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Personality and authenticity in light of the memory-modifying potential of optogenetics

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Abstract

There has been a growing interest in research concerning memory modification technologies (MMTs) in recent years. Neuroscientists and psychologists are beginning to explore the prospect of controllable and intentional modification of human memory. One of the technologies with the greatest potential to this end is optogenetics—an invasive neuromodulation technique involving the use of light to control the activity of individual brain cells. It has recently shown the potential to modify specific long-term memories in animal models in ways not yet possible with other MMTs. As the therapeutic potential of optogenetics has already prompted approval of the first human trials, it is especially important and timely to consider the opportunities and dangers this technology may entail. In this article, we focus on possible consequences of optogenetics as an MMT by analyzing fundamental threats potentially associated with memory modifications: the potential disruption of personality and authenticity.

Keywords: authenticity, personality, optogenetics, memory modification technologies (MMTs), self, neuroethics

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Introduction

There has been a growing interest in research concerning memory modification technologies (MMTs) in recent years. Neuroscientists and psychologists are beginning to explore the prospect of controllable and intentional modification of human memory with the goals of reducing the consequences of memories of traumatic events (Wood et al., 2015; Brunet et al., 2018); memory enhancement (Dresler et al. 2019); improving memory impairments observed in neurological conditions, such as diencephalic amnesia and Alzheimer's disease (Barnett, 2018); and diminishing the cravings of addicts (Roediger & Butler, 2011).

The most clinically relevant MMTs to this point have been memory-modifying drugs, such as propranolol and mifepristone, and behavioral techniques, such as extinction training and memory updating (Schiller et al., 2010; Schiller & Phelps, 2011). The established drugs manipulate the release of stress hormones (such as adrenaline, norepinephrine, and glucocorticoids that play roles in consolidation,¹ strengthening memories for events). These drugs have been shown to work effectively, decreasing or increasing the consolidation of an emotional memory, when administered shortly after the emotional event (Brunet et al., 2018; Cahill, 2003; Cahill, 1994; Kindt, Soeter, & Vervliet, 2009). However, victims of traumatic events typically approach help when memories are already well-consolidated, and they have already developed debilitating conditions such as post-traumatic stress disorder (PTSD), characterized by intrusive and persistent recollections of highly emotional memories (Daskalakis & Yehuda, 2014). Unfortunately, administering (the β -adrenergic blocker) propranolol or (the glucocorticoid antagonist) mifepristone during memory reconsolidation, i.e., when previously consolidated memories are made labile again via reactivation of the memory trace (Sandrini et al., 2015), has proven no more effective in blunting symptoms of PTSD than a placebo treatment (Wood et al., 2015; Chalkia et al., 2019). However, it is worth mentioning that when administered *prior* to memory reactivation, propranolol was shown to be effective in reducing PTSD symptoms (Brunet et al., 2018) or fear-related responses (Kindt et al., 2009; Soeter & Kindt, 2015). Nonetheless, some researchers argue that these results could be ascribed to disturbed memory retrieval or new facilitated learning (Phelps & Hofmann, 2019). Follow-up studies have provided support for these claims (Soeter & Kindt, 2010).

A major disadvantage of behavioral methods is that their effects are often temporary and unreliable, as shown by several independent attempts to translate laboratory findings into clinical practice (Phelps & Hofmann, 2019). Extinction training is a laboratory model for exposure therapy, during which a patient suffering from some form of anxiety disorder is repeatedly exposed to cues or situations that evoke fear in order to gradually reduce it and replace a fear-related memory with a new extinction memory. However, when the fear memory starts to dominate the extinction memory, the fear may return (Bouton & Nelson, 1998; Vansteenwegen et al., 2005). Behavioral memory updating is a type of modification of fearful memory that relies upon updating it with non-fearful information that is introduced upon memory retrieval during the reconsolidation window. Although this approach currently seems to be the most promising type of treatment for various affective disorders, it is not resistant to spontaneous recovery/relapse (Phelps & Hofmann, 2019).

¹ Most generally, memory relies on the encoding, storage, and retrieval of the content of the experience (Klein, 2015). The process of forming memories is called "consolidation." In the process of consolidation, new memories gradually transfer from an initial, labile state to a more permanent state via a complex process of stabilization of the memory trace (also called "memory-engram") (see, e.g., De Brigard, 2014c; Squire, 1984).

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3 Although contemporary MMTs have the potential to alter memory in a safe and clinically relevant
4 manner, they face several problems. First, memory-modifying drugs act non-selectively, which means that they
5 can also interfere with non-targeted emotional memories and can produce unintended memory changes
6 (Hurlemann et al., 2010). Second, MMT drugs do not erase memories: they merely remove the ‘sting’ of bad
7 memories, without affecting the ability to recall them (Kindt et al., 2009). Finally, these methods are not infallible.
8 For instance, as described above, the effects of behavioral therapies are not permanent, and some memories can
9 spontaneously return, along with the symptoms of a disorder that was temporarily in remission.
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13 However, new, promising MMTs have begun to appear. One such, with the potential to fight the
14 limitations of the existing MMTs and revolutionize the discussed field of research is optogenetics—a technique
15 that uses light to control the activity of individual brain cells. Neuroethical considerations seem vitally important
16 and timely in the case of optogenetics, as the therapeutic prospect of this technology has already prompted approval
17 for the first human trials. Although for now these studies seek to develop new treatments for intractable diseases,
18 such as blindness^{2,3}, optogenetics universal applicability can be expected to rapidly permeate other areas of clinical
19 research in the near future, including a focus on memory modification due to its massive potential. Some even
20 argue that optogenetics could soon become an alternative to deep brain stimulation (DBS)—another form of
21 invasive neuromodulation technology—which has become a widely accepted treatment for patients struggling with
22 a variety of neurological or psychiatric disorders over the last decade (Delbeke et al., 2017). This prediction seems
23 to gain further credibility as, due to rapid advancements in miniaturization of optogenetic-related devices (see,
24 e.g., Park et al., 2015; Repina, et al. 2019), optogenetics seems to no longer require an invasive surgical procedure
25 (Edward et al., 2018).
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33 **The memory-modifying potential of optogenetics**

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36 Optogenetics is a neuromodulatory technique involving the use of light to control activity of individual brain cells
37 (Boyden et al., 2005; Yizhar et al., 2011). In order to allow that, neurons are genetically modified (by inserting
38 opsin genes) to cause cells to express light-sensitive proteins. When illuminated with light, the channels of these
39 proteins regulate the flow of electrically charged ions across membranes, which exacerbates or inhibits each
40 neuron’s firing of action potentials, allowing or preventing its communication with other neurons (depending on
41 which light-activated protein is used). Thus, optogenetics allow to activation or deactivation of specific neurons
42 “at will.”
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46 What differentiates optogenetics from other neuromodulation methods, such as memory-modifying drugs
47 or application of electrical currents (used in DBS), is its excellent spatial and temporal resolution. For instance,
48 although electrical stimulation is time-specific, locally applied electrical currents spread non-selectively
49 throughout neural tissue, activating not only targeted cells, but also fibers in the vicinity of implanted electrodes
50 (Merrill et al., 2005). This can limit the effectiveness of this method, as shown by Suthana and Fried (2014), who
51 found that stimulation of the hippocampal neurons—although successful in inducing specific memory changes
52 using optogenetics—caused the disruption of memory processes when less precise and selective electrical currents
53 of DBS were applied. Pharmacological agents act more selectively than DBS—sparing fiber tracts and binding to
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59 ² <https://clinicaltrials.gov/ct2/show/NCT02556736>

60 ³ <https://clinicaltrials.gov/ct2/show/NCT03326336>

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3 specific receptors—but lack temporal specificity, causing changes in neuronal responding that can last for several
4 hours after administration (van Duuren et al., 2007). By contrast, optogenetics can modulate specific cellular
5 activity (often in reversible fashion) at time scales relevant to the temporal dynamic of neural networks (Yizhar et
6 al., 2011). Furthermore, as optogenetics uses light pulses, it is highly compatible with neural and electrochemistry
7 recording (Kim et al., 2017), making it possible to adapt stimulation parameters in real-time based on recorded
8 activity within neural circuits. These characteristics of optogenetics allow for far more precise as well as temporally
9 and spatially selective neural control than any other existing neuromodulation technology.

