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RESEARCH

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Potential for use of tetris in the neonatal unit – a scoping review

Victoria Elizabeth Mabel Craig¹ , Derek Francis McLaughlin¹ , Karen P. Devlin², Aiveen Higgins² and Breidge Boyle^{1*}

Abstract

Background Playing Tetris is a relatively new concept when considering how to treat or prevent post-traumatic stress symptoms (PTSS). Benefits have been identified regarding how playing the game can influence traumatic memory processing and storage. However, the concept is under-explored and can potentially help populations who are at risk of and are known to experience post-traumatic stress, such as parents of preterm infants in the Neonatal Unit. The aim of the review was to establish if preterm parents playing Tetris was a feasible option to potentially minimise PTSS.

Method A scoping review was conducted using PRISMA-ScR guidance. Databases searched were Cinahl, Medline and PsychInfo, over a 20 year period (2003-2023). Titles and abstracts were screened before analysis of full-text articles. A variety of clinical and experimental studies were examined, with differing trauma exposure experienced by participants.

Results Thirteen articles were reviewed and four common themes identified. These were memory consolidation, playing Tetris and its effect on intrusive memories (IMs), the effect on the brain and the acceptability as a technique to minimize PTSS in clinical trials.

Conclusion Tetris, in theory, is a first-aid intervention and has the potential to minimise the impact of trauma. Based on the findings of the review, Tetris has been effective in other clinical areas and deemed acceptable by participants. Therefore, Tetris is worthy of consideration for use in the population of preterm parents.

Keywords Tetris, Post-traumatic stress symptoms, Neonatal, Preterm parents

Introduction

Experiencing post-traumatic stress symptoms (PTSS) is a significant problem which impinges on the daily lives of those affected, and their relationships with others [1–5]. Specifically, PTSS can have a huge impact on the lives of preterm parents and their infants. This occurs as a result of spending days, weeks and even months in the highly stressful environment that is the neonatal unit (NNU). The tumultuous nature of the neonatal journey results from the changing nature of the stressors in the NNU [6–8]. As Shaw et al. (2009) stated, the perception is that

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parental distress and stress is part of the neonatal lived experience [9] – yet this does not make it acceptable. Acknowledgement of the problem ultimately means it is fundamental to find a solution. While time spent in the NNU shall never be completely free of stressors for parents, it may be possible to minimize the post-traumatic effect on their lives.

One such method of potentially minimizing PTSS is playing the computer game Tetris [2, 5]. Tetris is a computer game produced in the 1980s yet remains popular today [10]. The aim of the game is to rotate the falling block shapes to create solid horizontal rows when they land. As a horizontal row is completed, it disappears. As the game progresses the block shapes fall at a faster rate and the player must speed up their reactions to turn the blocks 90 degrees each time to make the blocks fit.

This is a relatively underexplored concept regarding its benefits in minimizing PTSS. To date no publications have explored its use by preterm parents while still in the NNU. The theory that Tetris can minimize intrusive memories / flashbacks [2, 5] could potentially help many parents who struggle with PTSS long after their baby has been discharged from the NNU.

Post-traumatic stress symptoms (PTSS)

Post-traumatic stress symptoms can lead to the development of post-traumatic stress disorder (PTSD), but not in all cases. PTSS can occur 3-4 weeks after the traumatic event [4, 11]. These symptoms include intrusive memories (flashbacks) and avoiding triggering reminders of the trauma including people and places. Other symptoms are negative thoughts including fear and guilt, and hyperarousal such as irritability and anger, and sleep disturbance [12, 13]. This final symptom, however, is stereotypical of a mother of a newborn baby [4]. Within the context of the NNU, breastfeeding mothers are asked to wake in the middle of the night to express breast milk, thus emulating how often a baby would feed.

Intrusive memories are a key problem associated with PTSD [5] – defined by James et al. (2015) and Holmes et al., (2009) as being the hallmark sign of PTSD development [14, 15]. They are repetitive, obtrusive and unwanted memories [2, 5, 16] which in themselves are distressing to endure. It is thought this is due to the differing nature of a flashback as opposed to a deliberately recalled memory. The flashback is intrusive by nature, unwanted, and experienced at the original emotional intensity as the trauma occurred [17]. In comparison, recalled memory is deliberate, and the “quality” of the emotional impact is dampened [17]. It is thought that intrusive memories (IM) instigate other symptoms of PTSD and prevent the memories of the trauma from becoming less intense [16].

Post-traumatic stress disorder (PTSD) is a significant problem in society. According to PTSD UK (2023) 50-70% of the UK population will experience trauma in their lifetime [18], and as a result, 20% of this group will develop PTSD. This equates to 10% of the population / over 6.6 million people [18]. Almost a quarter of a million new referrals were made in England alone between 2021/22 and 2022/23 [18] – this is a staggering number of people in need of help, and many more suffer in silence.

First aid techniques to prevent PTSS and PTSD

Early interventions after trauma and when to intervene is an ongoing topic of interest [19, 20]; thus, embracing the philosophy of “prevention is better than cure”. A recent systematic review and meta-analysis of early multiple session techniques to prevent PTSD was inconclusive [20]. Trauma-focused Cognitive Behavioural Therapy (CBT), EMDR, structured writing therapy diaries, and internet-based guided self-help were all found to be effective in this meta-analysis. Interventions began 2-4 weeks after a traumatic event and participants exhibited PTSS. Preventative measures had not been considered at the onset of trauma. As previously discussed, post-traumatic stress symptoms do not necessarily lead to a diagnosis of PTSD; or exposure to trauma [1]. Ultimately preventing PTSD is what should be strived for in caring for those who have undergone a traumatic experience.

A meta-analysis considering preventative measures found similar outcomes [19]. This review concluded that there is currently no “one size fits all” approach to provide universal preventative measures for PTSS. To some extent, the nature of the trauma and individuals’ needs lead to a “best fit” intervention. In relation to the previously unexplored phenomenon of minimizing PTSS in the NNU, it would be beneficial to explore more than one option. By doing so, the potential to find a feasible, acceptable and effective technique increases.

Each year it is thought that 64-80 newborns per 1000 live births throughout the world are admitted to the NNU [6]. This varies throughout the world and approximately 13% of live births in Northern Ireland are admitted [21]. The NNU is a daunting place to be as a new parent [6, 21, 22]. The impact of having a baby admitted to the NNU can have a long-lasting detrimental to maternal and paternal mental health [23]. The socioeconomic impact is hugely significant [23]. Perinatal mental health issues attribute to a cost of £8.1 billion for the UK economy [23, 24].

In Northern Ireland, where rates of PTSD, as a result of transgenerational trauma, are thought to be high [25] parents may face the birth of a premature or sick child with high baseline trauma scores. With approximately 1,800 babies admitted for neonatal care there every year

[21] almost double that number will experience the stress of being a NICU parent. A first aid type intervention, which minimizes the development of trauma in this population would be useful and Tetris, if there is evidence that it works, would be ideal.

The objective of this review is to provide evidence in the published literature about the role of Tetris in minimizing post-traumatic stress symptoms. The review shall also address if these findings can potentially help parents in the Neonatal Unit - a population in need of support after trauma [21].

