TEMPORAL SELF-APPRAISAL IN DEVELOPMENTAL AMNESIA

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Abstract

According to temporal self-appraisal theory, people evaluate themselves in the past in a way that makes them feel good about themselves in the present. In line with this theory, studies have shown that people believe their personality has changed more in the past than it will change in the future. This thesis investigated whether episodic memory plays a role in one's temporal self-appraisal. A person with developmental amnesia and episodic memory impairment (H.C.) was compared with groups of age-matched controls on tasks assessing their personality traits and social competence in the present, the past, and the future. H.C. and controls reported that their personality has changed more in the past five years than it will change in the next five years and rated their present selves as more socially competent than their past selves. The findings suggest that temporal self-appraisal does not require one to revisit experiences in episodic memory.

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Temporal Self-Appraisal in Developmental Amnesia

People tend to affirm their present self-regard by adjusting their view of themselves in the past (Wilson & Ross, 2003). According to temporal self-appraisal theory, they do so by evaluating themselves less favourably in the past, thereby inflating their self-worth in the present. In line with this theory, studies have shown that people erroneously tend to believe that their personality has changed more in a certain amount of time from the past to the present than it will change in the same amount time from the present to the future (Quoidbach, Gilbert, & Wilson, 2013). It has been suggested that both ends of this temporally based, self-serving bias may be influenced by one's autobiographical memories (i.e., memories related to personal facts and experiences; Quoidbach et al., 2013; Wilson & Ross, 2003). However, the relative contributions of episodic (i.e., the ability to mentally re-experience past events) and semantic (i.e., factual knowledge) components of autobiographical memory (Tulving, 1972) to temporal self-appraisal have not been formally tested. Specifically, it is unclear whether retrieval of past personal experiences that are specific to a time and place in episodic memory and/or personal semantic knowledge is necessary or sufficient to make reasonably consistent time-based judgments of the self. The current study investigates the contributions of episodic and semantic memory to temporal self-appraisal by testing H.C., an individual with developmental amnesia, on a series of temporal self-appraisal tasks. Individuals with developmental amnesia have profound lifelong impairment in episodic memory and relatively intact semantic memory. The findings may suggest a possible mechanism of the self-serving biases in temporal self-appraisal. If episodic memory is needed for temporal self-appraisal, H.C. should not show the same bias in temporal self-appraisal as healthy controls. However, if temporal self-appraisal can rely only on semantic memory, then H.C. should show the self-serving biases observed in controls.

Temporal Self-Appraisal

Temporal self-appraisal theory posits a bidirectional relationship between one's current self-identity and autobiographical memory (Wilson & Ross, 2003). Indeed, the way we appraise ourselves in the present influences the kind of memories we retrieve from the past (Wilson & Ross, 2003). For example, to inflate one's self-worth in the present, one would bring to mind more negative past memories to appraise one's present self as relatively superior to the past self. Conversely, memories of the past may influence our self-identity in the present (Wilson & Ross, 2003). For example, manipulation of one's subjective temporal distance (i.e., how close individuals feel to their past selves) leads to negative self-appraisals in the present if one's present self is perceived to be relatively close to a negative past experience. It follows that increasing the subjective temporal distance from past negative experiences leads to more positive self-appraisals in the present. According to temporal self-appraisal theory, subjective judgments of temporal distance, and not the objective distance (i.e., how long ago the event actually occurred), play an important role in one's self-appraisal in the present (Wilson & Ross, 2003). Findings supporting the temporal self-appraisal theory have been attributed to the malleability of memory, suggesting that we "reconstruct" the memory of our past selves in ways that make us feel good about ourselves in the present (Cameron, Wilson, & Ross, 2004). It has also been proposed that such memory biases could be creating an illusion of change (Conway & Ross, 1984). Although in this explanation of the memory bias, the researchers have not formally distinguished between different types of memory, the idea of reconstruction of the memory of our past selves suggests that the reference was likely to episodic memory.

Another related self-serving bias in self-appraisal is *the end of history illusion* (i.e., the belief that we have changed more in the past than we will change in the future; Quoidbach et al.,

2013). In that study, participants were randomly assigned to either reporter (i.e., describing themselves 10 years ago) or predictor (i.e., describing their predicted self 10 years from now) conditions. Both groups also provided their personality ratings in the present with the Ten Item Personality Inventory (Gosling, Rentfrow, & Swan, 2003). In a sample of 7519 adults, ranging in age from 18 to 68 years old, participants consistently reported a greater change in personality from past to present than they predicted to change from present to future (Quoidbach et al., 2013). As suggested by Quodibach et al., it is possible that the bias is associated with the difficulty of imagining future selves relative to remembering past selves. It is possible that when individuals have difficulty imagining themselves in the future it may erroneously lead them to believe that changes are unlikely. Case H.C. is a well-studied case of developmental amnesia, whose impairment in future imagining abilities is under debate (Hurley, Maguire, & Vargha-Khadem, 2011; Kwan et al., 2010). However, even if H.C.'s future imagining is indistinguishable from controls, it is superior to her episodic memory, a pattern that is unlike that of controls. If the end of history illusion depends on the relative difficulty of future imagining to episodic memory, we would not expect to observe this bias in H.C.

Autobiographical Memory and the Self

In memory research, there is a general distinction between episodic memory and semantic memory. When it comes to autobiographical memories, semantic autobiographical memory has been defined as a memory for personal facts (e.g., I live in Toronto; Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002). However, the distinction between episodic and semantic autobiographical memories is not always clear (Renoult, Davidson, Palombo, Moscovitch, & Levine, 2016). Recently, it was found that individuals with lesions to the medial temporal lobes (MTL) who have deficits in retrieving episodic memories also show deficits in

retrieving *experience-near* autobiographical facts that incorporate some spatiotemporal details about the events (e.g., my first child was born during a blizzard) relative to controls (Grilli & Verfaellie, 2016). In the same study, it was found that generation of *experience-far* autobiographical facts that do not contain spatiotemporal details (e.g., I have four siblings) was intact in patients whose lesions were restricted to the MTL. The findings of a recent ERP study suggest that the temporal component of self-knowledge (i.e., thinking of one's own characteristics in the past and in the future) may rely to some extent on one's capacity for mental time travel (Tanguay et al., 2018). Furthermore, the ERP results suggest that self-knowledge in the present (e.g., thinking to what extent a certain trait describes you in the present) shares more similarities with past and future self-knowledge (e.g., thinking to what extent a certain trait described you in the past or may describe you in the future) than with semantic knowledge (e.g., thinking to what extent a certain trait describes people of a certain occupation; Tanguay et al., 2018). The difference between self-knowledge and general semantic knowledge has also been noted in research focusing on the role of the self-reference effect in enhancing episodic memory in younger (Symons & Johnson, 1997) and older adults (Carson, Murphy, Moscovitch, & Rosenbaum, 2016).

