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Eradicating war memories: Neuroscientific reality and ethical concerns

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Abstract

Traumatic memories of war can result in mental disorders such as post-traumatic stress disorder (PTSD). PTSD is characterized by intrusive trauma memories and severe stress responses with devastating personal and societal consequences. Current treatments teach patients to regulate trauma memories, but many experience a return of symptoms even after initially successful treatment. Neuroscience is discovering ways to permanently modify trauma memories and prevent the return of symptoms. Such memory modification techniques (MMTs) have great clinical potential but also important ethical, legal and social implications. In this article, the authors describe

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PTSD, the role of memory in PTSD, its effects on the brain, and the limitations of current treatment methods. Then, the state of the art of the neuroscience of MMTs is presented. Within this realistic scientific framework the authors will discuss the ethical, legal and social implications of MMTs for the treatment of war-induced PTSD, especially in a military population. Three major sets of issues will be focused on: safety and social justice concerns, concerns about threats to authenticity and identity, and the possible legal and moral duties to retain certain memories. Finally, the article concludes that within scientific reality, concerns are limited and do not outweigh the potential benefits of developing treatments for patients.

Keywords: war, post-traumatic stress disorder, memory modification, neuroscience, ethics.

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Introduction

War can leave people with traumatic memories that can trigger mental disorders, such as post-traumatic stress disorder (PTSD). People with PTSD are haunted by intrusive traumatic memories that evoke severe fear responses. PTSD causes great suffering for affected individuals and weighs heavily as a disease burden on society. Current treatments help patients regulate fear, but many patients do not benefit from available treatments or experience a return of symptoms even after initially successful treatment.[1] This highlights a need to develop more effective and persistent treatments.

Neuroscience is discovering ways to modify or even eradicate specific emotional memories. Memory modification techniques (MMTs) have great potential to prevent or treat PTSD as they could be used to target trauma memories, which are at the root of suffering in PTSD. MMTs might therefore become a valuable instrument in the care of the wounded and sick, which has always been one of the central preoccupations of international humanitarian law and is the original purpose of the Red Cross movement.

Given the intimate connection between memories and personal identity, and the social significance of some memories, MMTs also have considerable ethical, legal and social implications. Bioethicists have debated these implications extensively.[2] Much of that debate, however, has taken place in broad terms, without being entirely clear what concerns or normative challenges relate to all uses, including therapeutic uses, of MMTs, and what concerns apply only to abuses or misuses (however those might be defined).

The bioethical discussion sometimes loses track of what is scientifically possible or even probable. We believe that, to reach a defensible conclusion, one must consider the actual effects (both intended effects and side effects) of MMTs.

1 Bram Vervliet, Michelle G. Craske and Dirk Hermans, "Fear Extinction and Relapse: State of the Art", *Annual Review of Clinical Psychology*, Vol. 9, No. 1, 2013.

2 For more information, see the section "Ethical, Legal and Social Issues" below.

We do not deny the value of speculating about scientific developments, which may help identify problems worthy of further contemplation,[3] and we agree with the idea that "ethical reflection should precede technological [and scientific] progress and possible future applications".[4] But judgements about the propriety or otherwise of biomedical interventions should be passed on the merits of those interventions, rather than on the basis of what other (more potent, more dangerous, etc.) interventions might be developed in the future. After all, to a sufficiently conservative observer, every advance in science and technology looks like the thin edge of some wedge. Moreover, an overly speculative approach can result in scientists discarding ethical concerns as unrealistic and refraining from participating in debate.

In this paper, we aim to do two things. First, we provide an overview of the neuroscience of traumatic memory and MMTs. We describe how traumatic memories contribute to mental disorders, particularly PTSD, and impact the brain, and we discuss current treatment methods for PTSD, their limitations, and the state of the art of MMTs. Second, drawing on these neuroscience insights, we discuss some ethical, legal and social implications of utilizing neuroscience to treat traumatic memories of war, especially in military populations. We focus on three major sets of issues: safety and social justice concerns, concerns about threats to authenticity and identity, and the possible legal and moral duties to retain certain memories.

War, psychological trauma, and the brain

Here we will provide a brief introduction to PTSD, discussing what it is, how commonly it occurs, what role memory plays in its development and treatment, and what impact psychological trauma (Latin for "wound") has on the brain.

PTSD as a mental disorder

PTSD is a mental disorder that can develop after severely distressing events such as war, sexual assault or witnessing a death, resulting in a traumatic experience that damages the mind (psychological trauma) by impacting the brain (physiological trauma).[5] People with PTSD persistently re-experience the traumatic experience via intrusive thoughts, nightmares, "flashbacks", and emotional and physical distress. They suffer negative thoughts and feelings, avoid trauma-related

3 See, e.g., Rebecca Roache, "Ethics, Speculation, and Values", *NanoEthics*, Vol. 2, No. 3, 2008.

4 Laura Y. Cabrera and Bernice S. Elger, "Memory Interventions in the Criminal Justice System: Some Practical Ethical Considerations", *Journal of Bioethical Inquiry*, Vol. 13, No. 1, 2016, p. 96.

5 American Psychiatric Association, *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR)*, Washington, DC, 2010. See also Edna B. Foa, Gail Steketee and Barbara Olasov Rothbaum, "Behavioral/Cognitive Conceptualizations of Post-Traumatic Stress Disorder", *Behavior Therapy*, Vol. 20, No. 2, 1989; Bessel A. van der Kolk, "The Psychobiology of Posttraumatic Stress Disorder", *Journal of Clinical Psychiatry*, Vol. 58, Suppl. 9, 1997; Anke Ehlers and David M. Clark, "A Cognitive Model of Posttraumatic Stress Disorder", *Behaviour Research & Therapy*, Vol. 38, No. 4, 2000; Chris R. Brewin and Emily A. Holmes, "Psychological Theories of Posttraumatic Stress Disorder", *Clinical Psychology Review*, Vol. 23, No. 3, 2003.

reminders and experience hyper-arousal symptoms such as irritability and difficulties concentrating or sleeping. In response to trauma-related stimuli they often experience dissociative symptoms such as depersonalization (feeling as if "this is not happening to me") or derealization ("things are not real").[6] Patients often report feeling as if the traumatic event is happening in "real time" instead of in the past, which evokes a sense of current threat.

Beyond psychological symptoms, people with PTSD often experience interpersonal, psychosocial and health problems. For example, they are at an increased risk of cardiovascular disease, drug addiction, intimate partner aggression, divorce, job loss and confrontations with the legal system.[7] The economic burden of PTSD to society during the 1990s was estimated to be $42.3 billion per year,[8] which will have likely risen by now due to the generally increasing medical costs.

Prevalence of PTSD

Exposure to psychological trauma is a common occurrence.[9] An estimated 50% of men and 60% of women experience at least one trauma during their lifetime.[10] Around 8% of these men and 20% of these women develop PTSD.[11] In a given year, 8% of the general population has a current diagnosis of PTSD.[12] Extrapolating, this means that ~26 million people in the United States, ~41 million in the European Union and ~110 million in China currently suffer from PTSD; numbers for developing countries might be even higher, as exposure to stressors may be greater.[13]

The prevalence of PTSD amongst soldiers is higher than in the general population. Of the roughly 2 million US soldiers who served during Operations Iraqi Freedom, Enduring Freedom, Desert Shield and Desert Storm, 10–20%, or some 200,000–400,000, experienced PTSD in a given year.[14] It is estimated that 30% of the approximately 3.4 million US soldiers (that is, roughly 1 million) who served in Vietnam will experience PTSD in their lifetime.[15] Amongst civilians in

6 American Psychiatric Association, *Diagnostic and Statistical Manual of Mental Disorders: DSM-5*, Washington, DC, 2013.

7 Terence M. Keane, Amy D. Marshall and Casey T. Taft, "Posttraumatic Stress Disorder: Etiology, Epidemiology, and Treatment Outcome", *Annual Review of Clinical Psychology*, Vol. 2, No. 1, 2006.

8 Paul E. Greenberg *et al.*, "The Economic Burden of Anxiety Disorders in the 1990s", *The Journal of Clinical Psychiatry*, Vol. 60, No. 7, 1999.

9 Ronald C. Kessler *et al.*, "Lifetime Prevalence and Age-of-Onset Distributions of DSM-IV Disorders in the National Comorbidity Survey Replication", *Archives of General Psychiatry*, Vol. 62, No. 6, 2005; T. M. Keane, A. D. Marshall and C. T. Taft, above note 7.

10 R. C. Kessler *et al.*, above note 9; T. M. Keane, A. D. Marshall and C. T. Taft, above note 7.

11 R. C. Kessler *et al.*, above note 9; T. M. Keane, A. D. Marshall and C. T. Taft, above note 7.

12 R. C. Kessler *et al.*, above note 9; T. M. Keane, A. D. Marshall and C. T. Taft, above note 7.

13 R. C. Kessler *et al.*, above note 9.

14 H. K. Kang, "Post-Traumatic Stress Disorder and Chronic Fatigue Syndrome-like Illness among Gulf War Veterans: A Population-based Survey of 30,000 Veterans", *American Journal of Epidemiology*, Vol. 157, No. 2, 2003.