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13 In the field of memory modification, the features of optogenetics described above offer the same
14 opportunities as existing MMTs, like modification of certain details of memories (Ramirez et al., 2013), and
15 alteration of the memory valence (Redondo et al., 2014), but also offer completely new potentials to alter
16 memories, such as providing access to forgotten infant memories (Guskjolen et al., 2018) or, remarkably, the
17 *reversible erasure* of a disturbing memory (Nabavi et al., 2014). In this article, we focus exclusively on
18 optogenetics' potential to switch on and off selected memories on demand as, until now, no other method has been
19 able to achieve this aim (but for an extensive overview of various ways in which memory can be modified with
20 the use of optogenetics as well as comparison of optogenetics to other MMTs, see Adamczyk & Zawadzki, 2020).

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24 The prospect of the extraordinary possibility to repeatedly deactivate and reactivate a specific memory
25 was achieved by modifying the synaptic strengths of neurons⁴ of a selected memory-engram via mechanisms of
26 long-term potentiation (LTP⁵) and long-term depression (LTD⁶) (Nabavi et al., 2014). Optogenetics is unique in
27 this approach, targeting neural mechanisms responsible directly for the encoding of a specific memory, not merely
28 mechanisms responsible for emotional component of that memory, as in the case of memory-modifying drugs or
29 behavioral therapies. Notably, another group of researchers demonstrated that by targeting hippocampal neurons
30 it is possible to deactivate and reactivate even very remote, firmly consolidated memories (Goshen et al., 2011)—
31 something that has never been achieved by any other MMT.

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Until now, this form of memory modification has never been seriously considered as a potential danger
implied by MMTs, as it was firmly in the realm of science-fiction rather than potential clinical use. Although for
now our considerations must rest on data from animal models, we argue that it is appropriate and timely to launch
a debate on potential ethical implications of these incredible possibilities, as many of the present optogenetic
studies are designed with the explicit goal of developing better-targeted brain stimulation treatments (Barnett et
al., 2018; Delbeke et al., 2017; Lux et al., 2015; for recent review, see Ramirez-Zamora et al., 2019). In our
considerations, we focus primarily on how optogenetics' potential for reversible erasure of memory may impact

⁴ A synapse is a structure that permits a neuron (or nerve cell) to pass an electrical or chemical signal to another neuron or to the target effector cell. Synaptic plasticity is the ability of synapses to strengthen or weaken over time in response to increases or decreases in their activity. Since memories are postulated to be represented by vastly interconnected neural circuits in the brain, synaptic plasticity is one of the important neurochemical foundations of learning and memory.

⁵ LTP is a probable neuronal mechanism for memory consolidation. It is a process whereby brief periods of synaptic activity can produce a long-lasting increase in the strength of a synapse, as shown by an increase in the size of the excitatory postsynaptic current (Lisman et al., 2012).

⁶ LTD is a process of selective weakening of the strength of a synapse. It is used to facilitate making use of increase in the strength of a synapse produced by LTP. LTD is necessary to this end as it enables encoding new information (e.g., memories) by preventing a synapse from reaching its ceiling level of efficiency.

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3 the authenticity of a person (but for a discussion of other neuroethical issues brought about by memory-modifying
4 potential of optogenetics, see Adamczyk & Zawadzki, 2020), which is one of the most fundamental aspects of
5 human existence, and which has been extensively discussed with regard to other MMTs (see Erler, 2011; Farah et
6 al., 2004; Hui & Fisher, 2015; Kass, 2003; Lavazza, 2015, 2018; Liao & Sandberg, 2008; Liao & Wasserman,
7 2007; Wolpe, 2002). More specifically, we show that memory modifications may impact authenticity by producing
8 changes at different levels of personality. After that, we discuss the potential consequences of memory erasure and
9 memory reactivation/reintroduction into the memory system—a challenge not yet posed by any other MMT.
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14 **Integrative model of personality studies**

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17 Before moving on to neuroethical considerations, it is essential that we define how authenticity relates to memory.
18 However, to our knowledge, there are no empirical studies that directly tackles this issue, as the notion of
19 authenticity derives from “folk psychology” (see Levy, 2011), and is contemporarily discussed primarily in
20 philosophy. In this article, we would like to embrace neuroethical considerations that are as empirically informed
21 as possible; thus, we will attempt to relate philosophical conceptions of authenticity to constructs used in
22 contemporary psychology—and more precisely, to those from the psychology of personality. As we demonstrate
23 below, one model of authenticity—that of Pugh, Maslen and Savulescu (2017b)—appears to be especially well-
24 suited for this task, and thus we discuss the potential consequences of optogenetics for authenticity primarily in
25 the light of their conception. We believe that connecting philosophical considerations on authenticity with the
26 psychological framework of personality studies has great potential, as authenticity-related constructs and their
27 relation to memory have been studied empirically in studies on personality. Thus, we adopt a novel empirically
28 informed approach to consider how optogenetically evoked memory changes can affect authenticity by considering
29 their impact on personality.
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36 Therefore, we will now introduce an increasingly accepted integrative framework for personality studies
37 (e.g., Adler et al., 2017; Hooker & McAdams, 2003; McAdams, 1995; McLean et al., 2019; Roberts & Wood,
38 2006). McAdams and Pals (2006) claim that the ultimate aim of psychology of personality is “to provide an
39 integrative framework for understanding the whole person.” To this end, they synthesized traditional theories and
40 recent research trends to conceive personality in terms of three basic levels. According to this framework,
41 personality is the product of individual variation on a general design with a primary function that can be best
42 understood in terms of evolutionary adeptness. It is expressed as a developing pattern of (I) *dispositional traits*,
43 (II) *characteristic adaptations*, and (III) *self-defining life narratives*, complexly and differentially situated in
44 culture and social context (see *Table 1*) (McAdams, 2013; McAdams & McLean, 2013).
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49 The first level (I) consists of variations on a small set of broad dispositional traits related to the cross-
50 situational consistency and longitudinal stability of personality dispositions. Dispositional traits consist of
51 decontextualized cognitive, emotional, temperamental and behavioral dispositions. Factor-analytic studies around
52 the world point to the fact that behavioral dispositions can be organized into five clusters, known as the Big Five:
53 extraversion (vs. introversion), neuroticism (vs. emotional stability), conscientiousness, agreeableness, and
54 openness to experience (Goldberg, 1993; McCrae & Costa Jr., 1997; McCrae & John, 1992). At the second level
55 (II) are situated characteristic adaptations. “If traits address the question of what kind of person a particular person
56 is, characteristic adaptations begin to move the inquiry to a more existential question: Who is the person?”
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3 (McAdams & Pals, 2006). Thus, the second level (II) of personality provides more specific and variable
4 information about the person. Characteristic adaptations are conditional, domain-specific and contextualized
5 within time, place and/or role. This level includes a person's motives (e.g., power, intimacy), values (e.g.,
6 veganism, conservatism), interests (e.g., sport, politics), coping styles (e.g., defense mechanisms, problem-focused
7 behavior), goals (e.g., current concerns, life projects), developmental responses (e.g., ego identity styles, levels of
8 generativity), cognitive schemas, moral strivings, or possible selves. This level is the most important for
9 determining: "what people want and do not want (e.g., success) in life and how they think about and go about
10 getting what they want and avoiding what they do not want in particular situations, during particular times in their
11 lives, and with respect to particular social roles" (McAdams, 2013). Finally, the third level (III) consists of
12 narrative identity. Narrative identity is the internalized life story of the self that persons construct to understand
13 who they are, how they came to be, and who and where they may be in the future. Thus, a life story consists of
14 selective reconstruction of the autobiographical past as well as narrative anticipation of the imagined future; as
15 such, it creates a coherent identity of a person in time and provides her with unity, purpose and meaning by enabling
16 her to make sense of her traits, motives, values, goals, or beliefs (Habermas & Bluck, 2000; McAdams, 2018). To
17 sum up, if the first two levels of personality build on human individuality, the third level enables a person to
18 construct her uniqueness and culturally anchored meanings.

