

Getting better without memory

Julia G. Halilova,¹ Donna Rose Addis,^{2,3} and R. Shayna Rosenbaum^{1,2}

¹Department of Psychology, York University, ²Rotman Research Institute, Baycrest Health Sciences University, 3560 Bathurst Street Toronto, Ontario M6A 2E1, Canada and ³Department of Psychology, University of Toronto

Correspondence should be addressed to R. Shayna Rosenbaum, Department of Psychology, York University, 4700 Keele Street, Toronto, ON M3J 1P3, Canada. E-mail: shaynar@yorku.ca.

Abstract

Does the tendency to adjust appraisals of ourselves in the past and future in order to maintain a favourable view of ourselves in the present require episodic memory? A developmental amnesic person with impaired episodic memory (HC) was compared with two groups of age-matched controls on tasks assessing the Big Five personality traits and social competence in relation to the past, present and future. Consistent with previous research, controls believed that their personality had changed more in the past 5 years than it will change in the next 5 years (i.e. the end-of-history illusion), and rated their present and future selves as more socially competent than their past selves (i.e. social improvement illusion), although this was moderated by self-esteem. Despite her lifelong episodic memory impairment, HC also showed these biases of temporal self-appraisal. Together, these findings do not support the theory that the temporal extension of the self-concept requires the ability to recollect richly detailed memories of the self in the past and future.

Key words: episodic memory; self-appraisal; developmental amnesia; case study; end-of-history illusion; social improvement illusion

Evolution dictates that humans strive to be better to survive (Darwin, 1859). To convince ourselves that we are attaining this goal and maintain our self-esteem, we tend to inflate our present and future self-worth by viewing ourselves less favourably in the past relative to the present (Wilson and Ross, 2003), and as having changed more in the past than we anticipate changing in the future (i.e. the end-of-history illusion; Quoidbach et al., 2013). Temporal self-appraisal biases are influenced by autobiographical memories of one's personal past (Wilson and Ross, 2003; Quoidbach et al., 2013). However, the unique contributions of different types of autobiographical memories, specifically semantic memory for self-related facts and episodic memory for detailed, context-rich experiences (Tulving, 1972, 2002), have not been investigated. Social and personality theories posit that the uniquely human ability to 'reconstruct' detailed episodic memories of our past selves in ways that make us feel good about ourselves in the present as underpinning temporal self-appraisal biases (Cameron et al., 2004). We evaluate this supposition by testing a developmental amnesic person, HC,

who has impaired episodic memory, to determine if she exhibits reduced biases in temporal self-appraisal.

The idea that our memories make us who we are has long been recognized by philosophers and neuroscientists (e.g. Locke, 1689; Sacks, 1970; Squire and Kandel, 1999). Numerous studies have identified links between the self and autobiographical memory (Addis and Tippett, 2008; Haslam et al., 2011; Singer et al., 2013; Habermas and Köber, 2015; Charlesworth et al., 2016; Eustache et al., 2016; Sokol et al., 2017; Stanley et al., 2017; Arnould et al., 2018; Lin, 2018). However, the ways in which different types of autobiographical memories contribute to the self remain a matter of debate (Prebble et al., 2013). Studies have demonstrated that semantic autobiographical memory can support self-appraisal of personality traits in both neurotypical individuals (e.g. Klein, Loftus, et al., 1996a; Grilli, 2017) as well as in amnesic individuals (Tulving, 1993; Klein, Sherman, et al., 1996b; Klein et al., 2002), which has led some to conceptualize self-appraisal as a primarily semantic task (Klein, Sherman, et al., 1996b; Symons and Johnson, 1997; Carson et al., 2018). Even

Received: 4 February 2020; Revised: 9 July 2020; Accepted: 11 July 2020

© The Author(s) 2020. Published by Oxford University Press. All rights reserved. For Permissions, please email: journals.permissions@oup.com

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact journals.permissions@oup.com

so, it cannot be assumed that self-appraisal depends solely on semantic memory, particularly when temporal in nature. This is an important consideration given that self-appraisal involves not only the evaluation of self in the present but also in the past and the future (Markus and Nurius, 1986; Prebble et al., 2013; Craver et al., 2014).