15 Richard A. Kulka *et al.*, *Trauma and the Vietnam War Generation: Report of Findings from the National Vietnam Veterans Readjustment Study*, Brunner and Mazel, New York, 1990.

armed conflict situations, the prevalence of PTSD is also around 30%.[16] Given the nature of contemporary conflicts, however, many more civilians than soldiers experience war and thus end up suffering from PTSD.[17]

PTSD and memory

While a number of psychological theories on PTSD have been put forward, memory plays a critical role in all of them.[18] Indeed, PTSD might even be considered a memory disorder.[19]

The defining onset of PTSD is a traumatic experience that results in the formation of a traumatic memory. The severity and the perceived threat of the traumatic experience predict PTSD severity,[20] and are also factors known to strengthen memory formation.[21] Moreover, PTSD may develop because the traumatic experience shatters our learned assumptions and beliefs about the safety of our world.[22]

PTSD is characterized by intrusive memories. The content of intrusive memories often includes trivial stimuli or situations that preceded the traumatic event.[23] For example, a war veteran may have intrusive memories of rustling leaves that were seen or heard prior to the emergence of enemy soldiers from the jungle. Such memories may serve as "warning signals" that are later interpreted as signals of impeding danger and thus evoke a sense of current threat. As such, intrusive memories are learned predictors of danger that come to evoke defensive responses, avoidance behaviours and involuntary retrieval of thoughts, feelings and memories of the traumatic event.

People with PTSD involuntarily re-experience intrusive memories as if happening in "real time", but often have difficulty purposefully recollecting the trauma memory.[24] They tend to recall disjointed fragments of the traumatic

16 Laila Farhood, Hani Dimassi and Tuija Lehtinen, "Exposure to War-Related Traumatic Events, Prevalence of PTSD, and General Psychiatric Morbidity in a Civilian Population From Southern Lebanon", *Journal of Transcultural Nursing*, Vol. 17, No. 4, 2006; Stephen Powell, "The Psychosocial Consequences of the 1992–5 War in Bosnia & Herzegovina", PhD thesis, Middlesex University, 2012; Marilyn K. Potts, "Long-Term Effects of Trauma: Post-Traumatic Stress among Civilian Internees of the Japanese during World War II", *Journal of Clinical Psychology*, Vol. 50, No. 5, 1994.

17 Barbara Lopes Cardozo, "Mental Health, Social Functioning, and Disability in Postwar Afghanistan", *Journal of the American Medical Association*, Vol. 292, No. 5, 2004.

18 C. R. Brewin and E. A. Holmes, above note 5.

19 E. B. Foa, G. Steketee and B. Olasov Rothbaum, above note 5.

20 Chris R. Brewin, Bernice Andrews and John D. Valentine, "Meta-Analysis of Risk Factors for Posttraumatic Stress Disorder in Trauma-Exposed Adults", *Journal of Consulting and Clinical Psychology*, Vol. 68, No. 5, 2000; Emily J. Ozer *et al.*, "Predictors of Posttraumatic Stress Disorder and Symptoms in Adults: A Meta-Analysis", *Psychological Bulletin*, Vol. 129, No. 1, 2003.

21 See Kevin S. LaBar and Roberto Cabeza, "Cognitive Neuroscience of Emotional Memory", *Nature Reviews Neuroscience*, Vol. 7, No. 1, 2006.

22 Ronnie Janoff-Bulman, *Shattered Assumptions: Towards a New Psychology of Trauma*, Free Press, New York, 1992; Mardi J. Horowitz, *Stress Response Syndromes: PTSD, Grief, Adjustment, and Dissociative Disorders*, Jason Aronson, Lanham, MD, 2014.

23 Anke Ehlers *et al.*, "The Nature of Intrusive Memories after Trauma: The Warning Signal Hypothesis", *Behaviour Research & Therapy*, Vol. 40, No. 9, 2002.

24 E. B. Foa, G. Steketee and B. Olasov Rothbaum, above note 5; A. Ehlers and D. M. Clark, above note 5; C. R. Brewin and E. A. Holmes, above note 5.

event; recall is often not chronological but jumps back and forth in time between events, and unlike in ordinary memory retrieval, people often get "stuck" or "hung up" on particular details and feelings. As such, traumatic memories in PTSD may be processed differently from ordinary emotional memories and may be qualitatively different and possibly stored differently in the brain.[25]

Many who experience psychological trauma will initially develop PTSD-like symptoms, but most will learn to overcome these symptoms over time.[26] Only a portion of people who experience trauma will not learn to control traumatic symptoms and will develop PTSD.[27] Thus, disturbances in learning to control emotional responses and memory for situations of safety also contribute to PTSD.

Effects of trauma on emotional memory systems in the brain

People with PTSD exhibit enhanced responses to aversive stimuli indicating hypersensitivity of the nervous system to stress, and hyper-reactivity to trauma-related stimuli. PTSD is associated with abnormalities in neurotransmitters (chemicals that allow communication between brain cells) and stress hormones, such as noradrenaline, serotonin and cortisol, as well as brain structure and function in regions involved in emotional memory and emotion regulation.[28] Brain abnormalities have been observed in the amygdala (important for learned threat responses), ventromedial prefrontal cortex (critical to inhibition of threat responses) and hippocampus (important for behavioural inhibition and memory for episodic events). This may explain the hyper-arousal and hyper-reactivity symptoms, inability to regulate fear, fragmentation of memory for the traumatic event, and re-experiencing of symptoms in PTSD. These abnormalities may constitute vulnerability factors, or may be acquired following trauma exposure, or may interact to contribute to PTSD.

Current treatments and their limitations

Treatments for PTSD continue to be developed based on advancing psychological and neuroscientific insights into the disease. Antidepressants, specifically selective serotonin reuptake inhibitors (SSRIs), are the most commonly prescribed

25 Chris R. Brewin *et al.*, "Intrusive Images in Psychological Disorders: Characteristics, Neural Mechanisms, and Treatment Implications", *Psychological Review*, Vol. 117, No. 1, 2010.

26 Jonathan I. Bisson *et al.*, "Post-Traumatic Stress Disorder", *British Medical Journal*, Vol. 351, No. h6161, 2015.

27 *Ibid.*

28 B. A. van der Kolk, above note 5; Rachel Yehuda *et al.*, "Hypothalamic-Pituitary-Adrenal Dysfunction in Posttraumatic Stress Disorder", *Biological Psychiatry*, Vol. 30, No. 10, 1991; J. Douglas Bremner and Eric Vermetten, "Neuroanatomical Changes Associated with Pharmacotherapy in Posttraumatic Stress Disorder", *Annals of the New York Academy of Sciences*, Vol. 1032, No. 1, 2004; Roger K. Pitman, Ann M. Rasmusson *et al.*, "Biological Studies of Post-Traumatic Stress Disorder", *Nature Reviews Neuroscience*, Vol. 13, No. 11, 2012.

pharmacotherapies for PTSD. However, SSRIs are only moderately effective for treating PTSD and are less effective than psychotherapy.[29] The primary psychological intervention for PTSD is exposure treatment.[30] In exposure treatment, patients are guided to vividly imagine the traumatic experience until their emotions reduce. People are asked to describe details of the traumatic experience and to re-evaluate and reinterpret stimuli, their meaning, and responses.[31] The goal is to reduce emotional responses and avoidance, and increase the feeling of control.

Most modern psychotherapies have integrated exposure treatment with other behavioural and cognitive approaches.[32] This can include reconstructing the traumatic experience in chronological order, learning to distinguish between stimuli and events that happened during the trauma experience ("then") and innocuous stimuli that trigger re-experiencing symptoms in the present ("now"), substituting negative thoughts for positive associations, and acquiring relaxation techniques, so that patients regain a sense of control over their emotions.

Psychotherapy is effective in reducing PTSD symptoms and reaching remission.[33] However, the majority of patients experience (some) return of symptoms even after initially successful treatment.[34] This indicates that although psychotherapy for PTSD aims to restructure memory, it probably does not change the trauma memory itself, leaving the risk of a return of symptoms.[35]

Neuroscience of memory modification

Modern neuroscience is discovering techniques to permanently modify the original threat memory itself, which has great potential for developing novel treatments for psychological trauma. To understand the clinical, ethical, legal and societal implications of MMTs, it is imperative to first understand something about the cognitive neuroscience of memory.

What is memory?

Memory is the capacity for persistence of information over time. For the purposes of cognitive neuroscience, memory can be defined as an internal representation of an experience captured in a physiological change in the brain, enabling the expression of the earlier experience in thought or behaviour.[36] This definition contains two

29 Michelle L. van Etten and Steven Taylor, "Comparative Efficacy of Treatments for Post-Traumatic Stress Disorder: A Meta-Analysis", *Clinical Psychology & Psychotherapy*, Vol. 5, No. 3, 1998.
30 Exposure treatment is based on extinction learning in Pavlovian conditioning: see text accompanying notes 46–48 below.
31 Peter J. Lang, "Imagery in Therapy: An Information Processing Analysis of Fear", *Behavior Therapy*, Vol. 8, No. 5, 1977.
32 See C. R. Brewin and E. A. Holmes, above note 5.
33 M. L. van Etten and S. Taylor, above note 29.
34 B. Vervliet, M. G. Craske and D. Hermans, above note 1.
35 See text accompanying notes 48–50 below.
36 Yadin Dudai, "Memory Concepts", in Henry L. Roediger, Yadin Dudai and Susan M. Fitzpatrick (eds), *Science of Memory: Concepts*, Oxford University Press, Oxford, 2007.

components: the expression of memory in thought or behaviour, and its neural underpinning. The latter component is called an "engram" or "memory trace".[37] This also means that with anything you learn, you are changing your brain.

Different "types" of memory

Different behaviours and thoughts are supported by distinct neural systems that all have the capacity for memory.[38] As a result, psychologists have distinguished between different types of memories.[39]

Two memory types that contribute to PTSD and that we will mainly discuss here are conditioned memories and episodic memories.[40] Aversive conditioned memories can be formed via Pavlovian threat conditioning where pairing a stimulus (such as a sound) with an aversive outcome (such as pain) can come to evoke defensive responses (for example, changes in heart rate), indicating the formation of an association between the stimulus and the outcome in memory.[41] Such conditioned threat memories may contribute to the hyper-arousal and re-experiencing of symptoms evoked by "warning signals" in PTSD.[42] Episodic memory involves memories of particular experiences that include associations between who, what, where, when and why[43] – for instance, recalling "in our mind's eye" a particularly distressing war experience. Episodic memories play a role in the re-experiencing of autobiographical events of the traumatic experience in PTSD. For example, "flashbacks" involve the reliving of the traumatic episode as if happening in real time. Furthermore, episodic memory of the traumatic experience is often fragmented in PTSD, and in extreme cases people may have no episodic memory of the traumatic event at all (amnesia).

