Trauma memory characteristics and the development of acute stress disorder and post-traumatic stress disorder in youth

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Abstract

Background & Objectives. The present study addresses gaps in knowledge regarding the association between trauma memory processes and posttraumatic stress responses in youth. Our primary goal was to explore the relative contribution of perceptions of trauma memory quality versus narrative trauma memory characteristics to explain overall adjustment. *Methods.* Children (N=67) were interviewed within four weeks (T1) of an injury leading to hospital treatment and then again eight weeks later (T2). In each interview, the child told a trauma narrative (which were later coded), and answered the Trauma Memory Quality Questionnaire (Meiser-Stedman, Smith, Yule, & Dalgleish, 2007a), a self-report measure indexing the sensory, fragmented, and disorganised aspects characteristics of trauma memory. They then completed a measure of PTS symptoms and associated psychopathology. *Results.* Self-reported trauma memory characteristics predicted PTS symptoms cross-sectionally and prospectively over time. At both time points, self-reported trauma memory characteristics accounted for all of the unique variance in symptoms initially explained by narrative characteristics. A reduction in self-report ratings, but not the hypothesised narrative features (e.g., disorganised or lexical elements of the narrative), significantly predicted a reduction in PTS symptoms over time. *Limitations.* The small sample size and the absence of a within-subjects narrative control were the main limitations of the study. *Conclusions.* These findings underscore the importance of self-reported trauma memory characteristics to the aetiology of PTSD.

1. Introduction

Several aspects of trauma memory have been implicated in the aetiology of PTSD across the life span (Brewin, Gregory, Lipton, & Burgess, 2010). However, these aspects of trauma memory have generally been less widely studied in child and adolescent samples. Understanding the relative contributions of aspects of trauma memory to overall adjustment in youth has the potential to provide important information about the profile of traumatic stress responses in youth.

Current theoretical conceptualisations of PTSD argue that characteristics of autobiographical trauma memories are central to the pathology of the disorder (Brewin, 2001; Brewin, Dalgleish, & Joseph, 1996; Ehlers & Clark, 2000). Before treatment, the PTSD sufferer's *intentional* autobiographical memory of the trauma is dominated by sensory/perceptual features, emotional elements, and their memories are thought to be more fragmented/disorganised and incomplete relative to memories of other sorts of experiences (Brewin, 2001; Brewin et al., 1996). This is caused by a combination of the adoption of suboptimal cognitive processes while encoding the trauma (Ehlers, Hackman, Ruths, & Clark, 2007), and a cascade of further unhelpful cognitive (e.g., appraisals) and behavioural symptoms (e.g., management strategies) afterwards (Halligan, Michael, Clark, & Ehlers, 2003). One important consequence of these poorly formed *intentional* memories is that the person is more vulnerable to recalling the trauma *involuntarily* (i.e., intrusively) (Brewin et al., 2010; Ehlers, Hackman, & Michael, 2004).

The structure of autobiographical trauma narratives are argued to be altered in the context of PTSD, with the emotional processing of trauma memories an important treatment component outlined by cognitive theories (Clark & Ehlers, 2004). In their seminal investigation, Foa, Molnar, and Cashman (1995) coded the verbal trauma narratives of adults before and after therapy to assess the nature of their voluntary memory retrieval. The main finding was that the adults that had recovered included a significantly higher percentage of thoughts reflective of attempts to organise the trauma memory (as compared to before treatment). In the past thirty years, the technique of using narratives to assess the nature of trauma memories has been replicated many times in adults (for review see O'Kearney & Perrott, 2006). Despite widespread examination, few qualitative markers have emerged as consistent predictors of the disorder (Halligan et al., 2003; Hellawell & Brewin, 2004; Jelinek et al.; Jones, Harvey, & Brewin, 2007; Moulds & Bryant, 2005; Murray, Ehlers, & Mayou, 2002; Tromp, Koss, Figueredo, & Tharan, 1995; van Minnen, Wessel, Dijkstra, & Roelefs, 2002; Zoellner, Alvarez-Conrad, & Foa, 2002). Two reasons for this are (a) that a variety of coding schemes have been used to measure the organisation and lexical content of trauma narratives, and, (b) there is vast heterogeneity with respect to samples and study designs.

Narrative techniques have seldom been used to explore the links of trauma memory and PTSD in children and young people. It is necessary to consider the most appropriate scheme to use with children at the outset. The Foa et al. (1995) scheme has some strengths and is widely considered the coding scheme of choice when applied to adults. Nevertheless, this may not be the best scheme for children. In their scheme, repetition is considered the most important index of fragmentation within its coding hierarchy[1]. We feel this priority is problematic as children often use repetition as a point of emphasis during discourse (O'Kearney & Perrott, 2006; O'Kearney, Speyer, & Kenardy, 2007). O'Kearney et al. (2007) introduced a scheme specifically for children. This scheme is summarised in Table 1. The key difference between this scheme and previously used coding schemes (e.g., Foa et al., 1995) is the assesment of the narrative’s level of fragmentation and temporal disorganisation using established child psycholinguistic principles for assessing *coherence* and *cohesion*. The

[1] The Foa et al. (1995) coding scheme states that when utterances of speech are determined as fitting two categories (e.g., emotions and repetitions), then the coder should choose the linguistic feature that is at the top of the hierarchy. Repetitions are listed at the top of this coding hierarchy.

underlying premise of cohesion/coherence theory is that a narrative can be conceived of as organised on multiple levels. Coherence is defined as the assessment of organisation in terms of a narrative’s macro-structure (Peterson & McCabe, 1983, 1991). It is operationalised by an assessment of the narrative’s sequencing, its context (i.e., person, place and time), the overall structure of the narrative (e.g., does it have a beginning, middle and ending), and the extent to which the narrative is evaluative. Cohesion is defined as the organisation of the narrative’s micro-structure. The use of various connective devices is assessed to determine the meaning or organisation of clauses (Halliday & Hasan, 1976). Connective devices assessed within the O'Kearney et al. (2007) scheme include *causal* markers (*because*, *so*), comparative markers (e.g., *but*), and temporal markers (e.g., *then*). To illustrate how connective devices aid undertanding, consider when the term ‘*then’* is added to the sentence “We went to the coffee shop and the clothes store and the park”. The sentence would now read “We went to the coffee shop *and then* to the clothes store and *then* to the park”. In the present study, we followed the scheme of O'Kearney et al. (2007) as in our view this scheme stands out from the others because it is consistent with well-established psycholinguistic principles adopted for coding aspects of discourse in children.

