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Reducing childbirth-related intrusive memories and PTSD symptoms via a single-session behavioural intervention including a visuospatial task: A proof-of-principle study

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ABSTRACT

Background: Intrusive memories (IMs) of traumatic events are a key symptom of posttraumatic stress disorder (PTSD), and contribute to its maintenance. This translational proof-of-principle study tested whether a single-session behavioural intervention reduced the number of childbirth-related IMs (CB-IMs) and childbirth-related PTSD (CB-PTSD) symptoms, in women traumatised by childbirth. The intervention was assumed to disrupt trauma memory reconsolidation.

Methods: In this pre-post study, 18 participants, whose traumatic childbirth had occurred between seven months and 6.9 years before, received an intervention combining childbirth-related reminder cues (including the return to maternity unit) with a visuospatial task. They recorded their daily CB-IMs in the two weeks pre-intervention (diary 1), the two weeks post-intervention (diary 2; primary outcome), and in week 5 and 6 post-intervention (diary 3). CB-PTSD symptom severity was assessed five days pre-intervention and one month post-intervention.

Results: Compared to diary 1, 15/18 participants had $\geq$ 50% fewer CB-IMs in diary 2. The median (*IQR*) reduction of the number of CB-IMs was 81.89% (39.58%) in diary 2, and persisted in diary 3 ($n = 17$). At one month post-intervention, CB-PTSD symptom severity was reduced by $\geq$ 50% in 10/18 participants. Of the 8 participants with a CB-PTSD diagnosis pre-intervention, none met diagnostic criteria post-intervention. The intervention was rated as highly acceptable.

Limitations: The design limits the causal interpretation of observed improvements.

Conclusion: This is the first time such a single-session behavioural intervention was tested for old and real-life single-event trauma. The promising results justify a randomized controlled trial, and may be a first step toward an innovative CB-PTSD treatment.

1. Introduction

Intrusive memories (IMs) are repeated, involuntary and distressing sensory-perceptual fragments of a trauma memory (American Psychiatric Association, 2013; Ehlers et al., 2002). They are a core symptom of posttraumatic stress disorder (PTSD) (Iyadurai et al., 2019), a mental health disorder having four main symptom clusters: intrusion (including IMs), avoidance of trauma-related reminders, negative alterations in cognitions and mood, and alteration in arousal and reactivity (American Psychiatric Association, 2013). It is hypothesized that IMs drive other PTSD symptoms (Solberg et al., 2016) and prevent the normative decay of trauma memories (Herz et al., 2020). Thus, targeting them could be a relevant strategy to tackle PTSD symptoms (Iyadurai et al., 2019; Singh et al., 2020).

A leading evidence-based PTSD treatment are trauma-focused cognitive behavioural therapies (National Institute for Health and Care Excellence, 2018), including exposure therapy. Based on extinction learning, exposure therapy does not prevent the return of the trauma-linked fear response (Monfils and Holmes, 2018). Indeed, extinction would produce a new memory trace inhibiting the original fear memory, which still exists and can thus resurface (Bouton, 2004). Therefore, innovative treatments directly targeting the original maladaptive memories would be advantageous.

Memory reconsolidation processes could be the starting point for

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such treatments. After memory reactivation (MR), triggered by memory reminder cues, memories may enter a transient state of malleability (Agren, 2014; Visser et al., 2018). During this time-dependant window of "memory lability" (Lee et al., 2017), opening within minutes following MR (Agren et al., 2012), memories can reconsolidate unchanged, strengthened, or weakened (Schwabe et al., 2014; Visser et al., 2018), depending on what happens when they were labile. This process has been termed reconsolidation. Although debated (Besnard et al., 2012), the memory reconsolidation hypothesis opens up exciting therapeutic perspectives. Assuming that PTSD results from maladaptive memories and excessive fear learning, reconsolidation-based interventions targeting and weakening the trauma memory could reduce its impact (Elsey and Kindt, 2017b). However, translating memory theory and emerging laboratory findings into clinical interventions poses challenges concerning 1) the trauma MR and memory labilisation (ML), and 2) the memory reconsolidation disruption (MRD).

First, MR depends on "boundary conditions" that are assumed to determine whether the memory is only recalled or reactivated-labilised (Treanor et al., 2017). Given that memories of trauma may be harder to labilise (Elsey and Kindt, 2017a), boundary conditions such as the reminder cue and context specificity are critical in the clinical context. *Reminder cue specificity* means that the cues used for MR must be close to the original memory, to avoid creating a new memory trace (Treanor et al., 2017). In PTSD, personal narratives provide idiosyncratic and specific reminder cues. *Context specificity*, i.e., being in a context similar to that of the initial trauma environment, could also facilitate MR (Hupbach et al., 2008). However, its translation is challenging: context cues can trigger intense emotions and re-visiting the trauma site may be impossible.

After MR, MRD could be achieved by engaging in a competing visuospatial task, resulting in fewer IMs (James et al., 2015). Indeed, IMs are thought to result from excessive sensory processing during the traumatic event (Brewin and Holmes, 2003), and are predominantly visual (Ehlers et al., 2002), i.e., mental imagery-based (Singh et al., 2020). After trauma ML, engaging in a visuospatial task may take up the visuospatial information processing capacities necessary for memory reconsolidation, particularly of its visual aspects (Andrade et al., 1997; Baddeley and Andrade, 2000; Holmes et al., 2009). Thus, a visuospatial task such as the game Tetris may create a sensory modality-specific interference with the trauma memory reconsolidation, and reduce the number of IMs (Holmes et al., 2009, 2010). As an illustration, two randomized controlled trials (RCT) showed that a behavioural intervention including Tetris carried out within *the six first posttraumatic hours*, during the initial memory consolidation, reduced the number of subsequent IMs (Horsch et al., 2017; Iyadurai et al., 2018). Given that intervening in the aftermath of a traumatic event is often impossible, adapting such interventions to propose them years later would be a significant clinical advance.

Encouragingly, three laboratory studies showed that playing Tetris after reactivating the memory of a 24 to 72-hours-old experimental trauma reduced IMs in healthy volunteers (Hagenaars et al., 2017; James et al., 2016; Kessler et al., 2020).On the clinical side, a single case series of patients with complex PTSD tested a multiple-session intervention consisting of describing the content of a specific IM (one per session) and playing Tetris for 25 min (Kessler et al., 2018): from pre- to post-intervention, the targeted IM frequency diminished by 64%. Similar improvements were reported in smaller studies (Iyadurai et al., 2020; Kanstrup et al., 2021).