One proposed framework for the study of the sense of self and autobiographical memory delineates sense of self along two dimensions: content of self (i.e., me-self) versus subjective sense of self (i.e., experience of selfhood), and present self versus temporally extended self (Prebble, Addis, & Tippett, 2013). According to the proposed model, temporal aspects of the content of self (e.g., rating one's traits during different lifetime periods) are supported by semanticized autobiographical memories that are essential for semantic continuity (Prebble et al., 2013).

In the Self Memory System (SMS) model of autobiographical memory, knowledge about the self is distinguished from the episodic memory system (Conway, Singer, & Tagini, 2004). However, the theory also posits a bidirectional relationship between the episodic memory system and one's knowledge of self, and that in order to maintain a stable and coherent view of the self, one relies on the episodic memory system (Conway et al., 2004). The model also suggests that retrieval of autobiographical memories relies on one's ability to integrate the knowledge of the self with episodic memories (Conway et al., 2004). The abundance of literature in different areas of psychology linking the self with episodic memory suggests that perhaps episodic memory plays an important role in one's self-appraisal. However, studies conducted in different groups of patients with brain lesions show mixed evidence regarding the role of episodic memory in one's self-knowledge.

Self-knowledge in Individuals with Memory Impairment

The idea that our memories make us who we are has inspired research into how individuals with memory impairments due to brain lesions or cognitive decline perceive themselves and their experiences over time. These findings also shed light on how self-knowledge is acquired and maintained in a neurotypical brain. After the onset of the disease, individuals with Alzheimer's (AD) undergo a substantial change in personality. For example, a person diagnosed with AD, K.R., was able to describe her premorbid personality but had difficulty updating her self-knowledge after disease onset (Klein, Cosmides, & Costabile, 2003). K.R. provided ratings of herself on a list of personality traits (e.g., "Does this word describe you: *Stubborn*? Yes or No"; Klein et al., 2003). Whereas the ratings were not significantly correlated with K.R.'s daughter's ratings of her mother in the present, K.R.'s ratings correlated significantly with her daughter's description of K.R.'s premorbid personality. A study of a group of 20

patients showed that individuals with AD tended to have a weaker, less concrete, and more negative sense of identity relative to controls (Addis & Tippett, 2004). Furthermore, significant correlations have been found between autobiographical memories (semantic and episodic) from childhood and early adulthood and the strength and quality of one's identity (Addis & Tippett, 2004). The findings from studies in AD patients suggest that perhaps certain aspects of self-knowledge (e.g., updating) are dependent on both episodic and semantic memory systems working together, which supports the idea put forward by the SMS model.

Other studies of self-knowledge in patients with memory impairments show that information about self is preserved even in individuals with profound deficits in episodic memory. Amnesic patients K.C. (Tulving, 1993) and D.B. (Klein, Rozendal, & Cosmides, 2002) were able to provide reasonably accurate ratings of their own personality traits. The patients' self-ratings on the lists of traits were strongly correlated with the ratings of the patients provided by their family members. These correlations were not significantly different from the correlations of self-ratings between the control group and their family members (Klein, Rozendal, et al., 2002; Tulving, 1993). Whereas individuals with deficits in both episodic and semantic memories (i.e., AD patients) have a weaker and more negative self-identity and are not able to update their self-knowledge, individuals whose deficits are restricted to episodic memory (i.e., individuals with hippocampal amnesia) are able to update their self-knowledge and provide relatively accurate self-ratings. However, even patients with impaired episodic memory but seemingly intact semantic memory show deficits in certain aspects of self-concept. A recent study of individuals with hippocampal amnesia investigated the extent to which the self-concept is supported by autobiographical memory (Grilli & Verfaellie, 2015). Eight amnesic patients and 12 controls completed eight "I am___" statements. Participants were asked to support their top

four statements with a narrative describing why they chose to describe themselves using those words (Grilli & Verfaellie, 2015). It was found that both groups mostly relied on their semantic memory to provide the self-supporting information, but amnesic patients generated fewer of the semantic memories than controls. The study also found that amnesic patients were less likely to include traits in their top four 'I am' statements, which could be due to their deficit in generating the trait-supporting semantic memories (Grilli & Verfaellie, 2015). The findings suggest the need to look beyond the self-ratings of personality in the present and investigate more detailed aspects of self-concept.

Self-knowledge was also tested in two patients with developmental amnesia (Picard et al., 2013). Whereas in adult-onset amnesia, patients could have developed a self-concept by relying on their pre-morbid episodic and semantic memories, individuals with developmental amnesia never develop typical episodic memory and acquired semantic memory in its relative absence. It was found that individuals with developmental amnesia were able to develop a multidimensional and coherent self-concept that was generally not significantly different from controls' (Picard et al., 2013). In the same study, it was also found that individuals with developmental amnesia tended to have a slightly more positive self-concept than neurotypical controls. Given a life-long deficit in episodic memory in this population, the ability to reflect on one's own personality in the past and the change in their personality over time need to be explored in order to better understand the role of episodic memory in one's self-knowledge. It has been argued that conceptual self-knowledge does not only involve the evaluation of self in the present but also involves evaluations of self in the past and the future (Markus & Nurius, 1986). On the other hand, studies in healthy individuals showed that present and past self-knowledge are associated with different patterns of brain activity (D'Argembeau et al., 2008). Therefore, it is unclear

whether individuals with developmental amnesia retain their temporal self-appraisal abilities in addition to their intact self-knowledge in the present.

If both past and future self-knowledge rely only on semantic memory, it is possible that, similar to other semantic knowledge (Gardiner, Brandt, Baddeley, Vargha-Khadem, & Mishkin, 2008), the actual personality change in individuals with developmental amnesia takes longer to update than in healthy controls. Alternatively, the self-concept may also be less stable because of the potential difficulty in accessing trait-supporting semantic knowledge.

Since the temporal self-appraisal theory highlights the role of one's subjective judgment of temporal distance in their self-appraisal, it is important to consider the performance of individuals with MTL on tasks involving temporal judgments and time perception. Hippocampal sensitivity to time perception has been well-established in the literature (Barnett, O'Neil, Watson, & Lee, 2014; Kraus, Robinson, White, Eichenbaum, & Hasselmo, 2012; MacDonald, Lepage, Eden, & Eichenbaum, 2011; Nichelli, Venneri, Molinari, Tavani, & Grafman, 1993). Individuals with MTL lesions showed impairments in estimating the duration of long (more than 4 min), but not short (less than 90 s) stimuli (Palombo, Keane, Verfaellie, 2016).

