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Psychological processes mediating the association between developmental trauma and specific psychotic symptoms in adults: a systematic review and meta-analysis

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Experiencing psychological trauma during childhood and/or adolescence is associated with an increased risk of psychosis in adulthood. However, we lack a clear knowledge of how developmental trauma induces vulnerability to psychotic symptoms. Understanding the psychological processes involved in this association is crucial to the development of preventive interventions and improved treatments. We sought to systematically review the literature and combine findings using meta-analytic techniques to establish the potential roles of psychological processes in the associations between developmental trauma and specific psychotic experiences (i.e., hallucinations, delusions and paranoia). Twenty-two studies met our inclusion criteria. We found mediating roles of dissociation, emotional dysregulation and post-traumatic stress disorder (PTSD) symptoms (avoidance, numbing and hyperarousal) between developmental trauma and hallucinations. There was also evidence of a mediating role of negative schemata, i.e. mental constructs of meanings, between developmental trauma and delusions as well as paranoia. Many studies to date have been of poor quality, and the field is limited by mostly cross-sectional research. Our findings suggest that there may be distinct psychological pathways from developmental trauma to psychotic phenomena in adulthood. Clinicians should ask people with psychosis about their history of developmental trauma, and screen patients with such a history for dissociation, emotional dysregulation and PTSD symptoms. Well conducted research with prospective designs, including neurocognitive assessment, is required in order to fully understand the biopsychosocial mechanisms underlying the association between developmental trauma and psychosis.

Key words: Developmental trauma, psychotic symptoms, childhood, adolescence, delusions, hallucinations, paranoia, post-traumatic stress disorder, dissociation, psychological processes

Causative associations between psychologically traumatic experiences during childhood and/or adolescence – hereon referred to as "developmental trauma" (DT) – and adult psychopathology were proposed in the 19th century by Breuer and Freud[1]. These theories were elaborated by Ferenczi[2], who suggested that childhood sexual abuse could give rise to psychotic symptoms in adults. Following these early conceptualizations, and notwithstanding unmeasured confounds, consistent observational evidence indicates that people who experience DT have a higher risk of psychosis in later life[3-7].

Meta-analyses indicate that the odds of experiencing a psychotic disorder are approximately three times higher in adult survivors of DT, compared to those who have not experienced DT, with the overall population attributable risk for development of psychosis associated with DT being 33%[6,8]. Importantly, the association between DT and psychosis during adulthood is unlikely to be the result of reverse causality or passive gene-environment correlations[9]. Clinically, adult survivors of DT with psychosis have a more severe illness and are more likely to be hospitalized than people with psychosis who have not experienced DT, indicative of the urgent need to improve treatment outcomes in this population[10,11].

There is, therefore, clear evidence that DT is associated with an increased risk and severity of psychosis, but an understanding of the processes or pathways involved is lacking. Whilst recent progress has been made in our knowledge of the biopsychosocial sequelae of DT[12], there remains a gap in understanding how psychotic symptoms arise following DT. This is a barrier to the development of effective secondary preventive measures for adult survivors of DT and treatments for survivors with psychosis[13].

Several lines of evidence support the view that post-traumatic stress disorder (PTSD)-type phenomena are associated with psychotic symptoms in adult survivors of DT with psychosis[14-20]. Stress-induced changes in information processing during exposure to psychological trauma may result in fragments of highly emotionally salient memories being laid down which lack temporospatial and sensory contextual data that would normally be present in non-traumatic episodic memory processing[21]. The re-emergence of these poorly integrated memories may underlie trauma-related hallucinations.

Additional processes that may be involved include dissociation, hyperarousal, avoidance and mood instability. Dissociation is an umbrella term used to refer to reactions including detachment (e.g., depersonalization and derealization) and compartmentalization (i.e., suppression of thoughts and emotions)[22]. Dissociation has been proposed to have an initial adaptive (defensive) role in response to traumatic experiences as part of the acute stress response[23,24]. However, peri-traumatic detachment is likely to interfere with encoding of material and therefore impair the quality of memory and distort meanings[22]. Furthermore, hyperarousal and avoidance have been proposed to increase vulnerability to psychosis through increased threat anticipation[25]. Mood instability may also create a mental environment

in which psychotic beliefs and experiences emerge[26]. For example, bursts of anxiety occurring with otherwise neutral environmental stimuli may be viewed as signs of threat, prompting a search for meaning and attribution to external agents, resulting in paranoia.

There are also further factors that can complicate the processing of DT. These relate to schemata (i.e., mental constructs of meanings) learned through experiences of trauma, such as negative beliefs about the self and beliefs that the environment is dangerous and uncontrollable. They may be involved in the evolution of psychotic experiences, for example, by influencing the content of hallucinations and/or delusional beliefs[27-29].

Together, these processes are likely to further result in isolation, potentially exacerbating suspicion of others and paranoid thinking through impaired social safety learning. Finally and importantly, additional complexities may arise from experiencing abuse from an attachment figure, which can be associated with difficulties in emotional regulation and interpersonal relationships[30].

Most research to date has investigated the relationships between trauma and psychotic symptoms in general, rather than specific psychotic symptom domains. Understanding the psychological processes associated with specific psychotic symptoms in the context of DT has the potential to lead to improved treatments, including both psychotherapies and pharmacotherapies.

We therefore sought to systematically review studies that have investigated psychological processes in relation to DT and specific psychotic symptom domains (i.e., hallucinations, delusions and paranoia) in adults. We also combined sets of findings using meta-analytic techniques in order to further contribute to this state-of-art review by indicating whether the psychological processes investigated are statistically significant across studies and quantifying the magnitude of their effects.

METHODS

This systematic review and meta-analysis was pre-registered on PROSPERO (registration no. CRD42018112883).

Inclusion criteria and search strategies

We included studies investigating the role of psychological processes potentially underlying the association between DT and specific psychotic symptom domains in adulthood. We included all types of clinical and community samples. We defined DT to comprise loss of a parent, childhood maltreatment and victimization (including sexual, physical and emotional

abuse, and bullying) and neglect. We excluded studies if they: a) did not measure specific psychotic symptoms and/or experiences, but examined psychotic symptoms as a whole (e.g., total score on a measure of psychotic symptoms such as the Positive and Negative Syndrome Scale, PANSS); b) did not differentiate between trauma experienced in childhood and adulthood; c) solely examined neurobiological processes with no measure of psychological processes, or d) were not available in English.

We systematically searched PubMed, Web of Science and PsycINFO. We used search terms that were related to psychosis (e.g., “psychosis” and “schizophreni*”) to identify studies investigating psychotic experiences in clinical, at-risk and non-clinical populations. We used search terms including “hallucinat*”, “delusion*”, “paranoi*” and “negative” to identify studies of specific psychotic symptoms. We used terms including “physical abuse”, “emotional abuse”, “psychological abuse”, “sexual abuse”, “neglect”, “molest*”, “bullied” and ”bully*” to identify studies of DT. We used terms including “mechanism”, “mediat*”, “process*", and “model” to identify studies examining potential mechanisms between DT and psychosis. No restrictions were placed on date of publications. The reference lists of suitable papers obtained from this search were hand-searched to identify further relevant studies.

After piloting the search and data extraction tool, the final search was conducted on August 26, 2020. Each stage of data screening and extraction was completed by two independent reviewers, and discrepancies were resolved with a third reviewer.

Quality assessment and strength of evidence

We used the Newcastle-Ottawa quality assessment scale to assess methodological quality and risk of bias[31]. In brief, each study is rated on three broad criteria: selection of the study groups; comparability of the groups; and the ascertainment of the exposure or outcome of interest. A score of 7 or more for case-control and cohort studies, and of 6 or more for cross-sectional studies, is indicative of “good” quality and bias control. Two reviewers independently applied the tool, and discrepancies were resolved through discussion with a third reviewer. As this is an under-researched area, all studies were included regardless of quality rating.

The Oxford Centre for Evidence-based Medicine – Levels of Evidence guideline was used to assign a level of evidence to each study, to facilitate the development of overall clinical recommendations[32]. This tool provides a hierarchy of study designs from 1 to 5, whereby a lower number indicates a higher level of evidence.

Meta-analyses

Where three or more studies investigating the same psychological mediating process for the same psychotic experience and/or symptom were available, we sought to combine sets of findings using meta-analytic techniques. Meta-analyses were performed using the 'metan' command in Stata (version 15), which employs a random effects model.