Beyond these preliminary results, many questions remain. First, such interventions have never been tested on memories of single-event real-life traumas that occurred years previously, such as a traumatic childbirth. Yet, single-event traumas have their own memory specificities: rather than targeting IMs one by one in different sessions (as in Kessler et al. (2018), where IMs could be linked to different traumatic events), it might be possible to aim for a global MR activating several hotspots related to the same traumatic event, drawing on the strong relationships within a single trauma memory network (Brewin and Holmes, 2003; Scully et al., 2017). Indeed, the different elements of a single-event trauma memory are assumed to be closely interconnected (Foa and Rothbaum, 1998), thus narrating the whole event may reactivate different hotspots and, in turn, allow the targeting of several IMs at the same time. Further research is needed but, for single-event traumas, even if individuals have IMs linked to different hotspots, it may be possible to target them all in one session and this may have advantages, such as speeding up treatment. Second, the benefits of this type of intervention on PTSD symptoms other than IMs are unclear. After several sessions, Kessler et al. (2018) reported a 50% PTSD score reduction in half of the participants; however, they had received other trauma-care in parallel. Third, we have little information on the effects of these interventions on the qualitative characteristics of IMs, including their associated distress, nowness (Michael et al., 2005), and sensory modality.

This translational proof-of-principle study tested whether a single-session behavioural intervention can reduce the number of childbirth-related IMs (CB-IMs) and childbirth-related PTSD (CB-PTSD) symptom severity. Indeed, CB-PTSD concerns up to 18.5% of mothers in high-risk samples (Yildiz et al., 2017). The intervention combined brief memory reminder cues of the traumatic childbirth, on the maternity ward where participants had given birth (hypothesised to allow MR), a 10-minute time gap (hypothesised to allow ML) and a Tetris gameplay procedure (hypothesised to allow MRD). The primary objective of this single-group pre-post study was to assess CB-PTSD symptom changes: compared to pre-intervention, it was expected that 1) the number of CB-IMs would be lower during the first two post-intervention weeks (primary outcome), and that this reduction would persist up to six weeks post-intervention, 2) CB-PTSD symptom severity would be lower at one month post-intervention. The secondary objective concerned intervention acceptability, which was expected to be high in view of the data collected in a previous study (Horsch et al., 2017) and the short duration of the assumed MR phase. Changes in CB-IMs characteristics between pre- and post-intervention measures, as well as participants' experience and compliance to the procedure, were also described.

2. Methods

2.1. Design and study population

A single group pre-post design was chosen for this proof-of-principle study. At the time of inclusion, participants had given birth to a live baby at the Lausanne University Hospital more than six weeks ago. They reported having had at least four CB-IMs over the past two weeks, which corresponds to « severe » IMs in the Clinician-Administered PTSD Scale for DSM-5 (CAPS-5) (Blake et al., 1995). CB-IMs had to be linked to labour, delivery, or the stay in the maternity ward. Women experiencing unrelated-to-childbirth IMs had to be able to distinguish them from CB-IMs. Exclusion criteria were: maternal or child severe illness, insufficient French-speaking level, established intellectual disability or psychiatric history (e.g., psychotic illness), alcohol abuse, or illegal drug use. Women who had ongoing childbirth-related psychological treatment were not eligible either. To avoid a floor effect, participants who reported less than two CB-IMs in their pre-intervention diary were excluded. The study was approved by the ethics committee for research in humans of the Canton of Vaud (approval number: 2019–01,435), and registered on ClinicalTrials.gov before recruitment began (trial number: NCT04286724). All participants provided written informed consent.

2.2. Sample size calculation

Given our experience with the study population (Horsch et al., 2017; Sandoz et al., 2019), we expected women to report approximately 5 ($SD = 3$) CB-IMs in the pre-intervention diary. Despite the large effect sizes reported in lab studies (James et al., 2015; Kessler et al., 2020), the

sample size calculation was conservative due to the study's exploratory nature. A sample size of $n = 18$ was considered as sufficient to detect a 35% reduction of the number of CB-IMs between diary 1 (pre-intervention) and diary 2 (post-intervention) (80% power; $\alpha = 0.05$) (primary outcome). Expecting a 20% drop-out and 20% exclusion due to less than two CB-IMs in the pre-intervention diary, we intended to recruit 25 participants. Recruitment took place between July 2020 and February 2021, data collection ended in April 2021. Of the $n = 194$ screened women, $n = 18$ received the intervention (Fig. 1).

2.3. Measures

Childbirth-related intrusive memories were daily self-reported in 14-day diaries, spanning the two pre-intervention weeks (diary 1), the