There are currently three cross-sectional studies that have explored the relation of narrative trauma memory to PTSD in youth. Supporting cognitive models, in a sample of acutely injured children higher levels of temporal disorganisation predicted parent report of the child’s overall adjustment to their PTSD symptoms (although these were largely in the sub-syndromal range) (Kenardy et al., 2007). However, the use of a very simple coding scheme and a parent reported measure of PTSD were serious limitations. O'Kearney et al. (2007) also studied the relationship of linguistic devices to sub-clusters of PTSD in a sample of acutely injured children using their specially developed coding scheme. Children experiencing intrusions told trauma narratives with fewer sensory/perceptual words (e.g., the car was *black*), fewer references to impaired encoding/retrieval (e.g., “I can’t remember”), and the use of lexical markers associated with meaning making (e.g., use of words like because and so).

Although narrative qualities provide important insights, each of the above studies is limited in that several different aspects of trauma memory are argued to be impaired in the context of PTSD, and therefore it is necessary to test the relative contributions of these aspects to overall adjustment. One pertinent aspect of trauma memory previously shown to be important in children with PTSD is the perception of trauma memory quality. It is important to note that perceptions of trauma memory quality (often indexed by measures such as the Trauma Memory Quality Questionnaire (TMQQ; Meiser-Stedman, Smith, Yule, & Dalgleish, 2007) are essentially meta-memory perceptions. These perceptions can be influenced by a number of factors other than the strength of the individual’s memory (Roebers & Schneider, 2001). Hence, whilst it is likely that perceived memory quality and narrative memory structure are related, they are distinct constructs, with the qualitative coding of memories arguably a slightly more objective way of obtaining information than asking someone to rate a questionnaire. The Ehlers and Clark (2000) model is unclear as to the importance of trauma narratives relative to perceptions of memory quality in driving adjustment. However, as the model argues it is the individual’s perception of their memory that drives their coping responses, it is plausible that perceptions of trauma memory quality would hold the stronger association. Inconsistent with this, the one study addressing these questions in youth (i.e., Salmond et al. (2011) showed that narrative disorganisation (coded according to the Foa et al. (1995) scheme) predicted ASD severity, but self-reported trauma memory characteristics did not contribute to symptom severity over and above narrative aspects.

In summary, studies have produced mixed results for the association of narrative memory processes to PTSD in children. The adoption of cross-sectional designs has also precluded a thorough investigation of the *causal* role of trauma memory features to PTSD development and *recovery*. Finally, with the exception of Salmond et al. (2011), the relative importance of narrative features and perceptions of trauma memory quality has not been widely studied.

Given this, the primary aim of the present study was to investigate the *relative* contribution of perceptions of trauma memory quality and trauma narrative memory variables to overall adjustment. We recruited a cohort of children and adolescents aged 7-16 years who were either admitted to hospital or attended the emergency department (ED) following a traumatic injury. The relationships of trauma memory characteristics to PTSD were examined acutely (i.e., $T1_{\text{trauma memory}} \rightarrow T1_{\text{PTS}}$), prospectively (i.e., $T1_{\text{trauma memory}} \rightarrow T2_{\text{PTS}}$), and then via analysis of change over time (i.e., $\text{Change}_{\text{trauma memory}} \rightarrow \text{Change}_{\text{PTS}}$) using bivariate correlations and hierarchical regression models. Based on cognitive models, we predicted that elevated T1 self-perceptions of trauma memory quality would hold positive bivariate correlations with T1 Acute Stress Disorder (ASD) symptoms and T2 Posttraumatic Stress (PTS) symptoms. It was expected that lower coherence scores (i.e., sequence, level of orientation, global coherence, evaluation) and lower proportions of cohesive markers (i.e., less use of temporal, causal, and comparative elements) would be associated with higher levels of T1 ASD symptoms and T2 PTS symptoms. In addition, we predicted that elevated proportions of sensory/perceptual features, negative emotions and references to impaired encoding/retrieval, and fewer thought references would correlate to ASD and PTS symptoms.

Based on our tentative argument that perceptions of trauma memory are a stronger driver of reactions to distress, we hypothesised that perceptons of trauma memory would predict PTSD over and above narrative variables. With respect to the investigation of change over time, we expected improvements to the coherence and cohesion of trauma narratives and a reduction in perceptions of trauma memory quality would be associated with a reduction in PTS symptoms.

2. Method

2.1 Participants

Participants were 67 children (*M*=11.77, *SD*=2.13) who had witnessed or were involved in a potentially distressing or traumatic event within the previous 4 weeks that led to attendance at a hospital accident and emergency department and/or admission to the paediatric ward. Children were: (a) aged between 7 and 16 years, (b) had not experienced loss of consciousness, and (c) were not experiencing ongoing trauma (e.g., exposure to domestic violence) (determined according to parent report).

The majority of participants were male (63%) and of Caucasian heritage (90%). Most had suffered an accidental injury (e.g., fall) (33%), followed by serious sporting injuries (e.g., bike accident) (55%), road traffic collision’s (8%), assaults (2%), and burns (2%). Equivalent proportions of children experienced minor (28%, bruises/abrasions), moderate (36%, broken bones) and major injuries (36%, multiple fractures). Approximately half the sample (54%) were hospitalised for their injuries (*M* = 1.45 days, *SD* = 1.86). The study had ethical approval from the relevant ethics committee. Both children and their parents gave informed consent prior to taking part.

