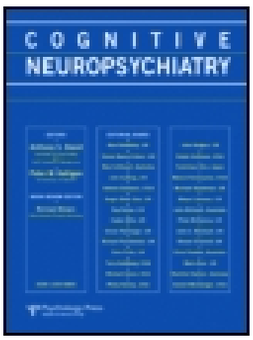

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Developing thinking around mental health science: the example of intrusive, emotional mental imagery after psychological trauma

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ABSTRACT

Introduction: One route to advancing psychological treatments is to harness mental health science, a multidisciplinary approach including individuals with lived experience and end users (e.g., Holmes, E. A., Craske, M. G., & Graybiel, A. M. (2014). Psychological treatments: A call for mental-health science. *Nature, 511*(7509), 287–289. doi:10.1038/511287a). While early days, we here illustrate a line of research explored by our group—intrusive imagery-based memories after trauma.

Method/Results: We illustrate three possible approaches through which mental health science may stimulate thinking around psychological treatment innovation. First, focusing on single/specific target symptoms rather than full, multifaceted psychiatric diagnoses (e.g., intrusive trauma memories rather than all of posttraumatic stress disorder). Second, investigating mechanisms that can be *modified* in treatment (treatment mechanisms), rather than those which cannot (e.g., processes only linked to aetiology). Finally, exploring novel ways of delivering psychological treatment (peer-/self-administration), given the prevalence of mental health problems globally, and the corresponding need for effective interventions that can be delivered at scale and remotely for example at times of crisis (e.g., current COVID-19 pandemic).

Conclusions: These three approaches suggest options for potential innovative avenues through which mental health science may be harnessed to recouple basic and applied research and transform treatment development.

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Mental health science; psychological treatments; global mental health; remote delivery; intrusive memories of trauma

Introduction

Given the lack of significant advances in psychological treatment over recent decades, new approaches to mental health treatment discovery and implementation are needed (Goodwin et al., 2018). Mental health science is an umbrella discipline that can link different disciplines to share a common pursuit (Holmes et al., 2014). Such disciplines

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include but are not limited to psychiatry, psychology, neuroscience, the social sciences, arts, economics, mathematics and epidemiology. Mental health science seeks to forge links between clinical and laboratory research communities to fuel treatment innovation together with people with lived experience and end users. A multidisciplinary approach with shared goals may open new ways of developing psychological treatments (Holmes et al., 2018). According to a 2014 "call for mental health science":

> Molecular and theoretical scientists need to engage with the challenges that face the clinical scientists who develop and deliver psychological treatments, and who evaluate their outcomes. And clinicians need to get involved in experimental science. Patients, mental-health-care providers and researchers of all stripes stand to benefit. (Holmes et al., 2014, p. 288)

What do we need to do to advance psychological treatments? To open a debate, the *Lancet Psychiatry* commission on psychological treatments research in tomorrow's science outlined 10 areas with substantial opportunity and scope for advancements. Examples include: "*How do existing treatments work? Making the case for the mechanisms of psychological treatments*" and "*Where can psychological treatments be deployed? Research to improve mental health worldwide*" (Holmes et al., 2018, p. 237).

In this invited commentary in *Cognitive Neuropsychiatry*, we take the liberty of using an example line of work from our group—intrusive, emotional mental imagery after psychological trauma. Please note this is early stage research and used to explore ideas in this space. Drawing on ideas in the abovementioned commission, we elaborate three (of many possible) avenues through which mental health science may open opportunities for innovation:

(1) Focusing on *single specific target symptoms* rather than full multifaceted mental disorder diagnoses. This seems consistent with a "core clinical feature" approach within psychiatric diagnosis (Kupfer & Regier, 2011), going back to the suggestion to focus on a "single striking clinical feature" or a "combination of clinical features" to describe the clinical picture of a disorder (Robins & Guze, 1970). Here, for example, rather than considering the full array of posttraumatic stress disorder (PTSD) symptoms, we focus on a core clinical feature—intrusive memories after trauma (Iyadurai et al., 2019; Porcheret et al., 2020).
(2) Investigating mechanisms that are *modifiable* in treatment rather than those that cannot be modified (i.e., linked only to aetiology). Many evidence-based treatments are available but little understanding exists of how they work (Holmes et al., 2018). Identifying mechanisms of change can help overcome conceptual challenges in treatment innovation (Kazdin, 2007). Psychological treatment mechanisms (i.e., the reasons and conditions under which interventions are effective) can range from the behavioural and cognitive, through to the molecular and social level. Experimental psychopathology provides an opportunity to study mechanisms. Showing that experimental manipulation of a proposed mechanism leads to symptom change is a powerful method for validation, and helps identify the key processes to be targeted. In turn, this helps to hone treatment strategies so they directly target such mechanisms, to remove irrelevant strategies, and to develop novel approaches (Holmes et al., 2018). Accordingly, we are interested in identifying and understanding specific modifiable mechanisms through which treatments to reduce intrusive memories work and may be leveraged (Holmes et al., 2020).