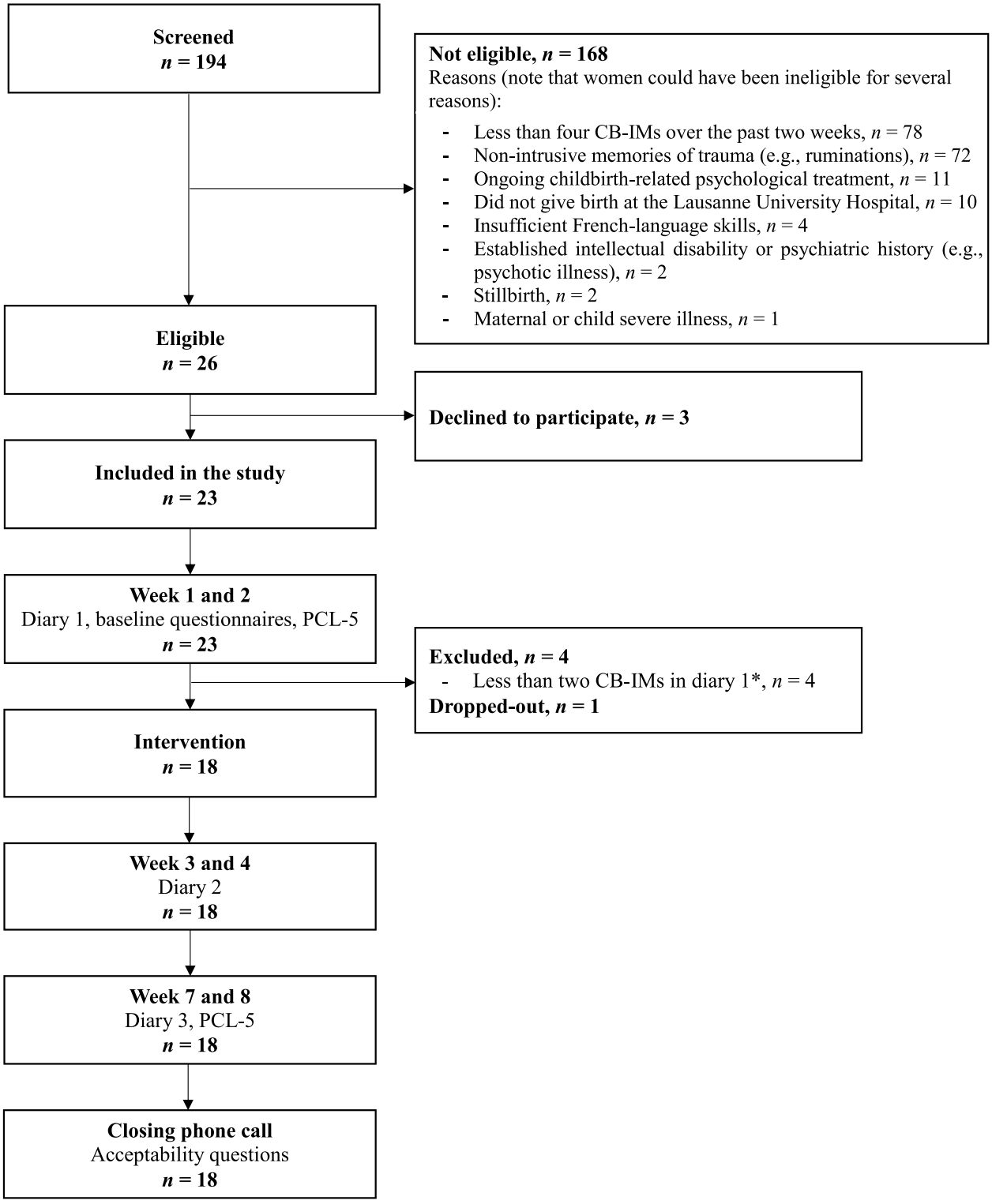


Fig. 1. Study flowchart. *Note.* CB-IMs = Childbirth-related intrusive memories; PCL-5 = PTSD Checklist for DSM-5. * If interested, these participants were still offered the intervention. Their data were not analysed.

first and second post-intervention weeks (diary 2), and the fifth and sixth post-intervention weeks (diary 3). Participants were instructed to briefly describe the content of each CB-IM, defined to them as "*involuntary memories in relation to the labour and birth of your child, that pop into your mind without warning*" (see Horsch et al. (2017) for the full instructions). Participants ticked a "no memory" box on days when they had not had any CB-IM. Each diary ended with a diary compliance question ("*To what extent were you able to report your intrusions in the diary?*"), which was answered on a 10-point scale from 1 (*not capable at all*), to 10 (*extremely capable*). For each CB-IM, participants also reported its associated distress, nowness, and sensory modalities (Supplementary Material, Section 1).

Childbirth-related PTSD symptoms were self-reported in the PTSD Checklist for DSM-5 (PCL-5) (Blevins et al., 2015), which contains 20 items assessing PTSD symptoms over the past month, on a five-point scale from 0 (*not at all*) to 4 (*extremely*). Items rated $\geq$ 2 reflect present symptoms. The PCL-5 allows to calculate a total severity score (range 0 − 80) and the four symptom cluster scores; higher scores indicate more severe symptoms. Participants were instructed to complete it in relation to the childbirth. The PCL-5 French version has good psychometric properties (Ashbaugh et al., 2016). For this study, Cronbach's α were 0.865 pre-intervention and 0.856 post-intervention.

Participants' experience during the intervention. Ten times during the intervention (Fig. 2), participants orally reported their emotional arousal using a 10-point visual analogue scale (VAS) ranging from 1 (*not stressed and/or anxious at all*) to 10 (*extremely stressed and/or anxious*). At the end of the putative MR phase, participants rated their childbirth memory vividness from 0% (*not at all vivid/intense memory*) to 100% (*extremely vivid/intense memory*) and the reminder cue specificity (boundary condition 1) (*"To what extent did you narrate your childbirth in a way that is faithful to your actual childbirth experience? (In other words, is what you have told similar to your experience, or is it very different?)"* on a 10-point scale from 1 (*not faithful at all/does not correspond at all*) to 10 (*extremely faithful/completely corresponds*)). After playing Tetris, they rated Tetris difficulty on 10-point scale from 1 (*very easy*) to 10 (*very difficult*). At the end of diary 2, participants answered a context specificity question (boundary condition 2) (*"How much did the maternity ward remind you of your childbirth?"*) on a 10-point scale from 1 (*not at all*) to 10 (*very strongly*). They were also invited to explain their ratings regarding the two boundary condition questions. Participants completed this questionnaire 14 days post-intervention to avoid interference with the memory reactivation-reconsolidation processes. Finally, during the last study phone call, participants indicated to what extend they expected their number of CB-IMs to change following the intervention, on a 21-point scale from −10 (*extremely decrease*) to 10 (*extremely increase*).

Intervention acceptability was assessed on a 10-point scale from 1 (*not at all acceptable*) to 10 (*extremely acceptable*). Participants were also asked whether they would be willing to participate in a second session if the intervention was scientifically proven to be useful; and to what extend they would recommend it to a friend, on a 10-point scale from 1 (*no, not at all*) to 10 (*yes, absolutely*).

Depression symptoms were self-reported on the 10-item Edinburgh Postnatal Depression Scale (EPDS) (Cox et al., 1987). EPDS items are scored on a four-point scale, from 0 to 3, higher total scores (range 0 − 30) reflect more severe symptoms. The clinical cut-off of the French version, which has good psychometric properties, is 10.5 (Guedeney and Fermanian, 1998). In this study, the Cronbach 's α was 0.838.

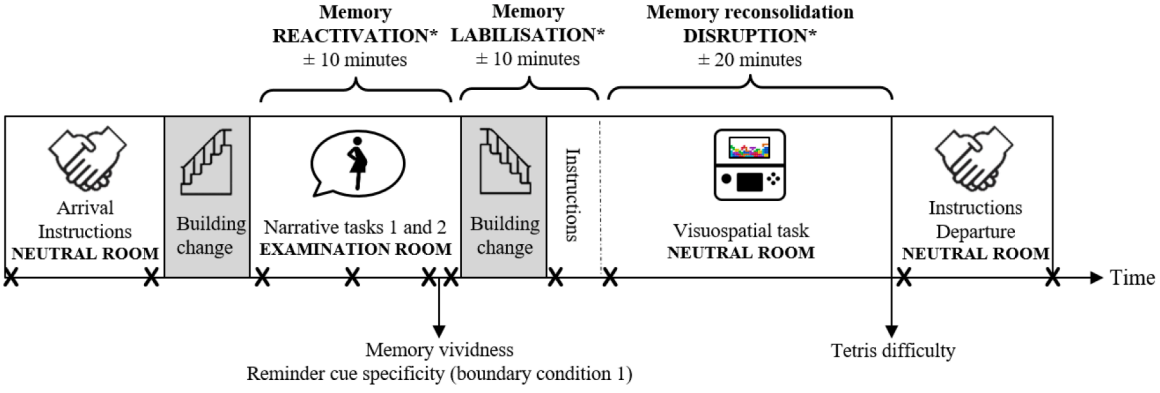
Sociodemographic characteristics. Participants' age, nationality, marital status, and education were self-reported.

