. Considering that the Q statistic was statistically significant, moderation analyses, using age, gender, methodological quality, and age of trauma as moderating variables, were carried out. We found a positive and significant effect of gender with an increase in the strength of effect size as the percentage of males decreased (see details in **table 5**).

Attention. Six studies, conducted on 393 participants, investigated differences in the Attention domain between individuals with and without PTSD. Because an equal number of observations were retrieved, a three-level meta-analysis was not performed. The effect size was positive and statistically significant (Supplement 2 b), and no publication bias was revealed by the Egger's test. These results are detailed in **table 4**. The Q statistic was statistically significant, indicating substantial heterogeneity, so moderation analyses were carried out using age, gender, methodological quality,

Table 4. Summary of samples' sizes, main meta-analytic effects, levels' analyses and publication analyses for studies investigating differences across individuals with and without post-traumatic stress disorder in cognitive functioning

Domain	Number of observed statistics	Number of studies	N	ES 90% CI	τ2level3	τ2level2	LRT (sig.)	Egger test sig.	Corrected ES 90% CI
Attention	6	6	392	.31 [.017 .558]	-	.06	-	.160	-
Functioning	6	5	1588	.29 [.092 .466]	.03	<.01	.03 (.861)	.571	
Functions	19	11	5791	.16 [.057 .262]	.02	.01	.90 (.344)	.006	.09 [-.021 .193]
Language	7	6	869	.26 [-.012 .497]	.08	<.01	1.05 (.306)	.068	
Memory	51	16	11358	.22 [.145 .295]	.02	<.01	20.78 (<.001)	-	.22 [.173 .277]
Speed	5	5	692	.16 [.032 .280]	-	<.01	-	.865	-
Visuo	4	4	2368	.47 [-.359 .883]	-	.29	-	.433	-

Note: LRT= Likelihood Ratio Test; sig.= p value; CI=Confidence Interval.

Table 5. Summary of heterogeneity and moderation analyses on studies investigating differences across individuals with and without post-traumatic stress disorder in cognitive functioning

Domain	Q	Intercept	Age	Gender	TraumaAge	Quality ^c
Attention	19.56*	.53	-.01	-.01*	.34*	-.22
Functioning	17.56*	.22	<.01	-.01*	.01	-.06
Functions	78.92*	.14*	<.01	<-.01	.02	.12
Language	25.67*	.30	<-.01	-.01*	.17	-.28
Memory	169.61*	.07*	<.01	<-.01	.02	.03
Visuo	309.50*	.42	-.01	<.01	-	-.68*

Note: * p value <.05; -= not tested; ^a= focal predictor: Mixed sample; ^b= focal predictor: Adulthood; ^c=focal predictor: Good.

and age of trauma as moderators. Results showed a positive and significant effect of gender with an increase in the strength of effect size as the percentage of males decreased. Also, the effect size was stronger in studies investigating childhood trauma or not specified age of trauma compared to studies investigating only trauma in adulthood. The results of moderation analyses are displayed in **table 5**.

Executive Functioning. Eleven studies investigated differences in the executive function domains between individuals with and without PTSD. These studies provided 19 observations conducted on 5791 participants. The comparison between a two-level and a three-level model indicated that these did not statistically differ, so a two-level meta-analysis was performed (See **table 4**). As displayed in **table 4**, the main effect was positive and statistically significant (Supplement 2 c) but the Egger's test identified publication bias. The Trim and Fill procedure indicates that the corrected effect size was still positive and statistically significant. Because the Q statistic was statistically significant, moderation analyses were carried out. First, we test the hypothesis that subdomains may moderate the observed effect size. However, the effect size was shown to not significantly differ between studies investigating flexibility and those

who did not ($\beta=.01, p>.05$), as well as between studies investigating inhibition and those who did not ($\beta=-.04, p>.05$). Similarly, age, gender, methodological quality, and age of trauma were not significant moderators (see **table 5**).

Language. Six studies investigated differences in the Language domain between individuals with and without PTSD. These studies provided seven observations conducted on 869 participants. The comparison between a two-level and a three-level model indicated that these did not statistically differ, so a two-level meta-analysis was performed (See **table 4**). As displayed in **table 4**, the main effect was positive but not statistically significant (Supplement 2 d) and no publication bias was identified. Considering that the Q statistic was statistically significant, moderation analyses, using age, gender, methodological quality, and age of trauma as moderating variables, were carried out. We found a positive and significant effect of gender with an increase in the strength of effect size as the percentage of males decreased (see details in **table 5**).