(3) Exploring *novel ways of delivering* psychological treatment (peer-/self-administration) to meet its central goal (i.e. reducing the burden of mental illness and related conditions) by maximising the likelihood of treatment reaching people in need (Fairburn & Patel, 2014), for example with lay therapists. The current dominant model of treatment delivery—individual psychotherapy—requires highly trained mental health professionals and is unlikely to meet the global need for mental health interventions (Kazdin & Blase, 2011). We consider it critical that this need drives the focus of research endeavours from the beginning and stimulates novel treatment approaches in themselves, which are easier to train - not just levels of therapist training of existing approaches.

We will take this idea for a walk applying these approaches to research on intrusive, emotional mental imagery of psychological trauma. The Diagnostic and Statistical Manual (DSM, American Psychiatric Association, 2013), defines psychological trauma as "Exposure to actual or threatened death, serious injury, or sexual violence" by either "directly experiencing the traumatic event(s)", or "witnessing, in person, the event(s) as it occurred to others" (p. 271). Following trauma, emotional mental images may involuntarily intrude into mind. Mental images are sensory-perceptual representations in the absence of percept (Pearson et al., 2015), e.g. "seeing in the mind's eye". Intrusive image-based memories of trauma are the core clinical feature (Kupfer & Regier, 2011) of PTSD (American Psychiatric Association, 2013, pp. 271–280) and a candidate target for novel interventions.

From complex disorder to core clinical symptom—intrusive memories as a target

Mental health professionals seek to diagnose a mental disorder and provide treatment according to evidence-based practice guidelines (van Os et al., 2019). Consequently, most research on trauma has focused on a diagnosable full mental health disorder, such as PTSD. However, there are 636,120 ways to diagnose PTSD in DSM (Galatzer-Levy & Bryant, 2013). Historically, treatment development efforts aimed at preventing PTSD soon after exposure to trauma have met numerous challenges. Focusing on full diagnoses may stall treatment innovation.

A promising approach might be to identify specific target symptoms (e.g., a core clinical feature) and investigate ways to specifically modify that single target. Modification could take place at many levels; from the molecular level (pharmacological manipulations) to the social level (changing one's social environment). Compared to the multifaceted diagnosis of PTSD, the single symptom of intrusive memories may provide an alternative, more focused therapeutic target (Iyadurai et al., 2019). A specific symptom approach is already entering the clinical research thinking in the area of PTSD. For example, the evidence-based UK NICE guidelines for PTSD (2018) recommend that clinicians:

> Consider CBT interventions targeted at specific symptoms such as sleep disturbance or anger, for adults with a diagnosis of PTSD or clinically important symptoms of PTSD who have presented more than 3 months after a traumatic event only if the person:
>
> - is unable or unwilling to engage in a trauma-focused intervention or

- has residual symptoms after a trauma-focused intervention. [2018] (National Institute for Health & Care Excellence NICE, 2018, PTSD [NG116], 1.6 Management of PTSD in children, young people and adults, Treatment for adults section 1.6.23)

A narrower symptom focus has potential to facilitate the development of simpler interventions targeting the core clinical feature of a disorder (Figure 1).

Network models on data from 2782 patients who had experienced different types of trauma revealed that intrusive memories were among the most central (i.e., sharing a number of outgoing, causal connections with other symptoms), and associated with the most severe PTSD symptoms (Fried et al., 2018). Intrusive memories of trauma are distressing in of themselves and can lead to functional impairment in everyday life (Iyadurai et al., 2019). The experience of intrusions on the day of trauma (in the emergency department) can predict intrusions later on (Porcheret et al., 2020). These findings open ways of thinking about identifying patients who will potentially benefit from interventions targeting intrusive memories after trauma, and suggest novel angles for treatment innovation.