Mental health history. Participants reported whether they had already received any psychological treatment linked with their traumatic childbirth experience and, if yes, of which type. They also indicated if they had ever experienced a traumatic event.

Obstetric and neonatal characteristics, including parity, information concerning the childbirth (date, mode of delivery, pregnancy type) and the neonate (Apgar scores, birth weight, gestational age) were retrieved from hospital birth records.

2.4. Recruitment and screening

Flyers advertising the study were displayed in places eligible women could frequent (e.g., nurseries). On the advertisements, it was indicated that the study was aimed at women who gave birth at the Lausanne University Hospital and were having "*images and thoughts of* [their] *birth that come back to* [them]". It was also specified that the objective of this research project was to investigate "*the efficacy of an activity to reduce intrusive memories after a difficult birth*". IMs were defined as "*involuntary images, thoughts, or sensations related to childbirth*". Moreover, the study psychologist (CD) contacted participants of completed observational studies of our research group, who had consented to be contacted



Note. Black crosses indicate an oral measure of emotional arousal with a 10-point visual analogue scale (VAS) ranging from 1 (*not stressed and/or anxious at all*) to 10 (*extremely stressed and/or anxious*). Details of each emotional arousal rating throughout the intervention is available in Supplementary Material, section 2.1.2.

* Memory processes supposedly involved.

Fig. 2. Schematic overview of the intervention procedure. *Note.* Black crosses indicate an oral measure of emotional arousal with a 10-point visual analogue scale (VAS) ranging from 1 (*not stressed and/or anxious at all*) to 10 (*extremely stressed and/or anxious*). Details of each emotional arousal rating throughout the intervention is available in Supplementary Material, section 2.1.2. * Memory processes supposedly involved.

concerning other studies.

Eligibility was screened by telephone by the study psychologist. The number of CB-IMs was assessed with the CAPS-5 (item B1) (Blake et al., 1995). Alcohol abuse was screened using the T-ACE questionnaire (Sokol et al., 1989), the other criteria were assessed with single-items. Women knew that the intervention would take place at the Lausanne University Hospital and comprise a childbirth evocation followed by a "*computerized task*". Non-eligible/non-interested women received a list of organisations who could support them concerning their childbirth experience. Their screening data were destroyed. Note that no eligible women explicitly refused to participate because of concerns about the COVID-19 pandemic.

2.5. Study procedure

2.5.1. Before the intervention

To situate the sample, participants completed the online baseline questionnaires (EPDS, sociodemographic, and mental health history questionnaires) on day 1 of diary 1. CB-PTSD symptoms were measured online five days pre-intervention (i.e., close to the intervention day, but not on the same day, to avoid interference with the trauma-related memory processes). In the meantime, participants completed diary 1 during the 14 pre-intervention days.

2.5.2. Intervention

On the 15th day, participants individually met the study psychologist in a neutral office of an administrative building, at the hospital (Fig. 2). They brought diary 1.

Given that the data collection was conducted during the COVID-19 pandemic, it should be noted that all appointments took place in strict compliance with the sanitary rules in application at the time in the Lausanne University Hospital. This included, for both the participant and the psychologist: wearing a surgical masque, hand disinfection on entering each building, and postponement of the appointment in case of symptoms suggestive of COVID-19. Participants had no direct contact with patients or healthcare professionals when they came to the maternity ward.

Assumed MR phase: After receiving detailed intervention-related information, participants went, with the psychologist, to a gynaecological examination room of the maternity ward, which was in a separate building. Reaching this room implied to walk past the delivery suite, and to cross the postpartum unit where they had been hospitalized. In the examination room, participants were asked to orally narrate their childbirth in 5–7 min, in chronological order, focusing on its unfolding rather than going into details (narrative task 1). The psychologist only intervened to ensure that participants recounted their entire childbirth within the allocated time (e.g., "*What happened next?*"). Following the same procedure, participants then narrated, during 3–5 min, the moment corresponding to the most frequent CB-IM of diary 1 in more detail (narrative task 2). After that, the childbirth was no longer discussed. Participants rated memory vividness and reminder cue specificity and returned, with the psychologist, to the neutral office.

Assumed ML phase: Because of the distance between the two buildings, ten minutes elapsed between the end of the narrative tasks and the beginning of Tetris, thus supposedly allowing for ML.

Assumed MRD phase: Participants were instructed to play Tetris ("Marathon" mode, sound and 3D switched off) according to the instructions detailed in Horsch et al. (2017). The psychologist explained that the objective of the game was to create as many complete horizontal lines as possible by moving and rotating blocks of seven different shapes and colours falling from the top to the bottom of the screen, before the latter was filled with the blocks, while using mental rotation. She showed them how to use the different buttons on the gaming device (Nintendo 3DS), and asked the participants to focus on the falling block and the next one, which was visible in a preview in the upper right corner of the screen. In order to promote mental rotation, participants were instructed to "*think about the best place to place the blocks in order to optimise space and make the lines complete*". Note that the focus was on applying mental rotation to the game, not on encouraging participants to get a high game score. Finally, the psychologist concluded by saying: "*it is very important that during the whole game you stay as focused as possible without, for example, looking at your phone or chatting with me*". After a three-minute practice run, participants played for 20 min. Before leaving, participants rated Tetris difficulty and were instructed not to play Tetris or seek information about its use in a healthcare context.

2.5.3. After the intervention

Participants completed diary 2 during the first 14 post-interventions days. At one month post-intervention, participants reported their CB-PTSD symptoms online again, and started completing diary 3 for the next 14 days. The study ended with an audio-recorded phone call. At first, a neutral research assistant asked participants the acceptability questions and checked that they had not received another childbirth-related psychological treatment, played Tetris since the intervention, or researched its therapeutic use. Finally, the study psychologist provided explanations regarding the study and discussed the participants' CB-PTSD symptom changes. Participants received a contact list in case they needed further professional help.