Imagining a Future Self

The ability to predict how one might change in the future may rely on one's ability to imagine the future. There are substantial similarities between retrieving past episodic memories and imagining potential future events that have not yet occurred as indicated by patient studies showing impaired episodic memory and future imagining in individuals with adult-onset amnesia (Andelman, Hoofien, Goldberg, Aizenstein, & Neufeld, 2010; Hassabis, Kumaran, Vann, & Maguire, 2007; Klein, Loftus, & Kihlstrom, 2002; Race, Keane, & Verfaellie, 2011) and neuroimaging studies showing that the two abilities activate a common network of brain regions

(Addis & Schacter, 2008; Addis, Wong, & Schacter, 2007; Buckner & Carroll, 2007; Kirwan, Ashby, & Nash, 2014; Spreng, Stevens, Chamberlain, Gilmore, & Schacter, 2010). Nevertheless, there are also key differences between the two processes. Past research suggests that imagining the future is more effortful and requires more cognitive resources than remembering the past (Addis, Wong, & Schacter, 2007). One possible explanation for the end of history illusion proposed by Quodibach et al. (2013) is that because imagining yourself in the future is a more effortful task than remembering yourself in the past, people think that they are not likely to change in the future. In individuals with developmental amnesia, the findings are mixed with regard to their ability to imagine the future (cf. Cooper, Vargha-Khadem, Gadian, & Maguire, 2011; Hurley et al., 2011; Kwan et al., 2010). Whereas one study found that amnesic case H.C. showed deficits in imagining future events (Kwan et al., 2010), a separate study showed that she was able to generate future scenarios (Hurley et al., 2011). The difference in the findings could be attributed to a practice effect in that, over repeated test sessions involving narrative construction tasks, H.C. had adjusted her strategy to maximize the number of generated details (Rabin, Carson, Gilboa, Stuss, & Rosenbaum, 2013). Even if individuals with developmental amnesia are able to imagine themselves in the future but are impaired in remembering themselves in the past, they would be expected to show the opposite of the end of history illusion (i.e., predicting to change more from present to future than reporting to have changed from past to present).

The purpose of the current research was to investigate the role of the episodic memory in supporting past, present, and future self-knowledge. This research also investigated whether the self-serving biases that allow us to see ourselves favourably in the present are preserved in individuals with developmental amnesia despite compromised episodic memory. Although

previous research shows that individuals with developmental and acquired amnesia are able to develop and update their personality, research to date has not assessed biases in past- and future-oriented view of the self that are typical of adults across lifespan. In order to answer these questions, an individual with developmental amnesia was tested on two temporal self-appraisal tasks: providing self-ratings of the Big Five personality traits and self-ratings social competence associated with past, present, and future time periods. Given a well-established life-long deficit in episodic memory, we speculate that any preserved form of self-knowledge in H.C. was acquired and maintained by relying on her semantic memories.

In Experiment 1, we compared case H.C. with a small group of age- and education - matched controls on two temporal self-appraisal tasks. In Experiment 2, we compared case H.C.'s performance to that of a separate, larger group of controls (all female), some of whom were matched to H.C. on the level of self-esteem, as this has been shown to influence temporal self-appraisal (Ross & Wilson, 2002). The larger control group allowed for an additional examination of the relationship between episodic memory and past self-appraisal, and between future imagining and future self-appraisal. Case H.C. was tested separately for each experiment. The test sessions were spaced six months apart to further ensure the reliability of findings in a single case.

Experiment 1

Method

Participants. H.C. is a 30-year-old woman with developmental amnesia. She was born prematurely and believed to have suffered respiratory distress soon after birth. She completed high school, 2 years of college (i.e., 14 years of education), and has successfully held several jobs. Whereas H.C.'s total brain volume (1270.83 cm^2) is not appreciably different from that of

controls, neuroimaging results showed that she has a reduced hippocampal volume of 29.5% on the left and 31.2% on the right (Olsen et al., 2013). Detailed analysis of H.C.'s MTL and surrounding structures showed a complete absence of the mammillary bodies and the bilateral thinning of the anterior fornix, along with malrotated hippocampi, suggestive of a congenital origin to her atypically developed hippocampal memory system (Rosenbaum et al., 2014). Similar to other cases of developmental amnesia, H.C. has impaired episodic memory and relatively intact semantic memory (Rosenbaum et al., 2011; but see Blumenthal et al., 2017). Her memory retrieval has been shown to benefit from repetition when the items are spaced instead of being presented in immediate succession (Green et al., 2014; Kim, Saberi, Wiseheart, & Rosenbaum, 2018). H.C. showed impaired memory for public events (Rosenbaum et al., 2011), imagining close others' experiences (Rabin et al., 2013), and working memory for previously unfamiliar words (Rose et al., 2012). In contrast, her working memory for famous faces and familiar words was found to be intact (Rose et al., 2012), as was her theory of mind (Rabin et al., 2013), ability to imagine unfamiliar people's experiences (Rabin et al., 2013), and future-oriented decision-making on tests of intertemporal choice (Kwan et al., 2013).

Although it appears that ratings of self-concept are intact in individuals with developmental amnesia, there is cursory evidence to suggest that H.C.'s self-description in the present may be impaired (unpublished data). When asked to describe herself in a paragraph, H.C. provided a relatively impoverished description of herself, mentioning only general characteristics (e.g., friendly, loyal) without providing any contextual information. In the current study, we wanted to formally investigate H.C.'s self-knowledge in the present, as well as to her self-appraisal in the past and in the future.

A group of 24 (18 female) age-matched (M = 28.30, SD = 2.79) controls with no known history of neurological or psychiatric illness was recruited for the study from the participant pools at the Rotman Research Institute and York University. The control group had on average 16.48 years of education (SD = 2.27). Participants signed informed consent forms and either received course credit or monetary compensation for participating in the study in accordance with the ethics boards of Baycrest Health Sciences and York University.

Measures and procedure. Testing was conducted in the laboratory, using paper-and-pencil versions of the questionnaires. Participants completed the questionnaires in the order presented below.

The end of history illusion. Participants were asked to rate their personality on the Ten Item Personality Inventory (TIPI; Gosling, Rentfrow, & Swann, 2003), a 10-item measure of the Big Five personality traits (i.e., conscientiousness, agreeableness, emotional stability, openness to experience, and extraversion). Participants were asked to rate how strongly they agree or disagree with each statement on a 7-point scale from 1 (strongly disagree) to 7 (strongly agree). Similar to the procedures described in Quadibach et al. (2013), participants were asked to complete the measure three times, rating their personality in the present, 5 years ago, and 5 years from now. The order of time periods was randomized for all participants. We calculated the total of absolute values of change for all of the Big Five traits in the past five years (i.e., the absolute difference between ratings in the present and five years ago), as well as in the next five years (i.e., the absolute difference between ratings in the present and five years from now).

Temporal self-appraisal. Participants were asked to rate their social competence during two past life periods: elementary school and high school (Ross & Wilson, 2002). For each time period, participants were asked to rate themselves on 11 attributes (e.g., popular, lonely) on a

semantic differential scale from 1 (unpopular) to 7 (popular). Participants were then asked to rate the pleasantness of their social experiences during that time period on a scale from -5 (very unpleasant) to +5 (very pleasant). Participants indicated the subjective distance of their current self from their past self by placing marks on two 190-mm lines. The responses on the first line range from 0 (feel very close to my past self) to 190 (feel very distant from my past self). The responses on the second line range from 0 (my past self feels very near) to 190 (my past self feels far away). Lastly, participants were asked to report how long ago it has really been since the last year of elementary school and high school. Participants then rated themselves on the same attributes in the present as well as how they imagined they would rate themselves on these attributes 5 years from now and 10 years from now.