2.2 Measures

2.2.1 Narratives. Prior to eliciting a trauma narrative the interviewer went through an open ended rapport building exercise (Lamb, Sternberg, & Esplin, 1998). The interviewer explained a story of a hypothetical scenario (e.g., going to the shop) where children could ask the experimenter questions, to ensure they adequately understood the demands of the task. The O'Kearney et al. (2007) narrative instructions were modified slightly to include an explicit instruction to describe the hospital experience. We did this because it is well known that young people can give brief or poorly organised narratives due to factors such as shyness, anxiety, or not understanding the nature of the instructions (O'Kearney & Perrott, 2006; Zoellner & Bittenger, 2004). The instructions provided were: *"In a moment I will ask you to tell me about your accident, how you felt, what you saw, who was there with you, everything. I would like you to describe the event as if it were happening right now. I would like you to tell me as many things as you can remember that happened during the accident and your visit to the hospital. First tell me about the accident and then tell me about your visit to the hospital. Things like what happened around you, how you were feeling, and what you were thinking during the accident and your visit to the hospital.* Two prompts were delivered at the end. (Prompt 1: "*Can you tell me anything else about the accident?* and Prompt 2: *Can you tell me anything else about your hospital visit?*").

The coding scheme was obtained from the author (O'Kearney), and he was consulted to clarify more ambiguous aspects of the scheme. Narratives were coded by hand by the first author (who was also the interviewer) and then 25% percent (n=33) were re-coded by a second rater unaware of participants' PTSD severity. Counts were used to determine the number of lexical (sensory, emotional, thought processing words) and cohesive (additive, temporal, causal, comparative) devices used in each in narrative. Percentages were then calculated for these various features by dividing these scores by the total word count of each narrative. A *z* score (hereafter defined as the temporal index) was calculated to handle the collinear relationship of additive with temporal devices demonstrated in previous research (i.e., $z_{add} - z_{temp}$) (O'Kearney et al., 2007). A negative correlation to symptoms suggests less temporal sequencing with higher symptoms levels. In contrast, coherence scores involved a single rating on global (rated from 0 to 6), orientation (rated from 0 to 2), sequence (rated from 0 to 2), and evaluation (rated from 0 to 2) dimensions.

Inter-rater reliability was high for the coding of lexical categories (*r*= .85 to *r*=.99) and acceptable for cohesive devices (*r*=.77 to *r*= .95; all *p*s < .001). Agreement for coherence ratings was moderate for levels of orientation (84.5%), global coherence (85.5%), and evaluation (84.5%), but lower for sequence ratings (72.7%).

The following self-report measures, whose strong psychometric properties have been documented previously, were also used.

2.2.2 The Trauma Memory Quality Questionnaire (TMQQ; Meiser-Stedman et al., 2007). The TMQQ is an 11-item measure (summed to obtain a total score) which indexes appraisals of the sensory, fragmented, and disorganised aspects of a memory for a single traumatic event. Compared with previous research (e.g., α=.76; Meiser-Stedman et al., 2007), the measure's internal reliability was lower than expected at T1 (α=.63) and T2 (α=.67).

2.2.3 Children's Acute Stress Questionnaire (CASQ; Kassam-Adams, 2006). The CASQ measures Acute Stress Disorder symptoms in children at T1 according to the DSM-IV criteria. Internal reliability for the CASQ total score was high (α=.88), and ranged from α=.65 to α=.77 for the respective subscales.

2.2.4 The Child Posttraumatic Stress Scale (CPSS; Foa, Johnson, Feeny, & Treadwell, 2001). The CPSS is a 24 item measure (2 event items, 17 symptom items, 7 items addressing interference with daily functioning) used to index DSM-IV PTSD symptoms. The scale's internal reliability was acceptable (α=.88) overall and ranged from α=.65 to α=.86 for individual subscales. The measure has previously published cut-off of ≥ 11 at T2 (considered to indicate probable PTSD; Foa et al., 2001)

2.2.5 Fear during the trauma. Fear was indexed by a single rating on a 10-item scale (0=very relaxed, 10=worst fear imaginable).

2.2.6 The verbal subtest of the Wechsler Intelligence Scale for Children Fourth Edition (WISC-IV; Wechsler, 2003). The vocabulary subtest was used to control for children's story telling abilities and involved children explaining the meaning of 36 words.

2.3 Procedure

All interviews were completed over the phone and audio-taped. Parents answered a brief demographic interview at T1 only. During the first interview (T1; four weeks) children answered the TMQQ, told their narrative of the trauma, completed the CASQ, and then the vocabulary subtest of the WISC-IV. The protocol for children was identical for the second interview (T2; 8-12 weeks) except that children did not complete the vocabulary subtest, and they completed the CPSS instead of the ASC-kids (to reflect the relevant DSM disorder at each time point, ASD versus PTSD). After completion, families were posted a $10 voucher to thank them for their involvement.

2.4 Data analysis

All analyses were carried out in SPSS version 21. Unless otherwise stated, all analyses were two tailed and alpha was set at .05. A square root transformation of the dependent variable (characterised by a moderate negative skew) was performed to meet the assumption that the residuals for a regression equation are normally distributed. As findings were replicated using transformed and raw scores, for ease of interpretation, prospective findings for the raw data are presented.

Bivariate correlations were used to examine relationships of different variables across varying time points. Hierarchical linear regression analyses were used to explore the relative importance of trauma memory characteristics to overall adjustment at T1 and T2. As different measures of trauma response were used at T1 and T2 (CASQ versus CPSS), *z* scores (e.g., $T2_{zPTS} – T1_{z\ PTS}$) were calculated for independent and dependent variables, to examine the relationship of trauma memory characteristics to PTSD symptoms over time.

The results of similar linear regression analyses carried out on DSM-IV sub-clusters are reported in supplementary tables (1-4). At the suggestion of a reviewer, in an additional sensitivity analysis, we carried out a series of independent samples t-tests comparing non-symptomatic children to children with a 'probable PTSD/ASD' diagnosis with respect to trauma memory characteristics.

3. Results

3.1 Preliminary analyses

3.1.2 Covariates. Factors such as injury severity, injury type, and verbal ability were not significantly related to ASD symptoms at T1 and T2. Younger children reported higher levels of ASD symptoms at T1 (r=-.48, p<.001) and PTS symptoms at T2 (r=-.41, p=.001). Children who at their T1 interview reported experiencing higher levels of peri-trauma fear also reported higher levels of PTS symptoms at T1 (r=.52, p<.001) and T2 (r=.36, p=.002).