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26 It is worth noting in the context of the third level of personality that one of the most influential theories
27 in neuroethics—Schechtman's narrative self-constitution view (Baylis, 2013; Schechtman, 1996, 2010, 2014)—
28 claims that narrative is something that one has to cultivate to be a person—to have a self.⁷ Schechtman further
29 imposes articulation (coherence of narrative) and reality (narrative must correspond to basic facts about the
30 person's life) constraints on narratives that can be regarded as constitutive of one's self (Schechtman, 1996, 113–
31 114). The claim that humans constitute their selves through self-narrative is, however, exposed to various
32 objections (see Mackenzie and Walker, 2015, 380–381). What is crucial to emphasize in the context of the
33 framework of personality described above is that although narrative (or life story) may be indeed a constitutive
34 condition of narrative identity (third level of personality), it is not a constitutive condition of the person's self (see
35 Zahavi, 2007), as there are other levels of personality. Narrative identity is just a particular way in which the self
36 may be arranged, constructed, and narrated for the functions of unity and purpose (McAdams, 1995). However,
37 one need not have unified and purposeful narrative identity to possess (I) dispositional traits and (II) characteristic
38 adaptations (e.g., as in the disorder called "dysnarrativia" (see, e.g., Young & Saver, 2001)). This shows that the
39 integrative framework described above is broader than the narrative self-constitution view—our personality (and
40 thus our self) is not limited to narrative identity. For this reason, in what follows we attempt to find a model of
41 authenticity that could capture potential consequences of optogenetical interventions regarding all levels of the
42 human self and personality: (I) dispositional traits, (II) characteristic adaptations, and (III) narrative identity (life
43 story).

44 45 46 47 48 49 50 51 52 53 54 **Psychology of memory**

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⁷ Cf. DeGrazia (2005) for another influential narrative theory.

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3 Before considering this framework in the context of neuroethical considerations on authenticity, we must elaborate
4 upon the contemporary psychology of memory as well as on how memory relates to the notion of personality
5 outlined above (see *Table 1*).
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7 As our considerations concerns the relation between memory and personality, and ultimately,
8 authenticity—that is, phenomena that persist across long stretches of time—we focus only on the long-term
9 memory system. A classical and broadly accepted taxonomical proposition is to distinguish between *declarative*
10 (explicit) and *nondeclarative* (implicit) memory (Squire, 1992, 2009; Squire et al., 1993; Tulving & Schacter,
11 1990). Psychologists usually hold that implicit (nondeclarative) memory—in contrast to declarative memory—
12 encompasses *all unconscious memories* and certain dispositions, abilities, or skills. The main types of implicit
13 memory are procedural, associative, non-associative, and priming (Camina & Güell, 2017). Declarative memory,
14 on the other hand, involves the encoding and storage of the content that an individual *brings* (or is at least able to
15 bring) *to consciousness* during retrieval (Squire, 2009; Tulving, 1995).
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20 Tulving (1972, 1985) famously proposed to distinguish declarative memory into two systems: *semantic*
21 and *episodic* memories. Semantic and episodic memories are believed to be *functionally independent*⁸ (see e.g.,
22 Klein, 2013; Klein & Gangi, 2010; Klein & Nichols, 2012; Klein et al., 1999). The semantic memory system
23 contains relatively general and context-free information: it usually “lacks memory” about the source of its
24 disposition, that is, it is experienced as knowledge without reference to the circumstances of where and when it
25 was acquired; furthermore, it is not usually self-referential, although it can include information about the self (see
26 Klein & Gangi, 2010; Klein & Nichols, 2012; Klein et al., 2008; Klein & Lax, 2010; Renoult et al., 2012). The
27 authors which hold this last view claim that semantic memory stores *factual self-knowledge* and also contains a
28 special subsystem that stores knowledge about the personality in the form of generalizations.
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33 This subsystem is termed *semantic trait self-knowledge*, and it is functionally independent from episodic
34 memory: “episodically based self-knowledge is not activated (consciously or unconsciously) when participants
35 perform semantic judgments about the self” (Klein, 2014a). Direct evidence for this independence is shown by
36 observations that individuals suffering episodic impairment know their personality traits despite being unable to
37 recall the particular experiences from which that knowledge could be derived (Klein & Gangi, 2010; Klein & Lax,
38 2010). The trait self-knowledge system also seems to be structurally independent (appearing to have a distinct
39 neuronal basis) from both episodic and factual self-knowledge systems as it “appears remarkably resilient in the
40 face of a variety—both with respect to type and severity—of neurological and cognitive impairment” (Klein &
41 Lax, 2010) resulting in the wreckage of both episodic and factual self-knowledge systems. Finally, it seems that
42 even acquisition of knowledge about one’s personality *does not require* episodic memory access (Klein & Gangi,
43 2010). These arguments, as well as the information provided about implicit (nondeclarative) memory and semantic
44 trait self-knowledge systems will be important when we return to considerations on the consequences of
45 optogenetical interventions on authenticity in the penultimate section.
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52 For now, however, we focus on episodic memory as it was (and often still is) commonly assumed as the
53 only kind of memory which makes available self-referential content. This assumption has led philosophers and
54 psychologists interested in the relation between memory and the self to preponderantly study and discuss the
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58 ⁸ In the context of memory systems the notion of functional independence means that: “one system can operate
59 independently of the other, though not necessarily as efficiently as it could with the support of the other intact
60 system” (Tulving, 1985, 66).

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3 episodic memory system (Klein, 2015). In contrast to semantic memory, episodic memory provides its owner with
4 a record of both the spatial and temporal characteristics of a specific remembered event, as well as the context of
5 acquiring a given memory. Thus, episodic memory is sometimes called what-where-when (*www*) knowledge
6 (Tulving, 1972). This function of episodic memory is thought to be realized by its distinct phenomenology (Dokic,
7 2014; Klein, 2015; Klein, 2013b, 2014b; Michaelian et al., 2016; Perner et al., 2007; Tulving, 2002). One of the
8 most influential concepts of the nature of this phenomenology refers to *autonoetic consciousness*. It is the idea that
9 episodic memory involves mental time travel located at a subjective time other than the present and accompanied
10 by the first-person perspective (Klein, 2013a, 2013c; Michaelian, 2016; Schacter et al., 2007; Suddendorf &
11 Corballis, 2007).