Results

The composite variables of the Big Five (i.e., emotional stability, extraversion, openness, agreeableness, and conscientiousness) [1] were constructed for the past, present, and future time periods. The absolute differences in each trait between past and present, and between present and future were summed together to obtain the reported change in the past five years and predicted change in the next five year. The control group reported having changed more in the past five years (M = 13.54, SD = 6.39) than predicting to change in the next five years (M = 9.54, SD = 2.92), $t(23) = 3.01$, $p = .006$, 95% CI [1.25, 6.75]. Case H.C. showed a similar pattern of results

[1] TIPI has been shown to have somewhat inferior Cronbach's alpha relative to larger measures of the Big Five. It has been pointed out that alphas may be not be an informative measure of internal consistency in scales with small number of items (Kline, 2000; Wood & Hampton, 2005). TIPI has shown adequate levels of: 1) convergence with widely used Big-Five measures in self, observer, and peer reports; 2) test-retest reliability; 3) patterns of predicted external correlates; and 4) convergence between self and observer ratings (Gosling et al., 2003).

(see Figure 1), reporting having changed more in the past five years (absolute difference in scores = 17) than she is predicting to change in the next five years (absolute difference in scores = 4). Crawford's t-test for single case studies (Crawford & Howell, 1998) showed no significant differences between the absolute values of change in the past five years and the next five years between controls and H.C., $t(23) = 1.35$, $p = .189$.

The scale of social competence showed high internal consistency for all time periods: elementary school ($\alpha = .91$), high school ($\alpha = .91$), present ($\alpha = .85$), 5 years from now ($\alpha = .85$), and 10 years from now ($\alpha = .85$). Repeated measures ANOVA indicated significant differences in self-appraisal in the control group across the time periods, $F(4, 96) = 5.55$, $p < .001$. Post hoc comparisons using the Tukey HSD test indicated that the mean self-appraisal in elementary school ($M = 4.45$, $SD = 1.34$) is significantly lower than in the present ($M = 5.06$, $SD = 0.95$), $p = .048$, five years from now ($M = 5.36$, $SD = 0.82$), $p < .001$, and 10 years from now ($M = 5.28$, $SD = 0.91$), $p = .002$. No differences in self-appraisal were observed between other time periods in the control group. H.C. showed a different pattern of results (see Figure 2); specifically her change in self-appraisal from high school to present was significantly different from that of controls, $t(23) = 2.37$, $p = .027$. Results of judgment of temporal distance are presented in Table 1. No significant differences were found between H.C. and the control group.

Experiment 2

Experiment 1 revealed no significant differences between H.C. and controls on the end of history illusion task, suggesting that past and future self-appraisal of personality does not require one to construct past or future episodes of oneself in context. The measure of social competence did not show the expected results in the group of control participants, such that participants did not evaluate themselves more positively in the present than in the final year of high school.

Previous research indicates that self-esteem is one of the moderators of temporal self-appraisal (Ross & Wilson, 2002). The purpose of Experiment 2 was to replicate the findings of Experiment 1 in a larger control group to obtain a subset of controls who match H.C.'s level of self-esteem, and to assess whether episodic memory and future imagining predict temporal self-appraisal biases in the sample of controls. Doing so also allowed us to establish consistency in H.C.'s responses by examining test-retest correlations.

Method

Participants. The sample size was determined a priori by conducting a power analysis in G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) with two groups, five measurements, $\alpha = .05$, a medium ES $f = .25$, and 80% power, $N = 78$. We oversampled and recruited 102 participants in order to be able to eliminate random responders, as well as to have a large enough subset of participants with the same level of self-esteem as case H.C. Two participants were removed from the analysis based on the conscientious responder scale (Marjanovic, Struthers, Cribbie, & Greenglass, 2014). The total sample of controls used for the analysis was composed of 100 (98 female) age-matched ($M = 31.68$, $SD = 2.96$) participants with no known history of neurological or psychiatric illness, recruited online via Prolific (www.prolific.ac). The control group had on average 16.24 years of education ($SD = 2.78$).

Measures. All of the measures used in Experiment 1 were used in Experiment 2. We also included questionnaires to assess ratings of episodic memory, future imagining, and related abilities, and self-esteem.

The Survey of Autobiographical Memory (SAM), a 26-item self-report inventory, was used to assess participants' naturalistic autobiographical memory (Palombo, Williams, Abdi, & Levine, 2013). The SAM is composed of four subscales: episodic memory (e.g., *When I*

remember events, I have a hard time determining the order of details of the event.), semantic memory (e.g., *I can easily remember names of famous people.*), spatial memory (e.g., *After I have visited an area, it is easy for me to find my way around the second time I visit.*), and future imagining (e.g., *When I imagine an event in the future, the event generates vivid mental images that are specific in time and place*.). Participants rated their agreement with each statement on a scale from 1 (strongly disagree) to 5 (strongly agree).

Participants' self-esteem was assessed with the Rosenberg Self-Esteem Scale (RSES)**,** a 10-item scale (e.g., *I certainly feel useless at times*) measuring both positive and negative feelings about the self (Rosenberg, 1965). All items were answered on a 4-point scale, with responses ranging from 0 (strongly disagree) to 3 (strongly agree). Five items were reverse scored.

We used the 5-item Conscientious Responder Scale (e.g., To answer this question, please choose option three, "neither agree nor disagree"; Marjanovic et al., 2014) to identify random responders.

Procedure. Participants accessed the study online via Qualtrics. After signing the informed consent form and agreeing to participate in the study, participants completed the questionnaires in the following order: RSES, TIPI, SAM, and the social competence questionnaire. The order of presentation of past, present, and future time periods for the TIPI and social competence questionnaire was randomized. The items of the Conscientious Responder Scale were randomly distributed throughout the survey. H.C. also took the survey online six months after she participated in the paper-and-pencil version of the task in Experiment 1. Participants received monetary compensation for participating in the study in accordance with the ethics boards of Baycrest Health Sciences and York University.

Results

First, we analyzed the results of the TIPI. Absolute values of difference between the present and the past five years, and between the present and the next five years were calculated by adding together absolute differences in ratings for each trait (e.g., agreeableness) between past and present, and future and present respectively. The control group, on average, reported having changed more in the past five years (M = 9.36, SD = 5.49) than expecting to change in the next five years (M = 7.60, SD = 4.51), $t(99) = 3.21$, $p < .001$, 95% CI [0.67, 2.85]. Regression analysis showed that the order of presentation of time periods (i.e., past, present, and future) had no effect on the results, $F(5,94) = 2.18$, $p = .062$, $R^2 = 0.10$. H.C.'s results strongly correlated with her responses 6 months ago (reported in Experiment 1), $r = .81$, $p < .001$. Similar to controls, H.C. reported having changed more in the past five years (absolute difference = 14) than expecting to change in the next five years (absolute difference = 4). Crawford's t-test showed no differences between H.C. and the control group, $t(99) = 1.49$, $p = .138$. We then ran analysis to determine whether episodic memory predicted the reported change in personality in the past five years, and whether future imagining predicted the expected change in the next five years in the control sample. Both, episodic memory and future imagining subscales of the SAM, showed high internal consistency, α = .86 and α = .81 respectively. In the control group, episodic memory did not predict the difference between the ratings of self in the past and the present, $\hat{\beta}$ = -0.07, SE = 0.04, $p = .068$. Similarly, future imagining scores did not predict the difference between the ratings of self in the future and the present, $\hat{\beta}$ = -0.002, SE = 0.04, $p = .961$.