Memory. Sixteen studies investigated differences in the Memory domain between individuals with and without PTSD. These studies provided 51 observations conducted on 11358 participants. The comparison

between a two-level and a three-level model indicated that a three-level model should be preferred (See **table 4**). As displayed in **table 4**, the main effect was positive and statistically significant (Supplement 2_e) as well as the effect size corrected for publication bias. The Q statistic was statistically significant, so moderation analyses were carried out. We first tested the hypothesis that the strength of effect size may differ between studies investigating long-term memory versus those that did not, but no significant moderation effect was identified ($\beta=.03$, $p>.05$). Then, the moderating role of age, gender, methodological quality, and age of trauma was tested, leading to non-statistically significant results (See **table 5**).

Processing Speed. Five studies, conducted on 692 participants, investigated differences in the Speed domain between individuals with and without PTSD. Because an equal number of observations were retrieved, three-level meta-analysis was not performed. The effect size was positive and statistically significant (Supplement 2_f), and no publication bias was revealed by the Egger's test. These results are detailed in **table 4**. The Q statistic was not statistically significant ($Q(4)=4.43$; $p>.05$), so moderation analyses were not carried out.

Visuospatial domain. Four studies, conducted on 2368 participants, investigated differences in the Visuo domain between individuals with and without PTSD. Because an equal number of observations were retrieved, three-level meta-analysis was not performed. The effect size was positive and statistically significant (Supplement 2_g), and no publication bias was revealed by the Egger's test. These results are detailed in **table 4**. Because the Q statistic was statistically significant, moderation analyses were not carried out. Specifically, we used age, gender and methodological quality as moderating variables. Analyses evidenced a negative and significant moderation effect of the methodological quality (See **table 5**).

Discussion

This systematic review and meta-analysis are aimed to summarize and discuss findings on the relationships between trauma and cognitive functioning. Findings obtained by using qualitative and quantitative analyses indicate a clear association between traumatic experience, its severity, and impaired cognitive performance across the lifespan. However, this association is expressed in different patterns across different cognitive domains.

The present study included empirical investigations that assessed cognitive functions classified into various macro-domains: executive functions, processing speed, attention, and memory. Moreover, a differentiation between studies analyzing trauma exposure versus non-exposure and studies analyzing PTSD and non-PTSD following trauma were considered. Our findings indicate an association between (i) trauma exposure and reduced functioning in the domains of attention, executive functions, and language domains. Additionally, a connection has been identified between PTSD and deficits in attention, executive functions, memory, visuospatial abilities, and processing speed domain. Despite the negative impact of traumatic experience on cognitive performance, the results confirm that the presence of a diagnosis of PTSD is associated with higher cognitive impairment, as demonstrated by the decline in global cognitive functioning in individuals with PTSD compared to those without PTSD. In

summary, studies focused on exposure to trauma and studies that investigated individuals with PTSD diagnosis confirmed a significant impact of the traumatic experience on cognitive functions, independently of the age at which the traumatic experience occurred (from childhood to adulthood) and the distinctive characteristics of the trauma (e.g., maltreatment, abuse, traumatic collective experiences like war), which vary across different studies.

Interestingly, certain distinctions can be ascribed to the comparison of groups with and without trauma, as well as groups with and without PTSD diagnosis. In cases where there was no significant effect on functioning related to traumatic experiences for some domains, such as language, memory, and processing speed, it was found that those who experienced any traumatic event had a worse condition regarding their attentive domain and executive functioning. Considering the diagnosis of PTSD, studies reported the effects of cognitive impairment on almost all domains except for language.