Methods

Scoping review

Scoping reviews are an increasingly popular method of reviewing literature [26]. The evolution of the early scoping review [27] has led to the development of guidance in the form of the PRISMA-ScR checklist [28] to ensure that the review is conducted methodically with rigor [29]. Through developing this framework scoping literature reviews can be critically appraised confidently under the gold standard established criteria.

A scoping review should be selected as opposed to a systematic review when limited review knowledge about a concept is available [26, 29–31]. The definition provided by Arksey and O'Malley (2005) – to examine the extent of the knowledge available, summarise and identify gaps – still stands [27]. However, the choice of scoping versus systematic depends on the intended outcome of the review. In addressing whether a study can be conducted within a specific setting, it is defined as a feasibility study [32, 33]. Suggesting that Tetris may have an impact on the post-traumatic stress of parents would initially be explored in this way. The acceptability of the intervention is determined by the views of those implementing and using it, to establish if the outcome is satisfactory [32–34]. Although Peters et al. (2021) and Munn et al. (2020) suggest that acceptability and feasibility studies are better suited to a systematic review, they do concede that when identifying concepts and mapping emerging knowledge, a scoping review is preferential [29, 32, 34, 35].

Using the JBI guidance [35] and that of Pollock et al. (2021) a scoping review was chosen in preference to a systematic review [36]. This was based on the premise of identifying key concepts within the literature (Tetris and the link to PTSS), and factors relating to the concept (how Tetris worked in relation to memory storage). A scoping review was chosen for this literature review based with the intended outcome being mapping knowledge [27, 28, 36] and ascertaining its potential use in another field (the Neonatal Unit) [26, 30]. The key phrase is mapping [26, 29, 31, 35]. As with any venture into the unfamiliar, mapping the information available thus far

can enable decision-making about future research and identify gaps [26, 31].

Search strategy

A relationship between the objective of the study and the eligibility criteria for the literature to be examined was compiled in the PCC framework and JBI guidance [35, 36] (Fig 1). The main objective of the literature search was identified as establishing if playing Tetris can minimise PTSS. By doing so the research question was formulated: What is known from existing literature about Tetris and minimizing post-traumatic stress symptoms? This then guided the PCC Framework [36], considering the population, concept and context of the literature to be reviewed (Fig. 1). The population of interest was deemed to be those at risk of developing PTSS. Concept was defined as the exploration of the impact of Tetris on memory; or that playing Tetris could potentially minimize the PTSS experienced by participants. The context of the literature to be studied was either a clinical trial or in an experimental trial in a laboratory situation [35].

Eligibility criteria

As identified in Fig. 1, the PCC framework led to detailing the inclusion criteria for the literature review [35, 36]. This is in line with the PRISMA-ScR checklist [28]. Articles were included if they were written within the past 20 years (2003-2023) and were published in English. Articles were to be considered if they discussed the use of Tetris in a clinical or experimental lab setting. Participants could be exposed to actual trauma to their person, or artificially through watching a traumatic film. The playing of Tetris could be documented as a lone technique or as a comparative technique to alternatives such as exercise or psychotherapy.

Selection of sources of evidence

A scoping literature review was conducted using the databases CINAHL, PsychINFO and Medline in April 2023. Access was made possible by the academic institution, Queens University Belfast. Search terms used were Tetris, trauma, memories and neonatal. Expansion of terms when offered through the database searches were neonatal intensive care, memory consolidation, intrusive thoughts, post-traumatic stress disorder producing hits.

Data extraction and charting

Information was documented based on the PCC concept as previously discussed to meet the objectives of the literature search and address the research question. Therefore, key information was documented from the study findings as was the population studied, the concept investigated in the studies, and the context in

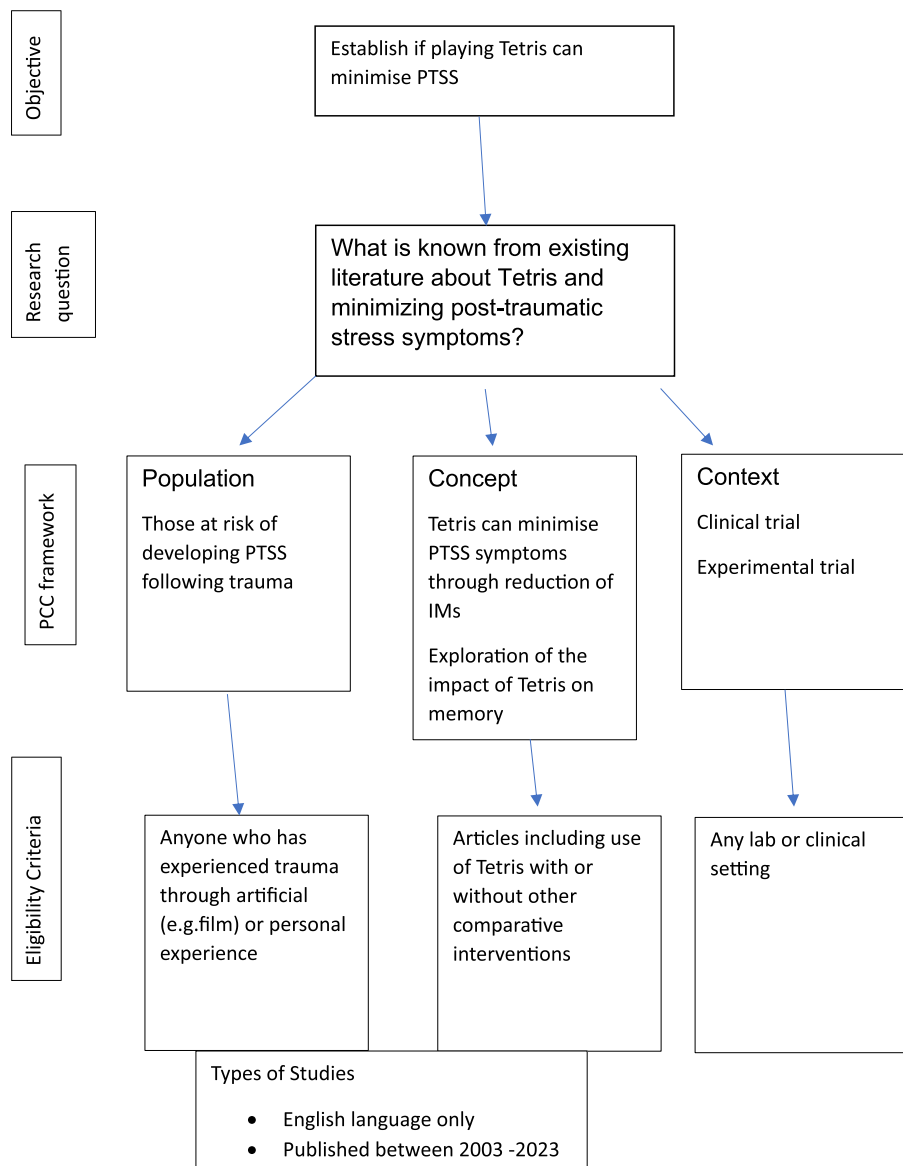


Fig. 1 PCC framework for scoping review

which the study took place. The chart used was agreed by the research team and completed independently by VC, DMcL and BB.. This provides transparency of findings and allows for replicability of the review [35], as guided by Pollock et al. (2021) [33]. The data was then analyzed using the reflective thematic analysis methods described by Braun and Clarke in 2019 [37]. The process of literature analysis was reflexive, leading to common themes to be conceptualized. These were based on the key findings of the articles in Table 1 [37].