Analysis of the social competence scale showed high internal consistency for each time period in the control group: elementary school (α = .94), high school (α = .96), the present (α = .89), 5 years from now (α = .90), and 10 years from now (α = .90). The order of presentation of

the time periods had no significant effect on the pattern of self-appraisal, $\chi^2(20) = 17.32$, $p = .632$. RSES showed high internal consistency ($\alpha = .89$). We used R package lme4 (Bates, Maechler & Bolker, 2012) to perform a linear mixed effects analysis to test whether the relationship between participants' ratings of social competence across time periods is moderated by the participants' self-esteem (see Table 2). Time period, self-esteem, and their interaction were entered as fixed effects in the model. We included subject as random intercept in the model. A likelihood ratio test comparing the full model with the interaction term against the null model without the interaction showed that self-appraisal across different time periods is moderated by self-esteem, $\chi^2(4) = 9.82$, $p = .044$. Analysis of simple slopes showed that individuals with higher self-esteem tended to appraise themselves more positively in the present, $\hat{\beta} = 0.10$, $SE = 0.02$, $t(242.68) = 4.35$, $p < .001$. Individuals with higher self-esteem also tended to appraise themselves more positively in high school, $\hat{\beta} = 0.05$, $SE = 0.02$, $t(242.68) = 2.08$, $p = .038$, but not in elementary school, $\hat{\beta} = 0.04$, $SE = 0.02$, $t(242.68) = 1.57$, $p = .117$. Each additional unit of self-esteem was also associated with significantly more positive self-appraisal 5 years from now, $\hat{\beta} = 0.08$, $SE = 0.02$, $t(242.68) = 3.41$, $p < .001$, and 10 years from now, $\hat{\beta} = 0.06$, $SE = 0.02$, $t(242.68) = 2.61$, $p = .009$. The results of the regression model suggest that it is necessary to control for the level of self-esteem in comparing temporal self-appraisal between H.C. and controls. H.C. scored high on the measure of self-esteem (28 out of 30). She previously also scored high (29 out of 30) on this measure about 6 months ago, suggesting high test-retest reliability. Controls ranged on the self-esteem scores from 5 to 29 ($M = 19.06$, $SD = 4.91$). We selected a subset of individuals with high self-esteem by including those with self-esteem scores

higher or equal to 21[2]. The high self-esteem subset was composed of 36 participants with an average age of 32.08 (*SD* = 3.09), an average education of 16.36 years (*SD* = 2.52), and an average self-esteem rating of 23.86 (*SD* = 2.52). Regression analysis showed that in the high self-esteem group, participants tended to rate themselves more negatively in elementary school, $\hat{\beta}$ = -0.32, *SE* = 0.16, *t*(140) = -1.99, *p* = .048, and in high school, $\hat{\beta}$ = -0.38, *SE* = 0.16, *t*(140) = -2.32, *p* = .022, than in the present. The self-ratings between the present and five years from now, and between the present and 10 years from now did not show significant differences, *t*(140) = 1.39, *p* = .168 and *t*(140) = 1.69, *p* = .093. Crawford's t-test showed no significant differences in the changes in self-appraisal from high school to present between H.C. and controls, *t*(35) = 1.53, *p* = .134. H.C.'s results strongly correlated with her responses on this task 6 months ago (reported in Experiment 1), *r* = .97, *p* < .001.

Based on SAM, controls reported that, on average, they are better at remembering the past (*M* = 132.93, *SD* = 57.95) than imagining the future (*M* = 126.45, *SD* = 48.47), *t*(99) = 4.96, *p* < .001, 95% CI [4.54, 10.59]. On the other hand, H.C. reported being better at imagining the future (94.32) than remembering the past (80.27). Lastly, we ran a regression analysis to estimate whether episodic memory and future imagining moderated the relationship between time periods and self-appraisal in controls. A 1-unit increase in episodic memory score was associated with $\hat{\beta}$ = 0.02 increase in self-appraisal in the present, *SE* = 0.01, *t*(85) = 3.54, *p* < .001. However, episodic memory did not moderate the relationship between time and self-appraisal, $\chi^2(4)$ = 4.75, *p* = .314. The future imagining subscale of the SAM did not moderate the relationship

[2] The self-esteem scores were approximately normally distributed, with the mean of 19.06 (*SD* = 4.91) and the median of 20.

between time and self-appraisal, $\chi^2(4) = 3.73$, $p = .445$. Controlling for objective distance, participants felt significantly closer to their future selves 10 years from now than back in high school, which was on average 14.47 years ago ($SD = 3.81$), $\hat{\beta} = -22.39$, $SE = 7.49$, $t(197) = -2.99$, $p = .003$. H.C.'s ratings of subjective temporal distance were not significantly different from that of controls for high school, $t(35) = 0.54$, $p = .593$, and for 10 years from now, $t(35) = -1.76$, $p = .09$.

Discussion

To determine contributions of episodic memory to biases in temporal self-appraisal, a person with impaired episodic memory was compared to controls in two experiments that used different measures (personality and social competence), samples (student and non-student), and contexts (laboratory, online). The second experiment also investigated whether episodic memory and future imagining could statistically explain the variability in temporal self-appraisal in the control group. We found that controls and H.C. showed typical self-appraisal biases when thinking about their past and future selves, such that they reported having changed more in the past five years than they expected to change in the next five years and rating themselves more positively in the present than in the past time periods. These biases were present despite impaired episodic memory in H.C., and they were not predicted by ratings of episodic memory or future imagining ability in controls. The results indicate that episodic memory and future imagining are unlikely to form the basis of the end of history illusion and time-based biases in social competence. The findings also contribute to cognitive explanations of the temporal self-appraisal theory in particular, and the theoretical link between autobiographical memory and self-identity more generally.

Possible Explanations of Temporal Self-Appraisal

It has been previously suggested that the biases in temporal self-appraisal could be explained by a relative difficulty of imagining the future compared to remembering the past (Quoidbach et al., 2013), memory bias (Cameron et al., 2004; Conway & Ross, 1984), and subjective temporal distance (Ross & Wilson, 2002). The current research explored these previously offered explanations for the temporal self-appraisal biases.