Identifying and targeting modifiable treatment mechanisms in the lab—an experimental psychopathology approach

Investigations of mechanisms of change can facilitate clinical treatment innovation (Kazdin, 2007). To advance psychological treatment targeting intrusive memories, we need to understand the processes involved in their onset, and the specific mechanisms modulating their expression. Such mechanisms could be studied at a variety of different levels (Holmes et al., 2020; Sanislow et al., 2019). Much of our work has focused on cognitive/behavioural levels, in line with our putative treatment approach (behavioural intervention).

An "experimental psychopathology" approach (Vervliet & Raes, 2013)—akin to experimental medicine (Bailey et al., 2011)—offers opportunities to study mechanisms. This

EXAMPLE POSSIBILITIES FOR NEW RESEARCH DIRECTIONS IN MENTAL HEALTH SCIENCE

Research direction	Reference	Example
Core clinical feature	Kupfer et al., 2011	Intrusive memories of a traumatic event
Specific target symptom	Iyadurai et al., 2019	Preventing intrusive memories after a traumatic event
Modifiable treatment mechanism	Kazdin, 2007	NMDA-receptor blockade (molecular) Working memory taxation (cognitive) Social support (social)
Global treatment dissemination	Fairburn & Patel, 2014	Remote delivery Peer- / Self-administration

Figure 1. Possible directions to open up questions in mental health science.

approach involves isolating and investigating intrusive memories away from the complexity of clinical settings; studying them under controlled conditions in the laboratory (Visser et al., 2018) and in a manner which enables conclusions about causality.

To identify modifiable treatment mechanisms, researchers must generate intrusive memories in the laboratory. A commonly used methodology is the trauma film paradigm (James et al., 2016), which involves participants viewing short distressing film clips with traumatic content—an experimental analogue to witnessing trauma. Participants subsequently record each occurrence (and content) of an intrusion of the film over a week.

Being able to *generate* intrusive memories in the laboratory allows to investigate mechanisms that could *modulate* them (i.e., reduce/increase their frequency). Memories may be modulated during their initial "consolidation" period as they do not reach their final form during or immediately after encoding. Post-encoding processes induce synaptic changes, including long-term potentiation, that are needed to stabilise the memory trace in the hours after its acquisition, making it initially malleable for interference (Visser et al., 2018). This opens up possibilities to identify specific mechanisms through which memory can be modulated in the laboratory for potential treatment gains.

Molecular level

A mechanistically-driven approach to modulating intrusive memories after experimental trauma at the molecular level is using nitrous oxide (Das et al., 2016). The N-methyl D-aspartate (NMDA) receptor antagonist has been implicated in the molecular basis of memory consolidation. Das and colleagues (2016) investigated whether inhaling nitrous oxide following the trauma film paradigm modulates intrusive memories of the film. Whilst the total number of intrusions in the week after analogue trauma did not differ between the experimental (inhaling nitrous oxide) and control (inhaling medical air) conditions, nitrous oxide sped up the reduction in intrusive memories compared to the control intervention. Thus, NMDA receptor blockage may be a potential means through which intrusive memories could be modified soon after trauma (Das et al., 2016).

Neural level

Neuroimaging studies have begun to explore the association between brain mechanisms activated during the encoding of a trauma film and later intrusive memories of the film. In two studies from our group, participants underwent fMRI whilst viewing a trauma film. Both the initial (Bourne et al., 2013) and replication study (Clark et al., 2016) showed that activity in the left IFG and middle temporal gyrus during film viewing distinguished scenes from a traumatic film that were the content of later intrusive memories from trauma scenes that were not subsequently intrusive. Using multivariate pattern analysis on data of both studies during film viewing enabled the prediction of later intrusive memories across participants with 68% accuracy, and within a participant with 97% accuracy (Clark et al., 2014). The left IFG may also be involved in the involuntary recall of intrusive memories triggered later by reminder cues in the scanner. Thus, similar neural processes may be involved in intrusive memory encoding and recall (Clark et al., 2016,

Figure 2). Should such neural findings be further replicated and extend to real-world trauma, they may suggest modifiable targets—e.g., for neuromodulation (Hanlon, 2019)—an exciting future research direction.