Hence, different "types" of memory contribute to distinct symptoms in PTSD. But how are these memories formed, and why are they so difficult to control or modify?

Neuroscience of memory formation

Experiences create patterns of neural activation in the brain via our senses. The formation of a memory of an experience involves the strengthening of connections between brain cells activated by an experience and requires

37 Richard Semon, *The Mneme*, Allen & Unwin, London, 1921, p. 12.
38 Katharina Henke, "A Model for Memory Systems Based on Processing Modes rather than Consciousness", *Nature Reviews Neuroscience*, Vol. 11, No. 7, 2010.
39 See Endel Tulving, "Episodic and Semantic Memory", in Endel Tulving and Wayne Donaldson (eds), *Organization of Memory*, Academic Press, New York, 1972; Larry R. Squire, "Memory and the Hippocampus: A Synthesis from Findings with Rats, Monkeys, and Humans", *Psychological Review*, Vol. 99, No. 2, 1992.
40 Larry R. Squire, "Memory Systems of the Brain: A Brief History and Current Perspective", *Neurobiology of Learning & Memory*, Vol. 82, No. 3, 2004.
41 Joseph E. LeDoux, "Emotion Circuits in the Brain", *Annual Review of Neuroscience*, Vol. 23, No. 1, 2000.
42 A. Ehlers and D. M. Clark, above note 5.
43 L. R. Squire, above note 39.

neurotransmitter signalling, gene transcription and protein synthesis. Drugs or other interventions administered right before or after learning – that is, at the moment of acquisition of information of an experience – can impair memory.[44] However, the same interventions administered hours after learning no longer have an effect on memory. This has led to the standard view on memory, which suggests that memories are initially labile (meaning they are sensitive to modification by interventions) but stabilize over time during a period of "consolidation", after which they are stable and can no longer be modified.[45] Neurotransmitters and hormones that are released during emotional experiences, such as noradrenaline and cortisol, can strengthen consolidation and as such result in an emotional memory enhancement.[46] At the same time, this implies that immediately before and after a traumatic experience, there may be a brief window of opportunity to prevent a trauma memory from becoming permanently stored or to minimize its emotional enhancement.[47]

Extinction and the return of symptoms

Patients often come into a therapist's office long after a trauma memory has formed and been consolidated. The often-observed return of PTSD symptoms even after initially successful psychotherapy can be explained because treatment (particularly exposure treatment) is based on principles of extinction learning of Pavlovian conditioning.[48]

During extinction training, a threatening stimulus is repeatedly presented without an aversive outcome so that over time the person will stop displaying threat-related defensive responses. However, extinction learning does not modify the original threat memory. It rather forms a novel safety memory in the ventromedial prefrontal cortex that inhibits the expression of threat responses in the amygdala, and this can give way to the return of threat responses with the passage of time, changes in context or increases in arousal.[49]

From an evolutionary perspective it makes sense not to overwrite a conditioned threat memory, as the threat memory is adaptive and protects us from danger. However, the unfortunate result is that psychotherapy most likely also does not alter the original trauma memory but forms a novel safety memory,[50] even though trauma memory is clearly maladaptive/harmful in PTSD. This leaves the risk of the return of symptoms even after initially successful treatment.

44 J. L. McGaugh, "Memory: A Century of Consolidation", *Science*, Vol. 287, No. 5451, 2000.
45 *Ibid.*
46 *Ibid.*
47 See text accompanying note 68 below.
48 B. Vervliet, M. G. Craske and D. Hermans, above note 1.
49 M. E. Bouton, "Context and Behavioral Processes in Extinction", *Learning & Memory*, Vol. 11, No. 5, 2004; Gregory J. Quirk and Devin Mueller, "Neural Mechanisms of Extinction Learning and Retrieval", *Neuropsychopharmacology*, Vol. 33, No. 1, 2008; Karyn M. Myers and Michael Davis, "Behavioral and Neural Analysis of Extinction", *Neuron*, Vol. 36, No. 4, 2002.
50 B. Vervliet, M. G. Craske and D. Hermans, above note 1.

Flexibility of memories

Notwithstanding the stabilization and persistence of memories, it is known that memories, particularly episodic memories, can be flexible.[51] Most of what we initially remember, we forget within twenty-four hours. What we still remember after twenty-four hours, we forget at a much slower rate.[52] When witnessing distressing events such as the Challenger Space Shuttle explosion or 9/11, we are often very sure about the accuracy of our episodic memories, but in fact we accurately remember only around 30%.[53] Furthermore, with a bit of suggestion, it is possible to make people remember things that never happened, like being lost in a mall as a child.[54]

We thus forget most of what we initially remember, and our memories can be highly inaccurate or even completely false. This flexibility of episodic memory is adaptive, as it helps us to survive. Our environments continuously change, and forgetting may allow us to get rid of outdated and unimportant information and keep our memory "fresh". At the same time, updating of episodic memories through new experiences and integration of memory from different experiences help us to better describe regularities of our environment. What is still unclear is whether the memory flexibility described here results from a modification of the original memory or confusion between different memories at the time of retrieval. Regardless, when discussing the ethical, legal and social implications of MMTs, it is critical to realize that memories are not a veridical reflection of the past but serve to support adaptive responses and decision-making in the future.

Memory reconsolidation

As discussed above, the classical view on memory suggests that memories are initially labile but stabilize over time during a period of consolidation, after which they remain essentially unchanged.[55] Hence, consolidation provides a brief time window after learning to interfere with memory formation and potentially for prophylactic use of MMTs to prevent the development of PTSD. But the standard view on memory indicates that once memory is consolidated, MMTs would no

51 Marijn C. W. Kroes and Guillén Fernández, "Dynamic Neural Systems Enable Adaptive, Flexible Memories", *Neuroscience & Biobehavioral Reviews*, Vol. 36, No. 7, 2012.

52 William Hirst *et al.*, "Long-term Memory for the Terrorist Attack of September 11: Flashbulb Memories, Event Memories, and the Factors that Influence Their Retention", *Journal of Experimental Psychology: General*, Vol. 138, No. 2, 2009.

53 Ulric Neisser and Nicole Harsch, "Phantom Flashbulbs: False Recollections of Hearing the News about Challenger", in Eugene Winograd and Ulric Neisser (eds.), *Affect and Accuracy in Recall*, Cambridge University Press, Cambridge, 1992; W. Hirst *et al.*, above note 52.

54 In a classic study, researchers asked participants to recall specific events that had happened to them when they were younger; these events were provided to the researchers by relatives of the participants. Intermixed with the real events, respondents were asked to remember a false event – being lost in a shopping mall. A third of participants reported remembering the false event and described it by adding more details to the suggested scenario. See Elizabeth F. Loftus and Jacqueline E. Pickrell, "The Formation of False Memories", *Psychiatric Annals*, Vol. 25, No. 12, 1995.

55 J. L. McGaugh, above note 44.

longer be able to prevent PTSD. Contemporary neuroscience, however, has challenged the classical view on memory and suggests that it is possible for MMTs to modify consolidated memories.[56] We will first discuss laboratory studies on modification of consolidated memories, and will then turn to clinical studies.

In a seminal study, Karim Nader and colleagues used rats to show that a brief reminder can reactivate a consolidated threat-conditioned memory and temporarily return the memory to a labile state requiring re-stabilization processes (such as protein synthesis), referred to as reconsolidation.[57] It was found that disrupting reconsolidation processes by blocking protein synthesis can result in the loss of the conditioned threat responses and prevent their return.[58] Note that Nader and colleagues purposefully do not call this memory erasure; as such a null hypothesis is scientifically impossible to confirm. In addition, we believe we should refrain from using the term "erasure", as such terminology may spark unnecessary negative sentiment among the public.

To disrupt reconsolidation, Nader and colleagues injected a toxic protein-synthesis inhibitor, which is clearly not safe for use in humans, into the brains of rats. Subsequent laboratory experiments showed that the administration of noradrenaline antagonists (or "beta-blockers", such as propranolol) could also disrupt reactivated memories and prevent the return of threat-conditioned responses in rodents and humans.[59] Note that the disruption of memory by interventions such as beta-blockers only occurs under specific circumstances, namely, when memory is reactivated by a brief reminder and when the intervention is administered within a short time period after the reminder – that is, during the reconsolidation window. Furthermore, behavioural interventions may also impair reconsolidation: reactivating a conditioned threat memory to return the memory to a labile state and then administering extinction training during the reconsolidation window (reactivation–extinction paradigm) can also prevent the return of conditioned threat responses.[60] Here the idea is that when memory is returned to a labile state, extinction can overwrite or update the original threat memory and thus negate the formation of a separate safety memory. Hence, the reactivation–extinction paradigm suggests that existing exposure treatments could be optimized by a minor change in procedures. Collectively, these laboratory experiments suggest that pharmacological and

56 Karim Nader and Oliver Hardt, "A Single Standard for Memory: The Case for Reconsolidation", *Nature Reviews Neuroscience*, Vol. 10, No. 3, 2009; M. C. W. Kroes *et al.*, above note 51.

57 Karim Nader, Glenn E. Schafe and Joseph E. Le Doux, "Fear Memories Require Protein Synthesis in the Amygdala for Reconsolidation after Retrieval", *Nature*, Vol. 406, No. 6797, 2000.