Previous research suggests that the end of history illusion could be explained by a relative difficulty in imagining the future compared to remembering the past (Quoidbach et al., 2013). However, in Experiment 2, future imagining scores did not predict controls' differences between the present and the future self-appraisal and episodic memory did not predict the difference between the past and the present self-appraisal. Similarly, H.C. has established difficulties remembering details of past events in episodic memory, whereas her future imagining is at least better than her episodic memory (Kwan et al., 2010) and possibly intact (Hurley et al., 2011), reflected in her current self-ratings of better future imagining ability than episodic memory. Yet, she, too, showed typical biases in thinking about the self from the past to present vs. present to future. If the reduced anticipated change in the future could be explained by one's difficulties in imagining the future, we would expect H.C. to show the opposite of the end of history illusion (i.e., reporting having changed less in the past five years than expecting to change in the next five years). These findings rule out the possibility that the end of history illusion is explained by greater difficulty imagining the future than remembering the past.

It has been previously proposed that an "illusion of change" in self-appraisal from the past to the present might be explained by a memory bias in people's reconstructions of past selves (Conway & Ross, 1984). In line with this idea, a presentism hypothesis suggests that people tend to reconstruct and interpret their past on the basis of their present knowledge and

motives (Cameron et al., 2004). The findings from the current research suggest that temporal self-appraisal does not require one to "reconstruct" the past self. Although individuals with episodic amnesia may retain their narrative construction abilities, provided that the relevant details of the story are available to them (Keven, Kurczek, Rosenbaum, & Craver, 2018, but see Race et al., 2011, 2015), their deficits in constructing past and future personal episodes are well-established (Hassabis et al., 2007; Schacter & Addis, 2007, Schacter et al., 2007). It is possible that H.C. was using the details from her life in the present as a prototype to construct a slightly more negative version of herself in the past. However, we view this explanation as unlikely because H.C.'s self-appraisal scores relating to the past time periods only weakly to moderately correlated with her self-appraisal in the present, yet, her self-appraisal in the past was strongly correlated between the two testing sessions that took place six months apart from each other.

According to temporal self-appraisal theory, temporal self-appraisal could be explained by one's subjective judgments of temporal distance (i.e., ratings of how far one feels from his or her past and future; Cameron et al., 2004; Ross & Wilson, 2002). In the current research, we did not find a significant relationship between subjective judgments of temporal distance and temporal self-appraisal. It is possible that given the moderating relationship with self-esteem, our high self-esteem subset was not large enough to detect the relationship. It was also found that H.C. was not different from controls in her subjective judgments of distance. This finding is consistent with the temporal self-appraisal theory because H.C. also showed an intact temporal self-appraisal bias. However, the finding contradicts the argument for memory bias proposed by the temporal self-appraisal theory (Cameron et al., 2004). If subjective judgment of temporal distance and temporal self-appraisal were supported by the episodic memory system, we would expect H.C.'s judgments to be systematically different from that of controls.

An alternative possibility is that H.C.'s self-ratings are inconsistent in light of her deficit in episodic memory. Given that H.C. does not rely on specific memories when providing self-ratings, we had to consider the possibility that her ratings are less stable over time and perhaps depend on her state when making those ratings. H.C. was tested on both tasks on two separate occasions spaced 6 months apart, and her ratings nevertheless were found to be highly correlated with each other. The results suggest that H.C. has a consistent sense of self and a stable idea of what she is like as a person. This finding contradicts the assumptions of the SMS model (Conway et al., 2004) that the episodic memory system and one's self-knowledge need to work together to maintain a stable and coherent view of self.

The Role of Self-Esteem in Temporal Self-Appraisal

In line with previous temporal self-appraisal finding (Ross & Wilson, 2003), controls rated themselves more negatively on the social competence scale in the past (i.e., elementary school and high school) relative to their self-ratings in the present. We also found that self-esteem moderated the pattern of temporal self-appraisal in the control group, further supporting the temporal self-appraisal theory. Moreover, we found that H.C.'s temporal self-appraisal pattern did not differ from that of a subset of controls who were matched to H.C. in terms of level of self-esteem. Although not significantly different from controls, H.C.'s greater difference in self-appraisal between high school and present could be explained by her very high self-esteem score. It is possible that in order to protect her high self-esteem in the present, H.C. may need to feel greater improvement in her social competence over time. Furthermore, in Experiment 2, episodic memory and future imagining did not predict the pattern of temporal self-appraisal in the control group. The findings suggest that temporal self-appraisal does not require one to conjure up specific memories or images of self in order to evaluate oneself in the present,

past, or future. The current results are consistent with the findings of other studies showing intact self-knowledge in individuals with MTL lesions (e.g., Klein et al., 2002; Picard et al., 2013; Tulving, 1993). The findings extend previous research by showing that individuals with MTL lesions not only are able to describe themselves in the present, but also retain their abilities think about their personality traits in the past and the future. Whereas previous research showed that individuals with acquired amnesia (Klein et al., 2002, Tulving, 1993) and developmental amnesia (Picard et al., 2013) may develop reasonably accurate self-knowledge in the present, our results suggest that they may also retain the ability to think about their personality and social competence in the past and in the future. Unlike individuals with acquired amnesia, who may rely on their episodic memory pre-injury, individuals with developmental amnesia never experienced normal episodic memory. Therefore, the findings in H.C. provide a strong basis for the argument of the lack of engagement of episodic memory in temporal self-appraisal.

Neural Underpinnings of Time-Based Judgments of Self

The findings suggest that one's temporal self-appraisal does not rely on the function of the MTL, but instead could be supported by other brain regions. A possible candidate is ventromedial prefrontal cortex (vmPFC). In a study of a group of individuals with a range of neurodegenerative conditions, present self-appraisal accuracy was correlated with the tissue content in the right vmPFC (Rosen et al., 2010). Several other studies investigated the role of vmPFC in self-appraisal (D'Argembeau, 2013; Kim & Johnson, 2015; Verfaellie, Wank, Reid, Race, & Keane, 2019). There is general agreement in the findings, such that vmPFC does not support self-reflection per se, but, rather, is involved in attributing personal value or personal significance to the processed information (D'Argembeau, 2013; Kim & Johnson, 2015). In a recent study investigating distinct contributions of vmPFC and MTL to self-related processing,

individuals with vmPFC lesions did not show differences in constructing future scenarios involving self or another person (Verfaellie et al., 2019). On the other hand, individuals with MTL lesions performed relatively better in the self condition than in another person condition (Verfaellie et al., 2019). The findings show the important role of vmPFC in the processing of self-relevant information. Furthermore, previous research shows that vmPFC has two schema-dependent functions: establishing context-relevant templates and mediating decision monitoring processes to ensure that only responses compatible with the template are enacted (Gilboa & Moscovitch, 2017). In line with this theory, studies of vmPFC patients found a reduced influence of schematic memory on recognition relative to neurotypical controls (Ghosh, Moscovitch, Colella, Gilboa, 2014; Spalding, Jones, Duff, Tranel, & Warren, 2015). Therefore, it is possible that H.C.'s temporal self-appraisal is supported by her relatively intact self-schema that reflects abstracted commonalities in self across multiple experiences during different life periods (e.g., feeling constantly rejected by peers in high school).