The effect size for each study was estimated by calculating Cohen's d and 95% confidence intervals (CIs). Studies reporting effect sizes which cannot be converted to Cohen's d were excluded from the meta-analysis. Pooled effect sizes were weighted based on the sizes of CIs. We tested heterogeneity by examining χ^2 and I^2 statistics**.** Jack-knife sensitivity analyses were performed by individually removing each study and re-running the meta-analyses.

RESULTS

Systematic review

Study characteristics

We identified 22 studies investigating psychological phenomena associated with DT and psychotic symptom domains, published between 2011 and 2020. Every study assessed DT retrospectively during adulthood based on self-report, and all but one[33] were mediation studies. Details of the selection process are presented in our PRISMA flow chart in Figure 1.

The 22 studies included 24,793 participants in total, of which 1,639 were from clinical and 23,154 from non-clinical samples (see Table 1). Clinical populations included patients diagnosed with schizophrenia, schizoaffective disorder, psychotic disorder, bipolar disorder, depression, relapsing psychosis, first episode psychosis, and those categorized as at ultra-high risk for developing psychosis as well as voice-hearers with a psychosis-related diagnosis.

Of the included papers, one was a cohort study, seven were case-control studies, and fourteen were cross-sectional studies. Ten studies used clinical interviews along with self-report questionnaires[26,33,36,43-45,47,48,52,53], one used a signal detection task to assess hallucination proneness[52], and one used a virtual reality scenario to assess paranoia[46].

Quality and strength of evidence appraisal

A detailed description of the methodological quality of the studies as measured on the Newcastle Ottawa Scale is presented in Table 2. Amongst studies which met the criteria for

"good" quality, there are two case-control studies[34,52], one cohort study[47], and two cross-sectional studies[33,43].

In terms of level of evidence, the included studies ranged from levels 2a to 3b. Two studies had the highest level of evidence. The first was a prospective study with good follow-up rates at three months (84.7%), that included a clinical sample recruited from mental health outpatient clinics and used validated clinical interviews[47]. The second analyzed data from 2000 and 2007 UK national surveys of psychiatric morbidity, which included an 18-month follow up of a sub-sample of the 2000 survey, and used validated clinician-rated and self-report measures[26]. Only one of those two studies was rated as "good" quality using our criteria for quality assessment[47].

We identified several methodological limitations of the included studies. While four of them were prospective[26,43,44,47], all but one of these made assessments at single time points and therefore provided cross-sectional data. The remaining studies were all retrospective and made assessments only at one time point. Furthermore, all studies except one[47] had poor follow-up rates. Although all studies utilized validated psychometric instruments, more than half relied on self-report measures only. In addition, several studies used methods of recruitment which may limit generalizability: three recruited non-clinical samples using snowballing[40,41,53], three enrolled clinical samples through case managers[36,40,41], and three used convenience sampling including, for example, advertisements in clinics[35,36,39].

We categorized studies into higher-order groupings to allow examination of the role of different psychological processes in the associations between psychotic symptoms and DT. Based on our search, we used the following groupings: dissociation, PTSD symptomatology, schemata and belief systems, obsessive-compulsive phenomena, emotional dysregulation, attachment and social cognition. Results of studies were then further subdivided into the different psychotic experiences examined, namely hallucinations, delusions and paranoia. A visual overview of the findings can be found in Figure 2.

Statistical approaches used

Details of the statistical methods used in the studies are provided in Table 1. Ten studies used mediation analyses[34,35,37,38,42,48-50,52,53], one used directed acyclic graphs[33], three studies adopted path models[40,41,46], four used regression models[26,39,43,45], and one applied a network analysis[44]. Of these, only six[35,39,43,45,50,53] accounted for potential confounders in their analyses.

Dissociation

There was converging evidence, also from high-quality studies, that dissociative processes mediate the relationship between childhood trauma and hallucinations during

adulthood[37,42,43,47,48,52]. This finding was consistent across clinical[43,47,48,52] and non-clinical[37,42] samples. One high-quality study[43] looked at types of dissociative phenomena, highlighting depersonalization and derealization as particularly important, rather than dissociative amnesia, or absorption and imaginative involvement. This study was conducted as part of a larger longitudinal study which assessed symptoms at baseline and at 3-, 6-, 12-, and 24-month follow-ups. However, results were reported from the 3-month follow-up only, and follow-up rates and results for other sessions were not presented. When looking at specific DT experiences, there was evidence from clinical and non-clinical samples that dissociation mediated the relationship between childhood sexual abuse and auditory hallucinations in adulthood[42,43,52].

In terms of delusions, a high-quality prospective cohort study[47] with good follow-up rates found evidence of a dose-response relationship between DT and delusions in adulthood, and dissociation partially mediated this relationship. However, whilst other studies reported associations between DT, delusions and dissociation, mediating effects were not observed[43,48]. We did not identify studies that investigated the relationship between dissociation and paranoia.

PTSD symptoms

There was evidence from two studies that PTSD symptoms mediated the association between childhood sexual abuse and auditory hallucinations in adulthood[43,45]. One study used data collected as part of the 2007 UK national survey of psychiatric morbidity[45], while the other used data collected as part of a larger longitudinal study[43]. Avoidance, numbing and hyperarousal were found to mediate this association, but not intrusive trauma memories[43].

Other studies investigated experiential avoidance and external misattribution (a form of source monitoring error where internal sensations or thoughts are attributed to an external source, i.e. something seen or heard), although they had methodological limitations. Experiential avoidance partially mediated the relationship between sexual abuse and hallucinations[40,41]. The role of external misattribution of post-traumatic intrusive memories, such as flashbacks, in the relationship between DT and hallucinations in adulthood was observed in one study[36]. Adults with psychosis who had experienced DT did not show greater external misattribution than those without a DT experience, or healthy controls without trauma[36].

Emotional dysregulation and affect

Nine studies examined the potential mediating role of variables associated with emotional

dysregulation[26,33,35,39,43-45,50,51], two of which used data from the same sample[26,33]. There was evidence, also from one high-quality study, that emotional symptoms including anxiety and depression mediated the association between DT experiences and hallucinations in adulthood[33,44,51], although this was not found in all studies[45,50]. In one study, there was an indirect effect of DT severity on voice-related distress through negative voice content[50].

The role of mood instability on auditory hallucinations specifically has also been investigated. One study[26] analyzed data collected from 2000 and 2007 UK national surveys of psychiatric morbidity. Mood instability was significantly predictive of hallucinations following childhood sexual abuse, and mediated a quarter of the association between childhood sexual abuse and auditory hallucinations in adulthood.

In terms of delusions, an affective pathway between childhood trauma and psychotic symptoms during adulthood was identified by a prospective study using a network analysis, and anxiety was the most significant mediator between childhood sexual abuse and delusions during adulthood, although follow-up rates were not given[44].

Two studies, one in a clinical[44] and the other in a sub-clinical sample[39], found that anxiety mediated the relationship between DT and paranoia later in life. These effects may be specific to adult-to-child maltreatment, as anxiety did not mediate the relationship between peer bullying and paranoia in a separate study, which was limited by its convenience sampling of undergraduate students[35]. Nonetheless, depression (and negative self-beliefs) did mediate specifically between experiences of indirect aggression in childhood and adulthood paranoia[35]. Evidence for the mediating role of depression between DT and paranoia has also been found by some other high-quality studies[39,43,51]. A recent study analyzing data from the 2000 and 2007 UK national surveys of psychiatric morbidity, using a Bayesian directed acyclic graph model, found no support for the mediating roles of depression, as well as anxiety or sleep disturbance, in the relationship between bullying victimization and persecutory ideation during adulthood, suggesting instead that these lie causally downstream from persecutory ideation[33]. A potential role for mood instability was found in another study for the association between childhood sexual abuse and adulthood persecutory ideation[26]. Taken together, these studies suggest that depression, anxiety and mood instability may be associated with increased risk of paranoia following certain types of DT.

Schemata, beliefs and metacognitive beliefs

A schema is a dynamic constellation of cognitions, feelings and motivations. In terms of delusions, there was evidence from one high-quality study[43] that the relationship between childhood emotional abuse and delusions in adulthood was mediated by negative other-beliefs, rather than negative self-beliefs. There was high-quality evidence that negative self

and other schemata mediate the association between DT, particularly emotional abuse and neglect, and paranoia in adulthood[34,43,53]. There was lower-quality evidence for a role of beliefs in a "just world" in the development of paranoia[53].