58 *Ibid.*

59 Jacek Dębiec and Joseph E. LeDoux, "Disruption of Reconsolidation but not Consolidation of Auditory Fear Conditioning by Noradrenergic Blockade in the Amygdala", *Neuroscience*, Vol. 129, No. 2, 2004; Merel Kindt, Marieke Soeter and Bram Vervliet, "Beyond Extinction: Erasing Human Fear Responses and Preventing the Return of Fear", *Nature Neuroscience*, Vol. 12, No. 3, 2009.

60 Marie-H. Monfils *et al.*, "Extinction-Reconsolidation Boundaries: Key to Persistent Attenuation of Fear Memories", *Science*, Vol. 324, No. 5929, 2009; Daniela Schiller *et al.*, "Preventing the Return of Fear in Humans Using Reconsolidation Update Mechanisms", *Nature*, Vol. 463, No. 7277, 2010.

behavioural interventions, such as the use of beta-blockers or reactivation–extinction training, can disturb reconsolidation of reactivated threat-conditioned memories (e.g. memory for tone–shock associations) resulting in the loss of the expected reaction to a learned threat.

Interestingly, initial laboratory studies in humans indicated that reconsolidation interventions (both beta-blockers and behavioural interventions) specifically disrupted threat-conditioned defensive responses (e.g. sweating or startle responses) but left intact participants' ability to explicitly recall the threatening experience to mind.[61] This has led to the suggestion that reconsolidation interventions affect only the "emotional" component of memory and preserve episodic memory.[62] However, subsequent studies indicate that reconsolidation interventions with beta-blockers and behavioural manipulations can diminish the emotional enhancement of episodic memory and that electrical brain stimulation can even fully eradicate specific episodic memories in humans.[63] For example, in one study people who received electroconvulsive treatment (ECT) for unipolar depression learned two slide-show stories a week prior to treatment.[64] Right before ECT, the participants were briefly reminded of one of the two stories to reactivate memory for this specific story. One day after the reminder and ECT, people could explicitly remember the story that they were not reminded of but could no longer remember the story of which they had been reminded. Thus, reconsolidation interventions can modify specific reactivated conditioned memories as well as episodic memories.

That said, reconsolidation interventions do not cause general memory impairments – meaning they do not impair all memories that we have.[65] Only the specific memory that is reactivated and returned to a labile state can be modified.

From a clinical perspective, there are a number of limitations to reconsolidation interventions. First, evidence for reconsolidation has been obtained across many experimental paradigms and species, but not all studies have yielded positive results.[66] Second, older memories, especially episodic memories, appear less sensitive to reconsolidation interventions.[67] Third, much is still unknown about the conditions under which memories do and do not return to a labile state and can be modified. Fourth, if memory is reactivated but no intervention is administered or if interventions fail, reconsolidation strengthens

61 D. Schiller *et al.*, above note 60; M. Kindt, M. Soeter and B. Vervliet, above note 59.

62 Marieke Soeter and Merel Kindt, "Dissociating Response Systems: Erasing Fear from Memory", *Neurobiology of Learning and Memory*, Vol. 94, No. 1, 2010; Jacek Dębiec and Margaret Altemus, "Toward a New Treatment for Traumatic Memories", *Cerebrum*, September 2006; James Elsey and Merel Kindt, "Manipulating Human Memory Through Reconsolidation: Ethical Implications of a New Therapeutic Approach", *AJOB Neuroscience*, Vol. 7, No. 4, 2016.

63 See Marijn C. W. Kroes *et al.*, "Translational Approaches Targeting Reconsolidation", in Trevor W. Robbins and Barbara J. Sahakian (eds), *Translational Neuropsychopharmacology*, Springer, Cham, 2016.

64 Marijn C. W. Kroes *et al.*, "An Electroconvulsive Therapy Procedure Impairs Reconsolidation of Episodic Memories in Humans", *Nature Neuroscience,* Vol. 17, No. 2, 2014.

65 K. Nader and O. Hardt, above note 56; M. C. W. Kroes *et al.*, above note 63.

66 M. C. W. Kroes *et al.*, above note 63.

67 *Ibid.*

memory. Hence, the opportunity to use reconsolidation-intervention techniques to treat patients who often have had traumatic memories for many years may be limited and, if interventions fail, reconsolidation may inadvertently strengthen trauma memories.[68] Much research is still needed to translate this laboratory research into effective clinical applications.

Reactivating a memory can provide an opportunity for interventions to steer the reconsolidation of a specific maladaptive memory in a particular direction and potentially treat stress and anxiety disorders, including PTSD. Importantly, reconsolidation interventions would require only minor changes to existing psychotherapeutic behavioural procedures (for example, adding a brief memory reactivation prior to standard exposure treatment) or would involve a precise combination of psychotherapy and administration of a single dose of medication.

Clinical trials of memory modification technology

Based on laboratory experiments, several clinical trials have investigated the potential to use MMTs to prevent the formation of trauma memory, enhance exposure treatment, or impair reconsolidation of trauma memory to treat patients.

The administration of a beta-blocker to people admitted to an emergency department after a traumatic experience reduced threat responses to trauma reminders and PTSD symptoms one month later.[69] Thus, beta-blockers may impair the consolidation of trauma memory and prevent the development of PTSD. However, the usefulness of this approach is limited, as the treatment needs to take place right after the traumatic experience to be effective, whereas most people with PTSD do not seek treatment until months after the trauma.

Another approach has been to improve exposure treatment by enhancing extinction learning – that is, by pharmacologically strengthening the formation of the safety memory that comes to inhibit threat responses. The administration of D-cycloserine (a drug that stimulates NMDA receptors, which are critical for the formation of new memories) can strengthen extinction learning, and its application prior to exposure treatment can improve treatment outcomes in patients with anxiety disorders.[70] However, the problem is that the medication needs to be given before treatment, when the outcome of the treatment cannot yet be known: if exposure treatment ends up being successful, the medication strengthens the formation of a safety memory, but if exposure treatment ends up being unsuccessful, the medication can inadvertently strengthen the trauma memory itself.

68 *Ibid.*

69 Roger K. Pitman, Kathy M. Sanders *et al.*, "Pilot Study of Secondary Prevention of Posttraumatic Stress Disorder with Propranolol", *Biological Psychiatry*, Vol. 51, No. 2, 2002.

70 See Stefan G. Hofmann, "Enhancing Exposure-Based Therapy from a Translational Research Perspective", *Behaviour Research & Therapy*, Vol. 45, No. 9, 2007; Kerry J. Ressler *et al.*, "Cognitive Enhancers as Adjuncts to Psychotherapy: Use of D-Cycloserine in Phobic Individuals to Facilitate Extinction of Fear", *Archives of General Psychiatry*, Vol. 61, No. 11, 2004.

The advantage of reconsolidation interventions is that they theoretically allow for the modification of specific memories at any time after learning and that the intervention can be applied after controlled memory reactivation. Initial clinical trials found that targeting reconsolidation of trauma memories with beta-blockers in PTSD patients can subsequently reduce threat responses to trauma reminders and reduce PTSD symptoms.[71] However, there are limitations to these studies,[72] and subsequent studies have failed to replicate them.[73] The effectiveness of a beta-blocker reconsolidation intervention to treat PTSD thus appears limited. Note that PTSD patients are haunted by intrusive emotional *episodic* memories[74] that they have often had for many years, and these may be particularly difficult to modify, as explained above. In that regard it is worth noting that targeting reconsolidation to treat specific phobias, which mainly involve conditioned responses, may be more effective.[75]

A series of interesting studies has attempted to disturb intrusive emotional episodic memories by using the computer game Tetris.[76] In a small clinical trial, having patients who entered the emergency department play Tetris was found to reduce intrusions, and there was some evidence for a reduction in PTSD symptoms.[77] The idea is that playing a visual-cognitive game like Tetris competes for the same limited neurocognitive resources that are necessary for the formation of emotional episodic memories and will thus disturb memory formation and prevent intrusions. A laboratory study reported that playing Tetris following memory reactivation can reduce intrusions in healthy participants (those who do not have PTSD or other psychiatric problems).[78] It would be interesting to see whether a Tetris reconsolidation intervention could reduce PTSD symptoms in a clinical trial.

In sum, clinical trials have shown that MMTs may prevent the formation of traumatic memories, can enhance exposure treatment, and may disrupt reconsolidation of consolidated memories. However, the efficacy of clinical

71 Alain Brunet, Scott P. Orr *et al.*, "Effect of Post-Retrieval Propranolol on Psychophysiologic Responding during Subsequent Script-Driven Traumatic Imagery in Post-Traumatic Stress Disorder", *Journal of Psychiatric Research*, Vol. 42, No. 6, 2008; Alain Brunet, Joaquin Poundja *et al.*, "Trauma Reactivation Under the Influence of Propranolol Decreases Posttraumatic Stress Symptoms and Disorder: 3 Open-Label Trials", *Journal of Clinical Psychopharmacology*, Vol. 31, No. 4, 2011; Alain Brunet, Émilie Thomas *et al.*, "Trauma Reactivation Plus Propranolol is Associated with Durably Low Physiological Responding during Subsequent Script-Driven Traumatic Imagery", *Canadian Journal of Psychiatry*, Vol. 59, No. 4, 2014.

72 M. C. W. Kroes *et al.*, above note 63.

73 Nellie E. Wood *et al.*, "Pharmacological Blockade of Memory Reconsolidation in Posttraumatic Stress Disorder: Three Negative Psychophysiological Studies", *Psychiatry Research*, Vol. 225, Nos 1–2, 2015.

74 C. R. Brewin *et al.*, above note 25.

75 Marieke Soeter and Merel Kindt, "An Abrupt Transformation of Phobic Behavior After a Post-Retrieval Amnesic Agent", *Biological Psychiatry*, Vol. 78, No. 12, 2015.