Results

The literature search initially identified 254 articles. Nine duplicate articles were removed. The titles of the remaining 245 were screened by two members of the research team, initially by title and abstract and 226 were excluded as they were irrelevant. Nineteen full text articles were reviewed and thirteen were deemed useful for the scoping review [36] (Fig. 2) Hand searching, using the reference lists, carried out by the research team, identified no further literature. A clinical trial

Table 1 Summary characteristics of the 23 studies included in this review

Tetris							
Title	Authors	Journal	Population	Context	Concept	Methodology	Key findings
Playing the computer game Tetris prior to viewing traumatic film	James et al. (2015) [14]	Psychological Science	Expt trial group n=52	Watching traumatic film	Playing tetris would disrupt reconsolidation of traumatic memories	12 min film +Tetris played 24 hr later Diary of IMs for 1/52	Can't do 2 things at once Is any double task effective? Fewer IMs in Tetris group vs control Need recall + Tetris to be effective
Visuospatial computer game play after memory reminder delivered three days after a traumatic film reduces the number of intrusive memories of the experimental trauma	Kessler et al. (2020) [38]	Journal of Behavioral Therapy and Experimental Psychiatry	Expt trial n=86	Watching traumatic film	Playing tetris would disrupt reconsolidation of traumatic memories	Film Recall of memory + Played Tetris or pub quiz 3/7 after first exposure to film	Both games reduced IMs even 3 days later Tetris more effective
Improving mental health and physiological stress responses in mothers following traumatic childbirth and in their infants: study protocol for the Swiss Traumatic birth Trial (START)	Sandoz et al. (2019) [3]	BMJ Open	Clinical trial (START) n=144	Following traumatic birth	Playing Tetris will reduce IMs	RCT Play Tetris within 6 hr of delivery	Outcome unknown
Trauma, treatment and Tetris: video gaming increases hippocampal volume in male patients with combat-related posttraumatic stress disorder	Butler et al. (2020) [39]	Journal of Psychiatry and Neuroscience	Ex-army personnel inpatients with established PTSD n=40	No neuro imaging has been assessed in those with existing PTSD	Playing Tetris will demonstrate neurological effect	Tetris 60 min each day for 6/52 Also receiving EMDR at same time	Increased hippocampal grey matter ad volume Reduced PTSD, depression and anxiety
Preventative efforts in the aftermath of analogue trauma: The effects of Tetris and exercise on intrusive images	Bruhl et al. (2019) [40]	Journal of Behavioral Therapy and Experimental Psychiatry	Expt trial n=71	Aerobic exercise may help reduce IMs	Will tetris, cycling or being sedentary have an effect on traumatic memory recall	Played Tetris, cycled or remain sedentary for 25 min Kept diary	no intervention was effective without prior recall of the trauma 1/52 later

Table 1 (continued)

Tetris							
Using a brief mental imagery competing task to reduce the number of intrusive memories: exploratory case series with trauma exposed women	Thorarinsdottir et al. (2022) [41]	Journal of MIR Formative Research	Clinical trial Est or sub threshold PTSD n=3	Novel interventions may help reduce IMs	Playing tetris will reduce number of IMs	Cue reminder Tetris for 25 min Kept diary at 1/12 and 3/12	Reduction in number of IMs from baseline to 3 mths
Visuospatial working memory tasks may not reduce the intensity or distress of intrusive memories	Badawi, Steel and Berle (2022) [42]	Frontiers in Psychiatry Frontiers Research Foundation	Expt trial Public volunteers n=110	Tetris or digital task may help reduce IMs	Intensity and distress of IMs may be reduced through VS tasks	RCT Watch film 10.5 min Play Tetris or Digital Corsi task for 12 min Kept diary	After 4 hr and recording in diary Intensity and distress of IMs not reduced
Selectively Interfering With Intrusive but Not Voluntary Memories of a Trauma Film: Accounting for the Role of Associative Memory	Lau-Zhu, Henson and Holmes (2021) [43]	Clinical Psychological Science	Clinical trial Est PTSD n=36	Watched traumatic film	Is playing Tetris effective on its own, or is recall of memory necessary	X11 3 sec Traumatic film stills watched Tetris 10 min Diary	Fewer IMs in first week with Tetris group
Reducing intrusive memories after trauma via a brief cognitive task intervention in the hospital emergency department: and exploratory pilot randomized controlled trial	Kanstrup et al. (2021) [44]	Translational Psychiatry	Clinical trial ED patients N=41	Exposure to trauma such as RTA or fall	Within 72 hours of attending ED, playing Tetris will reduce IMs	Played Tetris within 72 hours 10 min consecutively 20 min total	No -ve feedback Simple, scalable, cost-effective Fewer IMs after 1/52 and 5/52
Investigating the frequency of intrusive memories after 24 hours using a visuospatial interference intervention: a follow-up and extension	Brennen et al. (2021) [45]	European Journal of Psycho-traumatology	Clinical trial n=149	Watched film and either did nothing, played Tetris with prior recall, or without prior recall	Freq of IMs will reduce 24hr post Tetris	Trauma analogue film 12 min Tetris 12 min Kept diary of IMs for 8 days	No sig diff between groups on day 1, 2, 8

Table 1 (continued)

Tetris						
Preventing intrusive memories after trauma via a brief intervention involving Tetris computer game play in the emergency department: a proof-of-concept randomized controlled trial	Iyadurai et al. (2018) [5]	Molecular Psychiatry	Patients in ED after motor vehicle accident n=71	Play Tetris within 6 hr of accident	Playing tetris will reduce number of IMs at 1 wk and 1 mth	RCT Play tetris 20 min Less IMs at 1/52, but not at 1/12 ? use any VS game
Mobilum – a new mobile app to engage visuospatial processing for the reduction of intrusive visual memories	Kessler et al. (2018) [38]	mHealth	Expt trial Inpatients receiving psycho-therapeutic treatment n= 16	Play the game	Playing an alternative visuospatial game will be as effective as Tetris	Pilot study Played game 15 min over 5/7 Task was difficult and caused frustration
Tetris and Word games lead to fewer intrusive memories when applied several days after analogue trauma	Hagenaars et al. (2017) [46]	European journal of psycho-traumatology	students n=54	On recall memories return to WM and are labile	Undertaking a VS task days later will still be effective in reducing IMs	RCT Aversive film Tetris or game played with or without recall on day 4 IM diary kept day zero-4, and day 4-8 Word game was more effective than Tetris (minimal evidence as word game may have been more difficult to play)