In a non-clinical sample, abandonment schema mediated the relationship between childhood emotional abuse and auditory hallucinations in adulthood[37]. In the same study, subjugation and vulnerability schemata were involved in the association of emotional and sexual abuse with auditory hallucinations, although this was accounted for by dissociation[37].

Metacognitive beliefs, including those about the uncontrollability and danger of thoughts, as well as measures of cognitive confidence, need for control, and cognitive self-consciousness have also been investigated. When combined with subsequent stressors, these negative metacognitive beliefs partially mediated the relationship between DT and hallucinations[41]. However, these studies were of lower quality. We did not identify studies that investigated the relationship between metacognitive beliefs and paranoia.

Obsessive-compulsive spectrum phenomena

Data collected by the 2007 UK national survey of psychiatric morbidity were used to investigate the relationship between childhood sexual abuse, obsessive-compulsive symptoms and auditory verbal hallucinations. In this study, compulsions, but not obsessions, partially mediated the relationship between childhood sexual abuse and auditory verbal hallucinations in adulthood[45]. Paranoia and delusions in adulthood were not investigated as outcomes in this study, nor in any of the other studies.

Attachment and social processes

There was some evidence that disrupted attachment plays a mediating role in the relationship between childhood trauma and psychotic experiences during adulthood[37,49,51], although these studies were not rated as high-quality. Anxious attachment has been associated with higher severity and distress related to auditory hallucinations[49]. Furthermore, abandonment schema, arguably related to early attachment, mediated the relationship between emotional abuse and auditory hallucination proneness in adulthood[37].

There was some evidence of specificity in the mediating role of attachment styles in the relationship between trauma types and hallucinations. For example, anxious attachment partially mediated the relationship between childhood sexual abuse and adulthood hallucinations, whereas avoidant attachment mediated the relationship between being held captive or threatened with a weapon during development and adulthood hallucinations[51]. However, when the statistical model included measurements of depression, the mediating

effects of anxious and avoidant attachment were significantly reduced, and the effect of anxious attachment on the association between childhood sexual abuse and hallucinations in adulthood was no longer significant.

Avoidant and anxious attachment mediated the association between a range of DTs and adulthood paranoia[51]. The strongest association was found for anxious and avoidant attachment as a mediator between childhood neglect and paranoia in adulthood. These findings have also been extended to bullying, whereby bullying severity was significantly associated with paranoid ideation in later life, and this association was mediated by interpersonal sensitivity[46].

A more recent study with a non-clinical sample failed to find support for the rejection sensitivity model in the association between bullying and paranoid thinking in adulthood, instead finding that negative self-beliefs and depression mediated between childhood bullying experiences, specifically of indirect aggression, and adulthood paranoid thinking[35]. This study also found negative other-beliefs to mediate between direct verbal aggression in childhood and adulthood paranoid thinking.

Meta-analysis

We meta-analyzed the role of the following mediating relationships where three or more studies were available: dissociation and hallucinations[37,42,47,48,52], negative other-beliefs and paranoia[35,39,53] , and emotional dysregulation and hallucinations[26,33,45,50]. Although five studies investigated the mediating role between PTSD symptomatology and hallucinations[36,39,41,43,45], effect sizes of individual mediators could not be extracted from two of the studies[36,41].

Due to the low number of publications, we included studies in our meta-analysis regardless of quality or risk of bias. A visual overview of the findings can be found in Figure 3.

Dissociation and hallucinations

All five studies investigating dissociation as a mediator of psychosis found that it positively predicted hallucinations following DT[37,42,47,48,52]. One high-quality study was excluded from the meta-analysis due to its reporting of effect sizes as incidence rate ratios, which could not be directly converted to Cohen's d based on information provided[47].

Meta-analysis indicated that dissociation is a statistically significant mediator of the relationship between DT and hallucinations in adulthood (pooled Cohen's d=0.35; pooled 95% CI: 0.25-0.45, see Figure 4). There was high heterogeneity between studies (I^2=71.8%). Sensitivity analysis revealed that no study significantly affected the pooled effect size.

Schemata, beliefs and paranoia

Among the three studies included in the meta-analysis[35,39,53], two reported findings that negative other-beliefs mediate the association between DT and paranoid ideation in adulthood[35,53]. Although one other high-quality study included in the systematic review[34] also supported the mediating role of negative schemata between childhood mistreatment and adulthood paranoia, it was excluded from meta-analysis due to its focus on self schemata rather than schemata about others.

Meta-analysis indicated that negative other-beliefs are not a statistically significant mediator between DT and paranoia in adulthood (pooled Cohen's d=0.02; pooled 95% CI: −0.04 to 0.09, see Figure 5), with relatively low heterogeneity between studies (I^2=48.1%).

Emotional dysregulation and hallucinations

Four studies investigated the mediating role of emotional dysregulation in the development of hallucinations following DT exposure. Findings that mood instability mediated the development of auditory hallucinations were reported in two studies[26,33]. One of these studies was excluded from the meta-analysis due to employing directed acyclic graphs which estimated causal relationships in a form which could not be converted into Cohen's d effect size[33]. Two other studies found that depression had no mediating role between DT and auditory verbal hallucinations or voice-related distress in adulthood[45,50].

Meta-analysis indicated that emotional dysregulation is a statistically significant mediator between developmental trauma and auditory hallucinations in adulthood (pooled Cohen's d=0.06; pooled 95% CI: 0.02-0.10, see Figure 6). However, there was high heterogeneity between studies (I^2=85.8%). One study[45] had a substantially larger sample size (N=5,788) and smaller 95% CI than others and was assigned a weight of 84.53%. As a result, the pooled effect size was almost equal to that reported from this study. Sensitivity analysis revealed that one study affected the pooled effect size significantly[26]. Its removal altered the pooled effect size to become non-significant (pooled Cohen's d=0.022, pooled 95% CI: −0.021 to 0.066).

PTSD symptoms and hallucinations

Five studies investigated the mediating role of PTSD symptoms between DT and hallucinations in adulthood. Only one study investigated PTSD symptomatology as a whole[45]; four other studies investigated specific PTSD symptoms, including experiential avoidance[38,43], trauma-related intrusions[38,43], external misattribution[36,41], post-traumatic hyperarousal[43] and shame[38]. Effect sizes extracted from three studies[38,43,45] were included in the meta-analysis.

One study was excluded due to its use of a path analysis model which combined life hassles with developmental trauma[41]. Another study was excluded because effect sizes were not reported[36].

Meta-analysis indicated that PTSD symptoms, overall, are a statistically significant mediator between DT and hallucinations in adulthood (pooled Cohen's d=0.12; pooled 95% CI: 0.07-0.17, see Figure 7). However, there was high overall heterogeneity between studies (I^2=84.6%) and between subgroups. Sensitivity analysis revealed that no study significantly affected the pooled effect size.

DISCUSSION

In the first systematic review and meta-analysis of psychological phenomena potentially mediating the relationships between DT and specific psychotic symptom domains, we found evidence that dissociation, PTSD symptoms and emotional dysregulation are associated with hallucinations. We also found some evidence supporting associations of negative schemata with paranoia and delusions.

Major limitations of the existent literature include the reliance on self-report measures of DT obtained in adulthood, and self-report measures of psychopathology. Importantly, since the work presented here is based on cross-sectional studies, we are unable to make inferences regarding the temporality of phenomena investigated and causal effects between the variables. It is therefore still possible that specific psychotic symptoms may be mediating the effect of trauma on the psychological phenomena described. This highlights the need for longitudinal studies.

Interpretation of results

Our results extend previous models of the mechanisms underlying psychosis following trauma[54]. Experiencing psychological trauma is associated with dissociation, which is thought to function as an automatic coping (defence) mechanism[55]. The finding that dissociation may be a mediating factor between DT and hallucinations is in keeping with work on trauma and voice-hearing[5,56-59], although not all authors agree[60]. Indeed, there is longitudinal evidence that childhood dissociative experiences are associated with subsequent auditory hallucinations[61]. It has been suggested that dissociation may contribute to the development of hallucinations through decreasing an individual's ability to judge the reality of internal experiences, arguably a form of source attribution error[48,62]. Within this context, non-integrated trauma memories may be externally attributed as "voices" rather than "memories"[63]. In fact, there is recent evidence

that dissociation may be a marker of comorbidity of psychosis with PTSD[64]. A further possibility is that voice-hearing in the context of trauma is dissociative rather than psychotic in nature. Within this account, experiences of voices are dissociated or disowned components of the self that result from trauma[65].