3.1.3 Descriptives. The descriptive statistics for the sample are presented in Table 2. Children were experiencing low to moderate levels of Acute Stress Symptoms at Time 1. Likewise, children reported low to moderate levels of PTS symptoms at T2 although 22% of children (n=15) had a CPSS score of ≥ 11 at T2 (considered to indicate probable PTSD; Foa et al., 2001). Coding for lexical markers suggested sensory elements were most commonly seen in narratives (e.g., "I heard", "I thought"), followed by emotion references, thought processes ("I thought my life was over") and then references to impaired cognitive processing ("I couldn't think"). In terms of cohesion, narratives consisted primarily of temporal (e.g., *then*) and additive cohesive devices ($M_{additive}$ + $M_{temporal}$ = 84% of all cohesive markers in T1 narratives), and relatively few causal and comparative devices (M_{causal} + $M_{comparative}$ =10.42% of all cohesive markers in T1 narratives). Narratives were well structured globally, with moderate levels of sequence and orientation, but they contained very little evidence of evaluation. Age was unrelated to trauma memory characteristics with the exception that younger children reported higher scores on the TMQQ ($r=-.40$, $p=.001$). Of note, children with higher verbal intelligence told more globally coherent ($r=.27$, $p=.03$) and evaluative ($r=.28$, $p=.03$) narratives that included more orientation information ($r=.25$, $p=.05$).

3.2 Cross-sectional relationships of trauma memory characteristics and PTS symptoms at 1-4 weeks post-trauma

The correlations of T1 trauma memory characteristics with ASD symptoms at T1 and PTSD symptoms at T2 are presented in Table 3. Only 2 out of 11 narrative markers were significantly related to ASD symptoms. Consistent with cognitive models, the use of negative emotions ($r=.46$, $p<.001$) and the temporal index ($r=-.36$, $p=.002$) correlated to ASD symptoms at T1, with the latter correlation indicating the absence of temporal sequencing is releated to elevated ASD scores. Perceptions of trauma memory quality shared a strong and significant correlation with ASD symptoms at T1 ($r=.67$, $p<.001$). The lower bound confidence intervals of both the TMQQ and emotions cross-sectionally were >.25, indicating relatively robust relationships.

Table 4 summarises the results of a hierarchical regression analysis conducted to examine the relative contribution of trauma memory characteristics to ASD symptoms. Known covariates of ASD severity were entered in the first step, narrative markers were entered in the second step, and perceptions of trauma memory quality were entered in the third step. Acutely, T1 narrative features (step 2) and T1 perceptions of trauma memory quality (step 3) respectively accounted for 10.2% and 12.5% of the unique variance in T1 PTS symptoms. While age and narrative markers were significant contributors in the first step, $F(2, 64)=21.02$, $p<.001$, and second step, $F(2, 62)=6.34$, $p=.001$, the addition of perceptions of trauma memory quality meant narrative markers no longer accounted for unique variance in PTSD symptoms in the final model, $F(1, 61)=20.30$, $p<.001$.

Regression analyses were also performed for DSM-IV PTSD symptom sub-clusters, (see Supplementary Tables 1 and 2). The same pattern of results was replicated in that narrative markers were significant contributors in the second step, but not when perceptions of trauma memory quality were entered in the third step. It is also noteworthy that in the second step of the regression equation, in addition to the temporal index and negative emotions, lower levels of orientation were significantly associated with intrusions and lower levels of sequence were significantly associated with avoidance. These elements were not significant predictors in the final model.

Follow-up independent samples *t*-tests replicated these relationships, showing that children with probable PTSD included significantly more negative emotions, $t(65)=-2.75$; $p=.008$; $C_{95}I$: [-.44, .07]; $d=.78$, had a lower temporal index score, $t(65)=-2.45$; $p=.02$; 95% $C_{95}I$: [2.1, 20.3]; $d=1.69$, and had significantly higher scores on the TMQQ, $t(65)=-3.02$; $p=.004$; $C_{95}I$: [-6.67, -1.36], $d=1.41$.

3.3 Prospective relationships of trauma memory characteristics and PTS symptoms 3-months post-trauma

The T1 temporal index (i.e., absence of connectives such as 'then'etc.) predicted T2 PTS symptoms ($r=-.30$, $p=.002$) although the upper-bound limit of the confidence interval was less than -.10, indicating the possibility of this being a weak relationship. T1 emotions predicted T2 PTSD symptoms ($r=-.30$, $p=.002$).

As expected, the TMQQ as measured at T1 continued to demonstrate a strong relationship with T2 PTS symptoms ($r=.47$, $p<.001$). A hierarchical regression analysis investigated the relative importance of T1 trauma memory characteristics to explain T2 PTS (see Table 4). In the first step of the equation, covariates (fear and age) were entered. Narrative features were entered in the second step, and self-reported trauma memory characteristics entered in the last step. After accounting for the contribution of age (step 1),

$F(2, 64)=9.26$, $p<.001$, Narrative markers (Step 2) accounted for a non-significant 4.2% of unique variance in T2 PTS symptoms, $F(2, 62)=1.98$, $p=.15$, whereas perceptions of trauma memory quality (Step 3) explained 5.6% of unique variance in T2 PTS symptoms, $F(1, 61)=6.73$, $p=.01$.

Regression analyses performed for DSM-IV PTSD symptom sub-clusters, (see Supplementary Table 1 and 3) didn't replicate these relationships. T1 narratives markers were not associated with avoidance reactions. Step 3 of the other two models showed lower levels of sequencing predicted intrusions, and both sensory elements and perceptions of trauma memory quality significantly predicted arousal reactions.

Follow-up independent samples t-tests replicated these relationships, showing that children with probable PTSD at T2 had had a lower temporal index score, $t(65)=-3.50$; $p=.001$; $C_{95}I$: [7.2, 26]; $d=.73$ at T1, included significantly more negative emotions, $t(65)=-3.65$; $p=.001$; $C_{95}I$: [-.53, .13]; $d=.98$, and they also had significantly higher scores on the TMQQ, $t(65)=-3.50$; $p=.001$; $C_{95}I$: [7.17, 26.20], $d=-.86$.