Given the role of executive functions in daily life, this study provides evidence of a clinically relevant issue associated with exposure to trauma. In fact, executive functions are a set of cognitive functions that enable us to engage with the external environment adaptively and direct our behaviours toward specific objectives (Diamond, 2013; Miyake et al., 2000). In this sense, if a traumatic experience affects the individual's executive functions, it will have a cascading effect on their overall functioning and become a possible risk factor for the development of comorbidities, psychopathologies, or psychiatric conditions (Polak et al., 2012; Vargas et al., 2019). Moreover, it should be noted that when examining executive subdomains (inhibition, cognitive flexibility, and working memory (Miyake et al., 2000), a higher effect was observed for working memory, while moderate effects were found for both inhibition and cognitive flexibility. This finding should be considered in conjunction with the analyses conducted on groups exposed to trauma but differ for PTSD diagnosis. The results on the executive functions domain confirmed a moderate effect size, indicating the negative impact of PTSD on this domain. However, no significant differences in the effect size were found for the executive subdomains. This can be interpreted in two different ways. On one hand, trauma has a greater impact on working memory, which may affect daily functioning, regardless of whether a person has been diagnosed with PTSD. On the other hand, the severity of the PTSD diagnosis could have a pervasive impact on all subdomains, without a specific impact on one, but generally affects the quality of life of individuals with a clinical diagnosis (Blanchette & Caparos, 2016). Neuroimaging studies (Etkin & Wager, 2007; Shin & Liberzon, 2010) historically explored the relationship between trauma, PTSD, and executive functions, indicating the networks and structures involved in the symptoms and executive functioning features related to trauma (e.g., amygdala and insula and prefrontal regions). Polak and colleagues (2012), in a meta-analysis on the role of executive functions in PTSD, found that executive impairment is not exclusively linked to trauma exposure but also to PTSD symptoms. Their findings suggest that coping strategies or adaptive mentalization can serve as protective factors that aid in natural recovery from trauma and help prevent the development of PTSD (Polak et al., 2012). Focusing on the meta-analytic results of our work, these confirm previous studies on the shared neural substrate of executive functions (Bryant, 2021; Diamond, 2013). However, there is a lack of research examining the

three-way association between exposure to trauma with and without PTSD and non-exposure to trauma, with the aim to define the extent to which traumatic experience affects cognitive functions. Analyzing this aspect could provide valuable data regarding the relationship between the persistent use of avoidance coping strategies following traumatic experiences and cognitive impairment.

Considering the attention domain, it is worth noting that attention deficits are closely linked to the progression of PTSD (Aupperle et al., 2012; Qureshi et al., 2019). Additionally, the severity of PTSD symptoms can adversely affect the ability to sustain attention to task-relevant stimuli (Brownlow et al., 2014) and screen out irrelevant information, a difficulty that is not confined to specific trauma-related stimuli (Shucard et al., 2008). Together, these findings suggest that patients with PTSD exhibit deficits in the attentional control required to disengage attention from trauma-related stimuli (Ashley et al., 2013). Our study partially confirmed these results as we observed a reliable but low effect size for the visual search component of attention, which suggests a trauma-related impairment in this cognitive domain. However, most studies investigating executive functions primarily compare individuals with a history of exposure and non-exposure to traumatic events (Lakkireddy et al., 2022; Lu et al., 2017; Twamley et al., 2009), and few studies assessed the association between the severity of PTSD and attentional impairment (Burroughs et al., 2018; Kaye et al., 2014). These results highlight the need to further investigate the continuum from non-exposure to exposure associated with PTSD to confirm whether the experience of trauma or the severity of PTSD are more involved in cognitive impairment (Lokshina et al., 2021).

Despite analyzing the relationship between trauma exposure and non-exposure, no difference was observed in the memory domain, but a significant difference emerged considering PTSD. These results are consistent with Eisenberg et al. (2016) findings, who observed that PTSD symptom severity was associated with lower memory performance in a nonclinical sample. To better clarify this association, Sherrill and Magliano (2017) suggested that theories of event perception could help to explain everyday cognitive functioning deficits associated with PTSD. Moreover, PTSD symptoms have a causal relationship with maladaptive encoding, storage, and retrieval of trauma memories (Brewin et al., 2010). Some studies have attempted to investigate the connection between memory impairments and the processing stages (encoding, storage, and retrieval). Uddo et al. (1993) found no group differences on the first two trials of a list learning test, but on the last trials, the group with PTSD showed impaired acquisition. Yehuda (2004) found an impaired ability to learn new verbal information in Holocaust survivors with PTSD. A recent meta-analysis (Petzold & Bunzeck, 2022) summarizes the relationship between PTSD and episodic memory, demonstrating that the experience of trauma by itself is associated with episodic memory deficits beyond the trauma event. Moreover, PTSD further exacerbates these impairments. Despite our results showing a consistent relationship, future research is needed to clarify the role of premorbid cognitive levels of functioning. Indeed, a study found that pre-trauma cognitive dysfunctions are not only symptoms of PTSD but also a vulnerability factor for developing it (Parslow & Jorm, 2007).