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16 Some argue that the most important subtype of episodic memories consists of *autobiographical memories*
17 (e.g., Fivush et al., 2011; Fivush & Haden, 2003). However, it seems that it is better not to categorize
18 autobiographical memories as a subtype of episodic memories (Rubin, 2012; Singer et al., 2013; Singer & Conway,
19 2011), but rather as central elements of a larger dual memory system consisting of *autobiographical knowledge*
20 *base* and the *conceptual self*.⁹ The latter roughly corresponds to the second level of personality—characteristic
21 adaptations—and its components seem to be grounded mainly in trait and factual self-knowledge memory
22 systems¹⁰ (Singer et al., 2013). Thus, autobiographical memories consist of episodic memories slotted in the
23 autobiographical knowledge base and connected to the conceptual self. As such, autobiographical memories are
24 much richer than the usual episodic memories. They go beyond recalling of the *www* of an event as well as
25 autonoetic consciousness; they are sated with attitudes and emotions toward an event, and they are not devoid of
26 its evaluations; they often give explanations for what happened in terms of folk psychology, that is, motivations
27 and intentions of the self and other agents; and last but not least, they provide explanatory frameworks for what an
28 event *meant* for the person, and why it is *important* to the self (e.g., Bruner, 1990, 1997; Fivush, 2010; Fivush &
29 Nelson, 2006). Autobiographical memories are also very persistent—unlike episodic memories, which are often
30 elusive, they may last for years or even decades. Autobiographical memories are complex representations—they
31 require *memory specificity* given by specific episodic memories as well as the companion process of linking these
32 recollections to the conceptual self—the process termed *meaning making* (Pasupathi et al., 2007; Pasupathi &
33 Wainryb, 2010). All of these features of autobiographical memories make them most deeply processed and central
34 to ongoing concerns of the personality; they are “the nuclei of narrative identity”—their unique function is to
35 establish narrative identity (Singer et al. 2013). Those of autobiographical memories that establish most critical
36 and organizing themes of narrative identity of a person evolve into so-called *self-defining memories* (see, e.g.,
37 Blagov & Singer, 2004; Fivush et al., 2011; Singer et al., 2013; Thorne & McLean, 2003).

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48 Self-defining memories are most important and recurring “touchstones” of narrative identity. They reflect
49 most central areas of human concerns (e.g., intimacy, spirituality, personal failures and triumphs, or moments of
50 self-discovery) as well as unresolved conflicts (e.g., jealousy, sibling rivalries, ambivalence of a parental figure).
51 Furthermore, self-defining memories are characterized by affective intensity and repetitiveness in recalling (they
52 serve as “reference points to provide guidance or reinforcement with respect to specific current situations in the
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57 ⁹ More precisely, the conceptual self consists of narrative scripts, possible selves, self-with-other units, internal
58 working models, attitudes, self-attributed traits, values, and beliefs.

59 ¹⁰ However, as we will argue in the penultimate section, characteristic adaptations can be also be grounded in
60 implicit (non-declarative) knowledge.

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3 individuals' lives" (Singer & Blagov, 2004)), as well as associativeness (they are associated with a network of
4 related memories that share similar goals, concerns, outcomes, and affective responses¹¹); mental time travels to
5 self-defining memories are also especially vivid (Singer & Blagov, 2004; Singer & Salovey, 1993). Years of study
6 have demonstrated that self-defining memories have a significant role in individuals' life goals and emotional
7 experiences (see, e.g., Blagov & Singer, 2004; Islam et al., 2019; McLean & Thorne, 2003; Singer et al., 2013;
8 Singer & Bonalume, 2010; Sutin & Robins, 2005; Sutin & Stockdale, 2010; Wood & Conway, 2006). For example,
9 Singer and Blagov (2004) argue that self-defining memories may serve as the lens through which individuals
10 perceive new experiences, and as such they can create self-fulfilling patterns of interactions that further reinforce
11 *narrative scripts*¹² they previously delivered; thus, self-defining memories can schematize repetitive action–
12 outcome–emotional response sequences (Singer & Bonalume, 2010).

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18 To sum up this section, optogenetical interventions which aim to modify self-defining memories seem to
19 be most dangerous threat to personality. Thus, we start our considerations on the potential threats to persons'
20 authenticity in light of optogenetical erasure and reactivation/reintroduction of self-defining memories. Before
21 this, however, there is still one more piece of missing information—we must connect constructs utilized in
22 personality studies to the notion of authenticity.

23 24 25 26 **Normative value of authenticity and its relation to the integrative framework of personality studies**

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The framework proposed in the previous section does not provide easy reasons for why it is important or valuable to preserve intact every level of personality—(I) dispositional traits, (II) characteristic adaptations, and (III) narrative identity (life story). They obviously change naturally to some extent during our lives. In the neuroethical literature debating the normative importance of preserving certain features of the person's self, the popular answer for that dilemma has been to refer to the concept of authenticity. However, after such a theoretical move, the question of why preserving authenticity should be regarded as a normatively valuable arises. One can answer this question in the following ways: either by appealing to the idea that being authentic should be considered inherently valuable and worthy in itself; alternatively, authenticity can be found normatively valuable because it serves as a means to other ends. Proponent of the first of these perspectives can refer to¹³ a seminal work of Charles Taylor in which he argues that authenticity is a contemporary moral ideal, that is, "what a better or higher mode of life would be, where 'better' and 'higher' are defined not in terms of what we happen to desire or need, but offer a standard of what we ought to desire" (Taylor 1991, 16). A proponent of the second perspective can refer to psychological studies showing a vital role of authenticity in well-being (see Robinson et al., 2012; Sutton, 2020; Wang, 2016; Womick et al., 2019), or to the role of authenticity in personal autonomy (see, e.g., Christman, 2009, 2018; Dworkin, 1988; Frankfurt, 1971; Watson, 1975).

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Before moving on to relate the notion of authenticity to the integrative framework of personality studies, it is important to outline a theoretical map of philosophical conceptualizations of authenticity. Theories of authenticity can be roughly placed on a continuum between two poles: essentialist (self-discovery) and

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¹¹ Self-defining memories add an evaluative dimension to other memories.

¹² According to (Tomkins, 1978) narrative scripts are "an individual's rules for predicting, interpreting, responding to, and controlling a magnified set of scenes."

¹³ See also Varga (2012, 77), Ferrara (1998, 50-52, Ferrara (1997), and Pugh et al. (2017b).