Different Types of Self-Knowledge

The results suggest the importance of distinguishing between different types of self-knowledge. Whereas H.C.'s temporal sense of personality and what she is like socially appear to be consistent and intact, there may be aspects of self-appraisal that are impaired due to her lack of rich episodic memories. For example, when H.C. was asked to describe herself in her own words, the description was very impoverished. Although her ratings of self are consistent, it seems difficult for her to contextualize her traits and characteristics. When neurotypical adults were asked to describe themselves, even in very concise descriptions of self, participants tended to contextualize their traits (e.g., "introverted, especially in new situations", "I like quiet time, especially in natural environments", "I enjoy arts, particularly visual arts"). This type of

contextual information likely relies on participants' ability to recall specific events in which they were personally involved in the past and remember how they demonstrated their traits in those situations. This observation is consistent with work showing that individuals with MTL lesions experience deficits in generating episodic-near autobiographical facts that could provide spatiotemporal context to their narratives (Grilli & Verfaellie, 2016). It also supports the proposition made by the Pebble et al. (2013) model that abstract conceptual self-knowledge does not rely on the episodic memory system, but that episodic memory may enhance a more nuanced self-understanding by providing the necessary detail. The two self-appraisal tasks used here involved a different degree of abstraction. The Big Five personality questionnaire required participants to think about themselves more abstractly without necessarily having to recall specific examples of when they exhibited personality traits from episodic memory. The social competence questionnaire required participants to rate themselves in more specific social contexts (i.e., elementary school, high school) in the past, but again, this task did not require participants to retrieve memories from a specific time and place in order to generate the self-ratings. Whereas the self-competence task was more contextualized than the personality appraisal task, neither task required participants to generate concrete details of their personality.

Forms of Future Thinking

There is currently no agreement with regard to H.C.'s ability to imagine the future. If it is the case that H.C.'s future imagining is somewhat compromised, there are other forms of future thinking that remain intact, such as intertemporal choice (i.e., future-oriented decision-making). One way of investigating episodic memory contributions to other forms of future-oriented thinking would be to assess her performance on tests of temporal construal (i.e., the extent to which people's thinking is abstract or concrete; Liberman & Trope, 1998). The judgments of

temporal distance have also been shown to play an important role in temporal construal, with temporally near events represented in a concrete way (e.g., thinking of locking the door as putting a key in the lock) and temporally distant events represented in a more abstract way (e.g., locking the door as a means of securing the house; Liberman & Trope, 1998). Considering that no differences in the judgments of subjective temporal distance were found between H.C. and controls, it is reasonable to expect that episodic memory does not support temporal construal.

Conclusion

In two experiments, it was found that biases in one's temporal self-knowledge are not supported by one's episodic memory and future imagining. This research replicated previous research on temporal self-appraisal, showing that people tend to disparage their past selves in order to maintain positive self-esteem in the present. The end of history illusion was also replicated in this research, showing that individuals tend to report having changed more in a certain amount of time in the past than they anticipate changing in the same amount of time in the future. No significant relationship was found between subjective judgments of temporal distance and temporal self-appraisal. However, both H.C. and controls reported feeling closer to their future selves than to their past selves, which could potentially explain the end of history illusion. The findings suggest that temporal self-appraisal is not supported by one's episodic memory but, instead, might be supported by a personal schema that emerges from multiple experiences over time.

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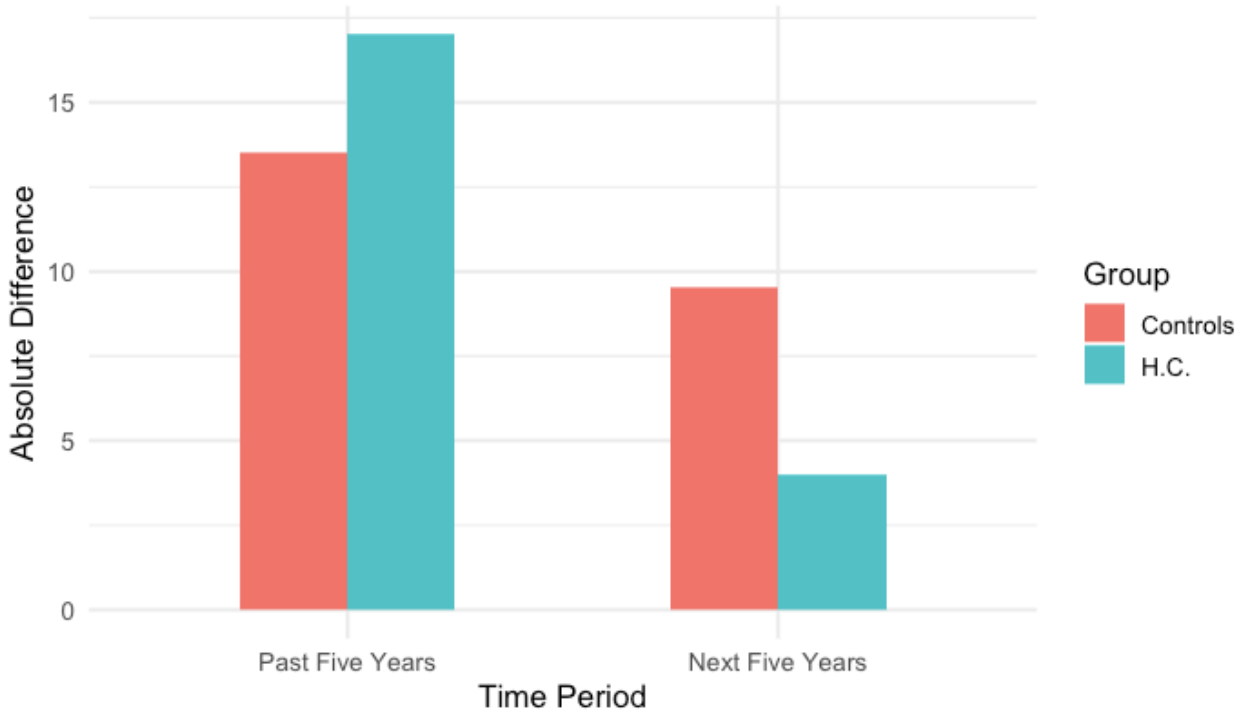

Figure 1. Reported and predicted personality change in controls and H.C. between the present and the past five years and the present and five years from now.