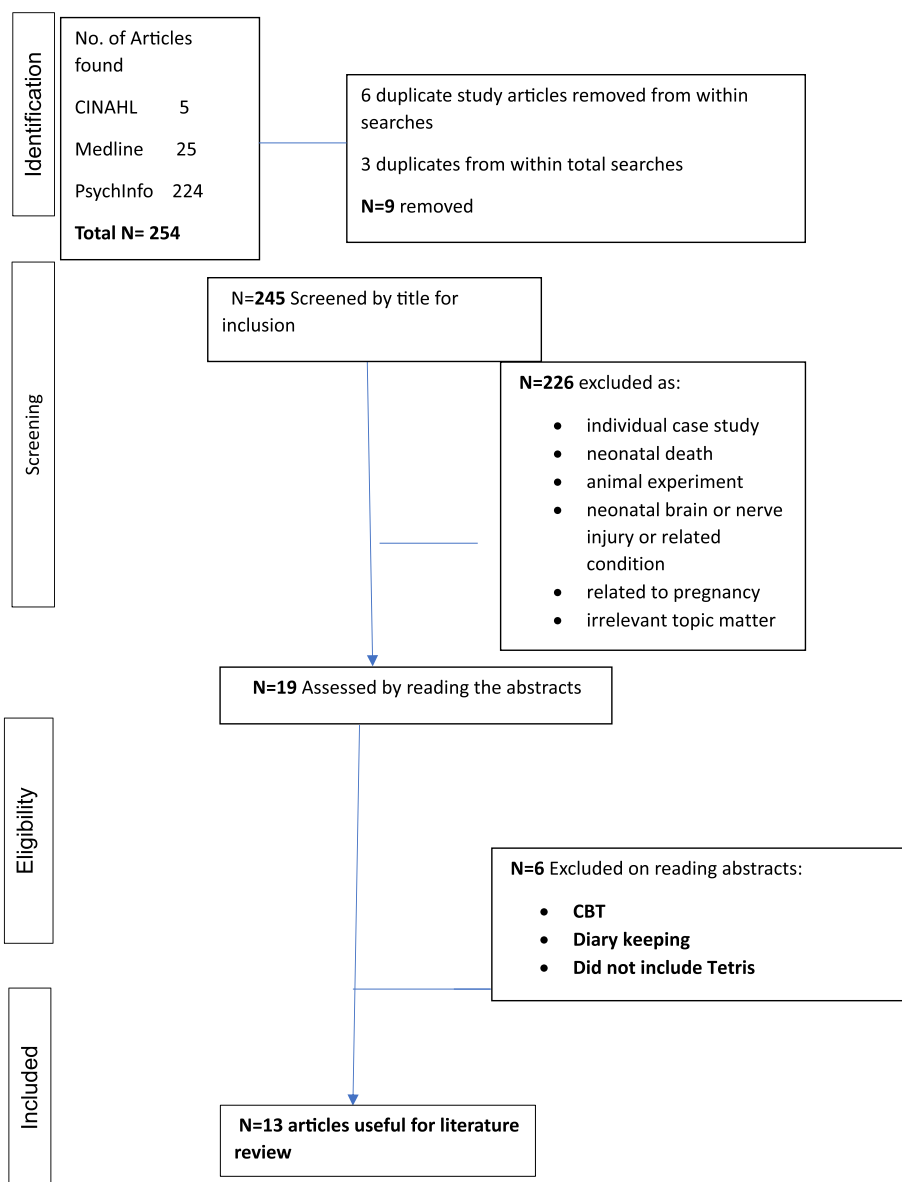


Fig. 2 Tetrtris literary search -April 2023

using Tetris was identified using <https://www.clinicaltrials.com> [3]. Researchers engaged in research in the area internationally were contacted regarding ongoing and unpublished work in the area but no grey literature was identified.

Findings

The findings of the scoping review can be categorized into four main categories or themes following thematic analysis [36], demonstrating their connection to the PCC Framework [35, 36]:

- Memory consolidation (Concept)
- Playing Tetris and its effect on intrusive memories (IMs) (Concept)
- The effect on the brain (Concept)
- Acceptability as a technique to minimize PTSS in clinical trials (Population, Context)

Memory consolidation after trauma

Following a traumatic event, the memories associated with it are malleable from 10 minutes following the

event until 6 hours afterwards [3, 16]. If a visuospatial intervention can be undertaken within this timeframe, such as playing the computer game Tetris, the number of IMs experienced by the player will reduce over the following weeks [2, 5]. Playing the game preoccupies the sites in the brain linked to processing and storage of information [10]. Visuospatial working memory resources compete with intrusive memory [3, 23], serving as what has become known as a “cognitive vaccine” [10, 43]. Badawi, Steele and Berle (2022) refer to this as the “visuospatial hypothesis” [42].

The brain cannot perform two tasks at once [47] and the memory storage process is disrupted [46]. Dual activities compete for the working memory capacity in the brain and reduce the vividness of the memory [14]. If the brain is unable to process the traumatic effects of the event experienced or observed, then the memory becomes less vivid and flashbacks occur less often [47].

Memory consolidation takes place within 6 hours [16, 23, 39]. Up to that point the memory is labile and as such the traumatic effect of the memory can be minimized through the technique of playing Tetris. However, for those with established PTSD, this window of opportunity has long since passed, yet the need for treatment remains [2, 39].

The key is to recall the memory, reactivating it as such. It is thought that the memory is now malleable once again and can therefore be manipulated as if it were recently formed [14, 39, 43]. Hagenaaers et al. (2017) suggest this malleableness is only in part [46]. It is now “updateable”, and its intensity can be weakened. This is achieved through competing for visuospatial working memory capacity as before, for example, through playing Tetris [46]. The memory is then reconsolidated within the brain [5, 14].

When considered separately, playing Tetris without recall of a traumatic memory, or recalling the memory alone will not reduce the incidence of IMs – it is the considered theory that the combination of recall and reconsolidation interferes with IM consolidation [14, 39, 44]. It is important to note that the accuracy of the memory remains intact [43]. Only the negative connotations associated with the recalled memory are affected when the gaming occurs prior to the reconsolidation phase of memory processing and storage [43]. Badawi, Steele and Berle (2022) did not support this theory [42], finding no difference in intensity and vividness of traumatic memories; although the sample number ($n=110$) is of a similar size to previous studies discussed. There is no evidence found in this literature review to support either theory regarding the

initial storage and processing of memories when Tetris is played within the 6-hour window post-trauma.

Playing Tetris and effectiveness on intrusive memories

In the studies reviewed the game is played on marathon mode, and in mute [14, 43]. Length of play varied from 10 continuous minutes to 20 minutes in total. The study by Brennen et al. (2021) did not play in marathon mode and played a basic format of the Tetris game (less vivid-coloured bricks) [45]. These are given as possible reasons why their study did not find a reduction in IMs reported. In most studies the game is played at once following the traumatic event or recall of the event, but one study by Butler et al. (2020) encouraged play for 60 minutes each day for a period of six weeks [39]. This study differed from the others in that the trial group of 40 ex-military personnel all had established PTSD and were undergoing EMDR simultaneously.