76 Emily A. Holmes *et al.*, "Can Playing the Computer Game 'Tetris' Reduce the Build-Up of Flashbacks for Trauma? A Proposal from Cognitive Science", *PLoS ONE*, Vol. 4, No. 1, 2009.

77 Lalitha Iyadurai *et al.*, "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", *Molecular Psychiatry*, Vol. 23, No. 3, 2018.

78 Ella L. James *et al.*, "Computer Game Play Reduces Intrusive Memories of Experimental Trauma via Reconsolidation-Update Mechanisms", *Psychological Science*, Vol. 26, No. 8, 2015.

translations has so far been limited, potentially because it is unclear how to optimally target trauma memories or because not all types of memory may be equally sensitive to MMTs.[79]

Ethical, legal and social issues

The possible use of MMTs raises important ethical, legal and social questions. Unfortunately, these questions do not lend themselves to comprehensive and universal answers.[80]

For one, any analysis would hinge upon whether an MMT is used (merely) to rid a person of an unpleasant and undesirable but adaptive memory, or whether it seeks to address a serious malady such as PTSD in which trauma memory is maladaptive to normal functioning and survival. Regrettably, much of the bioethical debate concerning MMTs has taken place in broad terms, leaving room for speculation as to whether the concerns raised apply to the use of MMTs therapeutically (however that might be delimited).[81] In this article, we will specifically restrict our focus to the use of MMTs in the prevention or treatment of PTSD in members of armed forces. In doing so, we do not seek to deny that MMTs could be misused or abused, but we want to avoid over-generalizing problems associated with potential abuse to the intervention as such.[82] After all, the fact that the recreational use of some medications (such as amphetamines) can potentially be dangerous and a source of serious social ills surely cannot mean that treating recognized maladies (such as narcolepsy) with that medication becomes objectionable. The problem of abuse would need to be managed with appropriate regulation and the professional ethics of medical practitioners, as is the case with many other medical interventions.

Furthermore, the juncture of intervention has considerable normative significance. As we noted earlier, MMTs could be used prophylactically to prevent symptoms of PTSD from ever developing, or as treatment when symptoms of PTSD have already manifested. These two options present somewhat different dilemmas. Much of the bioethical debate so far has focused on the prophylactic use of MMTs.[83] In this article, we want to draw attention to the differences and similarities of the diverse approaches from an ethical, legal and social perspective.

We begin our discussion with a foundational question, namely whether MMTs are safe and effective, and whether equitable access to them can be

79 M. C. W. Kroes *et al.*, above note 63.

80 More broadly on the need for a contextualized case-by-case assessment, see, e.g., President's Council on Bioethics, *Beyond Therapy: Biotechnology and the Pursuit of Happiness*, October 2003, p. 208; Neil Levy, *Neuroethics: Challenges for the 21st Century*, Cambridge University Press, Cambridge, 2007, p. 131; Erik Parens, "The Ethics of Memory Blunting and the Narcissism of Small Differences", *Neuroethics*, Vol. 3, No. 2, 2010, p. 106.

81 President's Council on Bioethics, above note 80, is a case in point.

82 Cf. N. Levy, above note 80, p. 131.

83 But see J. Elsey and M. Kindt, above note 62.

ensured. We then turn to a set of issues that we think are at the core of the debate around MMTs – though we doubt whether those issues are strictly speaking ethical, as they appear to be more broadly societal. The first of these is the notion that by modifying memories we jeopardize identities and fail to live an authentic life. The second is that MMTs interfere in normal psychological coping processes and deny benefits of learning to deal with trauma. The third and final issue that we will consider here is that, for different reasons, we might be duty bound to retain certain memories – that is, society may require us to retain certain memories.

Safety, effectiveness and equitable access

MMTs inevitably raise questions that pertain to all new medications or therapeutic devices. First, is the intervention safe – is it relatively free of serious adverse side effects? Second, is the intervention effective – does it achieve its intended purpose in clinical practice? Taken together, these questions are concerned with whether the benefits of the intervention in addressing a malady (here, PTSD) outweigh the known risks.

We addressed the effectiveness of different interventions in the previous section. To recapitulate, while more research is necessary, there is cause for cautious optimism that certain memory-modifying interventions may indeed bring relief from symptoms of PTSD.

With regard to safety, the question becomes more contextual. Different interventions, each with a different side-effect profile, can be used to interfere with the consolidation and reconsolidation of memories. Even the beta-blocker propranolol, generally regarded a relatively benign medication,[84] has some side effects. Indeed, because it is used to treat certain cardiovascular conditions, it must necessarily have cardiovascular side effects when used to produce neurocognitive effects.

Safety is a particularly pressing issue when it comes to prophylaxis. An over-generous prophylactic use would mean that many people would be exposed to the side effects of the intervention without gaining any benefits. The problem is that it is difficult to predict if and when PTSD might develop: not all traumatic events are so serious as to trigger PTSD, and not all people experiencing the same event develop PTSD.[85] Thus it is not clear who should receive prophylaxis.

The magnitude of this problem depends on whether we are concerned with pre-exposure prophylaxis (that is, in anticipation of a traumatic event) or post-exposure prophylaxis (that is, immediately after a traumatic event and in any event before symptoms of PTSD have developed). Pre-exposure prophylaxis is clearly more challenging because there is an added variable: not knowing if and when a traumatic event might take place. Thus, effective prophylaxis would require the use

84 Wayne Hall and Adrian Carter, "Debunking Alarmist Objections to the Pharmacological Prevention of PTSD", *American Journal of Bioethics*, Vol. 7, No. 9, 2007, pp. 23–24.

85 President's Council on Bioethics, above note 80, pp. 226, 228; Jennifer A. Bell, "Preventing Post-Traumatic Stress Disorder or Pathologizing Bad Memories?", *American Journal of Bioethics*, Vol. 7, No. 9, 2007, p. 29.

of long-acting interventions or keeping the person on a particular medication for days on end. Because most side effects of medications are dose-dependent, a prolonged administration of a medication is more likely to produce adverse effects.[86]

Aside from the consequences of long-term medication use, the medications that are likely candidates for MMTs may have an immediate operational impact, such as an impact on the ability of a soldier to perform tactically important tasks at a predictably high level. We can use beta-blockers as an illustration.

First, beta-blockers have physical side effects because they reduce heart rate. Thus, beta-blockers would likely improve the accuracy of a sniper, as they would increase his or her ability to fire shots between heartbeats. Yet, through the same mechanism, beta-blockers would reduce the volume of oxygen that the cardiovascular system can deliver to the muscles. Thus, beta-blockers would inhibit exercise performance and impair the ability of soldiers to meet the physical demands of combat.[87]

Secondly, beta-blockers can have effects on behaviour and cognition.[88] They interfere with the actions of stress hormones and as such can reduce arousal and feelings of anxiety. Stress hormones and arousal, however, "are central to the fight-or-flight response, and they trigger the heightened awareness necessary for soldiers to survive in combat situations".[89] Thus, beta-blockers might alter the fight-or-flight response, which has evolved as a survival mechanism, to a degree that it would place the soldier in greater danger in threatening circumstances.[90]

Finally, beta-blockers also affect decision-making,[91] raising the question as to whether they affect the way people resolve morally significant problems.[92] Recent studies indicate that propranolol leads to more deontological and less utilitarian decisions (at least in certain circumstances), and that it decreases response times and increases decisiveness.[93] More impulsive and less consequentialist decision-

86 See, e.g., C. Moret, M. Isaac, and M. Briley, "Problems Associated with Long-Term Treatment with Selective Serotonin Reuptake Inhibitors", *Journal of Psychopharmacology*, Vol. 23, No. 8, 2009.

87 Elise Donovan, "Propranolol Use in the Prevention and Treatment of Posttraumatic Stress Disorder in Military Veterans: Forgetting Therapy Revisited", *Perspectives in Biology & Medicine*, Vol. 53, No. 1, 2010, p. 70.

88 Gary Aston-Jones and Jonathan D. Cohen, "An Integrative Theory of Locus Coeruleus-Norepinephrine Function: Adaptive Gain and Optimal Performance", *Annual Review of Neuroscience*, Vol. 28, No. 1, 2005; Sebastien Bouret and Susan J. Sara, "Network Reset: A Simplified Overarching Theory of Locus Coeruleus Noradrenaline Function", *Trends in Neurosciences*, Vol. 28, No. 11, 2005.

89 E. Donovan, above note 87, p. 70.

90 Michael Henry, Jennifer R. Fishman and Stuart J. Youngner, "Propranolol and the Prevention of Post-Traumatic Stress Disorder: Is it Wrong to Erase the 'Sting' of Bad Memories?", *AJOB Neuroscience*, Vol. 7, No. 9, 2007, p. 16; Cynthia R. A. Aoki, "Rewriting My Autobiography: The Legal and Ethical Implications of Memory-Dampening Agents", *Bulletin of Science, Technology & Society*, Vol. 28, No. 4, 2008, p. 356.

91 Kenji Doya, "Modulators of Decision Making", *Nature Neuroscience*, Vol. 11, No. 4, 2008; Robert D. Rogers *et al.*, "Effects of Beta-Adrenoceptor Blockade on Components of Human Decision-Making", *Psychopharmacology*, Vol. 172, No. 2, 2004; Peter Sokol-Hessner *et al.*, "Determinants of Propranolol's Selective Effect on Loss Aversion", *Psychological Science*, Vol. 26, No. 7, 2015.

92 N. Levy, above note 80, pp. 187–195; Jillian Craigie, "Propranolol, Cognitive Biases, and Practical Decision-Making", *American Journal of Bioethics*, Vol. 7, No. 9, 2007, p. 31.