DT can alter emotion regulation and stress reactivity, including in individuals experiencing psychosis[66-68]. Our finding that emotional dysregulation plays a mediating role in hallucinations and paranoia is in line with the threat anticipation model[58,59]. Plausible mechanisms include sensitization to environmental stressors[69] and hyperactivity of hypothalamic-pituitary-adrenal (HPA) axis. Increased stress sensitivity is observed across the psychosis spectrum, including non-clinical populations[70], individuals at ultra-high risk of psychosis[71]; and clinical populations with psychotic disorder[67]. HPA axis hyperactivity has been found to precede onset of psychotic disorder[72], and is associated with both abnormal dopaminergic activity and structural changes in the brain[73]. There is also converging evidence that DT causes structural and network connectivity alterations in and between key regions involved in memory and emotional processing, including the hippocampus, the amygdala and anterior cingulate cortex[12]. These accounts are consistent with information processing models, whereby DT-induced brain changes result in greater amygdala-driven processing, impaired integration of information processing and more anomalous experiences[74].

Our finding that PTSD symptoms are implicated in the relationship between DT and hallucinations can be interpreted in the light of dominant models of PTSD[21,75]. Under normal conditions, perceptual, emotional and spatiotemporal information is encoded as an integrated contextual engram (representation), which is then perceived as having occurred in the past when the memory is recalled. Under traumatic conditions, perceptual and emotional information is encoded as sensory representations that have not been integrated and lack spatiotemporal information. Trauma memories are stored as unintegrated fragments, which are prone to involuntary retrieval and are re-experienced in an emotionally raw (unprocessed) form in the here and now. Such an account is consistent with findings that hallucinatory content is thematically linked to experiences of trauma[5,54,76-78]. Within this framework, an intrusive trauma memory may be misinterpreted in a psychotic way (i.e., the trauma memory is the anomalous experience that is mis-appraised). Failure of reality testing is a common sequel in PTSD patients[79], and hallucinations and delusions are considered a sign of this[80].

The possibility that PTSD and psychosis in the context of DT have shared underlying mechanisms is consistent with evidence from neuroimaging studies that brain regions including the hippocampus, amygdala and prefrontal cortex are implicated in PTSD[81], and that the structure and functioning of these regions differ between adult DT survivors with psychosis and individuals with psychosis who have not experienced DT[82].

Experiencing DT can understandably result in negative beliefs about the self and others.

It has consistently been hypothesized that paranoia and delusions result from disrupted belief systems[83], and our study lends some support to this. Further high-quality research in this area is needed to confirm the view that paranoia and delusions may arise from internalized (learned) negative schemata. It is likely that DT induces alterations in the threat system[12], so that individuals may anticipate threat and danger at significantly lower thresholds than their peers.

Clinical implications

People with psychosis are frequently not asked about their DT histories[87]. This may contribute to low service engagement amongst adult DT survivors with psychosis[87-89]. The situation is compounded by poor responses to initial disclosures of DT, including low referral rates for trauma-related interventions[90]. Clinicians should screen psychotic patients for PTSD, dissociative symptoms and emotional difficulties, and refer them for specialist treatment where available. Clinician leaders should develop effective treatment pathways for people with comorbid PTSD and psychosis. The relationship between psychosis in adult DT survivors and the new ICD-11 diagnosis of complex PTSD (i.e., PTSD plus persistent and pervasive disturbances in affect regulation, self-concept and relational functioning)[91,92] should be investigated.

Several psychotherapeutic and pharmacological interventions are available which target the processes outlined in this review. There is an evidence base for addressing emotional regulation through a range of psychotherapies, including mentalization-based therapy, cognitive-behavioral therapy (CBT) and dialectical-behavioral therapy. Evidence is emerging on successful psychotherapies that can target dissociation[93]. Further work is needed to evaluate these interventions in adult DT survivors with psychosis. There is a growing interest in trauma-focused CBT for psychosis, and the results of currently ongoing multicentre trials are awaited[94]. Regarding pharmacotherapy, medicines already exist that have an evidence base for the treatment of PTSD and are capable to address negative emotional processing biases[95]. Work is needed to investigate whether these agents are effective in reducing psychotic symptoms in this group of patients. Research is also warranted into pharmacological treatments for dissociation.

Strengths and limitations

This study has a number of strengths. It is the first study to systematically examine psychological mechanisms mediating between DT and specific symptoms of psychosis. Furthermore, our search terms were broad, and we did not restrict studies to specific forms of child abuse, leading to the inclusion of a broad range of studies in this area. We also did not

limit participant diagnoses, resulting in a transdiagnostic view of psychological processes associated with psychotic experiences.

However, it must be acknowledged that our review has some limitations. Included studies predominantly implemented cross-sectional mediation analyses, precluding inferences on causation. Most studies did not account for confounders when examining the associations between DT, the mediator (psychological phenomena of interest) and the outcome (psychotic experiences). There is a paucity of research using experimental vs. (observational) clinical psychological measures, and work is urgently needed into underlying neurocognitive mechanisms. A number of studies did not specify the type of DT experienced, and we were not able to account for the co-aggregation of experiences of trauma[96]. Furthermore, the majority of the studies relied on questionnaires as trauma measures rather than clinician rated tools. As with other research in the field, given the scarcity of phenomenological rigour in many of the included studies, a limitation lies in clinical diagnostic challenges and difficulties in classifying symptoms (e.g., psychotic vs. dissociative). Finally, our meta-analyses were limited by not including an assessment of publication bias, due to the insufficient number of studies available.

CONCLUSIONS

Our review has found evidence of mediating roles of dissociation, emotional dysregulation and PTSD symptoms between DT and hallucinations. There was also evidence of mediating roles of negative schemata between DT and delusions as well as paranoia. These findings suggest that there may be distinct psychological pathways from DT to psychotic phenomena in adulthood. However, the existing evidence is mostly based on cross-sectional studies, and more prospective research is needed.

There is a pressing need to elucidate the neurocognitive mechanisms involved and to further phenomenologically understand the subjective experience of DT survivors. Further work is needed to understand the relationships between psychosis in adult DT survivors and the new diagnostic construct of complex PTSD. Understanding the temporal dynamics of the relationships between DT, underlying mechanisms and psychotic symptoms is likely to be key to the development of new treatments and secondary preventive interventions.

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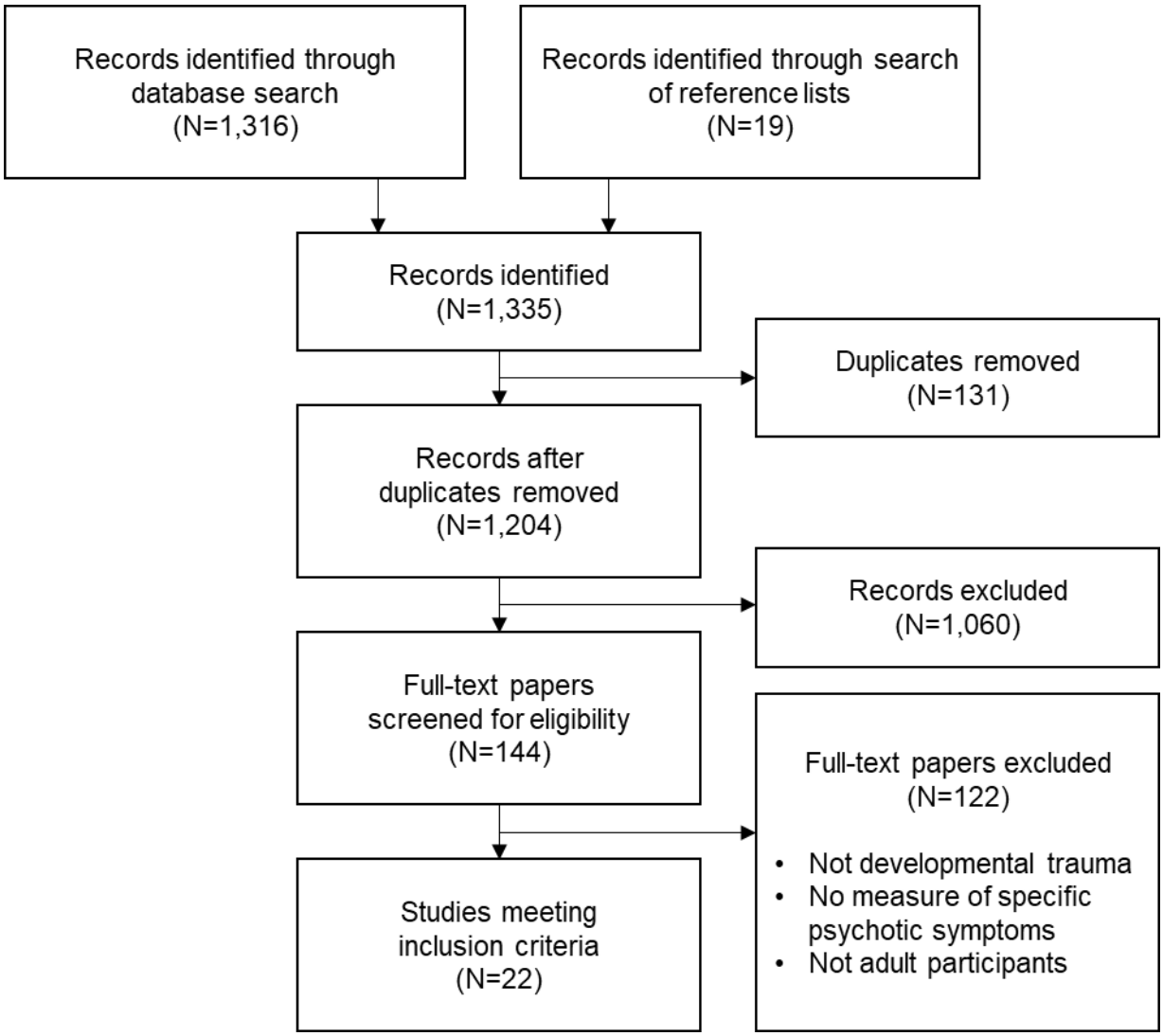