3.4 The relationship between changes in trauma memory characteristics and changes in post-traumatic stress symptoms

A series of within subject's t-tests assessed the change in trauma memory characteristics over time (see Table 2 for descriptive data). The structure of young people's narrative's changed very little, with the exception that narratives contained significantly more sensory features at T2 compared with T1, $t(66)=-2.20$, $p=.03$, $d=0.27$, CI_{95}: [.-.81, -.05]. At T2, children had lower perceptions of trauma memory quality scores (TMQQ), $t(66)=-3.92$, $p<.001$, $d=0.48$, CI_{95}: [1.07, 3.44]. A reduction in perceptions of trauma memory quality (i.e., the less fragmented and sensory in nature they became) also predicted a reduction PTS symptoms ($r=.39$, $C_{95}I$: [.17, .58], $p=.001$). A hierarchal regression was undertaken to ascertain the degree of this change (see Table 4). Age was controlled for in the first step, accounting for 0.3% of the variance of change in PTS scores from T1 to T2, $F(1, 65) = .17$, $p = .68$. The results of the second and final step suggested a reduction in perceptions of trauma memory quality accounted for 10.1% of the variability of the reduction in PTS symptoms, $F(1, 69) = 10.99$, $p = .002$. Follow-up regression analyses performed for DSM-IV PTSD symptom sub-clusters (see Supplementary Table 4) replicated these relationships in the analysis of avoidance and intrusion sub-clusters, but not the arousal sub-cluster.

4. Discussion

This study is, to our knowledge, the first prospective study assessing the relative contribution of perceptions of trauma memory quality and trauma narrative memory to overall adjustment acutely and at 3-months in a sample of children and young people. Our study furthers understanding of these relationships in a number of ways. First, perceptions of trauma memory quality were implicated in the aetiology of ASD and PTSD (over and above narrative characteristics). Second, trauma narrative memory characteristics were also implicated in the aetiology of PTSD acutely or prospectively over time, although not after accounting for perceptions of trauma memory quality. Third, as a child's self-ratings that their trauma memories were fragmented and full of sensory experiences reduced between one and three months post-trauma so too did their PTS symptoms.

Our findings confirmed our hypothesis that perceptions of trauma memory quality are a stronger driver of symptoms than narrative features. Our data are consistent with one previous adult study (Halligan et al., 2003), but inconsistent with the only other child focussed study by Salmond et al. (2011). There are several possible reasons for this. First, Salmond et al. (2011) asked individuals to answer the TMQQ immediately after telling their narrative whereas we asked young people to complete the questionnaire and then tell their narrative. Developmental studies highlight that a child's judgements of their memories for an experience (i.e., ratings on questionnaires) are influenced by the amount of time that has elapsed between their recent retrieval of that experience and the rating (Roebers & Schneider, 2001), which could mean the differences arose due to order effcts. Second, the coding schemes used in the two studies differed. A third difference was that their interviews were carried out in person whereas our interviews were carried out over the phone. There is the possibility that a phone interview context could have altered the content that children decided to include compared with an in person interview, but it is also possible that such a context provided a sense of security or anonymity, allowing for more open disclosure and this could have altered the content that children decided to include. One notable feature of this study was that the trauma narratives told were, on average, three times the length of those in O'Kearney et al. (2007). In our opinion, the inclusion of an open ended rapport building exercise, an example narrative and an explicit instruction to discuss the hospital visit, and the inclusion of two prompts at the end are also factors that likely contributed to this. Finally, one caveat to our finding that perceptions are a stronger drive of symptoms is the shared method variance of the TMQQ and PTSD measures, which could (in part) account for the significant relationships found.

Our results were partially consistent with cognitive behavioural conceptualisations of memory and PTSD (Brewin, 2001; Brewin et al., 1996; Ehlers & Clark, 2000). The temporal index (e.g., absence of terms like *before, then*) and enhanced negative emotional content of narratives correlated with acute stress symptoms, but only the temporal index of narratives prospectively predicted PTS symptoms over time. These relationships were in the direction specified by cognitive models (Brewin, 2001; Brewin et al., 1996; Ehlers & Clark, 2000). Ten of the 12 indices of narrative lexical features and trauma memory fragmentation examined in this study bore no relationship to adjustment. It is important to note that the analysis of PTSD symptom sub-clusters highlighted significant relationships of sequence, orientation and sensory/perceptual features in the direction suggested by Ehlers and Clark

(2000). These findings suggest that it is possible that slightly different memory factors/mechanisms lead to intrusion, avoidance and arousal reactions and it will be important to replicate these findings in a larger sample that examines the separate clusters of PTSD. The poor explanatory power of some narrative features to explain adjustment in this study could simply be because some symptomatic children are too avoidant to engage in the task, which would mean narratives are not a valid index of trauma memory characteristics. It should be recognised however that severity of symptoms in the current sample was low to moderate on average, thus this would counter this explanation. Nonetheless it could be that there are other, better ways of capturing trauma memory characteristics in children and young people.

There are several important avenues for future research. One important question involves assessing the extent to which judgments regarding gaps in memory for these experiences is representative of the underlying memory representation. This can only be achieved by investigating the accuracy of a PTSD sufferers' memory of the frightening experience. The findings must also be replicated in the context of symptom change during the course of therapy. If our findings are replicated, this would provide evidence that the focus of memory based components of cognitive-behavioral therapies such as prolonged expsoure and written exposure should include a focus on the correction of misappraisals regarding one's own memorial abilities.

Our findings must be interpreted in the context of the methodology and some potential limitations. Coding of narratives was carried out by the first author and this introduced a possible source of bias, although inter-rater reliability checks indicate this concern is probably unfounded. We controlled for children's story telling abilities using the vocabulary subtest of the WISC-IV, but to test whether our findings are simply reflecting a general recall style of sufferers with PTSD requires a within-subjects comparison of trauma narratives to a narrative of a neutral or negative (but non-traumatic) event. We observed lower than expected internal reliability for the TMQQ and this could have influenced the findings. Finally, we did not measure childrens' level of distress during the interview, which may have influenced their responses.

5. Conclusions

The present study provides the first prospective evidence regarding the role of perceptions of trauma memory and narrative trauma memories to the development of PTSD in children and young people. Our findings highlight the potential importance of early interventions that target self-reported perceptions of trauma memory quality to expedite the amelioration of PTS symptoms.

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Key Points

- This is the first prospective study of trauma narrative memory and stress responses in youth.
- Trauma narratives predicted adjustment before accounting for perceptions of trauma memory.
- Perceptions of trauma memory were implicated in ASD and PTSD and amelioration of symptoms.
- Perceptions of trauma memory may play an important role in the first few months of a trauma.