93 Sylvia Terbeck *et al.*, "Beta Adrenergic Blockade Reduces Utilitarian Judgement", *Biological Psychology*, Vol. 92, No. 2, 2013, p. 325.

making can pose problems for compliance with international humanitarian law. In particular, it might influence decision-making in circumstances where the law requires a fine consequentialist calculation, such as with the principle of proportionality, which requires balancing the anticipated military effect to be gained from an attack against the incidental loss caused to civilians and civilian objects.[94] Looking prospectively, medications might cause people to make different decisions than they would otherwise. Looking retrospectively, this might affect the degree of moral responsibility that could be assigned to them afterwards.[95]

The situation with post-exposure prophylaxis is slightly different. In effect, one variable – whether or not a traumatic event will occur – has been removed, and thus there is no need to keep people on medications preventatively for long periods; a short-term intervention may be sufficient right after a distressing event has taken place. Also, the effects on physical performance and decision-making can be discounted relatively easily on the assumption that the person will not need to engage in physically strenuous or morally taxing activities while undergoing post-exposure prophylaxis.

That does not, of course, completely obviate the problem of not knowing whom to treat, but there are other measures that can be taken to reduce that uncertainty. In other contexts, for example as concerns infectious diseases, decisions about post-exposure prophylaxis are frequently made by means of a probabilistic risk assessment and on the basis of previously adopted guidelines. This is the case, for instance, in the event of a suspected exposure to the human immunodeficiency virus (HIV)[96] or the rabies virus.[97]

Admittedly, the risk factors for developing PTSD are not as well understood as those for developing an HIV infection or rabies. However, already in one of the earliest clinical trials of propranolol as post-exposure prophylaxis, the administration of medication to people in a hospital emergency department after a traumatic event was based on psychological and physiological risk factors.[98] As our understanding of risk factors improves, more reliable guidelines can be developed for PTSD prophylaxis.

In any event, post-exposure prophylaxis of PTSD and the treatment of PTSD once symptoms have emerged would require the administration of medication only a limited number of times. This would help mitigate some of the concerns about safety.

94 See Protocol Additional (I) to the Geneva Conventions of 12 August 1949, and relating to the Protection of Victims of International Armed Conflicts, 1125 UNTS 3, 8 June 1977 (entered into force 7 December 1978), Art. 51(5)(b). The article prohibits the launching of "an attack which may be expected to cause incidental loss of civilian life, injury to civilians, damage to civilian objects, or a combination thereof, which would be excessive in relation to the concrete and direct military advantage anticipated".

95 Jessica Wolfendale, "Performance-Enhancing Technologies and Moral Responsibility in the Military", *American Journal of Bioethics*, Vol. 8, No. 2, 2008, p. 30.

96 See, e.g., P. Benn, M. Fisher and R. Kulasegaram, "UK Guideline for the Use of Post-Exposure Prophylaxis for HIV Following Sexual Exposure (2011)", *International Journal of STD & AIDS*, Vol. 22, No. 12, 2011; Australian Society for HIV Medicine, *Post-Exposure Prophylaxis after Non-Occupational and Occupational Exposure to HIV: Australian National Guidelines*, Darlinghurst, 2016.

97 See, for example, Kevin Brown, *PHE Guidelines on Rabies Post-Exposure Treatment*, Public Health England, London, June 2017.

98 R. K. Pitman, K. M. Sanders *et al.*, above note 69.

Thus, as a general matter, the use of medications for memory modification is likely to be safer than the prolonged use of antidepressants, anxiolytics, antipsychotics and hypnotics currently used in the management of PTSD symptoms.

All biomedical interventions also raise the question of equitable access. Would all those who could benefit from the intervention be able to gain access to it? Again, the fairly limited number of times a medication would need to be administered as an MMT in case of post-exposure prophylaxis or treatment would likely mean that it is cheaper than a prolonged symptomatic treatment with various psychoactive medications. That could make it a more equitable treatment option.[99]

In conclusion, there are reasons to be cautious about PTSD prophylaxis, especially pre-exposure prophylaxis. The long-term effects of such prophylaxis are not necessarily well understood, and the immediate side effects could be problematic in the military context. Therefore, the benefits of such prophylaxis might not necessarily outweigh the risks. If post-exposure prophylaxis and, even more so, treatment at a stage where PTSD symptoms first appear are no less effective than pre-exposure prophylactic intervention, the former seems to be the more ethically defensible option.

Identity and authenticity

The principal concerns around memory modification go well beyond these relatively technical matters – which, moreover, are not unique to the interventions that might be used as MMTs – and raise broader questions. Perhaps the most prominent of these is the worry that by permitting our memories to be modified, "we might succeed in erasing real suffering at the risk of falsifying our perception of the world and undermining our true identity".[100] Much of this concern seems to be premised on the idea advanced by John Locke in the late seventeenth century that our memories are what define us as persons – what give us identities that persist in time.[101] The problem that arises here relates to two interconnected philosophical notions: authenticity and narrative identity.[102] These cannot be fully unpacked here, but the basic idea – we largely are what we remember about ourselves and the world around us – makes a lot of intuitive sense. Most people would probably agree that by erasing all our memories, we would commit a kind of cognitive suicide. Accordingly, by modifying some of our memories, we would in a significant way be transforming ourselves.

An argument frequently advanced to mitigate these concerns is that MMTs affect only conditioned defensive responses to threats ("emotional responses") and

99 J. Bell, "Propranolol, Post-Traumatic Stress Disorder and Narrative Identity", *Journal of Medical Ethics*, Vol. 34, No. e23, 2008, p. 4.
100 President's Council on Bioethics, above note 80, p. 227.
101 John Locke, *An Essay Concerning Humane Understanding*, Book II, London, 1690, chap. 27.
102 See, in particular, Alexandre Erler, "Does Memory Modification Threaten Our Authenticity?", *Neuroethics*, Vol. 4, No. 3, 2011; Joseph Vukov, "Enduring Questions and the Ethics of Memory Blunting", *Journal of the American Philosophical Association*, Vol. 3, No. 2, 2017.

leave episodic memories completely intact.[103] The premise here is that mainly episodic memory contributes to our sense of self and, thus, if MMTs only affect conditioned responses, our identities would remain essentially unharmed. This argument is largely based on studies that have used beta-blockers. However, as discussed above, beta-blockers can also reduce the emotional enhancement of episodic memory. Furthermore, different MMTs, such as other medications or brain stimulation, can eradicate specific episodic memories altogether. MMTs can thus also impact episodic memories that contribute to our sense of identity. What's more, a problem in the argumentation is the assumption that "emotional responses" contribute less to our identity than episodic memories. This Cartesian view of separation between reason and emotion is false. Emotion and cognition are necessarily intertwined, to the degree that one cannot exist without the other.[104] Changing learned emotional responses would, thus, also alter reasoning and our personal identity.

Regardless of the effects of MMTs on both conditioned responses and episodic memory, we submit that MMTs do not necessarily impinge on identity and authenticity to such a degree that we should shun the treatment. As discussed above, by nature memories are flexible: we forget most of what we learn, and memories can be highly inaccurate or even entirely false. Yet none of this has been a source of major philosophical concern. The inability to account for each moment of one's waking hours with complete accuracy and full emotional vigour neither undermines our identity nor hampers normal functioning in daily life.[105] Quite the contrary, the flexibility of memory is adaptive and aids optimal decision-making in the future. Memory flexibility thus also constitutes a major way in which we build our autobiography and, by extension, our identity, which is fluid over time.

Even if concerns about identity might lead us to conclude that we ought not to have unfettered access to MMTs, this does not mean that they should not be used to treat PTSD. Indeed, the symptoms of PTSD can become so overwhelming as to fully consume a person's life: daily existence becomes haunted by memories of the past, resulting in major changes in personality and withdrawal from society to avoid stimuli that might trigger episodes of anxiety. Moreover, PTSD and suicidal behaviour are strongly correlated.[106] Thus, PTSD poses a risk not only to personal identity, but also to life. In PTSD, trauma memory is thus clearly

103 See the references cited in above note 62.

104 Antonio R. Damasio, *Descartes' Error: Emotion, Reason and the Human Brain*, Avon, New York, 1994; Elizabeth A. Phelps, Karolina M. Lempert and Peter Sokol-Hessner, "Emotion and Decision Making: Multiple Modulatory Neural Circuits", *Annual Review of Neuroscience*, Vol. 37, No. 1, 2014.

105 See, along the same lines, Adam J. Kolber, "Therapeutic Forgetting: The Legal and Ethical Implications of Memory Dampening", *Vanderbilt Law Review*, Vol. 59, No. 5, 2006, p. 1604; J. Bell, above note 99, p. 3; E. Donovan, above note 87, p. 68.