Figure 1 PRISMA flow chart

Table 1 Characteristics and main findings of included studies

Study	Study design	Level of evidence	Sample	Type of developmental trauma (DT)	Phenomenon investigated	Psychotic symptom focused on	Main findings
Appiah-Kusi et al[34]	Case-control	3a	30 individuals at ultra-high risk for psychosis and 38 healthy controls	Abuse (emotional, physical and sexual) and neglect (emotional and physical)	Negative self-schemata	Paranoid ideation	Negative cognitive schemata about the self partially mediated between emotional neglect in childhood and paranoia.
Ashford et al[35]	Cross-sectional	2b	135 undergraduate students	Bullying: indirect aggression, direct verbal aggression, direct physical aggression	Negative self- and other-beliefs, depression and anxiety, interpersonal sensitivity	Paranoid thoughts: persecution and social reference	Negative self-beliefs and depression mediated between childhood experience of indirect aggression and paranoia. Negative other-beliefs mediated between direct verbal aggression and paranoia.
Bendall et al[36]	Case-control	3a	44 individuals with first episode psychosis and 26 healthy controls	Abuse (emotional, physical and sexual) and neglect (emotional and physical)	External misattribution	Hallucinations	DT was not associated with external misattribution, which therefore did not mediate a relationship with hallucinations.
Bortolon et al[37]	Cross-sectional	2b	425 participants recruited online	Abuse (emotional, physical and sexual) and neglect (emotional and physical)	Dissociation and early maladaptive schemata	Auditory hallucinations	Dissociation mediated between DT and auditory hallucinations. Abandonment schema mediated between emotional abuse and auditory hallucinations.
Bortolon & Raffard[38]	Cross-sectional	2b	175 individuals from general population	Adverse childhood experiences, bullying victimization	Shame; trauma-related intrusions and avoidance	Hallucinations	Shame and intrusions mediated between DT and hallucinations.

Fisher et al[39]	Cross-sectional	3a	212 individuals from general population	Abuse (emotional, physical and sexual) and neglect (emotional and physical)	Negative beliefs about the self and others, depression and anxiety	Paranoia	Anxiety partially mediated between emotional abuse and paranoia. Negative self- and other-beliefs did not mediate between emotional or physical abuse and paranoia. Depression did not mediate either association.
Goldstone et al[40]	Case-control	3a	100 individuals with psychosis and 133 non-clinical participants	Physical and emotional trauma, sexual abuse	Experiential avoidance	Delusions	In non-clinical participants, experiential avoidance partially mediated between childhood emotional trauma, life hassles and subclinical delusions. In clinical participants, experiential avoidance partly mediated between childhood sexual trauma, life hassles and delusions.
Goldstone et al[41]	Case-control	3a	100 individuals with psychosis and 133 non-clinical participants	Physical and emotional trauma	Metacognitions and experiential avoidance	Hallucinations	In clinical participants, experiential avoidance and metacognitions partially mediated between DT and hallucinations. In non-clinical participants, metacognitions partially mediated between DT and hallucinations.
Gomez & Freyd[42]	Cross-sectional	2b	192 university students	Sexual abuse	Dissociation	Hallucinations	Dissociation partially mediated between childhood sexual abuse and hallucinations.
Hardy et al[43]	Cross-sectional	2b	228 individuals with relapsing psychosis	Direct, witnessed or vicarious: war, traffic accident, natural disaster, serious illness, sexual abuse, physical attack, threatened, bullying	Post-traumatic avoidance, hyperarousal and numbing, intrusive trauma memory, negative beliefs, depression	Auditory hallucinations and delusions (persecutory and referential)	Post-traumatic numbing, avoidance and hyperarousal mediated between childhood sexual abuse and auditory hallucinations. Negative other-beliefs mediated between childhood emotional abuse and persecutory delusions.

Isvoranu et al[44]	Cross-sectional	2b	552 individuals with psychosis	Childhood maltreatment; physical, emotional and sexual abuse; physical and emotional neglect	Symptoms of general psychopathology (somatic concern, anxiety, guilt, tension, mannerism and posturing, depression, motor retardation, uncooperativeness, unusual thought content, disorientation, poor attention, poor judgment and insight, disturbed willpower, poor impulse control, preoccupation, active social avoidance)	Positive and negative symptoms	Anxiety was the most significant mediator between sexual abuse and delusions, hallucinations and paranoia, as well as between physical abuse and paranoia.
Marwaha et al[26]	Cross-sectional (with a cohort component)	2a	7,403 non-clinical participants	Sexual abuse	Mood instability	Auditory hallucinations and paranoid ideation	Mood instability mediated a third of the association of child sexual abuse and persecutory ideation. Mood instability mediated a quarter of the association of child sexual abuse and auditory hallucinations.
McCarthy-Jones[45]	Cross-sectional	2b	5,788 individuals from the general population	Sexual abuse	Compulsions, obsessions, anxiety, depression, post-traumatic symptomology (hyperarousal and re-experience of memories)	Auditory verbal hallucinations	Compulsions partially mediated between childhood sexual abuse and auditory verbal hallucinations. Post-traumatic symptomology partially mediated between childhood sexual abuse and auditory verbal hallucinations.

McDonnell et al[46]	Case-control	3a	64 individuals at clinical high risk for psychosis	Bullying victimization	Interpersonal sensitivity	Paranoid ideation	Interpersonal sensitivity mediated between bullying severity and paranoid ideation.
Muenzenmaier et al[47]	Cohort study	2a	183 outpatients with schizophrenia, schizoaffective disorder, bipolar disorder or depression	Sexual, physical and emotional abuse, and stressful experiences related to the family environment (e.g., substance use, mental illness, witnessing abuse)	Dissociation	Delusions and hallucinations	Dissociation mediated between DT and hallucinations.
Moffa et al[33]	Cross-sectional	2b	General population data from Adult Psychiatric Morbidity Survey (2000 sample: N=8,580; 2007 sample: N=7,403)	Bullying victimization	Worry, mood instability, anxiety, depression	Persecutory ideation and hallucinations	Depression and persecutory ideation, as well as mood instability and worry (through depression), mediated between bullying and hallucinations.
Perona-Garcelan et al[48]	Cross-sectional	2b	71 individuals with psychosis	Sexual abuse, physical abuse, unexpected death of relative/friend, assault, transport accident	Dissociation	Delusions and hallucinations	Dissociation mediated between DT and hallucinations.
Pilton et al[49]	Cross-sectional	3a	55 voice-hearers with a psychosis-related diagnosis	Abuse (emotional, physical and sexual) and neglect (emotional and physical)	Adult attachment	Auditory hallucinations	Anxious attachment partially mediated between DT and auditory hallucination severity and voice-related distress.
Rosen et al[50]	Cross-sectional	2b	61 individuals with schizophrenia or psychotic bipolar disorder	Childhood adversity (abuse, neglect and household dysfunction)	Negative voice content and depression	Voice-related distress in auditory verbal hallucinations	DT had an indirect effect on voice-related distress through negative voice-content.
Sitko et al[51]	Cross-sectional	2b	5,877 non-clinical participants	Witnessed injury or killing, sexual assault, neglect, threatened with a weapon, held captive or kidnapped	Adult attachment and depression	Paranoia and hallucinations	Anxious and avoidant attachment mediated between childhood neglect and paranoia.