Studies have shown that Tetris has been successful in reducing the incidence of IMs within an experimental context [15, 38, 46, 48] and in trials with participants with established PTSD as an adjunct to EMDR treatment [39]. Iyadurai et al.'s study from 2018 in an English emergency department (ED) produced slightly better data (a 62% reduction in IMs) from a larger participant group ($n=71$) [5]. While Kanstrup et al.'s Swedish study (2021) of 41 participants in the ED observed a 48% reduction in IMs at one-week post-trauma [44], there was a remarkable 90% decrease in IMs at five weeks post-trauma. Following an emergency caesarean section, the group of 56 new mothers in Switzerland who played Tetris experienced 48% fewer IMs than their counterparts who received the usual post-natal care [23]. The START trial in Switzerland results are eagerly anticipated after a larger trial ($n=144$) exploring this same phenomenon [3].

In contrast, Brennen et al. (2021) observed no reduction in IMs reported after watching traumatic film material [45]. Among reasons previously discussed regarding the format of the Tetris game played, they also give other potential reasons for this difference in outcomes. Watching a poor-quality film on a smaller screen may account for this difference. The researchers also suggested a cultural reason in that the participants in their Norwegian study were less traumatized by the film than the English participants. This was in comparison to the study by James et al. (2015) which the researchers were comparing their work to [14].

Effects on the brain

Non-specified prefrontal regions of the brain which are involved in regulating the expression of fear have been

noted to be smaller in MRI scans of people with PTSD, which can increase in size with gaming [39]. However, Butler et al.'s study observed no such increase after the participants played Tetris for 6 months. They also hypothesized that hippocampal volume would increase through gaming, and this was found to be the case - as observed in MRI scans of participants who played Tetris. This increase in hippocampal volume coincided with a reduction in PTSD symptoms, possibly due to the hippocampus being the brain centre for memory consolidation and learning [39].

Stress has also been linked to glucocorticoid receptor activation which reduces the hippocampal volume, and a reduction in neurogenesis or neuron synthesis. Tetris can influence neurogenesis, which may aid a reduction in PTSS through the synthesis of new neurons. These form strong memory connections within the brain and weaken existing ones perhaps linked to trauma [39].

Acceptability of tetris in clinical trials

Tetris is presented as a feasible way to treat trauma [5, 23]. It is cost-effective as the game is free to download onto a smartphone. No clinical experts are required to recruit participants or to explain the purpose of or how to play the game, so is low intensity [5]. In studies using participants experiencing live trauma, the acceptability of the game as a potential tool to reduce trauma symptoms was demonstrated in the uptake of study recruitment - 48% in Iyadurai et al.'s study (2018) to 88% in Kanstrup et al.'s study (2021) [5, 44]. The game is considered simple and scalable regarding treating trauma [16, 44]. It is also enjoyable to play [14]. Kanstrup et al. (2021) found the nurses in the Emergency department were supportive of the study and implementation of the technique [44]. However, in this study, natural time gaps occur between elements of treatment as participants waited, for example, for x-rays. Therefore, time taken to play Tetris did not interfere with necessary care procedures.

Importantly no adverse effects were noted or reported [44]; in comparison to Holmes et al. (2009) who found that verbal computer games increased the intrusive memories caused by trauma [15]. It has been suggested that any visuospatial game involving mental rotation could work [5]. Another game designed by Kessler et al. in 2019 was not found to be as effective, possibly due to the level of difficulty and app design [2]. However, the positive feedback obtained showed its potential. Kessler et al.'s study highlighted that at present copyright laws did not affect the use of the Tetris game in studies concerning PTSD, but if the game should revolutionize the treatment of PTSS, then this may become an issue [2].

Discussion

The scoping review met the aim of the literary search: What is known from existing literature about Tetris and minimizing post-traumatic stress symptoms? Key factors associated with the concept were identified and examined [29]. Playing Tetris, as described, affects how traumatic memories are stored. Using the visuospatial working memory to play the game, while the brain tries to store the memory is considered a dual task. Although discussing EMDR, Englehard et al. (2010) stated that the act of performing these two tasks at the same time is what was found to reduce the vividness and emotional connotation of the memory [47]. By reducing the emotionality of the traumatic memory, fewer IMs are noted [2, 5, 23, 44]. Contradictory studies found no reduction in the number of IMs [45] or intensity [42].

Tetris, in theory, is a first-aid intervention and prevention in halting the full impact of trauma under the premise that prevention is better than cure. By reducing the impact of PTSS it would be hoped that PTSD could be avoided, and fewer referrals needed to further psychological support. If implemented within the context of the NNU, this technique could minimize the number of IMs experienced by preterm parents and reduce their PTSS. Evidence produced by the review suggests this is possible and worthy of consideration. This unexplored phenomenon is therefore identified as the gap in the literature and provides rationale for future study.

Potential impact of trauma in the NNU

Pierrehumbert et al.'s Swiss study in 2003 found that, 18 months after the birth, 34% of preterm mothers experienced PTSS compared to 4% of full-term mothers [49]. One of the instruments that they used to measure outcomes was a perinatal risk inventory (PRI) [50], where time spent in hospital is seen as an indicator of developmental risk. It is therefore difficult to say whether the higher prevalence of PTSS in the mothers of preterm infants is due to the birth or the time spent in hospital. Preterm birth, including time spent anticipating the imminent delivery with all the fear and uncertainty that suggests, is obviously a stressful event in itself. The closest relatable population to parents in the NNU is mothers following a traumatic birth. Horsch et al. (2017) first used Tetris after emergency caesarean sections with reported success [23]. Midwives of mothers who played Tetris following an emergency caesarean section deemed it neither time-consuming nor unreasonable alongside other essential tasks [23]. This further supports the theory that playing Tetris following a preterm birth and admission to the NNU is feasible.

The literature reviewed has demonstrated that the use of Tetris has been successfully trialed in clinical areas

[5, 23, 44]. As highlighted by Iyadurai et al. (2018), playing Tetris is simple and a low-intensity intervention [5]. It can even be considered enjoyable. Iyadurai et al. (2018) found that playing Tetris for 20 min significantly reduced the incidence of IMs following a motor vehicle accident [5]. The game was played in the ED, within six hours of the accident, indicating it was a feasible treatment to be offered in a busy clinical area. Kanstrup et al. (2021) also found favorable outcomes following the use of Tetris by patients in the ED, notably at five weeks after the trauma [44]. It is easy to see how a simple intervention such as Tetris could be used within six hours of a preterm birth to manipulate memory consolidation, reduce intrusive memories through its effect on the brain.

Among the preterm births, both mothers and fathers, whose babies had a higher PRI score and had spent more time in hospital, had statistically higher prevalence of PTSS [49]. What has not been tested is whether the continuing stress experienced by parents of a baby in NICU can be reduced by playing Tetris. Unlike a road traffic accident, or a traumatic birth, an NICU admission can mean days, weeks or even months of relentless trauma of intermittent severity. There is no evidence that Tetris, used either during or after the admission can counteract this level of trauma.