Psychophysiological level

Decreased heart rate at specific moments during a traumatic film (Holmes et al., 2004) and increased sympathetic activation (i.e., skin conductance during trauma film vs. neutral film) (Ripley et al., 2017) during encoding of experimental trauma have been associated with intrusive memories. Physiological processes to be targeted by future interventions remain to be developed. It will be critical to disentangle what may be *modifiable* versus what may be artefacts of other underlying processes, or provide a useful marker of treatment success.

Cognitive/behavioural level

Mechanistically-driven approaches to modifying intrusive memories after trauma have been examined at a cognitive/behavioural level (e.g., James et al., 2015; Lau-Zhu et al., 2019) by using a competing cognitive task. The rationale for this approach was developed by combining several lines of argument. Working memory theory (Baddeley, 2003) suggests that the human mind has limited capacity to process information of the same type at the same time. To limit the consolidation of intrusive memories, whilst a trauma memory hotspot is held in working memory (e.g., during memory consolidation) a cognitive interference task could compete for limited working memory resources (Holmes et al., 2009) and limit the (re)occurrence of an intrusive memory of that hotspot. The metaphor of a "cognitive vaccine" has been employed to describe the possibility that a powerful yet simple cognitive intervention delivered soon after trauma might prevent the subsequent emergence of intrusive memories. Essential to this was that intrusive memories take the form of mental images and that we could use imagery-competing tasks (Holmes & Mathews, 2005). Thus, we developed a competing cognitive task intervention procedure for malleable time windows.

Laboratory studies comparing the cognitive task intervention to control conditions have demonstrated that it results in a reduction in the number of intrusive memories over one week (e.g., Holmes et al., 2009; Holmes et al., 2010). This finding has been replicated by an independent research group (Badawi et al., 2019). We emphasise that this is a multi-component intervention (reminder cue followed by visuospatial computer game play "Tetris" with mental rotation instructions)—it is not "just playing Tetris". We have shown that the reminder cue is critical (Lau-Zhu et al., 2019, Exp. 3) and playing Tetris alone is ineffective (James et al., 2015). Other visuospatial tasks besides Tetris are also hypothesised to work by the theorised mechanisms and could be substituted as one of the intervention components (Deeprose et al., 2012; Holmes et al., 2004).

Using a similar protocol as in the laboratory, the cognitive task intervention procedure has shown early indication of translation into clinical settings in two proof-of-concept randomized controlled trials (RCT). A study with emergency department road traffic accident patients (Iyadurai et al., 2018) compared the impact of the cognitive task intervention with an attention placebo control (written activity log) delivered within six hours of the