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3 existentialist (self-creation) (Bublitz & Merkel, 2009). According to *the truth of essentialism*, authenticity entails
4 connecting one's present person-stage to one's *true self*—certain pre-given and more or less fixed characteristics
5 of a person's self through introspective voyage of self-discovery (see Erler, 2011, 2012; Erler & Hope, 2014;
6 Kraemer, 2011, 2013; Lavazza, 2018; Nyholm & O'Neill, 2016). It is worth noting, however, that being authentic
7 not only requires an exploratory journey; one's true self cannot remain permanently hidden—it has to be expressed
8 in one's way of living (Johansson et al., 2011). According to *the truth of existentialism*,¹⁴ even to think that we
9 have some fixed essence, such as the true self, seems to be an act of self-deception. A prominent representative of
10 the extreme version of this truth is Jean-Paul Sartre (1992 [1943]). He argues that one is not confined in any
11 relevant sense in choosing elements that creates one's self. Obviously, Sartre acknowledges that being humans,
12 we have certain tangible and concrete features or *facticity* making us what we are “in itself” (*en soi*)¹⁵. However,
13 we are also “for itself” (*pour soi*). *Ipsa facto*, we have the ability to reflectively distance from our facticity,
14 transcend what we are “in itself” by means of self-interpretation, and effectively constitute ourselves through this
15 act; to deny this is “bad faith”—a form of a negligence of a person's own freedom. According to Sartre, living
16 authentically requires that we face the brute fact that our existence has no meaning, value, or purpose that could
17 justify it independently from our choice to bestow these features upon our lives (we cannot even appeal to our true
18 selves for guidance); meaning, value, and purpose exist *only* because they were *chosen* by us and endure so long
19 as we endorse them. Therefore, we do not need to engage in an introspective journey of self-discovery; we can
20 construct ourselves in the process of self-creation.

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22 Levy's (2011) argues that when it comes to theorizing on the concept of authenticity, it is possible to stop
23 halfway and hold arguably the most commonsensical approach—namely, that: “we can emphasize self-discovery
24 without holding the empirically implausible notion that the self has a fixed essence; we can point to the fact that
25 persons do have dispositions and talents and personalities, which fit them better for some activities than for others
26 [...] without committing ourselves to the claim that people are immutable, and even without denying that genuinely
27 profound change is possible. We can emphasize self-creation without denying that change is difficult and always
28 only partial.” And even more strongly, Levy doubts whether: “the idea of radical and absolute choice which lies
29 at the heart of Sartre's existentialism is even coherent: choice requires preexisting values for options to be
30 available” (Levy, 2018). In effect, Levy denies both the essentialist's notion of the fixed true self as well as the
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47 ¹⁴ Or, rather “the truth of extreme existentialism”; or, more precisely, “the truth of early Sartre of *Being and*
48 *Nothingness*.” It would be obviously overstatement to identify above “truth” as representative for such a diverse
49 philosophical tradition as existentialism. Here, we are not attempting to give justice to the massive literature on
50 this topic, but merely presenting an “ideal type” of existentialist's concept of authenticity to outline oppositional
51 spectrum of conceptualizations of authenticity. We think that radicalness of Sartre's early work in that regard work
52 well to this end.

53 ¹⁵ As Lucas (2014) points out although “Heidegger and Sartre disagree on many points [...] they agree on the idea
54 that the historicity of the self should be conceived in terms of *thrown projection*.” In a nutshell, *thrownness*
55 (Heidegger, 1962 [1927], §29) refers to the contingency of our facticity and its recalcitrance in the face of
56 *projective* character of human choices in the process of self-creation. Although we lack the space to further discuss
57 it, we think that Sartre's early view should be nonetheless positioned further on the spectrum of existentialists
58 accounts of authenticity than Heidegger's conception, as Sartre emphasizes the far greater (radical) freedom in the
59 process of self-creation.
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3 existentialist's notion of the radical freedom in self-creation. We find Levy's dual-basis approach¹⁶ both
4 theoretically and empirically appealing. For one, he circumvents problematic notion of the self with a pre-given,
5 fixed, and immutable essence; something that is metaphysically suspicious—let alone an epistemological obstacle
6 of how to arrive at the correct answer about what the true self of the particular person is. Further, his model
7 acknowledges each human's role in the process of self-creation, and, at the same time, denies metaphysically
8 questionable libertarian notion of an absolute and unconstrained choice—something that would be achievable only
9 if we as the for-itself were being causally cut off from external influences (Levy, 2018). Thanks to Levy's dual-
10 basis framework, we can recognize that our choices are constrained by our facticity (i.e., personality) without
11 denying the reality of constructive role of our selves.

12
13 Pugh, Maslen and Savulescu (2017b) build their coherentist model of authenticity basing on Levy's dual-
14 basis framework. Their account also corresponds particularly well to the integrative framework of personality
15 described above by referring roughly to all of the levels of personality (see *Table 1*). For this reason, we follow
16 Pugh, Maslen and Savulescu's model in our considerations on the potential consequences of optogenetic
17 interventions to persons' authenticity. Pugh, Maslen and Savulescu (2017b) model can be summarized well by the
18 following remark: "[...] it is through the lens of our evaluations, themselves developed in the light of our personal
19 history and our stable, long-lasting characteristics and traits, that we are able to understand which of our features
20 we want to be incorporated into our understanding of who we really are." Before the neuroethical discussion, we
21 would like to position this model in the context of more theoretically and empirically grounded terms of the
22 framework of personality studies. Pugh, Maslen and Savulescu's evaluations can be identified with values,
23 corresponding to a subcategory of characteristic adaptations (II). "Long-lasting characteristics and traits" seem to
24 correspond to dispositional traits (I). They also postulate that "personal history" plays an important role in living
25 authentically, which corresponds to level (III)—narrative identity (or life story) (see *Table 1*). Therefore, Pugh,
26 Maslen and Savulescu's model corresponds to a broadly accepted psychological framework of personality studies,
27 and is consistent with the contemporary scientific understanding of personality.

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29 Pugh, Maslen and Savulescu emphasize critical role of values (a subcategory of level II) for authenticity.
30 They claim that values can generate and sustain rationally endorsed desires that motivate behavior that resists the
31 influences of more basic drives and urges. Thus, according to Pugh, Maslen and Savulescu, preserving a person's
32 dispositional traits (level I) does not have to be inherently normative. One can disvalue aspects of one's own long-
33 lasting characteristics and traits and actively shape it according to one's values. However, Pugh, Maslen, and
34 Savulescu (2017a) argue that a value refer to "an agent's endorsement of some end as good in a reason implying
35 sense. If one values x, then one believes that one has a reason to pursue x: values are thus inherently normative".
36 Based on this assumption, they conclude that one should be most concerned with neurotechnological interventions
37 which affect: "[...] the authenticity of an agent's values, especially where these values inform treatment decisions.
38 Interventions that affect the authenticity of an agent's traits, on the other hand, are only problematic in so far as
39 the agent, all things considered, (authentically) disvalues this influence" (Pugh, Maslen, Savulescu, 2017b). From
40 this perspective, therefore, it is most important to consider whether modifying people's memories using
41 optogenetics may influence their values.

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59 ¹⁶ A similar dual-basis account of authenticity can be found in Elliott (2011), Nyholm and O'Neill (2017) as well
60 as Erler and Hope (2014a).

Table 1.

Memory systems that may be important for specific levels of personality and how these levels may be important for authenticity.

| Memory Systems | Integrative Framework of Personality | Authenticity | |
|---|---|---|---------------|
| (e.g., Klein, Lax, 2010; Singer et al., 2013) | (e.g., McAdams, Pals, 2006) | (Pugh, Maslen, Savulescu, 2017b) | |
| Implicit memory | Dispositional traits (e.g., Big Five) | Long lasting characteristics and traits | |
| Trait self-knowledge | | | |
| Implicit memory | Characteristic adaptations | Values (Evaluations) | |
| Trait self-knowledge | | | Interests |
| | | | Motives |
| Factual self-knowledge | | | Coping styles |
| | Goals | | |
| Autobiographic memory (including self-defining memories) | Values | | |
| | Developmental responses | | |
| | Cognitive schemas | | |
| Autobiographical memory (critical role of self-defining memory) | Moral strivings | Personal History | |
| | Possible selves | | |
| | Narrative identity (Life story) | | |

Note. Values—a subset of Characteristic adaptations from Integrative Framework of Personality—correspond to Values (Evaluations) level from Authenticity model.