However, the hallmark symptom of post-traumatic stress is noted as flashbacks or intrusive memories (IMs) [5, 14, 23]. These are unwelcome and distressing for the person who experienced trauma, being unintentionally recalled [2, 5, 16]. Parents experience many traumas during their stay in the NNU – separation from their baby, observing their baby undergo medical procedures, and worsening of their condition. The ongoing nature of trauma in the NNU creates new memories and the potential for more flashbacks to occur. The possibility that this could be minimized for parents of preterm infants is a concept that is worthy of exploration. Playing Tetris has the potential to reduce the number of IMs and their vividness [5, 38, 44].

If the parents were encouraged to play Tetris early after preterm delivery, and when they felt stressed during their NICU stay, they potentially could reduce the number of IMs. As stated by Deforges et al. (2022), Butler et al. (2020) and Horsch et al. (2017), memory is labile for up to six hours after experiencing trauma [16, 23, 39]. Herein lies the window of opportunity to minimize the effect of the trauma by applying a first aid intervention. The relentless nature of stress in NICU would necessitate the parent playing Tetris frequently.

Where Tetris is used as a curative rather than a first aid intervention, previous studies have demonstrated the necessity to recall the traumatic memory before such

an intervention would be introduced in order to have an effect [14, 39, 43]. In doing so the memory is reconsolidated. However, if the memory is only partially malleable as Hagens et al. (2017) posits [46], the intervention may not be as successful as it potentially could be. Therefore, introducing the intervention as early as possible before memory consolidation takes place may be more beneficial in reducing IMs [5].

In terms of general first aid, Tetris is considered to be the treatment given at the moment the accident occurs, providing immediate care. The aim is to control the impact to health caused by the injury. If considered in regard to parents in the NNU, the first aid treatment offered should also be both immediate and ongoing. In doing so, it could be suggested the impact of the recurring traumas to mental health are minimized. Therefore, Tetris could be considered as a first aid intervention for potential use in the NNU.

It has been suggested that any visuospatial game task may be worthy of consideration [5, 14]. However, the review has demonstrated that not all games are accepted as a feasible alternative [2] or can be detrimental causing more IMs [15]. In the 2017 study by Hagens et al. a word game was found to be slightly better, 1.6 times more likely, than Tetris in reducing the number of IMs experienced after watching a traumatic film [46].

In recent studies by Malouf et al. (2022) and Brunson et al., (2021), almost 40% preterm mothers experienced PTSS at six months following discharge from the NNU [51, 52]. In the longitudinal study conducted by Brunson et al. (2021) these figures remained elevated at 18 months (60.4%) [52]. However, Malouf et al. (2022) found that after one year this dropped to 27.1% in their international systematic review of 56 studies [51]. When compared to full term mothers, preterm mothers are noted to be at greater risk of developing PTSS [12, 49, 53]. The need to prevent PTSS in preterm parents is paramount and ways to achieve this need to be explored.

Strengths and limitations

The main strength of this scoping review was the research team carrying it out. The team consisted of a trauma consultant with experience of using EMDR to treat complex PTSD, clinical and academic neonatal nurses, two of which are trained in EMDR, a neonatologist and a clinical psychologist with a special interest in the mental health of parents on the neonatal unit. This meant that, although the published literature is sparse, they were able to bring a wealth of experience to using Braun and Clarke's [37] reflexive thematic analysis methods. Although the formal search was only carried out in three databases, before seeking to publish, the search was

repeated in EMBASE and no further relevant literature was identified. A research framework such as the theoretical framework of acceptability was not used to guide data collection and could be viewed as a limitation of the study. Also, there were varied participant groups across all the different articles. It would not be possible to group all together to form any significant relationships between studies or effectiveness of Tetris on the participants.

Conclusions

This scoping review of existing literature has established the knowledge map of the concept investigated. Playing Tetris has been found to alleviate the core hallmark symptom of post-traumatic stress through a reduction of IMs [3, 5, 23, 44]. The underlying theory that taxing the visuospatial working memory while storing the traumatic memory provides reasoning as to why playing Tetris is beneficial following trauma [5]. The experimental and clinical trials support the theories in various settings.

The simplicity of the technique [44] suggests potential in addressing the problem of PTSS among preterm parents in the NNU. So too, does the translational nature of findings from previous studies. There is no evidence in published literature to date to suggest that interventions in this area have previously been researched; and so identifies a significant gap in the literature which needs to be addressed. Prevention is always better than cure. As this is a known population who experience PTSS and can proceed to the development of PTSD, it is worthwhile pursuing this line of thought to generate knowledge in this area. However, before a large research trial can be planned to test the effectiveness of any intervention, the Medical Research Council advises that the acceptability of that intervention to a given population and the feasibility of introducing it are assessed in a clinical setting [32–34]. This is the next necessary step in finding evidence that Tetris is a viable option for reducing PTSS in parents of preterm infants.

Appendix 1

Checklist for PRISMA-ScR

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	2,3
ABSTRACT			

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
INTRODUCTION			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	3-6
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	6
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	NA
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	10
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	10

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	10
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	10, 17
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	112-15
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	10
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	6, 7
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	16, 17
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	10
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	12-15
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	12-15

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	12-15
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	18-22
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	22-26
Limitations	20	Discuss the limitations of the scoping review process.	26, 27
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	27, 28
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	28

JB Joanna Briggs Institute, *PRISMA-ScR* Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews

*Where sources of evidence (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

†A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with information sources (see first footnote)

‡The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting

[§]The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document)

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med.* 2018;169:467–473. <https://doi.org/10.7326/M18-0850>

Authors' contributions

Data searches and manuscript written by VC with input from BB, DMcL, KD and AH. All authors reviewed manuscript.

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Availability of data and materials