Although it has been theorized that trait self-knowledge supports a sense of self both in the present and over time (Klein and Lax, 2010), there is increasing evidence to suggest that episodic memory and its interplay with semantic memory may provide an important means by which the self is temporally extended (e.g. Prebble, 2014; Tippett et al., 2018). For instance, studies have shown that the quality of episodic memories is associated with the sense of self continuity over time (D'Argembeau et al., 2012; Bouizegarene and Philippe, 2016; Sokol et al., 2017; Lind and Thomsen, 2018; Lengen et al., 2019), possibly by providing the details necessary for nuanced representations of what we were like in the past (Addis and Tippett, 2004; Tippett et al., 2018). As yet, however, the contribution of episodic memory to the appraisal of the temporally extended self has not been investigated.

Previous attempts to distinguish the relative contributions of episodic and semantic memory to trait self-knowledge have assessed individuals with hippocampal amnesia, characterized by profound deficit in episodic memory and relatively intact semantic memory. A number of these cases exhibit preserved self-appraisal of personality traits (Tulving, 1993; Klein et al., 2002), suggesting that this ability relies primarily on semantic memory. However, these individuals acquired amnesia later in life, and the possibility that they relied on their premorbid episodic memory—that is, memories acquired normally before the onset of amnesia—to evaluate their self-concept cannot be ruled out entirely. Thus, individuals with developmental amnesia who have a lifelong deficit in episodic memory are particularly informative. Although their amnesia is not complete in that they may be able to recall some past personal experiences, what remains of their episodic memory is largely deficient in terms of quantity and quality of details (Vargha-Khadem et al., 2003; Kwan et al., 2010; Rosenbaum et al., 2011). Therefore, developmental amnesia may provide additional insight into understanding the contributions of episodic memory to self-appraisal.

Here we assess developmental amnesic case HC's self-appraisal abilities both in and beyond the present. In each of two experiments, we examined the presence of two different temporal biases typically exhibited by neurotypical adults, which we hypothesized should be reduced in HC relative to control participants if normally developed episodic memory is indeed necessary for self-appraisal beyond the present. The first bias was the tendency to report greater change in one's personality in the past than is expected in the future (i.e. the end-of-history illusion). We predicted that, relative to control participants, HC should exhibit a smaller difference between the degree of personality change she reports over the past 5 years vs the degree of change she expects to occur in the next 5 years. The second bias we investigated was the tendency to rate one's social competence in the past more negatively relative to the present and the future, which we name the 'social improvement illusion'. We predicted that HC would perceive less improvement in her social competence between high school and the present than control participants. Finally, based on previous findings that subjective temporal distance (i.e. how close individuals feel to their past selves) predicts temporal self-appraisal (Wilson and Ross, 2003), we also compared HC's subjective temporal distance to that of control participants, predicting that if these temporal self-appraisal biases are reduced in HC, she should also feel

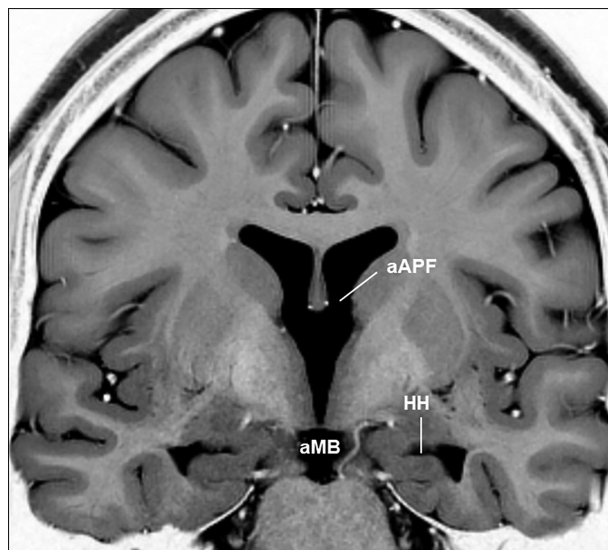


Fig. 1. Inverted coronal T2 images perpendicular to the hippocampus through the hippocampal head (HH). Poor digitation of the HH, absence of the mammillary bodies (aMB) and anterior pillar of fornix (aAPF) in HC Image also shows blurred internal structures of the hippocampus. The left side of the brain is on the left as per neurological convention.

closer to her past and future, in line with her reduced ability to mentally time travel into the past and future.