2.6. Data analysis

Two-tailed tests and an alpha level of 0.05 were used for statistical tests. The choice of parametric or non-parametric tests depended on whether the appropriate statistical assumptions were met or not. Descriptive statistics of continuous data are mean and standard deviation, or median and interquartile range (*IQR*) if the data were not normally distributed according to a Shapiro-Wilk test. Analyses were carried out with IBM SPSS version 27; except for the Wilcoxon signed-rank tests, the McNemar test, and Fig. 3, which were generated with R version 4.0.5 (R Core Team, 2021). Data are available free of charge and without restriction from the open access repository Zenodo : https://zenodo.org/record/5959273.

Differences in the number of CB-IMs across the three diaries were investigated with a Friedman test. Wilcoxon signed-rank tests with a Bonferroni correction were used for *post-hoc* pairwise comparisons, including between diary 1 and 2 (primary study outcome). Effect sizes were computed using the following formula: $r = Z/\sqrt{N}$ (N = total number of pairs) (Kassambara, 2021) (r interpretation: −0.1 = small; −0.3 = moderate; −0.5 = large effect size) (Fritz et al., 2012). Confidence intervals were calculated using bootstrapping on 1000 samples. The same approach was used to inspect differences in diary compliance. Changes in CB-IMs characteristics are reported in Supplementary Material, section 1.

Differences between pre- and post-intervention CB-PTSD symptoms (total severity and each symptom cluster score) were analysed with paired *t*-tests. Effect sizes were estimated with Hedges' *g* (interpretation: 0.2 = small; 0.5 = moderate; 0.8 = large effect size) (Lakens, 2013). The evolution of the number of participants meeting the CB-PTSD diagnostic criteria was examined *post-hoc*, with a McNemar's test with continuity correction.

The number of participants showing more than a 50% reduction of their CB-IMs or total CB-PTSD symptom severity between pre- and post-intervention measurement was reported, as this conservative criterion is one way to quantify the proportion of participants responding to an intervention (Kessler et al., 2018). To illustrate the results, some participants' quotes are reported in Supplementary Material, section 2.

A research assistant uninvolved in data collection checked 100% of the data for accuracy for the primary analysis of CB-IMs, and a randomly selected 50% of data for all other analyses. There was no missing data. Participants reported 360 diary entries. Two trained psychologists, who were uninvolved in data collection and blind to diary time points, independently checked the content of all entries to detect non-

compliance with diary instructions. They reached a 100% agreement. Ten diary entries were excluded from the analyses for one of the following reasons: 1) unrelated to the childbirth (three entries, $n = 3$), 2) not IM (e.g., unequivocally a verbal rumination) (two entries, $n = 2$), 3) provoked by a new traumatic experience involving a life threat to oneself or the child (five entries, $n = 1$). Analyses were thus carried out on 350 CB-IMs (e.g., *"when he was born, not breathing"* (P14), *"the team arrives in a hurry. I am losing a lot of blood and I don't understand anything"* (P08), "*I am alone with the pain, I am afraid to die"* (P02), *"They take me to the operating theatre and I think that if I die my husband will not make it"* (P16)).

One participant, who will henceforth be referred to as "P18", did not comply with the intervention instructions. She stated that she intentionally did not immerse herself in her childbirth memory and that her narratives were not faithful to her actual experience (5 out 10 on the reminder cue specificity question). She was the only participant whose response to this question was an extreme outlier, defined as being more than three *IQR* above quartile 3 (*Group Mdn* = 9.50; *IQR* = 1). She wrote that, during the narrative tasks, she "*developed the same avoidance strategies as with the flashbacks"* and thus that what she narrated *"was only very mildly faithful to* [her] *real experience*". Because the procedure was not correctly followed, P18 was excluded from the analyses. Except for the sample description (Table 1), her data are reported and discussed separately (Supplementary Material, Section 3).

3. Results

3.1. Characteristics of the study sample

At the time of the intervention, the childbirth had occurred between seven months and 6.9 years earlier (*Mdn* = 2.01 years, *IQR* = 2.23). Participants were Swiss or from another European country, and mostly in a relationship (Table 1). Eight participants met the diagnostic criteria for CB-PTSD; the mean depression score was above the clinical cut-off. Four participants had received a psychological treatment addressing their traumatic childbirth experience. Three had received psychotherapy (one of whom received Eye Movement Desensitization and Reprocessing), one had received both pharmaco- and psychotherapy.

3.2. Intervention characteristics and participants' compliance to instructions

The median duration of the assumed MR and MRD phases were 10 and 20 min, respectively (Supplementary Material, Table S1). Participants' median (*IQR*) emotional arousal rating was 5.75/10 (2.38) during the assumed MR phase (VAS3 to 6, Fig. 2), and 2/10 (1) at the beginning and the end of the appointment. Participants' median rating of their childbirth memory vividness was 80% (15). They reported that their narratives were extremely faithful to their actual childbirth experience (*Mdn* = 10/10, *IQR* = 1) (reminder cue specificity, boundary condition 1), and that the maternity ward strongly reminded them of their childbirth (*Mdn* = 9/10, *IQR* = 3) (context specificity, boundary condition 2). This was reflected in their comments (Supplementary Material, Section 2.1). The median rating of Tetris difficulty was 2/10 (2). Participants did not expect their number of CB-IMs to change following the intervention (*M* = −0.29, *SD* = 4.71).

3.3. Number of CB-IMs

Diary compliance was high and stable across diaries, $\chi^2(2) = 1.064$, $p = .587$. The median (*IQR*) was 8/10 (3) in diary 1, 9/10 (4) in diary 2 and 9/10 (4) in diary 3. The median number of CB-IMs was 11 (6) in diary 1, 2 (4) in diary 2 and 2 (3) in diary 3 (Fig. 3). It significantly differed between the diaries, $\chi^2(2) = 26.548$, $p < .001$. Participants reported fewer IMs in diary 2 *vs.* diary 1, $Z = -3.500$, $p < .001$, and in diary 3 *vs.* diary 1, $Z = -3.600$, $p < .001$. Effect sizes were large, $r = -0.849$ [95%*CI*: −0.841, −0.851] and $r = -0.873$ [95%*CI*: −0.868, −0.875], respectively. There was no difference between diary 2 and 3, $Z = -0.950$, $p = .342$.

The median (*IQR*) reduction of the number of CB-IMs was 81.82% (39.58) in diary 2 *vs.* diary 1, and 76.92% (28.99) in diary 3 *vs.* diary 1. Overall, 15/17 participants reported a reduction of more than 50% in their number of CB-IMs between diary 1 and 2, and 16 between diary 1 and 3 (see Supplementary Material section 2 for participants' comments and their day-to-day CB-IMs).