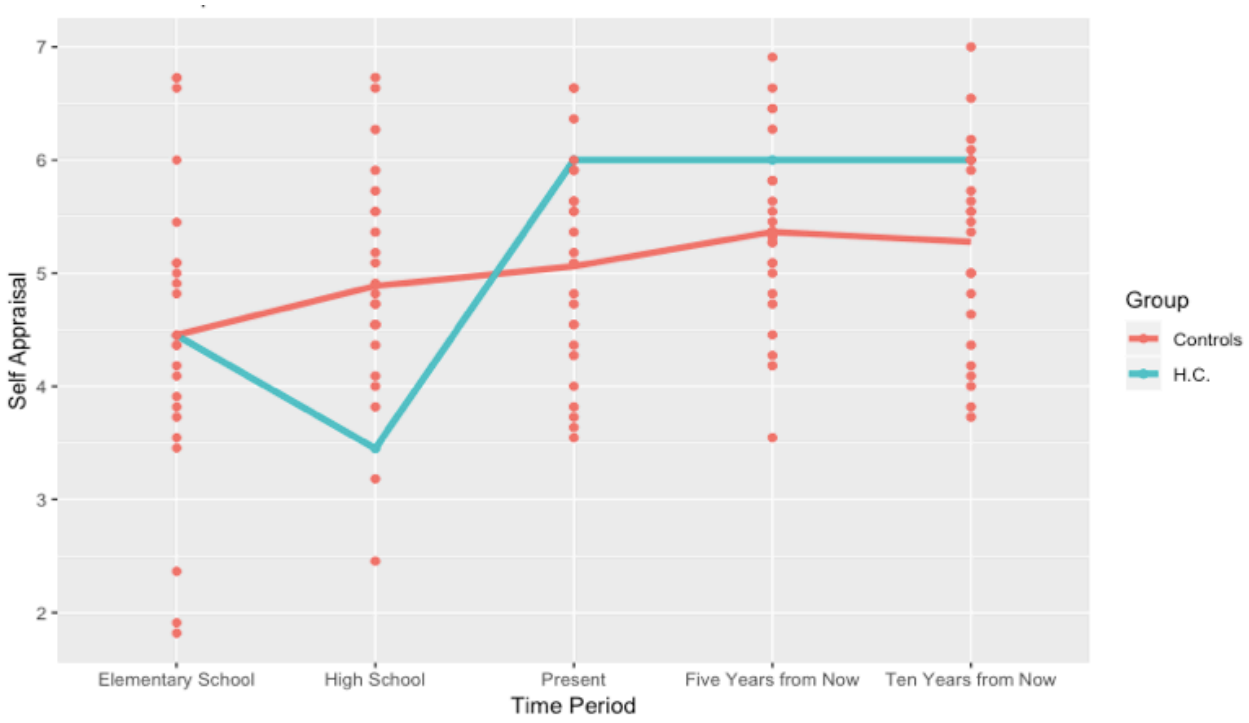

Figure 2. Social competence in H.C. and controls (Experiment 1) across five time periods (elementary school, high school, present, five years from now, and ten years from now), with higher scores reflecting a more positive self-appraisal.

Table 1. Results of the Crawford t-tests, comparing the judgments of subjective temporal distance between H.C. and controls across past and future time periods.

	Controls		H.C.		
Measure	*M*	*SD*		*t*(23)	*p*
Objective Temporal Distance					
Elementary School	16.65	3.52	18		
High School	10.91	3.19	12		
Subjective Temporal Distance					
Elementary School	110.92	50.70	128	0.33	.744
High School	105.12	48.73	148	0.86	.398
Five Years from Now	70.46	39.32	46	-0.61	.548
Ten Years from Now	94.5	45.60	50	-0.96	.349

Table 2. Model with Self-Appraisal Regressed on Time Period and Self-Esteem

	Self-appraisal		
Fixed Effects	$\hat{\beta}$	*SE*	*t*
Intercept	2.581	0.46	5.66***
Elementary School	1.192	0.45	2.63**
High School	1.416	0.45	2.21*
Five Years from Now	0.779	0.45	1.72
Ten Years from Now	1.300	0.45	2.87**
Self-Esteem	0.101	0.02	4.35***
Self-Esteem × Elementary School	-0.064	0.02	-2.79**
Self-Esteem × High School	-0.052	0.02	-2.28*
Self-Esteem × Five Years from Now	-0.022	0.02	-0.95
Self-Esteem × Ten Years from Now	-0.040	0.02	-1.75
Random Effects	$\hat{\beta}$	*SD*	
Participants			
Intercept error variance	0.646	0.80	
Residual	0.635	0.80	

Note. Present time period was used as the reference condition in the analysis.
*$p < .05$, **$p < .01$, ***$p < .001$

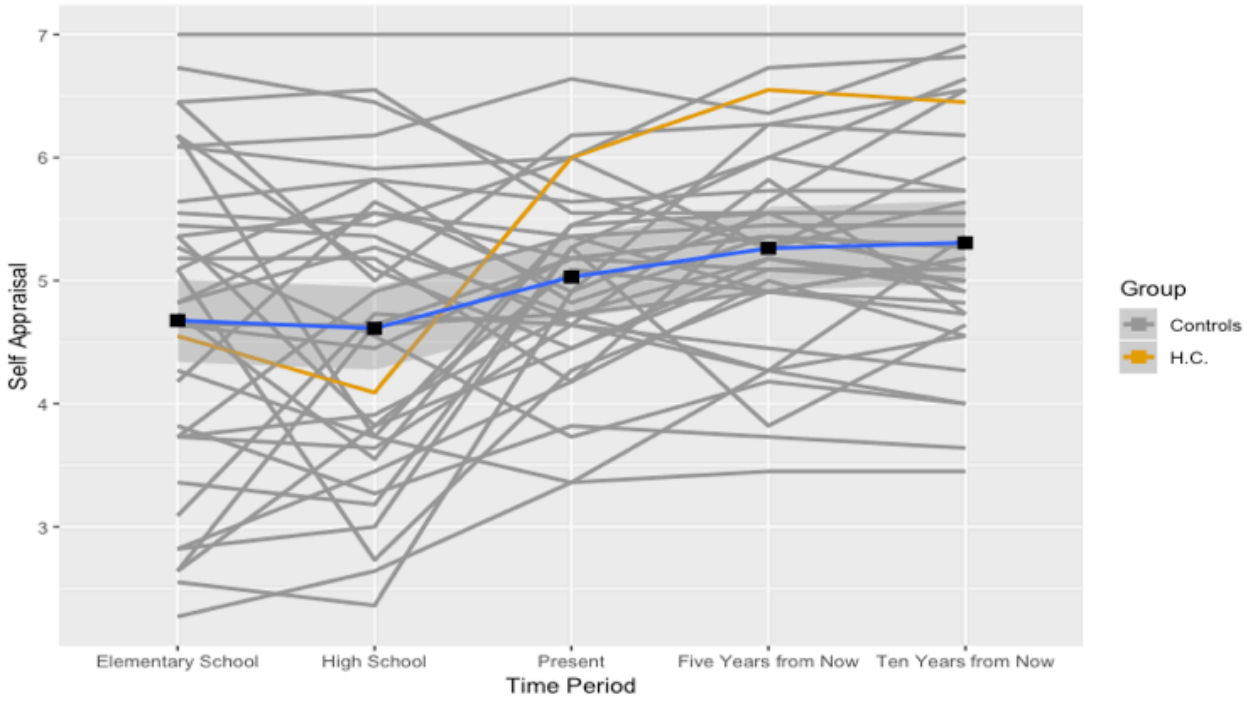

Figure 3. Social competence in H.C. and controls (Experiment 2) across five time periods (elementary school, high school, present, five years from now, and 10 years from now), with higher scores reflecting more positive self-appraisal. The blue line indicates the mean pattern of results for the control group, with the grey shaded area around it reflecting standard errors.