Varese et al[52]	Case-control	2b	45 patients with schizophrenia spectrum disorders and 20 healthy controls	Sexual abuse, punishment, negative home environment, emotional abuse	Dissociation	Hallucinations	Dissociation mediated between DT and hallucination proneness.
Wickham & Bentall[53]	Case-control	2b	72 patients with schizophrenia spectrum disorders and 72 healthy controls	Emotional, physical and sexual abuse; emotional and physical neglect; bullying	Beliefs in a “just world”	Hallucinations and paranoia	Personal, but not general, beliefs in a “just world” partially mediated between childhood neglect and paranoia.

Table 2 Quality and risk of bias assessment results using the Newcastle-Ottawa scale

Case-control studies

Study	Selection				Comparability		Exposure			Total score (out of 9)
	Adequate case definition	Representative-ness of cases	Selection of controls	Definition of controls	Comparability of cases and controls on the basis of the design or analysis		Ascertainment of exposure	Same method of ascertainment for cases and controls	Non-response rate	
Appiah-Kusi et al[34]	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	7
Bendall et al[36]	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	6
Goldstone et al[40]	Yes	Yes	Yes	No	No	No	No	Yes	No	4
Goldstone et al[41]	Yes	Yes	No	No	No	No	No	Yes	No	3
Varese et al[52]	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	7
Wickham & Bentall[53]	Yes	Yes	Yes	No	Yes	No	No	Yes	No	5

Cohort studies

Study	Selection				Comparability		Outcome			Total score (out of 9)
	Representative-ness of exposed cohort	Selection of non-exposed cohort	Ascertainment of exposure	Demonstration that outcome was not present at start of study	Comparability of cases and controls on the basis of design or analysis		Ascertainment of outcome	Was follow-up long enough for outcomes to occur?	Adequacy of follow-up of cohorts	
Muenzenmaier et al[47]	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	7

Cross-sectional studies

Study	Selection			Comparability		Outcome		Total score (out of 7)
	Representative-ness of the sample	Non-response rate	Ascertainment of the exposure (valid measure)	Subjects in different outcome groups are comparable, based on study design or analysis; confounding factors are controlled		Assessment of the outcome (blinded?)	Statistical test	
Ashford et al[35]	No	No	Yes	Yes	Yes	No	Yes	4
Bortolon et al[37]	No	No	Yes	Yes	Yes	No	No	3
Bortolon & Raffard[38]	No	Yes	Yes	Yes	Yes	No	Yes	5
Fisher et al[39]	Yes	No	Yes	Yes	Yes	No	No	4
Gomez & Freyd[42]	No	No	No	No	No	No	Yes	1
Hardy et al[43]	Yes	Yes	Yes	Yes	Yes	No	Yes	6
Isvoranu et al[44]	Yes	No	Yes	Yes	Yes	No	Yes	5
Marwaha et al[26]	Yes	No	Yes	Yes	Yes	Yes	No	5
McCarthy-Jones[45]	Yes	No	Yes	Yes	Yes	No	Yes	5
McDonnell et al[46]	Yes	No	Yes	No	No	No	Yes	3
Moffa et al[33]	Yes	No	Yes	Yes	Yes	Yes	Yes	6
Perona-Garcelan et al[48]	Yes	No	No	No	No	No	Yes	2
Pilton et al[49]	Yes	No	Yes	No	No	No	Yes	3
Rosen et al[50]	Yes	No	Yes	Yes	Yes	No	Yes	5
Sitko et al[51]	Yes	No	No	Yes	Yes	No	Yes	4

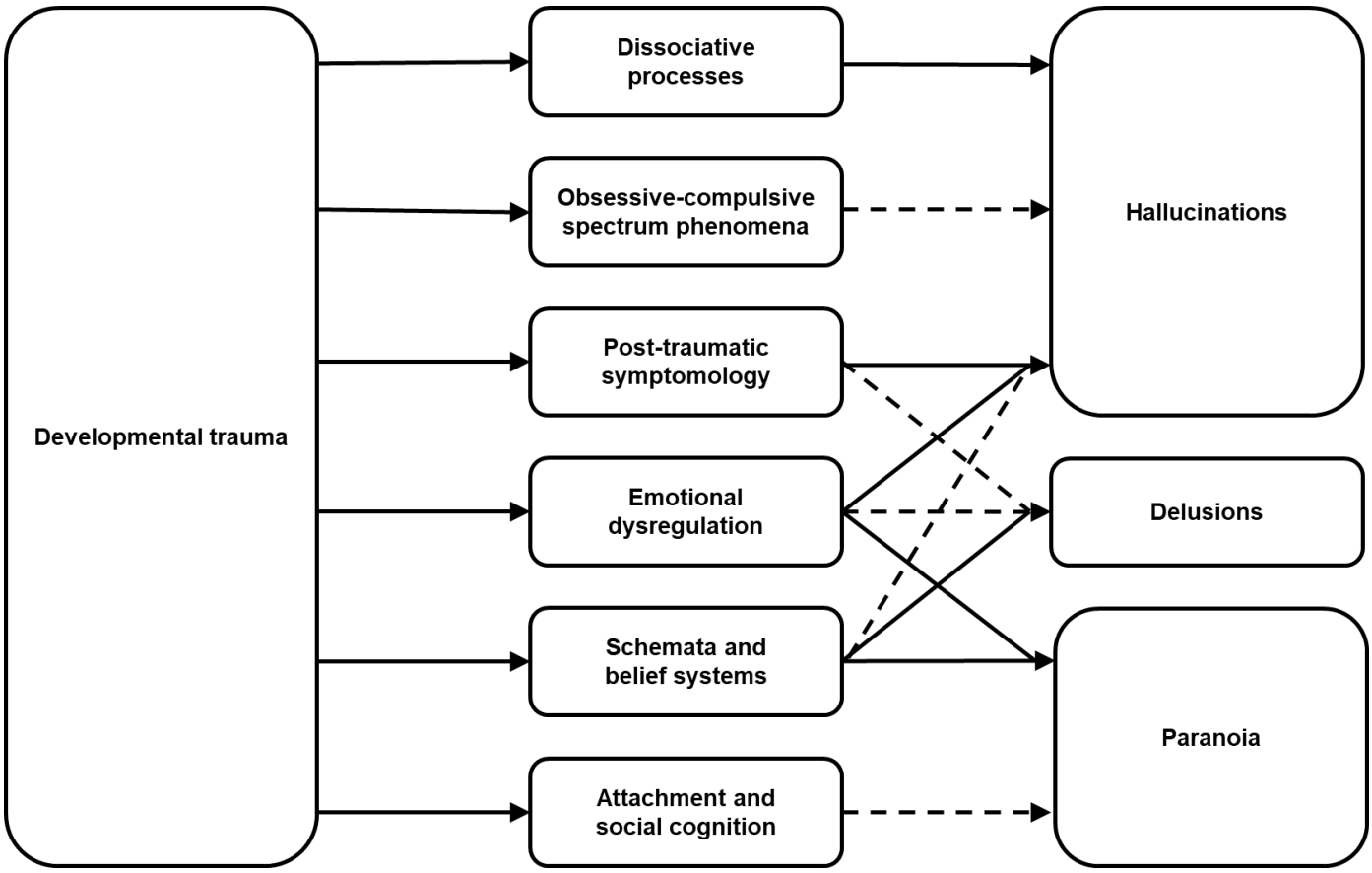

Figure 2 Overview of findings from the systematic review (solid arrows represent mediating paths supported by converging evidence from more than one study; dashed arrows represent mediating paths supported by one study only)