Table 1
Sociodemographic, obstetrical, neonatal, and mental health characteristics of the study sample ($n = 18$).

Sample characteristics	Frequency (%)	Median (*IQR*) or Mean (*SD*)[a]
Sociodemographic characteristics at the time of the intervention		
Age (years)		33.55 (6.35)△
Time since traumatic childbirth (years)		2.01 (2.23)
Nationality		
Swiss	12 (66.67)	
Other European	6 (33.33)	
Education		
Secondary/high school	1 (5.56)	
Apprenticeship	7 (38.89)	
University	10 (55.55)	
Marital status		
Married or cohabiting	17 (94.44)	
Single	1 (5.56)	
Obstetrical variables		
Parity		
Nulliparous	13 (72.22)	
Parous	5 (27.78)	
Mode of delivery		
Non instrumental vaginal delivery	6 (33.33)	
Vacuum or forceps-assisted delivery	4 (22.22)	
Planned caesarean section	1 (5.56)	
Emergency caesarean section	7 (38.89)	
Gestational age (weeks)		39.42 (2.46)
Pregnancy type		
Single	16 (88.89)	
Multiple	2 (11.11)	
Neonatal variables[b]		
Apgar score		
Apgar score 1 min		9 (3)
Apgar score 5 min		9 (1)
Birth weight (grams)		3,125 (858)
Mental health variables before intervention		
Prior psychological trauma	8 (44.44)	
Depression symptoms (EPDS score)		10.67 (4.63)△
Probable depression[c]	8 (44.44)	
CB-PTSD symptom severity (PCL-5 score)		27.89 (12.14)△
CB-PTSD diagnostic criteria[d]	8 (44.44)	
Previously received a psychological treatment addressing their traumatic childbirth experience	4 (22.22)	

Note. EPDS = Edinburgh Postnatal Depression Scale (range 0–30); CB-PTSD = Childbirth-related posttraumatic stress disorder; PCL-5 = PTSD Checklist for DSM-5 (range 0 − 80).

[a] Median and interquartile ranges are reported if the data did not follow a normal distribution according to a Shapiro-Wilk test.

△ Reported values are a mean and standard deviation.

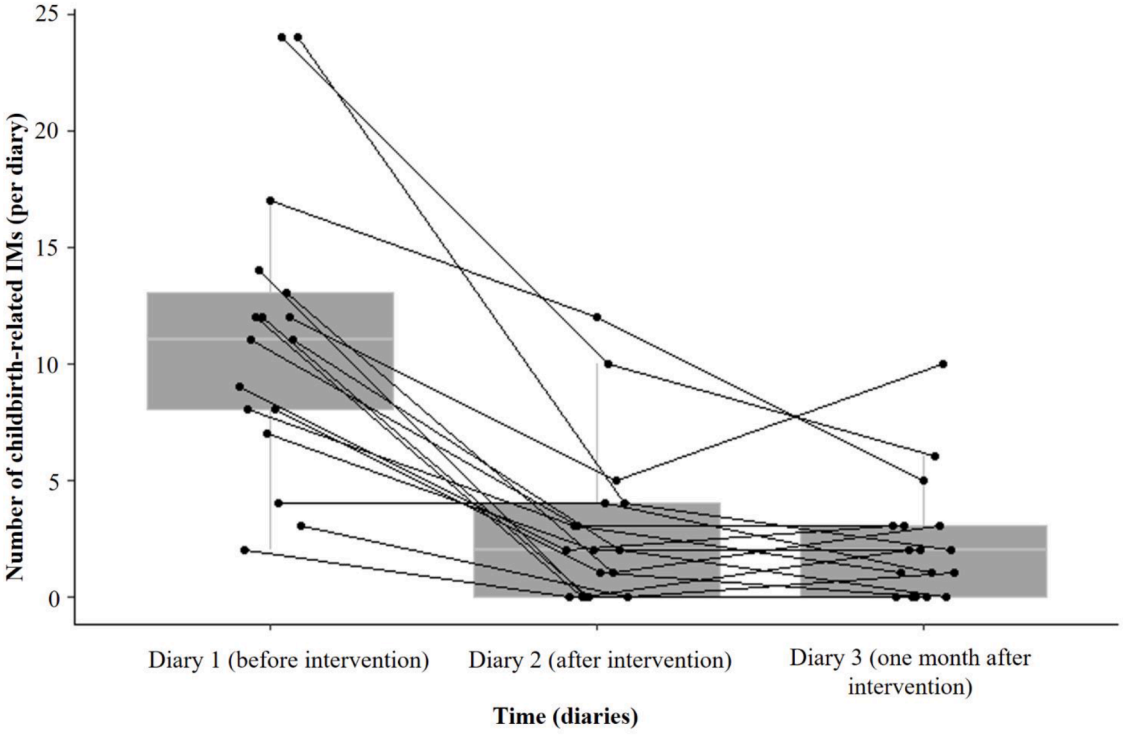
[b] In case of multiple pregnancy, data of the firstborn child was used.

[c] EPDS score > 10.5.

[d] At least one intrusion, one avoidance, two negative alteration in cognitions and mood, and two alterations in arousal and reactivity symptoms reported on PCL-5.

3.4. CB-PTSD symptoms

Total CB-PTSD symptom severity was, on average, reduced by 56.76% (*SD* = 28.97) ($p < .001$; Table 2, Fig. 4) between five days pre-intervention and one month post-intervention, and the four symptom



Note. Black lines correspond to individual trajectories (n = 17). Diary 1 covered the 14 days before the intervention, diary 2 covered the 14 days following the intervention, and diary 3 covered 14 days from one month post-intervention (i.e., the 5th and 6th post-intervention weeks). Box plots represent group medians and interquartile ranges.

Fig. 3. Number of childbirth-related intrusive memories (IMs) across the diaries (n = 17). *Note.* Black lines correspond to individual trajectories (n = 17). Diary 1 covered the 14 days before the intervention, diary 2 covered the 14 days following the intervention, and diary 3 covered 14 days from one month post-intervention (i.e., the 5th and 6th post-intervention weeks). Box plots represent group medians and interquartile ranges.

Table 2
Comparisons between childbirth-related PTSD symptoms five days before and one month after the intervention (n = 17).