106 This is true even after controlling for physical illness and other mental disorders. See Jitender Sareen, Tanya Houlahan *et al.*, "Anxiety Disorders Associated with Suicidal Ideation and Suicide Attempts in the National Comorbidity Survey", *Journal of Nervous & Mental Disease*, Vol. 193, No. 7, 2005; Jitender Sareen, Brian J. Cox *et al.*, "Physical and Mental Comorbidity, Disability, and Suicidal Behavior Associated with Posttraumatic Stress Disorder in a Large Community Sample", *Psychosomatic Medicine*, Vol. 69, No. 3, 2007.

maladaptive. MMTs may allow people with PTSD to regain adaptive responses and return to normal life and, as such, may facilitate the maintenance of identity rather than undermine it.[107]

Normal recovery and traumatic growth

Another common concern about memory modification is that it would interfere with normal recovery from trauma – "working things through", if you will.[108] Moreover, going through such a process has certain adaptive consequences, which have been conceptualized as post-traumatic growth (PTG). This may be manifested in different ways, including "an increased appreciation for life in general, more meaningful interpersonal relationships, an increased sense of personal strength, changed priorities, and a richer existential and spiritual life".[109] MMTs would seem to deny traumatized persons the benefits of experiencing PTG,[110] which is said to be far more common in the wake of traumatic events than PTSD.[111]

For persons who suffer from PTSD, however, traumatic memories and the associated emotions are so powerful as to make it impossible to "work things through".[112] Their "experiences are simply tragic and terrifying, offering virtually no opportunity for redemption or transformation", and "even if it is better to weave traumatic events into positive, life-affirming narratives, many people are never able to do so".[113] Also, an individual who is afflicted to the point of functional loss or self-harm may simply be incapable of experiencing PTG.[114]

Furthermore, it is by no means clear that MMTs and PTG are mutually exclusive. In fact, MMTs may lay the groundwork for recovery and PTG. It is perfectly possible that MMTs "might make it easier for trauma survivors to face and incorporate traumatic recollections, and in that sense could facilitate long-term adaptation",[115] "may enable such people to make life transformations that they would be *incapable* of making in the absence of the medications",[116] and "may aid in induction of PTG as well as relieve PTSD".[117]

107 See, e.g., David Wasserman, "Making Memory Lose Its Sting", *Philosophy & Public Policy Quarterly*, Vol. 24, No. 4, 2004, p. 14; A. J. Kolber, above note 105, p. 1604; J. Bell, above note 99, p. 4; E. Donovan, above note 87, p. 72.
108 Daniel L. Schacter, *The Seven Sins of Memory: How the Mind Forgets and Remembers*, Houghton Mifflin, Boston, MA, 2001, p. 183; President's Council on Bioethics, above note 80, p. 226; Emily A. Holmes, Anders Sandberg and Lalitha Iyadurai, "Erasing Trauma Memories", *British Journal of Psychiatry*, Vol. 197, No. 5, 2010.
109 Richard G. Tedeschi and Lawrence G. Calhoun, "Posttraumatic Growth: Conceptual Foundations and Empirical Evidence", *Psychological Inquiry*, Vol. 15, No. 1, 2004.
110 Jason E. Warnick, "Propranolol and Its Potential Inhibition of Positive Post-Traumatic Growth", *American Journal of Bioethics*, Vol. 7, No. 9, 2007, p. 37.
111 E. Parens, above note 80, p. 102.
112 M. Henry, J. R. Fishman and S. J. Youngner, above note 90, p. 16.
113 A. J. Kolber, above note 105, pp. 1599, 1600.
114 E. Donovan, above note 87, p. 70.
115 D. L. Schacter, above note 108, p. 183.
116 A. J. Kolber, above note 105, p. 1600 (emphasis in original).
117 E. Donovan, above note 87, p. 70.

There is more merit in the concern over a circumvention of natural processes when MMTs are used prophylactically. The question does arise as to whether we should be prepared to "replace this near-universal feature of human life [i.e. PTG] with a mass preventative pharmacotherapy that benefits a small minority of the population."[118] Again, however, it is not clear whether MMTs would necessarily replace PTG; in persons at risk of PTSD, prophylactic MMTs may well contribute to ensuring that natural processes (including PTG) take place. To use an analogy, if a person fractures a bone, we do not allow nature to simply take its course. We may need to realign the fracture and set a cast in order for optimal healing to take place. Likewise, MMTs may return patients on a natural path to recovery.[119]

A duty to remember?

Another major concern about MMTs is the risk of altering memories that we might be under a duty to preserve for the common good. Arguably, collective memories of atrocities, and of the carnage of war more generally, depend upon individuals retaining undiluted recollections of these events.[120] Thus, modifying our memories of such events not only poses a risk to our personal identity "but also prevents the sharing of these narratives, which could potentially help others in society change and evolve".[121]

Lieutenant-General Roméo Dallaire, the commander of the United Nations Assistance Mission for Rwanda during the genocide, is sometimes used as an example.[122] Dallaire had been put in an impossible situation – the wholly inadequate forces that had been placed under his command were unable to stop the slaughter of hundreds of thousands of Tutsis and moderate Hutus. As Dallaire himself put it in a poignant book about the genocide, he and his troops were "reduced to the role of accountants keeping track of how many were being killed".[123]

Through the book and many public appearances, Dallaire became a powerful advocate for humanitarian intervention – but he also suffered, and continues to suffer, from PTSD; indeed, his anguish has led him to self-harm.[124] One commentator speculates that had Dallaire "taken memory-dampening agents, [he] may not have been able to achieve the same level of influence on society".[125] On one view, Dallaire may have succeeded so well in telling the world

118 J. E. Warnick, above note 110, p. 37.
119 E. A. Holmes, A. Sandberg and L. Iyadurai, above note 108.
120 President's Council on Bioethics, above note 80, p. 231.
121 C. R. A. Aoki, above note 90, p. 357.
122 Robin Marantz Henig, "The Quest to Forget", *New York Times Magazine*, 4 April 2004; D. Wasserman, above note 107, p. 12; C. R. A. Aoki, above note 90, pp. 356–357.
123 Roméo Dallaire, *Shake Hands with the Devil: The Failure of Humanity in Rwanda*, Carroll & Graf, New York, 2004, p. 374.
124 This is the subject of another book: Roméo Dallaire and Jessica Dee Humphreys, *Waiting for First Light: My Ongoing Battle with PTSD*, Random House, Toronto, 2016.
125 C. R. A. Aoki, above note 90, p. 357; cf. D. Wasserman, above note 107, p. 12.

about the plight of Rwanda because he is "the most powerful and untainted witness" to the genocide.[126] On an alternative (much more troubling) view, some of Dallaire's effectiveness as an advocate may have derived from his own suffering. Thus, Dallaire's suffering might have in some ways been symbolic of how the international community had failed the Rwandans, and may have served as a reminder of this failure to that community. This point could be formulated more broadly, suggesting that having struggling veterans in our midst serves to remind the society of the horrors of war.

While we sympathize with the idea that society should not be disconnected from the conflicts that are fought on its behalf, treating service members as instruments in obtaining that goal fundamentally dehumanizes them. We agree with one prominent bioethicist who thinks that "[t]he notion that we need to have suffering martyrs among us is cruel and exploitative".[127] Also, there is undoubtedly "some hypocrisy in the contention that soldiers ought to bear painful trauma for what others have commanded them to do".[128]

From a legal perspective, the problem with memory modification is that it may limit society's access to memory as evidence, such as eyewitness testimony.[129] While this point is well taken, it should not be overemphasized. For one, the value of eyewitness testimony is probably overstated in the first place. Individuals' recollections of events are less reliable than one might think. It is all too easy to think of memory as some sort of a documentary film that can be replayed in court as necessary, but the ability of humans to remember has evolved not so as to forensically document the past, but so as to prepare us for the future. Thus, memories get reinterpreted and reconfigured as new experiences become integrated into an autobiography. For this reason, eyewitness testimonies require – or should require – extensive corroborative evidence.

In any event, even recognizing that society sometimes has a reasonable expectation about accessing someone's memories, that right cannot be absolute. The interests of the society in obtaining the memory and the individual's interest in not suffering from traumatic memories need to be balanced. What is more, for post-trauma MMTs to work, the details of a traumatic memory would first have to be identified by a therapist prior to treatment. As such, there would be a detailed archive of memory prior to modification.

Furthermore, MMTs are unlikely to completely eradicate a memory. Realistically, were he to be treated with MMTs, Dallaire would no longer suffer (as much) but would still remember what had happened and that he had suffered, so as to be able to appreciate the importance of the memory. This likely would still leave him as a strong spokesperson for humanitarian intervention. Also, persons with PTSD often have difficulty recalling particular events and articulating their

126 D. Wasserman, above note 107, p. 12.
127 Arthur Caplan, quoted in Greg Miller, "Learning to Forget", *Science*, Vol. 304, No. 5667, 2004, p. 36.
128 Christoph Bublitz and Martin Dresler, "A Duty to Remember, a Right to Forget? Memory Manipulations and the Law", in Jens Clausen and Neil Levy (eds), *Handbook of Neuroethics*, Springer, Dordrecht, 2015, p. 1300.
129 See such concerns summarized in, e.g., A. J. Kolber, above note 105, pp. 1579–1582.

experiences as a coherent narrative; thus, PTSD treatment might not undermine but might instead enhance people's ability to meet the duty to remember.

A duty to suffer?

A slightly different need to preserve memories arguably arises with respect to people who have committed objectionable acts and feel pangs of guilt afterwards. Lady MacBeth has thus become something of a recurrent character in bioethical discussions on MMTs.[130] There appears to be broad agreement that people should not have access to MMTs to "relieve anguish that is proportionate to their own actions".[131] This seems uncontroversial inasmuch as such interventions are not meant to be available to anyone who simply wants to dampen undesirable and even troubling memories; rather, they are intended for people with maladaptive memories such as in the case of PTSD. Some of the commentary on this point might be interpreted as doubting the appropriateness of providing MMTs to persons who have developed PTSD as a result of their own wrongdoing.[132]

This line of thinking may be based on an idea that PTSD is some especially sharp form of guilt or remorse. This is a misconception. PTSD is a serious and potentially debilitating mental health condition, not merely a feeling or a state of mind. Leaving it untreated is problematic both from a prudential and an ethical perspective. As for the former, a strong association exists between PTSD symptoms and the risk of re-offending.[133] Thus, however attractive PTSD symptoms may seem to some as a form of retribution, perpetuating the condition seems wholly counterproductive from the perspective of rehabilitating offenders and reintegrating them into society. From an ethical perspective, a hallmark of a civilized society is that it provides adequate health care to those who it has convicted of wrongdoing.[134] Conversely, the idea that a medical practitioner would deny treatment to a patient not because of futility or shortage of resources but simply because of legal or ethical misgivings about the patient's prior conduct flies in the face of medical ethics.[135]

130 President's Council on Bioethics, above note 80, pp. 206–207, 212, 232; D. Wasserman, above note 107, pp. 14–15; E. Parens, above note 80; A. Erler, above note 102; C. Bublitz and M. Dresler, above note 128, p. 1299; J. Vukov, above note 102, p. 243.