Optogenetic modifications of self-defining memories as the threat to authenticity

In light of the theoretical frameworks we have outlined above (psychology of memory, psychology of personality, and Pugh, Maslen and Savulescu's model of authenticity), consider the story of Elizabeth (here we present a slightly modified version of the case depicted by Erler, 2011), who suffered from social exclusion and bullying in her school years, but later was able to build a satisfying life. Nonetheless, Elizabeth is still haunted by vivid memories of being victimized. A friend of Elizabeth with a similar background, Sonya, was instead able to let things go. Seeing it, Elizabeth felt envious of such a "lightness of being" and decided to undergo treatment with optogenetics. The intervention was successful, and Elizabeth got rid of the memories of being abused. As a result, Elizabeth's overall well-being has apparently improved. However, since she was a victim of abuse, she wholeheartedly fought all forms of bullying her whole life until the procedure. She even established and worked at a full-time job at an anti-bullying organization. Therefore, Elizabeth's memories of being victimized can be very plausibly categorized as her self-defining memories (see section *Psychology of memory*)—which seems to be even more probable given that traumatic experiences can play a critical role in forming identity (Kolk, 2014; McAdams & Jones, 2017; Wilson, 2006). According to Pugh, Maslen and Savulescu's model, (i) a person is authentic as far as intervention-induced elements of the self—and most importantly, values—can be grounded by coherence with other long-standing, cohering and rationally intelligible elements of her character (personality) system. Pugh, Maslen and Savulescu also argue that (ii) values develop in light of our personal history (life story) and our stable,

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3 long-lasting characteristics and traits. In the following section, we present arguments for why Elizabeth's
4 authenticity seems to be endangered by optogenetic erasure of her self-defining memories. Most generally, we
5 argue that in the most plausible scenario she will have to entirely reconstruct her life story after this procedure. In
6 light of (ii), it leads to conclusion that (i) cannot be fulfilled, that is, Elizabeth will experience changes in the
7 elements of the self that are not possible to ground in her personality system. Let us elaborate.
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10 As we discussed earlier, self-defining memories connect a person to the most critical themes of her
11 narrative identity. For Elizabeth, this theme is one of redemption—a wide-spread theme among generative
12 American adults (McAdams, 2011). More generally, the theme of redemption points to an adaptational challenge
13 of how humans make narrative sense of suffering in their lives. A redemption sequence marks a transition in a life
14 story from an emotionally negative experience to a positive outcome or attribution about the self (McAdams, 2006;
15 McAdams & McLean, 2013). Thus, being deprived of her self-defining memories of victimization could leave
16 Elizabeth unable to connect with redemption story of overcoming traumatic memories to help other victims of
17 abuse. Consequently, she may not be able to position herself as a protagonist and engage in an unfolding life story
18 that had this redemption sequence at its core. Ultimately, her narrative identity may require almost entire
19 rebuilding, as she had constructed it around this redemptive theme.
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25 Regarding the function of self-defining memories, Singer and Blagov (2004) claim that “self-defining
26 memory and its consideration in consciousness integrates the cognitive, affective, and motivational systems into a
27 unified entity that allows the personality as a whole to focus on a specific functional priority, as determined by
28 one’s sense of identity.” Thus, by erasing self-defining memories with all their vividness and affective intensity as
29 well as the above discussed centrality in her (redemptive) life story, Elizabeth may lose her lived experience of the
30 suffering associated with bullying and be deprived of the very ability to feel like a victim again, or even to believe
31 that it was she, herself, who was the subject of victimization, and as a result may become less sensitive in this
32 regard. Thus, Elizabeth arguably would lose her ability to integrate her affective and motivational system of
33 personality to realize the mission of helping victims of prosecution and align with it her (once) authentic desire to
34 do so. Therefore, although erasure of her self-defining memories may plausibly allow Elizabeth to create a brand
35 new narrative identity by means of which she could acquire “peace of mind,” she would most likely lose some of
36 the values (or more broadly—characteristic adaptations) that she once appreciated and found authentic (e.g., being
37 compassionate toward victims of abuse, helping victims is important, etc.) in the process. As the result, she might
38 even resign from her anti-bullying organization in order to (for example) find a more profitable career (e.g., work
39 at a financial institution).
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46 This perspective of radical change of Elizabeth seems even more plausible in light of that the fact the
47 affect system implicated in self-defining memories “adds an evaluative dimension to every memory” (Singer &
48 Blagov, 2004). Thus, there is a possibility that erasing Elizabeth’s memories of victimization may not only change
49 *some* of her values, but lead to pervasive changes in her personality system—changes which embrace a whole web
50 of characteristic adaptations (including her values), and as a result, infringe her overall evaluative scheme. If this
51 is the case, it is very problematic in the lens of Pugh, Maslen and Savulescu’s model, as the lineage of change in
52 a person’s character must be traceable over the diachronic process of intelligible rational change. However,
53 incorporating the new values, new life path, and new life story discussed above into Elizabeth’s long-standing,
54 cohering, and rationally intelligible elements of personality system seems almost impossible, as they are entirely
55 different—some are in almost direct opposition to the elements that were historically most pervasive in Elizabeth’s
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3 character. Moreover, particularly problematic in this context is that Elizabeth, in the very process of incorporating
4 these elements into her understanding of who she is after the intervention, would have to do this in light of values
5 that had already been modified—that is, in the light of inauthentic evaluation. Thus, there is a threat that
6 incorporation of *any* elements into her understanding of who she really is after optogenetics will be inauthentic—as
7 stability of values, that is, the potential to trace them back over diachronic process of intelligible rational change,
8 is crucially important in Pugh, Maslen and Savulescu’s model of authenticity, and this very stability would be
9 infringed upon by erasure of self-defining memories.

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13 We think that one attempt to save Elizabeth’s authenticity in the case above could be for Pugh, Maslen,
14 and Savulescu to allow *others* to contribute in Elizabeth’s process of *self-re-creation*. Pugh, Maslen, and Savulescu
15 (2017b) actually allow “third parties to offer some practical guidance about how the individual might go about
16 making this decision, perhaps by drawing her attention to the strength of certain reasons, and the goods at stake in
17 her decision,” though they nonetheless maintain “that it seems *prima facie* problematic to ascertain authenticity, a
18 concept whose value is tied to individual meaning, by reference to the *values of others*.” However, in the case
19 discussed above mere persuasion could prove ineffective in shaping Elizabeth’s self-re-creational process, as she
20 could have her own new (inauthentic) evaluations about which she feels strongly and that shape the lens through
21 which she incorporates new elements into her self-understanding. Thus, it may be necessary to follow relational
22 conceptions of self and authenticity and allow for more pervasive role of others in the process of self-re-creation.
23 For example, Nyholm and O’Neill (2017) argue that the patient’s family may take a more proactive role and
24 actively contribute to the patient’s choices on the basis of (once) shared values and for the sake of their relationship.
25 In Elizabeth’s case it could mean that third parties could participate in the process of her self-creation by assessing
26 whether optogenetical erasure of memories modified Elizabeth such that she is inauthentic (i.e., she does not hold
27 previously shared values), and if this were the case, they could decide whether the intervention should be reversed
28 by reactivation/reintroduction of memories which has been erased (or more precisely—deactivated). Such an
29 approach could be further justified by the claim that it is not only sensible in such “hard cases,” such as Elizabeth’s,
30 but it is also inevitable and pervasive in our everyday lives as, according to feminist relational theory, we “cannot
31 be self-creators but ‘are (and can only be) dynamic complex co-creations informed by the perspectives and creative
32 intentions of others’ (Baylis 2012, 118). [...] Constructing a narrative identity is therefore an ongoing negotiation
33 between first-person self-ascriptions of identity, second-person recognition (or misrecognition) by others, and
34 third-person identity ascriptions, such as ascriptions of personality, character, action attributions, and so on”
35 (Mackenzie & Walker, 2015).¹⁷ Pugh, Maslen, and Savulescu (2017b), however, would surely oppose such a
36 solution, as they argue that “the identification of authentic desires as those that are congruous with widely shared
37 values raises the prospect that this strategy might in practice amount to dressing up considerations of beneficence
38 in the language of autonomy; this in turn, is a good recipe for paternalism, albeit via the back door.”