To achieve the third aim of our study, this meta-analysis tested the possible impact of the sample's characteristics on the study results. Specifically, gender,

age of the sample, and age of the traumatic experience were considered as moderators. Results did not highlight a significant relationship between trauma and cognitive functioning, suggesting that poorer cognitive functioning emerges after traumatic events regardless of these variables. On the other hand, the relationship between PTSD symptoms and poorer cognitive performance was accounted by concurrent factors, such as gender (i.e., global functioning, language), with females that appear more vulnerable, and type of trauma (i.e., attention), with childhood trauma affecting the relationship. These findings are consistent with the results of previous reviews (Kavanaugh et al., 2017; Perfect et al., 2016; Young-Southward et al., 2020) and meta-analyses (Malarbi et al., 2017; Masson et al., 2015) suggesting that infancy and early childhood are sensitive periods during which the brain and cognitive functions are particularly vulnerable to the toxic stress that trauma exposure represents. Despite this result, the fact that childhood trauma did not result to be associated with worse cognitive functioning in the other domains compared to adulthood trauma was quite unexpected. Different reasons may account for this. First, from a methodological point of view, our moderation analyses may have lacked sufficient power to identify significant effects. Then, it should be noted that most of the studies investigating adulthood trauma did not exclude participants having experienced childhood trauma despite adverse childhood experience is a powerful risk factor for victimization in adulthood (Fereidooni et al., 2023). From this perspective, the unique role of adulthood trauma in cognitive functioning may not have been identified by studies and, consequently, this meta-analysis. Future additional and exhaustive primary studies on the topic may allow the use of meta-analytic structural equation modelling to overcome this issue.

Despite the valuable insights provided by this study, including meta-analytic evidence, we cannot draw strong conclusions about the significance of the effect sizes due to the generally low power of the studies. This important limitation of the study may be ascribed to multiple factors. First, as emerged from the analysis of tools used to evaluate cognitive functions and trauma, the heterogeneity in measures across studies impacts the overall power of the analyses. In this sense, a relevant aspect that should be considered from a theoretical and practical perspective is the phenomenon of task impurity. Similar tasks are adopted to determine performance in different domains, just as a single task can provide information on several cognitive functions (Sörqvist, 2014). In accordance with this, adopting tasks in a trans-functional or multi-functional manner could play a role in reducing the effect or increasing heterogeneity when observing performance or differences in functioning on the single domain rather than overall cognitive functioning. Also, detecting the role of specific types of traumas rather than classifying the experiences in the domains adopted in the studies would be an alternative way of analyzing this matter. Nevertheless, the high heterogeneity of the trauma classification could always hinder the analysis. Moreover, the studies reviewed and meta-analyzed did not offer insight into the causality between trauma and cognitive functioning. Although we suggested a point of view in which traumatic experiences may affect cognitive functions, these assumptions require support from longitudinal studies, which are still lacking. For instance, childhood abuse is associated with school dropout, which, in turn, is likely to impact cognitive functioning negatively (Mennen et al., 2022).

An important limitation of the present review

concerns the specificity of the search strategy adopted. Our use of cognitive impairment-related keywords (e.g., dement, “cognitive decline”, “cognitive dysfunction”) may have inadvertently narrowed the scope of the literature retrieved. This approach differs from previous reviews that employed broader cognition-related terms (e.g., cognit*, neurocognit*, neuropsych*; Schuitevoerder et al., 2013; Vargas et al., 2019). This discrepancy likely contributed to the omission of some relevant studies—including research conducted in clinical populations other than PTSD—and may explain why certain pertinent works (e.g., Sideli et al., 2023) were not captured in our initial search. Future updates of this review would therefore benefit from replicating the search using broader cognitive keywords to enhance comparability with earlier reviews and reduce the risk of missing potentially relevant contributions.

Another limitation of our study delineates a potential intriguing direction for future research that may want to better focus on the clinical characteristics of the sample recruited in the studies included. Indeed, despite we did not exclude studies conducted on samples suffering from psychiatric disorders other than PTSD, we did not systematically extract and code this information and evaluate the potential moderating role of this variable. It should be noted that in most of the studies included, suffering from some psychiatric disorder was not an exclusion criterion and the clinical composition of the sample was likely to be heterogeneous. More research performed on more homogeneous clinical samples may illuminate the complex impact of the interactions between trauma exposure, PTSD, and comorbid non-PTSD mental disorders on cognitive functioning.

In conclusion, the evidence presented in this study provides different research and clinical implications. First, the suggestion of the direct association between trauma and cognitive functions suggests the importance of further examining the characteristics of the trauma with the aim to overcome the weakness of evidence on how different traumas may differentially affect individuals’ health and impair different cognitive domains. This would significantly impact clinical practice by providing clear guidelines for intervening in traumatic experiences throughout the life span to reduce the risk of cognitive impairment. This need is also supported by the evidence on childhood trauma. A preventive approach can be proposed with the aim of reducing the impact of early traumatic experiences on cognitive functions in younger people, reducing long-term effects on lifespan (Rosen et al., 2018) and enhancing people’s resilience.

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