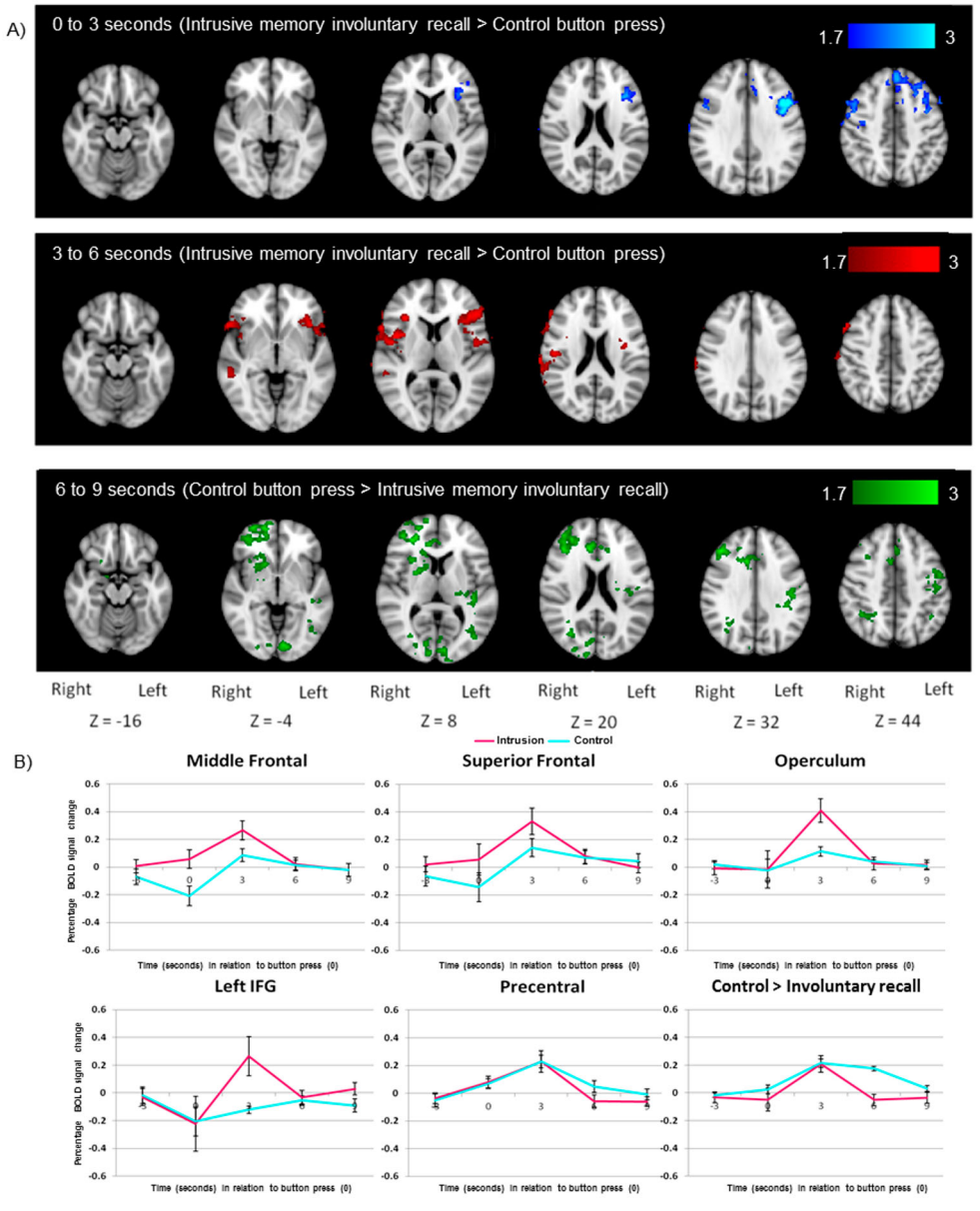

Figure 2. Intrusive memory involuntary recall after viewing film with traumatic content in an MRI scanner. (a) Whole-brain analysis showing the increased blood oxygen level-dependent (BOLD) response for intrusive memory involuntary recall v. control button press group at the two time bins (0–3 and 3–6 s in relation to the button press) showing significant differences in activation, and the one time bin (6–9 s) showing increased BOLD response for the control button press group v. intrusive memory involuntary recall. (b) Region-of-interest profile plots of the signal change observed across each time bin from −3 to +12 s in relation to the button press. Intrusive memory involuntary recall signal change activation is shown in pink, control button press signal change activation in light blue. Values are means, with standard deviations represented by vertical bars. IFG, Inferior frontal gyrus. Figure reprinted from Clark et al. (2016) with permission.

accident on intrusive trauma memory frequency over the subsequent week. As hypothesised, participants in the intervention condition reported fewer intrusive memories (Iyadurai et al., 2018). Another RCT with women whose babies were delivered by emergency caesarean section (traumatic childbirth, Horsch et al., 2017) demonstrated that those who received the cognitive task intervention within 6 hours reported fewer intrusive memories of the birth in the subsequent week relative to those who received usual care.

In the laboratory, we have found that the intervention specifically reduces the occurrence of *involuntary* intrusive memories, whereas voluntary memories (deliberately recalled facts about the trauma) remain preserved (James et al., 2015; Lau-Zhu et al., 2019). These findings support the idea that intrusive memories are "special" (i.e., functionally dissociable from the episodic memory system, Brewin, 2014). Various theories have considered the formation of intrusive memories. For example, a recent neuroscientific account suggests that intrusive memory representations result from facilitated memory encoding (specifically sensory and affective aspects) via potentiated amygdala functioning after stress exposure alongside weakened hippocampal activity down-modulating contextual binding (Bisby & Burgess, 2017; Bisby et al., 2020; Sierk et al., 2019). Our findings showing that the behavioural intervention specifically reduces intrusive, not voluntary memories, of analogue trauma (Lau-Zhu et al., 2019) provide further experimental evidence for such separate-trace theories, which interestingly stand in contrast to standard single-trace accounts of human memory (Berntsen, 2010).