131 E. Parens, above note 80, p. 106.

132 For a careful examination of this issue, see Karola Kreitmair, "Memory Manipulation in the Context of Punishment and Atonement", *AJOB Neuroscience*, Vol. 7, No. 4, 2016.

133 Vittoria Ardino, Luca Milani and Paola di Blasio, "PTSD and Re-Offending Risk: The Mediating Role of Worry and a Negative Perception of Other People's Support", *European Journal of Psychotraumatology*, Vol. 4, 2013.

134 On prison health-care ethics generally, see Hans Wolff *et al.*, "Health Care in Custody: Ethical Fundamentals", *Bioethica Forum*, Vol. 5, No. 4, 2012; Andres Lehtmets and Jörg Pont, *Prison Health Care and Medical Ethics: A Manual for Health-Care Workers and Other Prison Staff with Responsibility for Prisoners' Well-Being*, Council of Europe, November 2014.

135 There is broad support for the "principle of equivalence of care", which requires prisoners to be provided health care equivalent in quality to that provided to the general public. For critical discussions of this concept, see Gérard Niveau, "Relevance and Limits of the Principle of 'Equivalence of Care' in Prison Medicine", *Journal of Medical Ethics*, Vol. 33, No. 10, 2007; Fabrice Jotterand and Tenzin Wangmo, "The Principle of Equivalence Reconsidered: Assessing the Relevance of the Principle of Equivalence in Prison Medicine", *American Journal of Bioethics*, Vol. 14, No. 7, 2014.

Indeed, it would not be acceptable to modify the standard of care so as to increase or maintain suffering that has been caused by the antisocial conduct of the person. For example, it would be inappropriate for a medical practitioner to remove a bullet without anaesthesia simply because the person was shot in a firefight with police. In fact, refusal to provide anaesthesia to a person on the basis of their criminal history would almost certainly breach the prohibition against torture or cruel, inhuman or degrading treatment or punishment.[136]

Even more dubiously, PTSD treatment has been questioned in the context of warfare. For example, one commentator has asked – rhetorically, we presume – "If soldiers did something that ended up with children getting killed, do you want to give them beta-blockers so that they can do it again?"[137] The question itself is problematic. No one would deny that the death of children – indeed, anyone – in conflict is unfortunate and regrettable. Yet even the death of children does not necessarily amount to a wrongdoing on the part of the individual soldier. For example, under the law of armed conflict, children taking a direct part in hostilities can be lawfully targeted.[138] Soldiers who find themselves in a position where their only viable course of action is to use lethal force against a child soldier would, no doubt, be seriously scarred and potentially at risk of PTSD.

In any event, the two problems identified with respect to criminals arise with even more vigour when it comes to soldiers. For one, veterans with PTSD are statistically more likely to engage in antisocial behaviour than veterans who do not have PTSD.[139] Thus, again, leaving PTSD untreated could be highly counterproductive both in terms of soldiers continuing military service and re-entering civilian society. Furthermore, one expects the armed forces to provide every medical assistance available to physically wounded soldiers in an attempt to restore them to health and, alas, to allow them to fight another day. With this in mind, to deny PTSD treatment to a soldier because the treatment might permit them to return to combat is simply preposterous. A serious ethical problem would arise, however, if some form of MMT was applied prior to conflict with a view to generally morally desensitizing soldiers. Yet this would no longer be a problem about prevention or treatment of PTSD, which is the focus of this article.

Conclusion

PTSD is a mental disorder that can develop following traumatic experiences such as war, is characterized by intrusive memories and has major personal, societal and economic consequences. Memory of a traumatic experience lies at the root of

136 For a discussion of associated human rights issues in a different context, see Joseph Amon and Diederik Lohman, "Denial of Pain Treatment and the Prohibition of Torture, Cruel, Inhuman or Degrading Treatment or Punishment", *Interights Bulletin*, Vol. 16, No. 4, 2011.

137 Paul McHugh, quoted in Jim Giles, "Beta-Blockers Tackle Memories of Horror", *Nature*, Vol. 436, No. 7050, 2005.

138 For a brief discussion, see René Provost, "Targeting Child Soldiers", *EJIL: Talk!*, 12 January 2016.

139 Stephanie Booth-Kewley *et al.*, "Factors Associated with Antisocial Behavior in Combat Veterans", *Aggressive Behavior*, Vol. 36, No. 5, 2010.

suffering in PTSD, which has been associated with abnormalities in brain regions involved in memory and emotions. Although psychotherapy is an effective treatment for PTSD, many people experience a return of PTSD symptoms even after initially successful treatment. The return of symptoms can be explained because exposure treatment relies on the principles of extinction learning, which does not modify the original trauma memory itself but forms a competing safety memory that inhibits the expression of the trauma memory. One of the reasons for this is that memories are initially labile but stabilize over time during a period of consolidation, after which the memory is insensitive to modification. There is thus a brief period before and after learning during which consolidation can be disturbed, potentially providing a window of opportunity to prevent the formation of trauma memory. However, as patients generally do not visit a therapist's office until long after the traumatic event, the practical application of MMT for disturbing consolidation and preventing PTSD is limited. An interesting potential solution relates to the discovery that reactivating a consolidated memory can temporarily return it to a labile state requiring re-stabilization processes to be maintained, referred to as reconsolidation. MMTs can steer or even disrupt reconsolidation and permanently change memory expression, potentially allowing for the development of more robust and persistent treatments for consolidated trauma memories.

Initial clinical trials allow for cautious optimism that certain MMTs may indeed bring relief from symptoms of PTSD. MMTs may disturb consolidation and prevent the formation of trauma memory, enhance exposure treatment to improve control over PTSD symptoms, or modify reconsolidation to eradicate maladaptive symptoms in PTSD. MMTs tap into the natural neural mechanisms that underlie the flexibility of memory to guide specific memories in a particular direction.

We focused our discussion of the ethical, legal and social implications of the application of MMTs to adjust maladaptive trauma memories in PTSD, particularly in military populations. With regard to the safety of MMTs and equitable access to them, there is reason to be cautious about the prophylactic use of MMTs for PTSD. Many concerns are, however, alleviated in the case of post-exposure prophylaxis where treatment can be restricted to people who have experienced a distressing event or have actually developed PTSD and because treatments can be restricted to short-term interventions. One set of concerns relates to the notion that MMTs may jeopardize our identities and our ability to live an authentic life. MMTs, however, do not cause general memory impairments but target specific memories. Moreover, the use of MMTs to treat PTSD is unlikely to result in a full loss of memory for the traumatic experience but may allow for a diminishment of maladaptive symptoms evoked by specific stimuli. MMTs may eradicate maladaptive intrusive memories, allowing people with PTSD to regain their usual identity and an authentic life. Similarly, the second concern is that MMTs could interfere with normal psychological coping following trauma. However, PTSD is characterized by an inability to cope with trauma that severely hinders people's personal growth. MMTs may thus place people with PTSD back on a natural path to recovery. The third concern is that MMTs may impair memories which we are

duty-bound to maintain. Once again, MMTs are unlikely to fully eradicate memories and even if they can, in the case of post-exposure prophylactic use, an archive of the memory can be made first. Furthermore, memories are notoriously unreliable as legal evidence and in the case of fragmented trauma memory in PTSD, MMTs may even enable people to remember the traumatic event better. Most importantly though, refraining from treating a serious mental disorder such as PTSD on the basis of a social demand for memory, even in the case of criminal wrongdoing, flies in the face of medical ethics.

Based on the evidence available, we categorically reject any broad claim that "the costs to individuals and to society in using … memory-dampening agents would significantly outweigh their potential benefits".[140] In order to reach defensible ethical conclusions, MMTs would need to be assessed in a context-specific manner, and in light of their primary effects and likely side effects. Knee-jerk reactions to MMTs on the basis of their possible abuse are counterproductive.

Moreover, we agree with those who have suggested that investigating the viability of MMTs as a treatment in a military population is not only ethically permissible but required.[141] A society that in the interests of its own security is prepared to place individuals in harm's way must be prepared to succour those individuals when they sustain physical or psychological injuries. If MMTs prove to be a safe and effective means of treating PTSD, their use must be considered. That said, where there is a real risk to societally significant memories, there clearly arises a need to balance the interests of a person to be free from suffering and the society's (narrowly construed) right to access the memories that are the cause of the suffering.

This article has focused on the use of MMTs to treat PTSD, specifically in military populations. MMTs provide an opportunity to relieve severe suffering from mental disease in military populations, restore people's identity and authenticity, return them to a path of natural recovery and personal growth, and improve their memories to societies' benefit. The risks of using MMTs are limited as MMTs target specific maladaptive memories and the modification of specific memories does not jeopardize personal identity, opportunity for personal growth or social demand for memory preservation. We recognize that MMTs may have other ethical implications for potential misuse, which require their own ethical discussion in the future, but we note that the likelihood of MMTs being misused is small within the near future and does not outweigh the potential benefits for patients, while legal regulations of professional ethics for medical practitioners are already in place. Assuming the safety and efficacy of a particular intervention, we see nothing strikingly unethical about treating soldiers who have developed PTSD with MMTs. If PTSD is construed as a health condition, it should be treated with the most effective means available, which might be MMTs at some point in time. Within a realistic scientific framework, the potential benefits of research into developing the use of MMTs to treat PTSD outweigh any potential ethical, legal, and societal concerns at this time.

140 C. R. A. Aoki, above note 90, p. 356.
141 See, for example, E. Donovan, above note 87, pp. 70, 72.