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Table 1. Outline of narrative coding scheme (O'Kearney & Perrott, 2006; O'Kearney et al., 2007).

	Description	*Example*
Lexical Features (calculated as a % of the total word of count of each narrative).		
Emotions	The inclusion of negative emotions in the narrative	"I felt *scared*"
Sensory/perceptual	References to visual, auditory, and sensory information in the narrative	"I *heard* a loud noise"
Impaired thinking	References to impaired encoding or retrieval processes in the narrative	"I *forget* about the ambulance"
Presence of thoughts	References to cognitive processes in the narrative	I *thought* my life was over
Cohesion (calculated as a % of the total number of cohesive devices in the narrative)		
Additive	Linking words which provide more information or detail about events	and, also, in addition
Causal	Linking words which assist to establish the cause of events.	because, so
Comparison	Linking words which highlight perceived similarities/differences.	but, more than, less than
Temporal	Linking words which sequentially order two events in time.	then, next, before, later
Coherence		
Global (0-6)	The story is logically organised with a beginning, middle and an end-point.	
Orientation (0-2)	The level of context provided in the story (e.g., time, place, and setting).	
Sequence (0-2)	The series of events is told in the correct order and there is little repetition.	
Evaluation (0-2)	The extent to which the narrator tells the reader what to think about the events being narrated (e.g., exaggerations, explanations, judgments)	

Table 2. Descriptive statistics for trauma memory characteristics at Time 1 and Time 2

	Mean (Standard Deviation)	
	Time 1	*Time 2*
Narratives		
Narrative word count	475.59 (391.08)	402.29 (374.83)
Lexical Features[1]		
Emotions	0.28 (0.33)	0.28 (0.64)
Presence of thoughts	0.60 (0.58)	0.61 (0.88)
Impaired thinking	0.26 (0.35)	0.26 (0.54)
Sensory/perceptual	2.19 (1.18)	2.61 (1.69)
Cohesive devices[2]		
Additive	38.26 (13.87)	38.68 (16.86)
Comparative	3.76 (4.04)	3.50 (4.13)
Causal	10.39 (7.75)	9.67 (8.41)
Temporal	46.17 (16.18)	47.81 (17.44)
Coherence		
Global (0-5)	4.97 (1.3)	5.07 (1.42)
Orientation (0–2)	0.93 (0.68)	0.85 (0.67)
Sequence (0–2)	1.16 (0.51)	1.32 (0.59)
Evaluation (0-2)	0.69 (0.84)	0.51 (0.71)
Meta-memory processes		
TMQQ	24.68 (4.81)	22.13 (5.51)
Self-report		
CASQ	11.03 (7.81)	
CPSS[3]		7.09 (8.39)
Fear during the trauma	5.09 (3.00)	5.19 (2.75)

[1] Calculated as a percentage of the child's narrative word count (%).
[2] Calculated as a percentage of the total number of cohesive devices used in the narrative (%).
[3] Twenty two percent of children (n=15) had a CPSS score of $\geq$ 11 at T2.
Note. CASQ= Children's Acute Stress Questionnaire, CPSS = Children's Posttraumatic Stress Scale, TMQQ = Trauma Memory Quality Questionnaire.

Table 3. Bivariate correlations between narrative features, trauma memory constructs at T, and PTSD symptoms at T1 and T2.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.
Narrative measures																	
1. Emotions	1	.27*	-.06	-.04	-.37**	.27*	.28*	.11	.02	.05	.23	.36**	.29*	-.17	-.02	.46**	.27*
2. Thoughts		1	.28*	-.18	-.03	.16	.25*	-.16	-.14	-.15	.36**	.03	.10	-.16	-.06	.15	.11
3.Impaired thinking			1	-.30	-.09	-.15	.08	-.05	-.01	.06	.06	-02	.15	-.07	.04	.04	-.07
4.Sensory/perceptual				1	-.15	.17	-.01	.23	.17	-.07	.24*	.04	.12	.13	.08	-.03	.16
5.Temporal					1	-.12	-.15	.10	.04	.34**	-.02	-.32**	-.25*	.09	-.10	-.36**	-.30*
6. Causal						1	.54	.22	.11	-.00	.56**	.00	.07	.02	.03	.04	.19
7. Comparative							1	.10	.12	.01	.45**	-.01	.11	-.03	-.03	.08	.13
8.Global								1	.38**	.12	.34**	.00	.13	.02	.27*	-.15	-.07
9.Orientation									1	.12	.28*	-.27*	-.07	.18	.25*	-.09	-.08
10.Sequence										1	.09	-.16	.13	.12	.08	-.18	-.21
11.Evaluation											1	-.12	.07	.10	.28*	-.05	.03
Other																	
12.TMQQ												1	.32**	-.40**	-.19	.67**	.50**
13.Fear													1	-.28*	-.25	.54**	.37**
14.Age														1	.05	-.48**	-.39**
15.Vocabulary															1	-.05	.02
16. T1 ASD																1	.66**
17. T2 PTSD																	1

Note. **p* < .01;***p* <.001; TMQQ = Trauma Memory Quality Questionnaire; ASD=Acute Stress Disorder; PTSD=Post-traumatic Stress Disorder.

Table 4. Regressions of trauma memory characteristics and acute stress symptoms and posttraumatic stress symptoms.

	(a) Acute ASD[1]						**(b) Prospective PTSD[2]**						**(c) Change PTS[3]**				
	B	**95% CI**	**SE**	**β**	**ΔR^2**		**B**	**95% CI**	**SE**	**β**	**ΔR^2**		**B**	**95% CI**	**SE**	**β**	**ΔR^2**
Step 1					39.6**	Step 1					*23.0***	Step 1					*3.0*
Age	-1.33**	-2.1, -.59	.37	-.36		Age	-1.13*	-2.0, .29	.45	-.31		Age	-.17	-.97, .64	.40	-.05	
Fear[4]	-1.10**	.32, 1.3	.26	.42		Fear[4]	.73*	.14, 1.31	.30	.28							
Step 2					10.2*	Step 2					4.7	Step 2[7]					14.6**
Emotions[5]	5.83*	1.2, 10.5	2.33	.25		Emotions	1.8	-3.7, 7.4	2.8	.08		Age	-.07	-.82, .68	.38		
Temporal[6]	-.66	-1.5, .17	.41	-.16		Temporal[6]	.21	-1.8, .21	.51	-.21		ΔTMQQ	.55	.22, .89	.17		
Step 3[7]					12.5**	Step 3[7]					7.2*						
TMQQ	.68**	.38, 1.0	.15	.42		TMQQ	.52*	.14, .91	.20	.32							
Age	-.76*	-1.4, -.12	.32	-.21		Age	-.73*	-1.6, .11	.42	-.20							
Fear[4]	.69*	.24, 1.1	.23	.26		Fear[4]	.45	-.14, 1.0	.30	.17							
Emotions[5]	3.9	-.23, 8.1	2.08	.17		Emotions	.38	-5.1, 5.8	.48	.02							
Temporal[6]	.32	-1.1, .42	.37	-.08													