In the abovementioned studies, the intervention was primarily delivered within six hours of experimental/actual trauma to prevent the initial consolidation of intrusive memories. Basic research on "memory reconsolidation" prompted the proposal that even older, already established emotional memories can become malleable again once they are reactivated. It is hypothesised that upon their retrieval, memories enter a transient labile state that allows for updating (i.e. new information can be integrated with the reactivated memory) (Visser et al., 2018). This possibility may open new opportunities for translational research (Milton & Holmes, 2018), to target older memories of traumatic events. The intervention protocol for day 1 memories has been adapted for application to older memories; e.g. one (James et al., 2015), three (Kessler et al., 2019) and four days (Hagenaars et al., 2017) following experimental trauma.

Such work has led to the development of a clinical protocol to target intrusive memories of long-standing trauma in inpatients with intrusive trauma memories associated with complex PTSD (Kessler et al., 2018). In this single case series, 20 inpatients monitored the occurrence of intrusive memories over the course of their admission to an inpatient ward (5–10 weeks). Weekly sessions of the cognitive task intervention involved a memory-reminder for one memory selected by each patient, followed by 25 minutes of playing Tetris (using mental rotation). Some intrusions were never targeted. The frequency of targeted intrusive memories reduced by an average of 64% from baseline to post-intervention. Untargeted intrusions reduced in frequency by an average of 11% over a comparable time period (Kessler et al., 2018). Next steps include establishing whether results replicate, and extending them to target older trauma memories in outpatient and community settings. Further case series work examines details of developing the intervention to reduce intrusive memories of trauma e.g. with people who are refugees (Kanstrup et al., 2020) and also with a case of bipolar disorder (Iyadurai et al., 2020).

Social level

We can also focus on potential social mechanisms involved in the formation or maintenance of intrusive memories after trauma. A lack of social support or social connections after a disaster were related to higher levels of PTSD symptoms in meta-analyses (Ozer et al., 2008). Little is known about the mechanisms behind the effect of interpersonal processes on intrusive memory formation.

In the laboratory, few studies have explored how social interactions after analogue trauma modulate intrusive memories. In one study, participants who received negative reactions (e.g., sarcasm) from a romantic partner after viewing a trauma film reported more intrusive memories of the film during the following 72 hours compared to those whose partners displayed positive responses (e.g., comforting; Woodward & Gayle Beck, 2017). Investigating the impact of simply delivered social support interventions on intrusive memories is of interest. The simplest interventions (e.g., the presence of a supportive other, rather than verbal dialogue per se) could open options. For global scalability, testing the possibility that such interventions could be implemented by members of the public rather than professionals, represents a potentially fruitful line of future research.