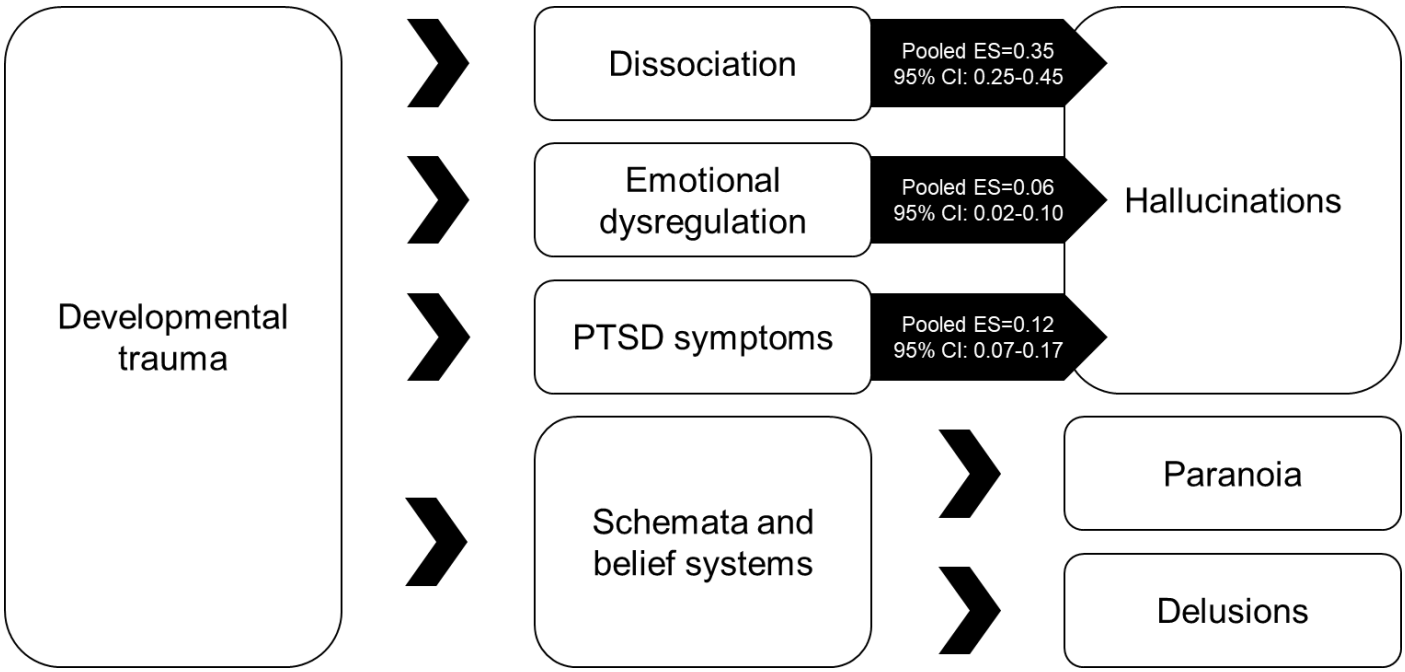

Figure 3 Overview of converging findings from high-quality studies and meta-analysis (thin arrows indicate paths supported by evidence from high-quality studies, thick arrows indicate paths supported by meta-analysis in addition to high-quality studies). Effect size (ES) is reported as Cohen's d.

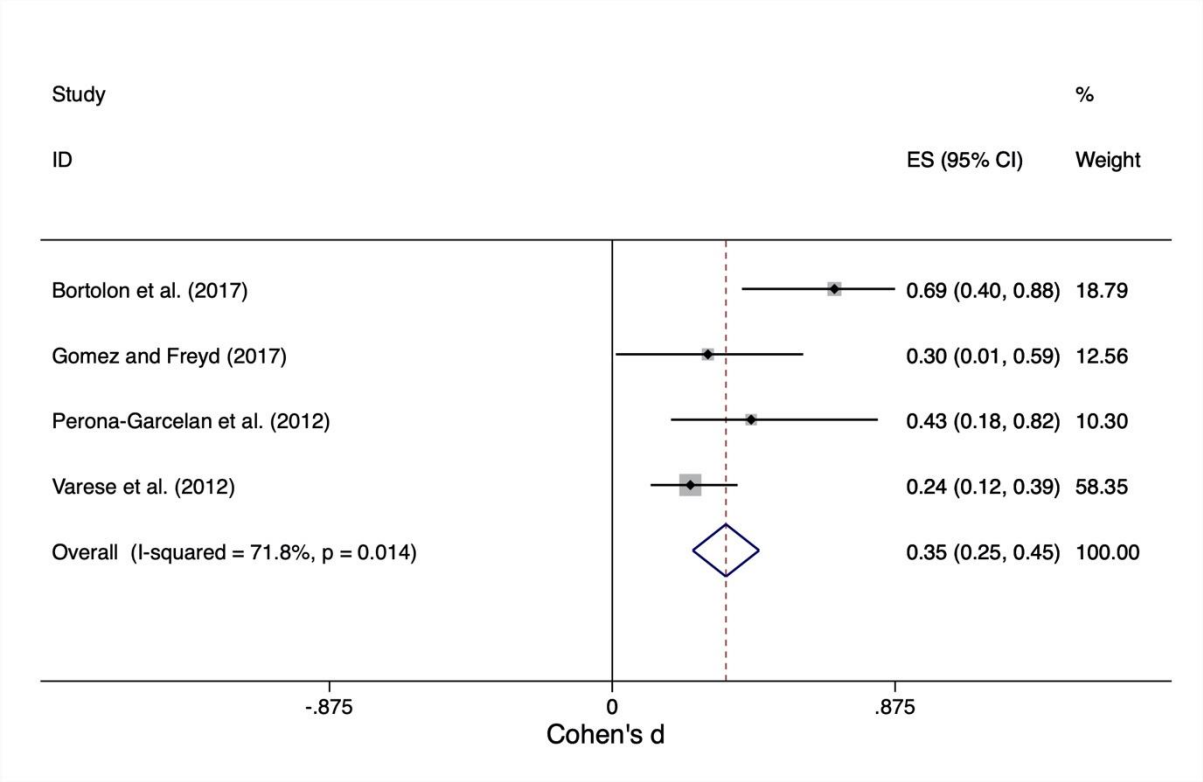

Figure 4 Meta-analysis of dissociation as a mediator between developmental trauma and hallucinations in adulthood. Sizes of grey squares represent weights of Cohen's d effect size (ES) according to sample size; horizontal lines indicate 95% CIs; the diamond represents the overall ES and 95% CIs.

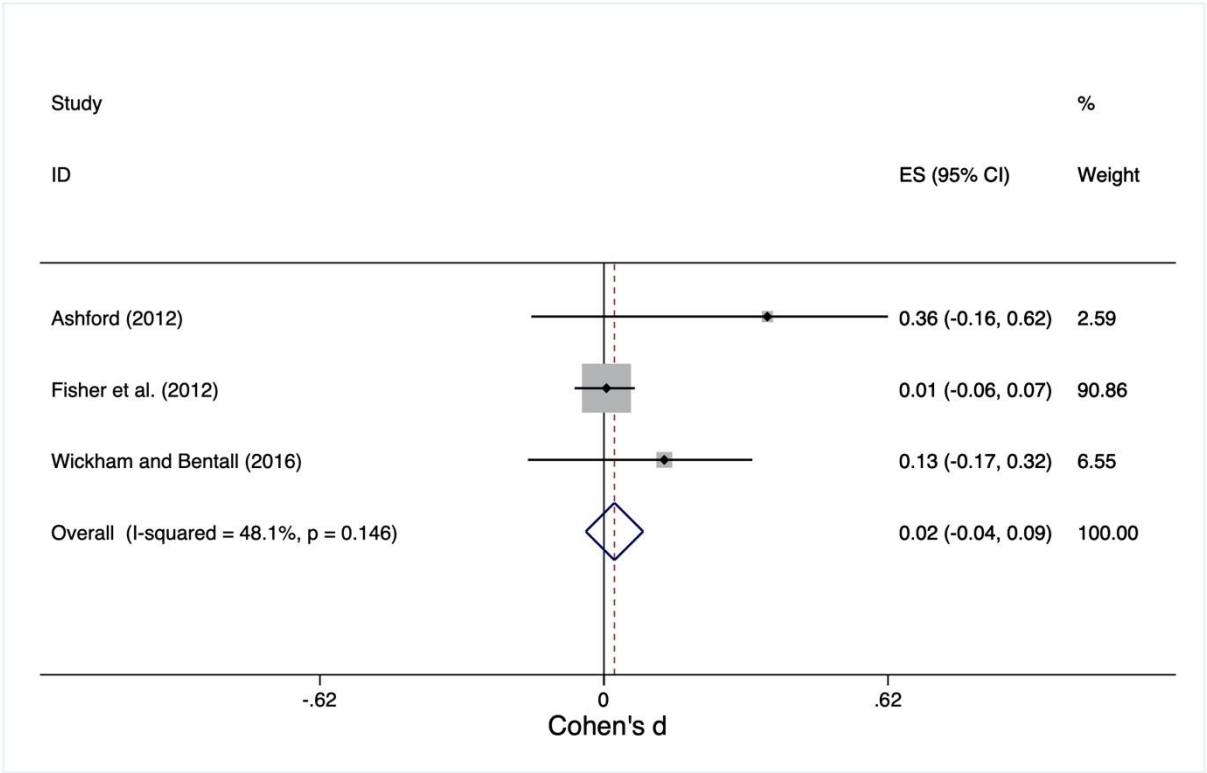

Figure 5 Meta-analysis of negative other-beliefs as a mediator between developmental trauma and paranoia in adulthood. Sizes of grey squares represent weights of Cohen's d effect size (ES) according to sample size; horizontal lines indicate 95% CIs; the diamond represents the overall ES and 95% CIs.