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Declarations

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Competing interests

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References

- Hoppen TH, Jehn M, Holling H, Mutz J, Kip A, Nexhmedin M. The Efficacy and Acceptability of Psychological Interventions for Adult PTSD: A Network and Pairwise Meta-Analysis of Randomized Controlled Trials. *J Consult Clin Psychol.* 2023;91(8):445–61.
- Kessler H, Dangellia L, Kessler R, Mahnke V, Herpertz S, Kehyayan A. Mobilum – a new mobile app to engage visuospatial processing for the reduction of intrusive visual memories. *Mhealth.* 2019;5:49. Available at: <https://doi.org/10.21037/mhealth.2019.09.15>.
- Sandoz V, Deforges C, Stuijtzand S, Epiney M, Vial Y, Sekarski N, Messerli-Burgy N, Ehlert U, Bickle-Graz M, Morisod Harari M, Porcheret K, Schechter DS, Ayers S, Holmes EA, Horsch A. Improving mental health and physiological stress responses in mothers following traumatic childbirth and in their infants: study protocol for the Swiss TrAumatic biRth Trial (START). *Br Med J Open.* 2019. Available at: <https://doi.org/10.1136/bmjopen-2019-032469>.
- Bromley P, Hollins Martin CJ, Patterson J. Post traumatic stress disorder post childbirth versus postnatal depression: a guide for midwives. *Br J Midwifery.* 2017;25(8):484–90.
- Iyadurai L, Blackwell SE, Meiser-Stedman R, Watson PC, Bonsall MB, Geddes JR, Nobre AC, Holmes EA. Preventing intrusive memories after trauma via a brief intervention involving Tetris computer game play in the emergency department: a proof-of-concept randomized controlled trial. *Mol Psychiatry.* 2018;23:674–82.
- Caporali C, Pisoni C, Gasparini L, Ballante E, Zecca M, Orcesi S, Provenzi L. A global perspective on parental stress in the neonatal intensive care unit: a meta-analytic study. *J Perinatol.* 2020;40:1739–52.
- Ong SL, Abdullah KL, Danaee M, Soh KL, Soh KG, Japar S. Stress and anxiety among mothers of premature infants in a Malaysian neonatal intensive care unit. *J Reprod Infant Psychol.* 2019;37(2):193–205.
- Sanders MR, Hall SL. Trauma-informed care in the newborn intensive care unit: promoting safety, security and connectedness. *J Perinatol.* 2017;38(1):1–8.
- Shaw RJ, Bernard RS, de Blois T, Ikuta LM, Ginzburg K, Koopman C. The Relationship Between Acute Stress Disorder and Posttraumatic Stress Disorder in the Neonatal Intensive Care Unit. *Psychosom.* 2009;50(2):93–183.
- Lau-Zhu A, Holmes EA, Butterfield S, Holmes J. Selective Association Between Tetris Game Play and Visuospatial Working Memory: A preliminary Investigation. *Appl Cogn Psychol.* 2017;31:438–45.
- Slade P, Molyneux R, Watt A. A systematic review of clinical effectiveness of psychological interventions to reduce post traumatic stress symptoms following childbirth and a meta-analysis of facilitators and barriers to uptake of psychological care. *J Affect Dis.* 2021;281:678–94.
- Tofighi Naeem A, Shariat M, Zarkesh MR, Abedinia N, Teimoorbakhsh S, Nayeri F. () "Posttraumatic Stress Disorder and Associated Risk Factors Among Parents of Hospitalized Term and Preterm Neonates." *Iran J Pediatr.* 2019;29(3):e87799. Available at: <https://doi.org/10.5812/ijp.87799>
- Bisson JI, Andrew M, Roberts N, Cooper R, Lewis C. Psychological therapies for chronic post-traumatic stress disorder (PTSD) in adults (review). *Cochrane Database Syst Rev.* 2013. Available at: <https://doi.org/10.1002/14651858.CD003388.pub4>.
- James EA, Bonsall MB, Hoppitt L, Tunbridge EM, Geddes JR, Milton AM, Holmes EA. Computer Game Play Reduces Intrusive Memories of Experimental Trauma via Reconsolidation-Update Mechanisms. *Psychol Sci.* 2015;26(8):1201–15.
- Holmes EA, James EL, Coode-Bate T, Deeprase C. Can Playing the Computer Game "Tetris" Reduce the Build-Up of Flashbacks for Trauma? A Proposal from Cognitive Science. *One.* 2009;4(1):e4153. Available at: <https://doi.org/10.1371/journal.pone.0004153>
- Deforges C, Fort D, Stuijtzand S, Holmes EA, Horsch A. Reducing childbirth-related intrusive memories and PTSD symptoms via a single-session behavioural intervention including a visuospatial task: A proof-of-principle study. *J Affect Dis.* 2022;303:64–73.
- Brewin CR, Dalgleish T, Joseph S. A Dual Representation Theory of Post-traumatic Stress Disorder. *Psychol Rev.* 1996;103(4):670–86.
- PTSD UK (2023) Post Traumatic Stress Disorder stats and figures. Available at: <https://www.ptsduk.org/ptsd-stats/> (Accessed 21/02/23).
- Bisson JI, Wright LA, Jones KA, Lewis C, Phelps AJ, Sijbrandij M, Varker T, Roberts NP. "Preventing the onset of post traumatic stress disorder". *Clinical Psychology Review.* 86, 102004. Available at: 2021. <https://doi.org/10.1016/j.cpr.2021.102004>.
- Roberts NP, Kitchiner NJ, Kenardy J, Lewis CE, Bisson JI. Early psychological intervention following recent trauma: A systematic review and meta-analysis. *European Journal of Psychotraumatology.* 10,1695486. Available at: 2019. <https://doi.org/10.1080/2008198.2019.1695486>.
- Anderson, J. & Constable, S. (2018) Bliss and TinyLife: Northern Ireland Baby Report 2018. Available at: <https://s3.eu-west-2.amazonaws.com/files.bliss.org.uk/images/Bliss-and-TinyLife-Northern-Ireland-baby-report-2018.pdf> (Accessed: 09/11/22).
- Chiorino V, Cattaneo MC, Macchi EA, Salerno R, Roveraro S, Bertolucci GG, Mosca F, Fumagalli M, Cortinovis I, Carletto S, Fernandez I. The EMDR Recent Birth Trauma Protocol: a pilot randomized clinical trial after traumatic childbirth. *Psychol Health.* 2020;35(7):795–810.
- Horsch A, Vial Y, Favrod C, Morisod-Harari M, Blackwell SE, Watson P, Iyadurai L, Bonsall MB, Holmes EA. Reducing intrusive traumatic memories after emergency caesarean section: A proof-of-principle randomized controlled study. *Behav Res Therapy.* 2017;94:36–47.
- Baur, A., Parsonage, M., Knapp, M., Lemmi, V., Adelaja, B. (2014) The costs of perinatal mental health problems. London: Centre for Menat Health and London School of Economics. Available at: <https://www.centreformentalhealth.org.uk/sites/default/files/2018-09/costsofperinatal.pdf> (Accessed 02/02/23).