Note. ***p* <.001; **p<.05*; TMQQ = Trauma Memory Quality Questionnaire.
[1] Acute relationships of 4 week process variables → T1 ~ 4 week acute stress symptoms.
[2] T1 ~ 4 week process variables → T2 ~ 8-12 week post-traumatic stress symptoms.
[3] z T2-T1 change process variables → Z T2-T1 post-traumatic stress symptoms (calculated by a z-score of difference between CPSS total at time 2 and ASD total score at time 1).

[4] Rated by the child on a 10-point scale (0=very relaxed, 10=worst fear imaginable).
[5] The inclusion of negative emotions in the narrative (calculated as a percentage of the total word of count of each narrative).
[6] Linking words/cohesive devices which sequentially order two events in time calculated as a percentage of the total number of cohesive devices in the narrative. A z-score was created for use of temporal to additive devices in the narrative as this is a collinear relationship. A positive index score shows the inclusion of a greater proportion of time markers.
[7] Unstandardized residuals, confidence intervals, standardised β coefficients and R squared change statistics are presented for the final step of each model.

Supplementary Table 1. Bivariate correlations of T1 trauma memory characteristics and subclusters of ASD and PTSD symptoms.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. Emotions	1	.27*	-.06	-.04	-.37**	.27*	.28*	.11	.02	.05	.23	.36**	.29*	-.17	.40**	.24	.41**	.35**	.18	.12
2.Thoughts		1	.28*	-.18	-.03	.16	.25*	-.16	-.14	-.15	.36**	.03	.10	-.16	.14	.07	.15	.15	.16	.00
3.Impaired thinking			1	-.30	-.09	-.15	.08	-.05	-.01	.06	.06	-02	.15	-.07	.03	-.08	.04	-.14	.04	-.09
4.Sensory				1	-.15	.17	-.01	.23	.17	-.07	.24*	.04	.12	.13	-.07	-.06	.11	.01	.12	.24*
5.Temporal index					1	-.12	-.15	.10	.04	.34**	-.02	-.32**	-.25*	.09	-.37**	-.37*	-.28*	-.26*	-.24	-.22
6.Causal						1	.54	.22	.11	-.00	.56**	.00	.07	.02	-.07	-.06	.04	.13	.16	.22
7.Comparitive							1	.10	.12	.01	.45**	-.01	.11	-.03	-.02	.04	.11	.13	.14	.13
8.Global								1	.38**	.12	.34**	-.05	.13	.12	-.15	-.14	-.08	-.02	-.22	.04
9.Orientation									1	.12	.28*	-.27*	.07	.18	-.29	-.11	.10	-.13	-.08	-.03
10.Sequence										1	.09	-.16	.13	.12	-.22	-.25*	-.12	-.25*	-.21	-.10
11.Evaluation											1	-.12	.07	.10	-.13	-.07	-.08	.04	.05	.06
12.TMQQ												1	.32**	-.40**	.72**	.56**	.43**	.40**	.41**	.40**
13.Fear													1	-.28*	.49**	.35**	.43**	.36**	.30*	.29*
14.Age														1	-.48**	-.45**	-.27*	-.50**	-.41**	-.22
15. T1 intrusion															1	.71**	.48**	.52**	.48**	.43**
16. T1 avoidance																1	.61**	.41**	.50**	.42**

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
17. T1 arousal																	1	.36**	.55**	.46**
18. T2 intrusion																		1	.59**	.50**
19. T2 avoidance																			1	.69**
20. T2 arousal																				1

Note. *p < .01;**p <.001; TMQQ = Trauma Memory Quality Questionnaire.

Supplementary Table 2. Regressions of time 1 trauma memory characteristics and sub-clusters of time 1 Acute Stress Disorder symptoms.

	(a) Intrusions						**(b) Avoidance**						**(c) Arousal**				
	B	**95% CI**	**SE**	**β**	**ΔR²**		**B**	**95% CI**	**SE**	**β**	**ΔR²**		**B**	**95% CI**	**SE**	**β**	**ΔR²**
Step 1					36.3**	Step 1						Step 1					20.7**
Age	-.39**	-.62, -.17	.11	-.37		Age	-.44**	-.44, .13	.13	-.38	25.8**	Age	-.18	-.44, .08	-.13	-.16	
Fear[1]	.29**	.14, .45	.08	.39		Fear[1]	.20*	.20, .09	.09	.24		Fear[1]	.30*	.12, .48	.09	.38	
Step 2						Step 2					10.0*	Step 2					9.0*
Temporal[2]	.23	-.48, .01	.12	-.19	13.2*	Temporal[2]	-.27	-1.7, .10	.16	-.21		Temporal[2]	-.13	-.42, .17	.15	-.10	
Emotions[3]	1.4*	.00, 2.8	.69	.20		Emotions[3]	.34*	.34, .84	.84	.05		Emotions[3]	1.9*	.23, 3.5	.83	.27	
Orientation[4]	-.70*	-1.3, -.07	.31	-.21		Sequence[6]	-.78	-.78, .55	.55	-.17							
Step 3[5]					14.9**	Step 3[5]					8.9*	Step 3[5]					3.7
TMQQ	.23**	.14, .32	.05	.47		TMQQ	.18*	.06, .30	.06	.36		TMQQ	.11*	-.01, .23	.06	.23	
Age	-.19*	-.38, -.01	.09	-.18		Age	-.28*	-.52, .03	.12	-.24		Age	-.07	-.33, .18	.13	-.07	
Fear[1]	.17*	.04, .30	.07	.22		Fear[1]	.12	.05, .09	.15	.15		Fear	.20*	.02, .38	.09	.26	
Temporal[2]	-.13	-.34, .08	.10	-.10		Temporal[2]	-.21	.52, .10	.15	-.11		Temporal	-.07	-.37, .23	.15	-.06	
Emotions[3]	.71	-.49, 1.9	.61	.10		Emotions[3]	-.21	-1.8, 1.4	.81	-.03		Emotions	1.6	-.09, 3.2	.83	.22	
Orientation[4]	-.37	-.91, .17	.27	-.11		Sequence[6]	-.59	-1.6, .45	.52	-.12							

[1] Rated by the child on a 10-point scale (0=very relaxed, 10=worst fear imaginable).