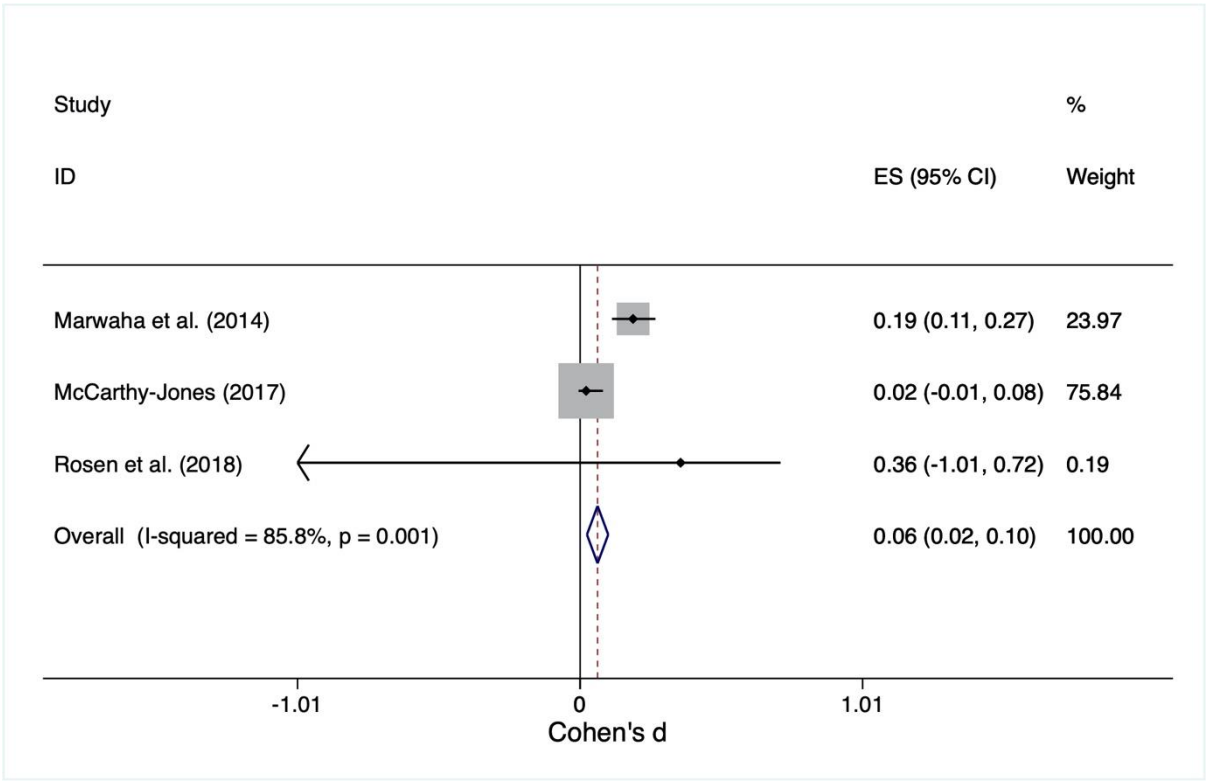

Figure 6 Meta-analysis of emotional dysregulation as a mediator between developmental trauma and auditory hallucinations in adulthood. Sizes of grey squares represent weights of Cohen's d effect size (ES) according to sample size; horizontal lines indicate 95% CIs; the diamond represents the overall ES and 95% CIs.

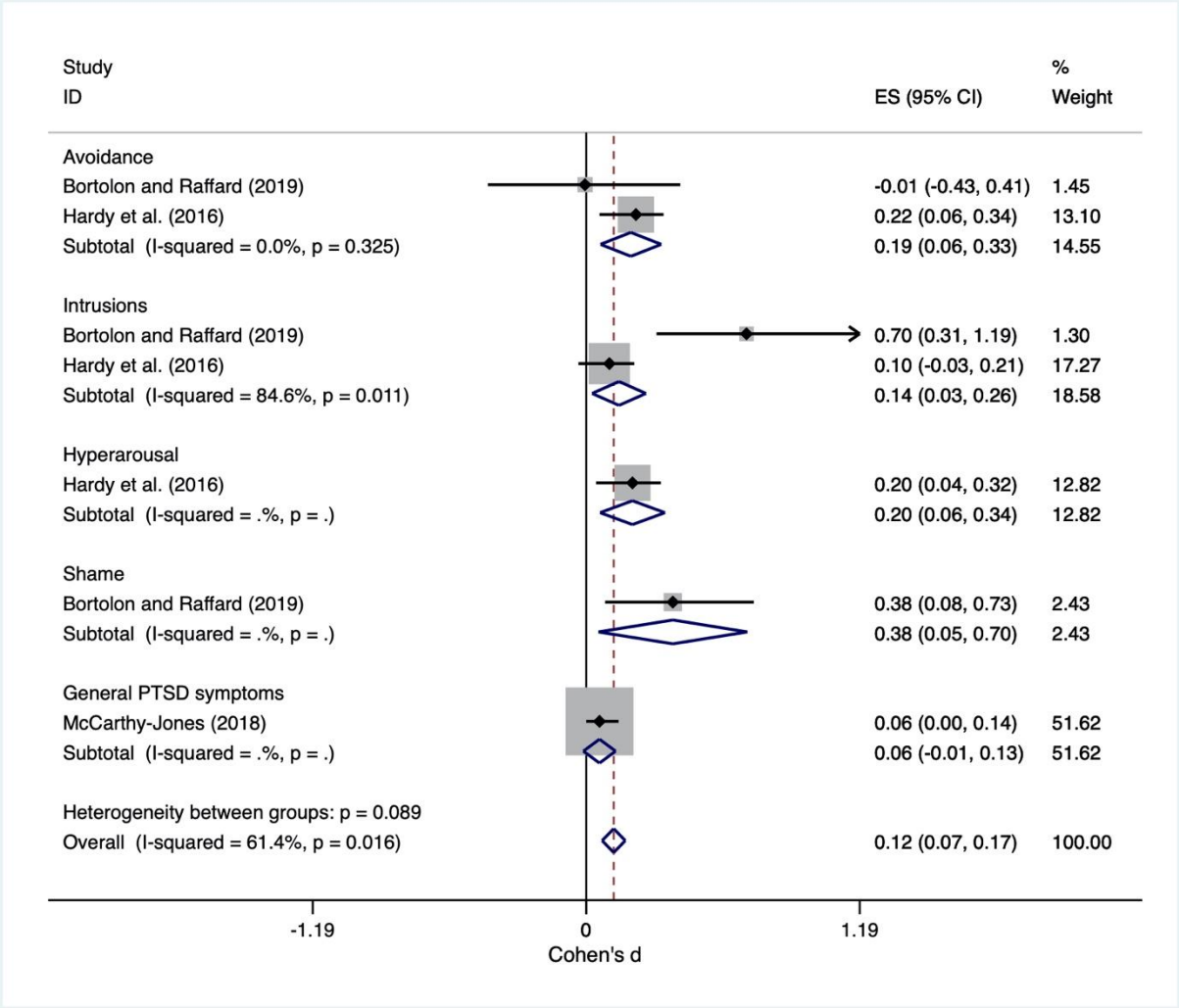

Figure 7 Meta-analysis of post-traumatic stress disorder (PTSD) symptoms as a mediator between developmental trauma and hallucinations in adulthood. Sizes of grey squares represent weights of Cohen's d effect size (ES) according to sample size; horizontal lines indicate 95% CIs; diamonds represent the overall ES and 95% CIs.