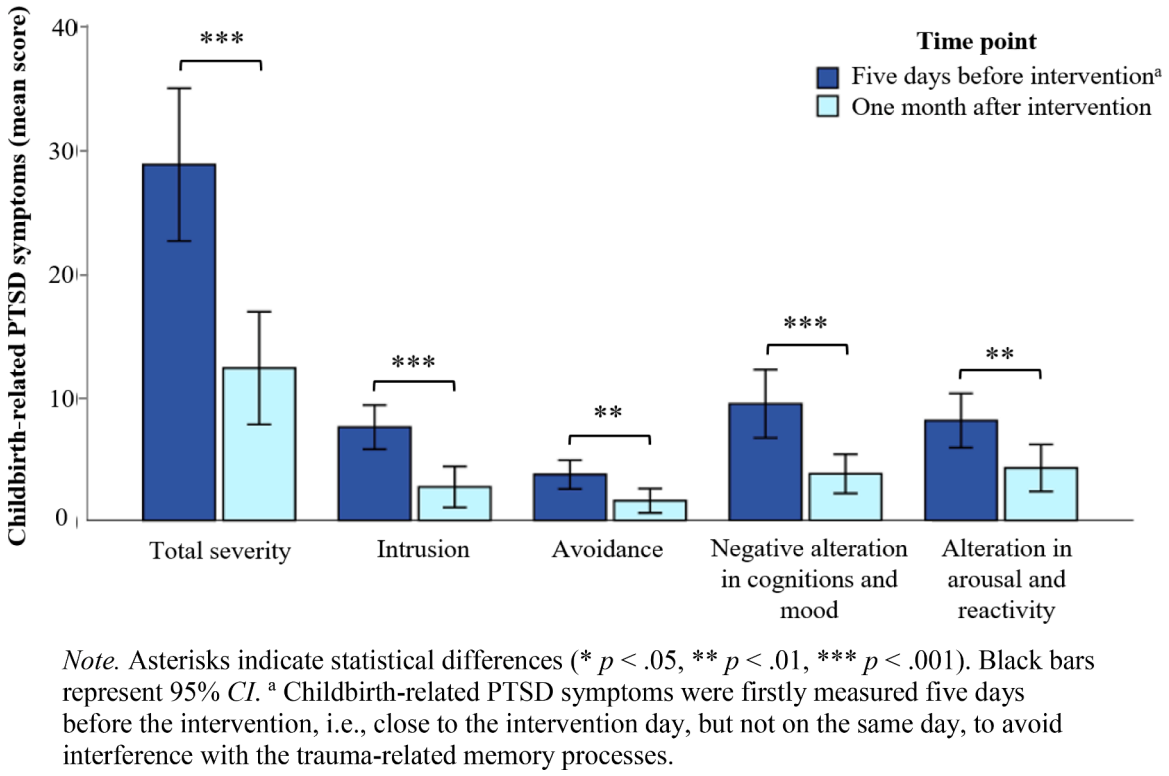
	Before intervention Mean (*SD*)	After intervention Mean (*SD*)	*t*(16)	*g*	95% *CI* for *g*	*p*
Total severity score	28.71 (12)	12.29 (8.84)	6.190***	1.466	0.771, 2.140	< 0.001
Intrusion symptom cluster score[a]	7.53 (3.47)	2.71 (3.22)	5.705***	1.351	0.684, 1.997	< 0.001
Avoidance symptom cluster score[b]	3.71 (2.26)	1.59 (1.91)	3.960**	0.938	0.363, 1.493	.001
Negative alteration in cognitions and mood symptom cluster score[c]	9.41 (5.36)	3.76 (3.07)	5.159***	1.222	0.585, 1.837	< 0.001
Alteration in arousal and reactivity symptom cluster score[d]	8.06 (4.26)	4.24 (3.68)	3.378**	.800	0.251, 1.330	.004

Note. Symptoms were measured with the PTSD Checklist for DSM-5 (adapted for childbirth) (PCL-5) (range 0 − 80).
* $p < .05$.
[a] PCL-5 intrusion subscale (5 items; range 0 − 20).
[b] PCL-5 avoidance subscale (2 items; range 0 − 8).
[c] PCL-5 negative alteration in cognitions and mood subscale (7 items; range 0 − 28).
[d] PCL-5 alteration in arousal and reactivity subscale (6 items; range 0 − 24).
** $p < .01$.
*** $p < .001$.

cluster scores also decreased. All effect sizes were large (Hedge's g > 0.8). A 50% reduction of CB-PTSD total symptom severity was observed in 10/17 participants. Significantly fewer participants met CB-PTSD diagnostic criteria after the intervention (n = 0 (0%)), than before (n = 8 (47.06%)), p = .013 (see Table 1 for details about CB-PTSD diagnostic criteria with the PCL-5). Some reported that they were no longer afraid to become pregnant again, or that their everyday life had improved (Supplementary Material, Section 2.3).

3.5. Intervention acceptability

The median rating of intervention acceptability was 9/10 (3). If scientifically proven to be useful, participants would recommend the intervention to a friend at 10/10 (*IQR* = 1), and 100% of them would



Note. Asterisks indicate statistical differences (* $p < .05$, ** $p < .01$, *** $p < .001$). Black bars represent 95% *CI*. [a] Childbirth-related PTSD symptoms were firstly measured five days before the intervention, i.e., close to the intervention day, but not on the same day, to avoid interference with the trauma-related memory processes.

Fig. 4. Mean scores of childbirth-related PTSD symptoms five days before and one month after the intervention ($n = 17$). *Note.* Asterisks indicate statistical differences (* $p < .05$, ** $p < .01$, *** $p < .001$). Black bars represent 95% *CI*. [a] Childbirth-related PTSD symptoms were firstly measured five days before the intervention, i.e., close to the intervention day, but not on the same day, to avoid interference with the trauma-related memory processes.

have been willing to participate in a second session.

4. Discussion

In this translational single-group pre-post study, participants traumatised by childbirth received a brief, single-session behavioural intervention, which combined real-life memory reminders with a visuospatial task. Compared to the two weeks pre-intervention, 15/18 participants had at least 50% fewer CB-IMs during the first two post-intervention weeks, and this large reduction persisted up to six weeks post-intervention. Furthermore, compared to baseline levels, the total CB-PTSD symptom severity and each of the four symptom clusters were largely reduced at one month post-intervention. Thus, the intervention appeared to successfully reduce CB-PTSD symptoms in participants, despite high depression symptoms at baseline and a history of unsuccessful pharmaco- or psychotherapy for some of them. The intervention was unanimously rated as very acceptable, and participants would strongly recommend it. In light of these results, this study could be a promising step toward a brief, simple and low-cost evidence-based clinical intervention for CB-PTSD symptom reduction.