[2] Linking words/cohesive devices which sequentially order two events in time calculated as a percentage of the total number of cohesive devices in the narrative. A z-score was created for use of temporal to additive devices in the narrative as this is a collinear relationship. A positive index score shows the inclusion of a greater proportion of time markers.

[3] The inclusion of negative emotions in the narrative (calculated as a percentage of the total word of count of each narrative).

[4] The level of context provided in the story (e.g., time, place, and setting) rated on a 3-point scale (higher scores are indicative of narratives with better levels of context).

[5] Unstandardized residuals, confidence intervals, standard errors, standardised β coefficients and R squared change statistics are presented for the full model in the final step.

[6] The series of events is told in the correct order and there is little repetition rated on a 3-point scale (higher scores are indicative of narratives with higher levels of sequencing).

Note. TMQQ=Trauma Memory Quality Questionnaire

Supplementary Table 3. Regressions of time 1 trauma memory characteristics and time 2 sub-clusters of PTSD symptoms.

	(a) Intrusions						**(b) Avoidance**						**(c) Arousal**				
	B	**95% CI**	**SE**	**β**	**Δ R^2**		**B**	**95% CI**	**SE**	**β**	**Δ R^2**		**B**	**95% CI**	**SE**	**β**	**Δ R^2**
Step 1					29.8**	Step 1					20.2**	Step 1					10.3*
Age	-.52*	-.78, -.25	.13	-.43		Age	-.48*	-.80, -.17	.16	-.35*		Age	-.31	-.80, .18	.25	-.16	
Fear[1]	.21**	.02, -.39	.10	.24		Fear[1]	.19*	-.04, .42	.11	.20		Fear[1]	.34*	-.01, .69	.18	.24	
Step 2					10.8*	Step 2[5]					5.6*	Step 2					5.8
Temporal[2]	.00	-.34, .33	.17	-.00		TMQQ	.16*	.01, .31	.07	.26		Sensory[6]	.88*	.03, 1.73	.43	.25	
Emotions[3]	1.84*	.12, 3.5	.86	.24		Age	-.37*	-.69, -.04	.17	-.27							
Sequence[4]	-1.3*	-2.4, -.13	.56	-.25		Fear	.13	-.10, .36	.11	.14							
Step 3[5]					.4							Step 3[5]					7.8*
TMQQ	.04	-.01, .17	.06	.08								TMQQ	.28*	.06, .50	.11	.31	
Age	-.41*	-.68, -.14	.14	-.34								Age	-.18	-.68, .31	.25	-.10	
Fear[1]	.118	-.02, .37	.10	.20								Fear[1]	.18	-.16, .53	.17	.13	
Emotions[3]	1.7	-.07, 3.5	.89	.22								Sensory[6]	.82*	.00, 1.6	.41	.23	
Sequence[4]	-1.2*	-2.4, -.07	.57	-.24													

[1] Rated by the child on a 10-point scale (0=very relaxed, 10=worst fear imaginable).

[2] Linking words/cohesive devices which sequentially order two events in time calculated as a percentage of the total number of cohesive devices in the narrative. A z-score was created for use of temporal to additive devices in the narrative as this is a collinear relationship. A positive index score shows the inclusion of a greater proportion of time markers.
[3] The inclusion of negative emotions in the narrative (calculated as a percentage of the total word of count of each narrative).
[4] The series of events is told in the correct order and there is little repetition rated on a 3-point scale (higher scores are indicative of narratives with higher levels of sequencing).
[5] Unstandardized residuals, confidence intervals, standard errors, standardised β coefficients and R squared change statistics are presented for the full model in the final step of each model.
[6] References to visual, auditory, sensory and olfactory information in the narrative (calculated as a percentage of the total word of count of each narrative).
Note. TMQQ=Trauma Memory Quality Questionnaire.

Supplementary Table 4. Regressions changes in trauma memory characteristics and changes of sub-clusters of PTS symptoms between T1 and T2.

	(a) Δ Intrusions[4]					(b) Δ Avoidance[4]						(c) Δ Arousal[4]					
	B	**95% CI**	**SE**	**β**	**Δ R^2**		**B**	**95% CI**	**SE**	**β**	**Δ R^2**		**B**	**95% CI**	**SE**	**β**	**Δ R^2**
Step 1					0.00	Step 1					.2	Step 1					.2
Age	-.01	-.12, .11	.06	-.06		Age	.02	-.10, .14	.06	.04		Age	.02	-.10, .14	.06	.051	
Step 2[2]					22.4**	Step 2[2]					11.5*	Step 2[2]					1.1
Δ TMQQ[3]	-.10**	-.14, -.05	.02	-.45		Δ TMQQ[3]	-.07*	-.12, -.02	.03	-.34		ΔTMQQ[3]	-.02*	-.08, .03	.03	.25	
Age	-.03	-.13, .08	.05	-.05		Age	-.01	-.10, .12	.06	.01		Age	-.00	-.10, .14	.06	-.01	

[1]Rated by the child on a 10-point scale (0=very relaxed, 10=worst fear imaginable).
[2]Unstandardized residuals, confidence intervals, standard errors, standardised β coefficients and R squared change statistics of all model variables are presented for the full model in step 2.
[3]A difference was created to assess the change in TMQQ scores between time 1 and time 2.
[4] As different measures of trauma response were used at T1 and T2, *z* scores were created to assess differences in symptom clusters between time 1 and time 2.
Note. TMQQ=Trauma Memory Quality Questionnaire.