25. Gallagher E, Hamber B, Joy E. Perspectives and possibilities: mental health in post agreement Northern Ireland. *Shared Space: A Research Journal on Peace, Conflict and Community Relations in Northern Ireland*. 2012;13:63–78.
26. Pham MT, Rajic A, Greig JD, Sargeant JM, Papadopoulos A, McEwen SA. A scoping review of scoping reviews: advancing the approach and enhancing the consistency. *Research Synthesis Methods*. 2014;5:371–85.
27. Arksey H, O'Malley L. Scoping studies: Towards a methodological framework. *International Journal of Research Methodology*. 2005;8(1):19–32.
28. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, Hempel S, Akl EA, Chang C, McGowan J, Stewart L, Hartling L, Aldcroft A, Wilson MG, Garrity C, Lewin S, Godfrey CM, Macdonald MT, Langlois EV, Soares-Weiser K, Moriarty J, Clifford T, Tunçalp Ö, Straus SE. "PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Annals of Internal Medicine*. 2018;169(7):467–73.
29. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur, A., Aromataris, E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *British Medical Council Medical Research Methodology*. 2018;18:143.
30. McMeekin N, Wu O, Germeni E, Briggs A. How methodological frameworks are being developed: evidence from a scoping review. *British Medical Council Medical Research Methodology*. 2020;20:173.
31. Peters MDJ, Godfrey CM, Khalil H, McInerney P, Parker D, Soares CB. Guidance for conducting systematic scoping reviews. *International Journal of Evidence-Based Healthcare*. 2015;13:141–6.
32. Eldridge SM, Lancaster GA, Campbell MJ, Thabane L, Hopewell S, Coleman CL, Bond CM. Defining Feasibility and Pilot Studies in Preparation for Randomised Controlled Trials: Development of a Conceptual Framework. *PLoS One*, 11 (3): e0150205. Available at: 2016. <https://doi.org/10.1371/journal.pone.0150205>.
33. Proctor E, Silmere H, Raghavan R, Hovmand P, Aarons G, Bunker A, Griffey R, Hensley M. Outcomes for Implementation Research: Conceptual Distinctions, Measurement Challenges, and Research Agenda. *Administration and Policy in Mental Health and Mental Health Services Research*. 2011;38:65–76. Available at: <https://doi.org/10.1007/s10488-010-0319-7>.
34. Pearson N, Naylor P-J, Ashe MC, Fernandez M, Yoong SL, Wolfenden L. "Guidance for conducting feasibility and pilot studies for implementation trials", *Pilot and Feasibility Studies*, 6:167. Available at: 2020. <https://doi.org/10.1186/s40814-020-00634-w>.
35. Peters MDJ, Marnie C, Truccho AC, Pollock D, Munn Z, Alexander L, McInerney P, Godfrey CM, Khalil H. Updated methodological guidance for the conduct of scoping reviews. *JBI Evidence Implementation*. 2021;19:3–10.
36. Pollock D, Davies EL, Peters MDJ, Tricco A, Alexander L, McInerney P, Godfrey CM, Khalil H, Munn Z. Undertaking a scoping review: A Practical guide for nursing and midwifery students, clinicians, researchers, and academics. *Journal of Advanced Nursing*. 2021;77:2102–13.
37. Braun V, Clarke V. Reflecting on reflexive thematic analysis. *Qualitative research in sport exercise and health*. 2019;11(4):589–97.
38. Kessler, H., Schmidt, A-C, James, E.L., Blackwell, S.E., von Rauchhaupt, M., Harren, K., Kehyayan, A., Ian A Clark, I.A., Sauvage, M, Herpertz, S., Axmacher, N., Holmes, E.A (2020) "Visuospatial computer game play after memory reminder delivered three days after a traumatic film reduces the number of intrusive memories of the experimental trauma", *Journal of Behavioral Therapy and Experimental Psychiatry*, 67:101454. Available at: <https://pubmed.ncbi.nlm.nih.gov/31036259/>
39. Butler O, Herr K, Willmund G, Gallinat J, Kuhn S, Zimmermann P. Trauma, treatment and Tetris: video gaming increases hippocampal volume in male patients with combat-related posttraumatic stress disorder. *J Psychiatry Neurosci*. 2020;45(4):279–87.
40. Bruhl A, Heinrichs N, Bernstein EE, McNally RJ. Preventive efforts in the aftermath of analogue trauma: The effects of Tetris and exercise on intrusive images. *J Behav Ther Exp Psychiatry*. 2019;64:31–5. Available at: <http://dx.doi.org/10.21037/mhealth.2019.09.15>.
41. Thorarinsdottir K, Holmes EA, Hardarson J, Stephensen ES, Jonasdottir MH, Kanstrup M, Singh L, Hauksdottir A, Halldorsdottir T, Gudmundsdottir B, Thordardottir E, Valdimarsdottir U, Bjornsson A. Using a brief mental imagery competing task to reduce the number of intrusive memories: exploratory case series with trauma exposed women. *J MIR Formative Res*. 2022;6(7):e37382. Available at: <http://dx.doi.org/10.2196/37382>.
42. Badawi A, Steele Z, Berle D. "Visuospatial Working Memory Tasks May Not Reduce the Intensity or Distress of Intrusive Memories", *Frontiers in Psychiatry*, 13:769957. Available at: 2022. <https://doi.org/10.3389/fpsy.2022.769957>.
43. Lau-Zhu A, Henson RN, Holmes EA. Selectively Interfering With Intrusive but Not Voluntary Memories of a Trauma Film: Accounting for the Role of Associative Memory. *Clinical Psychological Science*. 2021;9(6):1128–43.
44. Kanstrup M, Singh L, Goransson KE, Widoff J, Taylor RS, Gamble B, Iyadurai L, Moulds ML, Holmes EA. "Reducing intrusive memories after trauma via a brief cognitive task intervention in the hospital emergency department: and exploratory pilot randomized controlled trial", *Translational Psychiatry*, 11 (30). Available at: 2021. <https://doi.org/10.1038/s41398-020-01124-6>.
45. Brennen T, Blix I, Alexander Nissen A, Holmes EA, Skumlien M, Solberg O. "Investigating the frequency of intrusive memories after 24 hours using a visuospatial interference intervention: a follow-up and extension", *European Journal of Psychotraumatology*, 12(1):1953788. Available at: 2021. <https://doi.org/10.1080/20008198.2021.1953788>.
46. Hagenaaers MA, Holmes EA, Klaassen F, Klassen BE. "Tetris and Word games lead to fewer intrusive memories when applied several days after analogue trauma", *European Journal of Psychotraumatology*, 8. Available at: 2017. <https://doi.org/10.1080/20008198.2017.1386959>.
47. Engelhard IM, van Uijen SL, van den Hout MA. "The impact of taxing working memory on negative and positive memories", *European Journal of Psychotraumatology*, 1. Available at: 2010. <https://doi.org/10.3402/ejpt.v.1i0.5623>.
48. Holmes EA, James EL, Kilford EJ, Deeprose C. Key Steps in Developing a Cognitive Vaccine against Traumatic Flashbacks: Visuospatial Tetris versus Verbal Pub Quiz. *PLoS One* Available at: 2010. <https://doi.org/10.1371/journal.pone.0013706>.
49. Pierrehumbert B, Nicole A, Muller-Nix C, Forcada-Guex M, Ansermet F. Parental post-traumatic reactions after premature birth: implications for sleeping and eating problems in the infant. *Archives of Disease in Childhood-Fetal and Neonatal Edition*. 2003;88(5):F400–4. Available at: <https://doi.org/10.1136/fn.88.5.F400>.
50. Scheiner AP, Sexton ME. Prediction of developmental outcome using a perinatal risk inventory. *Pediatrics*. 1991;88:1135–43.
51. Malouf R, Sian Harrison S, Burton HAL, Gale C, Stein A, Franck LS, Alderdice F. Prevalence of anxiety and post-traumatic stress (PTS) among the parents of babies admitted to neonatal units: A systematic review and meta-analysis. *Lancet*. 2022. Available at: <https://doi.org/10.1016/j.ejclinm.2021.101233>.
52. Brunson E, Thierry A, Ligier F, Vulliez-Coady L, Novo A, Rolland A-C, Eutrope J. Prevalences and predictive factors of maternal trauma through 18 months after premature birth: A longitudinal, observational and descriptive study. *PLoS One*. 2021;16(2):e0246758. Available at: <https://doi.org/10.1371/journal.pone.0246758>.
53. Ghorbhani M, Dolatian M, Shams J, Alavi-Majid H, Tavakolian S. Factors associated with Posttraumatic Stress Disorder and Its Coping Styles in Parents of Preterm and Full-Term Infants. *Glob J Health Sci*. 2014;6(3):65–73. Available at: <https://pubmed.ncbi.nlm.nih.gov/24762347/>.

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