A unique feature of this intervention was the participants' in vivo return to the trauma context during the putative MR phase. Unlike still images (Hagenaars et al., 2017) or written narratives (Kessler et al., 2018), the reminder cues were multi-sensory (e.g., hospital smell, newborn crying) and highly immersive (Supplementary Material, Section 2.1). Combined with the brief recount of the whole birth, this return likely facilitated a global reactivation of the childbirth memory (Debiec et al., 2013), rather than of a particular memory hotspot, like in Kessler et al. (2018). Participants' ratings suggested that both the context specificity and the reminder cue specificity boundary conditions were met. Importantly, the reminder cue specificity question allowed to identify the participant who did not follow the instructions.

Some findings were unexpected. For example, CB-IMs with a visual component did not appear to reduce more than non-visual CB-IMs after the intervention (Supplementary Material, section 1.1). Yet, assuming that a visuospatial task would specifically interfere with the reconsolidation of visual aspects of memory, one would expect this to be the case. Thus, Tetris may induce a more global engagement of memory resources - not just visual ones. The momentary increase of P18's CB-IMs also deserves comment. The data suggested that her trauma MR failed due to non-compliance with the instructions. Further discussion and suggestions to avoid this outcome are available in Supplementary Material, Section 3. Future studies should consider measures that would allow all participants to follow the instructions.

Importantly, the reduction of CB-PTSD symptoms, in line with our hypotheses, is insufficient to confirm that memory reactivation-reconsolidation processes actually took place during the intervention. Indeed, the latter are not measurable in such clinical interventions (Visser et al., 2018). It is therefore possible that separate or additional mechanisms have led to the observed improvements. For instance, even though participants did not anticipate a CB-IMs reduction, the intervention benefits may have been accentuated by positive expectations linked to help-seeking. Narrating the childbirth, returning to the trauma context, or monitoring the CB-IMs may in itself have had therapeutic properties. While it was not the current study's objective, studying the underlying mechanisms would be necessary to improve the intervention.

4.1. Strengths and limitations

To our knowledge, this is the first reconsolidation-based intervention involving a visuospatial task to target IMs linked with an old and single-event real-life event. It includes innovative and theory-driven adaptations, such as the single-session format and the use of trauma context. Daily measurement of CB-IMs for six weeks allowed for a detailed assessment of the trajectory of participants' symptomatology over the

weeks. Furthermore, the study was conducted rigorously, as indicated by the study registration prior to recruitment, no post-intervention drop-out, and no missing data.

However, this study has several limitations, the first of which is inherent in its design: the comparison of pre- and post-intervention measures does not allow to affirm that the observed improvements were caused by the intervention. CB-IMs may have spontaneously declined over time, although this seems unlikely, given that participants had given birth several years earlier (see Soderquist et al., 2006) and that some of them had unsuccessfully engaged in prior pharmaco- or psychotherapy. Despite the design's shortcomings, it seemed the most appropriate for this proof-of-principle study, prior to a full RCT. Indeed, to the best of our knowledge, this was the first study to test a behavioural intervention including a visuospatial task to reduce established PTSD symptoms in individuals who experienced old and single-event real-life traumas (as a reminder, the traumatic birth had occurred between seven months and 6.9 years earlier). In the absence of preliminary clinical data, an RCT design would not have been resource-efficient.

Furthermore, given that the sample size was calculated to assess the reduction in the number of CB-IMs, it was insufficient for complementary analyses that could have provided some insights into the intervention mechanisms and potential improvement (e.g., the relationship between high emotional arousal during the narrative tasks and CB-PTSD symptom reduction). The daily reporting of CB-IMs also has limitations because participants may have been more attentive than usual to their CB-IMs, thus increasing their perceived number. Moreover, seeing the diary at home may have triggered additional CB-IMs.

4.2. Perspectives and future studies

The results of this study warrant a RCT, which would incorporate a clinical interview in addition to self-report questionnaires for CB-PTSD symptom assessment. Such an RCT could also examine if the number of pre-intervention CB-IMs is a predictor of overall CB-PTSD symptom reduction. If not, the intervention might be suitable to help-seeking parents suffering from CB-PTSD symptoms but having rare CB-IMs (as it was the case of 78 women screened for this study). In addition, with a sufficient sample size, a future RCT could clarify whether the time since birth affects the efficacy of the intervention. Finally, beyond the perinatal context, this intervention may apply to other trauma types, such as healthcare professionals (Singh et al., 2021), whose PTSD prevalence is 21.5% during the COVID-19 pandemic (Marvaldi et al., 2021).

Another critical step would be to identify which elements of the trauma context, including potential mismatches with the remembered place (Fernandez et al., 2016), are important to trigger MR. In the case of CB-PTSD, for example, returning to any maternity ward may be sufficient, which would make the intervention more widely accessible. Identifying the most decisive context-related cues could help to make the intervention available when the trauma context cannot be visited, by reproducing only these particular elements (e.g., with virtual reality). This could even make it possible to propose a remotely delivered digital variant of the intervention (see Singh et al., 2021), where the confrontation with the context is done by viewing video sequences produced in the maternity ward, from the participants' homes. Additionally, by reducing reminder cues to a minimum, the procedure may also become easier to handle for patients.

Examining components of this intervention in the laboratory, for instance with the trauma film paradigm (James et al., 2016), could also give insights into its mechanisms. For example, distinguishing the memory reactivation components (including coming back to the room where the trauma film was initially watched) from the visuospatial task procedure could help to determine whether, as suggested by a memory reconsolidation perspective, only the combination of these components is beneficial (Elsey et al., 2018; James et al., 2015).

5. Conclusion

This translational proof-of-principle intervention study provides preliminary evidence that a brief behavioural intervention can reduce CB-PTSD symptoms following a traumatic childbirth. It is a first step toward the development of a single-session and low-cost evidence-based intervention, enabling durable treatment of (CB-)PTSD symptoms. Future studies are necessary to follow up on these promising results, using more sophisticated designs and larger sample sizes.

Author statement contributors

C. Deforges, S. Stuijfzand and A. Horsch conceptualized the study. C. Deforges collected the data, in collaboration with D. Fort. C. Deforges performed all the analyses. C. Deforges drafted the initial manuscript, with the contribution of D. Fort for the method section. E. A. Holmes contributed with her expertise in intrusive memories and memory updating-based interventions, as well as the interpretation of the data. All authors approved the final manuscript as submitted, and agreed to be accountable for all aspects of the work. A. Horsch was the PhD supervisor of C. Deforges.

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Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jad.2022.01.108.

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