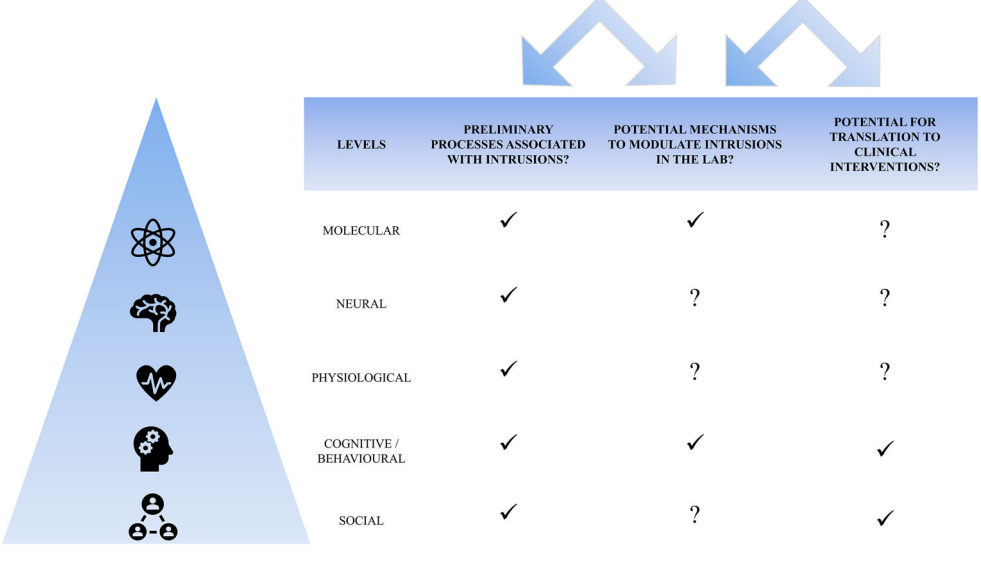

Figure 3. Schematic overview illustrating a way to explore existing research on mechanisms related to intrusion formation, modulation and clinical translation. This figure depicts (a) processes associated with intrusion formation (b) mechanisms to modulate intrusions in the laboratory, and (c) potential translations to clinical interventions across mechanistic levels (molecular, neural, physiological, cognitive/behavioural, and social). A check mark indicates that initial findings have been published. A question mark indicates uncertainties, overall opening options for further research combining ideas between disciplines.

Mental health science—a call to the deliberate (re)coupling of basic and applied research

Identifying processes that are associated with intrusions and mechanisms to modulate them in the laboratory may bring us closer to developing mechanistically informed treatments which specifically target intrusive memories. Many questions remain unanswered, particularly regarding the potential translation to clinical interventions (Figure 3). Combined efforts which bring together different research communities with a patient perspective are needed. We may need to think creatively about how individual levels of mechanism could be combined (Holmes et al., 2018, Part 3). By way of example, questions such as "*can neuromodulation (e.g., TMS/neurofeedback,* Tracy & David, 2015*) be combined with existing techniques (e.g., cognitive interventions) to leverage their effects on intrusive memories?*" await test.

It is imperative to draw on synergies from parallel efforts made in separate fields to leverage psychological treatment research (Goodwin et al., 2018). Past advances in treatment development have often been achieved by basic science and clinical practice "joining forces". Unfortunately, basic researchers and clinicians still often operate in fundamentally different worlds, as highlighted in a recent review of translational research on fear conditioning: "Neuroscientists and mental health clinicians have different theoretical approaches, use different methods and, overall, talk different languages" Fullana et al., (2020, p. 5). A problem-focused (rather than discussion focused) approach may illuminate new paths to treatment innovation through an iterative process of designing solutions through active involvement of those with lived experience of the phenomena of interest.

Other important aims of mental health science include efforts to include researchers from non-clinical disciplines to contribute to psychological treatment research. For instance, mathematicians could provide new ways to capture treatment outcomes with advanced analysis methods that introduce mechanisms into the understanding of cognitive processes (mechacognition) (Bonsall et al., 2015).

From therapist-led treatment to self-administration—toward new ways of delivering psychological treatment

When developing novel interventions, treatment scalability and possibility for remote delivery are crucial aspects to keep in mind. Current psychological treatment approaches are not accessible on a large enough scale to meet the global need for mental health treatment. In a recent discussion article in *World Psychiatry*, van Os et al. (2019) state that:

> The yearly prevalence of diagnosable mental suffering is around 20%, whilst mental health services have the capacity to treat 4–6% of the population in a given year. These figures indicate that there is considerable scope for public mental health, in the sense of freely accessible sources of information, self-management and peer support e-communities. (p. 93)

The global cost of mental health conditions are estimated to grow to US$ 6.0 trillion by 2030 (Bloom et al., 2011). We urgently need new ways of delivering treatment to bridge the gap between the high prevalence of mental disorders and the relatively low capacity of current mental health services. Novel mass treatment approaches should not require highly trained mental health professionals, shifting from "therapist-led" to "program-led" treatment (e.g., online self-help interventions, Fairburn & Patel, 2014).

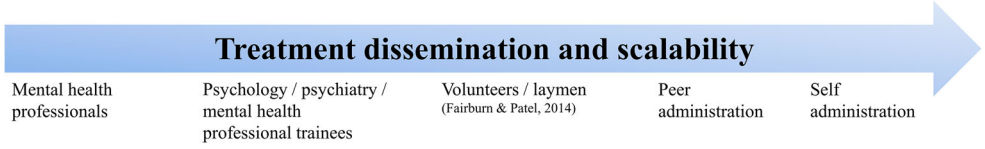

Figure 4. Schematic overview of ways to disseminate psychological treatment. A shift from delivering psychological treatment through highly trained mental health professionals to self-administration can increase scalability to meet the global need for mental health treatment.