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51 We would like to consider, therefore, if the potential of optogenetics to reactivate/reintroduce memories
52 that have been deactivated could be indeed a solution if the issues discussed above arise. At face value, the
53 possibility of restoring self-defining memories that were the subjects of erasure/deactivation seems to be a win-
54 win situation—if Elizabeth would lose authenticity or some other undesirable state of affairs would occur after
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58 ¹⁷ Mackenzie and Walker (2015) also argue that “the appeal to authenticity is redundant and blurs the distinction
59 between narrative identity and autonomy.” However, as this is not relevant to the argument that we outlined above,
60 we set this issue aside.

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3 erasure of her self-defining memories (and if third parties were able to diagnose that it is the case), assuming the
4 proactive role of others in the process of self-re-creation, we could always restore missing memories and
5 everything should return to “normal.” However, what if it is not the case? What if Elizabeth’s personality changed
6 so much as the result of this optogenetical intervention that she could not return to her “old self”? More precisely,
7 it seems possible that once Elizabeth had her self-defining memories erased, she—as we already argued above—
8 would had lost her lived experience of the suffering associated with bullying along with the epistemic potential to
9 believe that it was she, herself, who was the subject of victimization. As the result, she would most plausibly have
10 to reconstruct her life story (by dropping redemptive tale among other) and her evaluative scheme would
11 potentially also change in the result. If this were indeed the case, reintroducing memories of victimization into the
12 memory system of “new Elizabeth” may not bring the desired results of realigning the affective, motivational, and
13 evaluative features of the self-defining memories of “old Elizabeth” with returning to her “old story.” On the
14 contrary, she may find herself alienated from the reintroduced memories, as she may not feel that she is the same
15 person anymore; thus, reactivation of her (once) self-defining memories may not be as resurrective for the “old
16 version” of Elizabeth as we might presume.

23 24 **Self-relevant semantic and non-declarative memory systems and the prospect of preserving authenticity** 25 **after optogenetic memory modifications**

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29 We believe that the problems discussed above are worth further discussion and problematization, and that there is
30 a need for a further debate concerning the possible threats to authenticity posed by the memory-modifying potential
31 of optogenetics. However, here we would like to present a more soothing perspective in this regard, as we think
32 that there is also solid ground for arguing that, in light of the contemporary neuropsychological data—even if the
33 idea that erasing self-defining memories can jeopardize ones’ characteristic adaptations (including values), and
34 consequently disrupt one’s authenticity is sound—the likelihood of such a state of affairs may be lower than we
35 previously assumed, as it may depend on whether removing these memories would simultaneously erase self-
36 relevant semantic memories as well as a person’s implicit (non-declarative) memories.

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41 Psychological studies on memory over the past thirty years have provided evidence that there are some
42 reasons for optimism in this regard, as two further kinds of memory systems—both structurally and functionally
43 independent from episodic memory (and, thus from self-defining memory)—are self-relevant (see section
44 *Psychology of memory*). These are factual self-knowledge (e.g., Elizabeth’s knowledge of that: *I am 42 and work*
45 *for an anti-bullying organization*), and trait self-knowledge, the system that stores information about one’s own
46 personality in the form of traits generalizations (e.g., *Self of Elizabeth: Always compassionate*) (Klein et al., 2008;
47 Klein & Gangi, 2010; Klein & Lax, 2010). As Klein and Nichols (2012) conclude regarding the latter: “This system
48 delivers a sense of the self given by pre-computed summaries of the dispositions one manifested in various
49 behavioral episodes.”

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54 Considering the above and given the specificity (spatial and temporal resolution) of optogenetics, we
55 suggest that if Elizabeth was free from her self-defining memories of victimization due to optogenetic intervention,
56 she would still retain trait self-knowledge, that is, knowledge about her own personality in the form of
57 generalizations as well as factual self-knowledge. Thus, it seems that even if Elizabeth’s narrative would be
58 disrupted as the result of erasure of self-defining memories, her long-term values and motivations could arguably
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3 remain unchanged. She would have access to knowledge about her characteristic adaptations through trait self-
4 knowledge memory; furthermore, it seems likely that her idea of who she is, that is, her narrative self-
5 understanding, could be relatively easily reconstructed in the process of deliberation on the content of her trait
6 self-knowledge and her factual self-knowledge. Thus, under this interpretation, she would not have to trade “peace
7 of mind” resulting from getting rid of traumatic memories for values—optogenetics could allow her to have them
8 both with time and effort. If this were the case, the optogenetic intervention discussed above may actually be
9 unproblematic by the lights of Pugh, Maslen and Savulescu’s model of authenticity, as Elizabeth’s long-standing,
10 cohering and rationally intelligible elements of personality could arguably remain intact.
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13 We review our discussion of the implicit (non-declarative) memory system (see section *Psychology of*
14 *memory*) and consider how Camina and Güell (2017) elaborate on the difference between declarative and non-
15 declarative memories and their connection to personality: “[A]n adverse event in childhood (e.g., seeing your
16 grandfather being run over by a combine) can, on the one hand, consolidate as a stable declarative memory for the
17 event itself (the sound of a combine always makes you remember that moment-episodic memory) and, on the other
18 hand, can crystallize in non-declarative memory and result in a phobia experienced as a personality trait rather
19 than as a mere memory (being near a combine will always produce panic and induces a desire to escape that
20 situation-associative memory).” Hence, it seems that one’s basic levels of personality, i.e., dispositional traits as
21 well as characteristic adaptations, may be directly shaped by experiences without the need for conscious
22 deliberations on events or evaluative endorsement of what the consequences for one’s personality may be (see also
23 section *Psychology of memory*). Moreover, expression of one’s personality seems to be possible without retrieval
24 (or even without storage) of information from episodic or semantic trait self-knowledge memory systems.
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27 In lights of these considerations, one could argue for an even stronger thesis than that already discussed
28 in this section: erasure of self-defining memories as well as erasure of both self-relevant memories of factual self-
29 knowledge and trait self-knowledge might not actually rob Elizabeth of her authenticity as her long-standing
30 dispositions could remain unchanged. In other words, she could be left with a “free-floating” but persistent
31 disposition, e.g., to help others suffering from victimization¹⁸. However, we think that this conclusion may be
32 premature, as there is some important aspect missing in this analysis. Although we agree that many of Elizabeth’s
33 crucial behavioral dispositions could remain intact, there seems to be a gap between the free-floating dispositions
34 of a person and elements of her authentic personality. We construct “models” of the personalities of others by
35 observing their behaviors; however, we are more familiar with our own personalities, as we have had more time
36 to become acquainted with ourselves. We have the ability to mentally time-travel to our past disposition, and we
37 may even play a role in our self-creation. However, after the erasure of the products of these processes of self-
38 discovery and self-creation—self-defining memories, factual self-knowledge, and trait self-knowledge—Elizabeth
39 would lose basic self-knowledge along with the very possibility to experience her self-defining memories
40 firsthand, and as a result would fall into a position similar to somebody who has to learn about one’s self from the
41 third-person perspective. In effect, it seems fair to say, she would lose her authenticity for at least some period
42 after this memory-modifying intervention—that is, until she rediscovered her factual self-knowledge and trait self-
43 knowledge and reconstructed her life story. We are not claiming, however, that she would lose her authenticity
44 permanently. As long-standing, cohering and rationally intelligible (at least from the third-person perspective)
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59 ¹⁸ For a similar conclusion, but considering somewhat different case (not in the context of optogenetics), and with
60 different theoretical background see Gligorov (2016, 90-92).