The need for effective interventions that can be delivered both remotely and at scale becomes even more salient and urgent during the current COVID-19 pandemic (Holmes et al., 2020). First, due to risk of disease transmission it is no longer possible to deliver face-to-face psychological therapy. Remote options (including telephone and internet digital options) suitable for online clinics and community need innovation (Holmes et al., 2018, "*Technology—can we transform the availability and efficacy of psychological treatment through new technologies?*"). Second, in the domain of focus in this paper—post-traumatic stress—the pandemic has led to increased exposure to psychological trauma (e.g. direct exposure to, or witnessing, severe injury/death related to COVID-19) both for the general population (Garfin et al., 2020), and in specific groups such as frontline medical staff (Kang et al., 2020). Third, clearly many other mental health issues require support remotely and at scale, in particular for vulnerable groups during the pandemic. Such populations include those with existing mental health problems, people who may develop problems de novo e.g. isolated children or elderly, and frontline health-care workers exposed to stress and trauma (Holmes et al., 2020) as well as those from BAME communities (O'Connor et al., 2020). Innovation for global mental health here too will be aided by mechanistically driven ideas from experimental science, so that they can be brief, modular, efficacious and flexible—streamlined to remove unnecessary components and best adapted to align with cultural norms and conditions (Holmes et al., 2018, "*Where can psychological treatments be deployed? Research to improve mental health worldwide*").

The type of simple intervention we have discussed here, including computer game play, has the potential to be further developed for remote delivery as well as peer- or self-administration (Figure 4). We do not suggest that this intervention is a magic bullet. Rather, we propose that the relative brevity of the training required for its implementation, and the simplicity of delivery, renders evaluation of whether the intervention can effectively be delivered remotely and at scale an important research question which awaits test.

Conclusion

New approaches to mental health treatment innovation are needed given the slow advances in treatment development over recent decades. In this piece we have first emphasised the value of a targeted single symptom management approach as one potential way to advance psychological treatments. We propose that focussing on intrusive memories as a specific target symptom after trauma (Iyadurai et al., 2019) may facilitate a novel shift in the focus of trauma therapies, and make it easier to draw on advances from basic science.

Second, we have suggested an experimental psychopathology approach to guide investigations of specific mechanisms to modulate intrusive memories in the laboratory. The effectiveness of manipulating mechanisms which modulate intrusive memories can then be tested in the laboratory and ultimately be translated into the clinic and beyond (Holmes et al., 2020).

Third, we have argued that in order to overcome barriers in psychological treatment and meet the current challenge posed by mental health problems on a global scale, new ways of disseminating psychological interventions are needed (van Os et al., 2019). Simple self-help interventions could make psychological treatment available at a larger scale (Fairburn & Patel, 2014). Such interventions would potentially transform the lives of the millions of individuals worldwide who are affected by psychological disorders.

In summary, using the example of intrusive memories after traumatic events, we have illustrated that mental health science has potential to open up questions an dpotentially transform treatment development by adopting innovative practices that include but are not limited to: (1) identifying and targeting single core clinical features that, if addressed, could add significant value to end users, (2) adopting rigorous experimental methods to test modifiable treatment mechanisms, and (3) prioritising the development of scalable interventions that are accessible remotely yet low-cost.

Acknowledgement

Figure 2 was originally published by Clark et al. (2016) at Cambridge University Press under the Creative Commons Attribution License and is reprinted with permission.

Disclosure statement

EAH reports serving on the board of trustees of the charity MQ: Transforming Mental Health and receives no remuneration for this role. EAH receives royalties from books and occasional fees for workshops and invited addresses; receives occasional consultancy fees from the Swedish agency for health technology assessment and assessment of social services; and reports grants from The OAK Foundation (OCAY-18-442), the Lupina Foundation, and the Swedish Research Council (2017-00957). MLM is a Consulting Editor of Clinical Psychological Science and Journal of Experimental Psychology: Applied, and a member of the editorial boards of Behaviour Research and Therapy, Journal of Behavior Therapy and Experimental Psychiatry and Journal of Experimental Psychopathology. She receives no remuneration for these roles. LS, LE and JLJ report no potential conflict of interest.

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