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3 elements of Elizabeth's personality might remain intact, the foundation for developing her life story would still be
4 somewhere "deep inside herself," or rather, stored among her synapses. However, as the only remaining elements
5 of some of the most important ingredients of Elizabeth's personality would be crystalized in the form of free-
6 floating dispositions in such a case, she would have to work for self-rediscovery in a way similar to how we get to
7 know others. This would mean that she could quite often be surprised by her own choices, actions, and preferences.
8 In principle, however, with time—as she rediscovered more and more of her dispositional traits and characteristic
9 adaptations and developed her new narrative identity—she could become authentic again and live a life free of
10 traumatic experiences. We are not sure if these considerations are also in line with the spirit of the model of Pugh,
11 Maslen, and Savulescu; however, as their view has the advantage of being *diachronic*,¹⁹ the process of *reclaiming*
12 authenticity described above could plausibly agree with their proposition.

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18 As considerations in this section suggest, diachronic coherence and the stability of personality required
19 for authenticity in Pugh, Maslen and Savulescu's model may not be solely the result of self-defining memories;
20 self-relevant semantic memories and implicit memories can be also relevant in this regard. As such, the erasure of
21 self-defining memories via optogenetics can actually be less problematic than we argued in the previous section.
22 Moreover, as the person arguably does not become "someone else"—thanks to other self-relevant semantic
23 knowledge (both factual and trait self-knowledge) or implicit memory, which can constitute the basis of one's
24 personality—the reactivation/reintroduction of deactivated self-defining memories may appear a better solution
25 than depicted in the previous section. Therefore, we suggest that which of these considerations (presented in
26 previous or current section) turns out to be true will determine, at least to some extent, the liberality of future
27 policy regarding optogenetic memory modification.

32 33 **Conclusions**

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36 Contemporary knowledge in psychology and neuroscience does not allow us to state unequivocally how the values,
37 traits, behaviors and self-narrative of persons would change under the precise and selective memory modification
38 optogenetics promises. For now, we cannot state with certainty if erasing a particular traumatic memory would or
39 would not change a person's evaluative and dispositional behavioral scheme.

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45 ¹⁹ Synchronicity means that authenticity can be assessed in an isolated time-slice (Pugh, Maslen, Savulescu,
46 2017b). According to one of the most influential synchronic accounts of authenticity—Frankfurt's (1988, 1998)
47 wholeheartedness approach (authenticity is a part of a broader "Frankfurtian" account of autonomy), elements of
48 the self are authentic if endorsed wholeheartedly. More precisely, a person is authentic when she identifies her
49 second-order desires with her first-order desires and this identification is made without reservations—the person
50 who makes it must believe that further inquiry cannot change her mind (Frankfurt 1988, 21; 163; 168). Thus, if a
51 person's actions and choices are guided by the desires and preferences with which she identifies wholeheartedly,
52 these actions and choices are authentic. To access a person's authenticity in a synchronic account such as
53 Frankfurt's, one cannot appeal to enduring elements of the person's self and personality; one simply asks whether
54 the person commits herself wholeheartedly to whatever she decides *here and now*. The problem with this approach
55 is that it is not clear "what basis there could be for grounding the authenticity of elements of the agent's self,
56 including that agent's present values, other than the values that the agent exhibits *here and now*; however, this is
57 the very element of the self whose authenticity is under question" after interventions, such as those involving
58 optogenetic memory-modifications" (Pugh, Maslen, Savulescu, 2017b). For this reason, Pugh, Maslen and
59 Savulescu postulate that *diachronicity* is crucial for neuroethical accounts of authenticity.

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3 It appears that selective rewriting of human lives by tampering with memories is the natural propensity
4 of human brain, wired into our cognitive and deliberative system (see, e.g., De Brigard, 2014a). Therefore, by
5 refining our memory with memory-modifying neurotechnologies, we could achieve the means to do so more
6 accurately and effectively, providing hope to those more scantily endowed by nature with these kinds of abilities.
7 On the other hand, we should be cautious when it comes to fiddling with memories, as it can have tangible
8 consequences. Modulation of memory by means of optogenetics goes against the “natural” or “default” way in
9 which people typically introduce “changes” in their memory system. While naturally occurring memory-
10 modifications are modest in their extent and are spread over time, memory changes that occur due to optogenetics
11 can concern our most precious life events and can be introduced rapidly. Thus, it may be challenging to reconcile
12 them with our other memories or values that underlie our self-narrations. Moreover, these memories may be at
13 odds with our self-understanding, since the nature of humanity causes us to value and promote the process of
14 reflective self-creation that takes place over the course of our lives, not minutes or seconds, as in the case of
15 optogenetics.

16 Erasing selected painful autobiographical memories may be possible in the future. In designing future
17 policies, we should approach existing scientific knowledge regarding the potential side effects of MMTs and
18 carefully examine all pros and cons of a particular memory modifying procedure. However, we should also bear
19 in mind that any decision to intervene in one’s memory cannot be based on a purely scientific view of the world.
20 In this article, we argued that we should pay special attention to authenticity, as it seems to play a crucial role in
21 valuable, rationally endorsed life. As a person’s values grow out of life experiences, erasing and tampering with
22 memories may make a person’s authenticity vanish along with them.

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Table 1.

Memory systems that may be important for specific levels of personality and how these levels may be important for authenticity.

| Memory Systems (e.g., Klein, Lax, 2010; Singer et al., 2013) | Integrative Framework of Personality (e.g., McAdams, Pals, 2006) | Authenticity (Pugh, Maslen, Savulescu, 2017b) |
|--|--|---|
| Implicit memory | Dispositional traits (e.g., Big Five) | Long lasting characteristics and traits |
| Trait self-knowledge | | |
| Implicit memory | | Interests |
| | | Motives |
| Trait self-knowledge | | Coping styles |
| | | Goals |
| Factual self-knowledge | Characteristic adaptations | Values |
| | | Values (Evaluations) |
| | | Developmental responses |
| Autobiographic memory (including self-defining memories) | | Cognitive schemas |
| | | Moral strivings |
| | | Possible selves |
| Autobiographical memory (critical role of self-defining memory) | Narrative identity (Life story) | Personal History |

Note. Values—a subset of Characteristic adaptations from Integrative Framework of Personality—correspond to Values (Evaluations) level from Authenticity model.