Experiment 1

Method

Participants. HC is a right-handed woman with developmental amnesia who was 30 years old at the time of testing. 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. HC's hippocampal memory system is characterized by malrotated hippocampi that are reduced in volume by 29.5% on the left and 31.2% on the right and complete absence of the mammillary bodies and anterior fornix (see Fig. 1; Olsen et al., 2013; Rosenbaum et al., 2014). The developmental nature of these abnormalities allows for assessment of the appraisal of self over time in an individual who never fully developed episodic memory. Indeed, like other cases of developmental amnesia (e.g. Vargha-Khadem et al., 2002; Picard et al., 2013), HC has deficient episodic memory and relatively intact semantic memory (Kwan et al., 2010; Rosenbaum et al., 2011; but see Blumenthal et al., 2017). While HC scores in the average range on most tasks of semantic knowledge, she is in the impaired range on episodic memory tasks. For instance, when retrieving past personal events, HC generated significantly fewer episodic details and attained significantly lower memory objective ratings of memory quality (e.g. vividness, emotionality) than a matched control group (Kwan et al., 2010), indicative of impaired episodic autobiographical memory. HC's recall of external details (including personal semantic information) on autobiographical memory tasks was intact (Kwan et al., 2010; Rosenbaum et al., 2011). HC's memory retrieval has been shown to benefit normally from repetition when the items are spaced instead of presented in immediate succession (Green et al., 2014; Kim et al., 2018). Table 1 summarizes HC's performance on a range of standardized tasks of episodic and semantic memory.

HC's working memory is impaired for previously unfamiliar words but preserved for famous faces and familiar words (Rose

Table 1. HC's performance on standardized memory tasks as documented in Rosenbaum et al. (2011)

Test	Normed score	Percentile rank
<i>Episodic memory</i>		
Wechsler Memory Scale-III		
Logical Memory I, immediate recall (scaled score)	4	2nd
Logical Memory II, delayed recall (scaled score)	1	<1st
California Verbal Learning Test-II		
Total trials 1–5 (T-score)	38	12th
Short delay free recall (z-score)	-4	<1st
Long delay free recall (z-score)	-3	<1st
Royer Osterreith Complex Figure Test		
Immediate recall (T-score)	<20	<1st
Delayed recall (T-score)	<20	<1st
<i>Semantic memory</i>		
WASI Similarities (T-score)	50	50th
WASI Vocabulary (T-score)	68th	
WAIS-III Information (scaled score)	12	73rd

Note. WASI: Wechsler Abbreviated Scale of Intelligence; WAIS: Wechsler Adult Intelligence Scale.

et al., 2012). She has impaired memory for public events (Rosenbaum et al., 2011) and has difficulty imagining close others' experiences (Rabin et al., 2013), although the extent to which she is able to imagine details of her own future experiences is unclear (cf. Kwan et al., 2010; Hurley et al., 2011). In contrast, her theory of mind on standard tests (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 appear to be intact (Kwan et al., 2013). HC is also characterized by a strong Past-Positive time orientation on the Zimbardo Time Perspective Inventory (Zimbardo and Boyd, 1999), reflecting her warm and sentimental attitude towards the past (Kwan et al., 2013).

A group of 24 (18 female) age-matched ($M = 28.30$, $s.d. = 2.79$) controls with no known history of neurological or psychiatric conditions was recruited for the study from the participant pools at Baycrest Health Sciences and York University. The control group had on average 16.48 years of education ($s.d. = 2.27$), which is not significantly different from HC, $t(23) = -1.06$, $P = 0.30$. Participants signed informed consent forms and received course credit 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. Participants completed paper-and-pencil versions of the questionnaires in the order presented below. For both measures, the order of time periods was randomized.

Ten item personality inventory (Gosling et al., 2003). Participants rated their Big Five personality traits (i.e. conscientiousness, agreeableness, emotional stability, openness to experience, and extraversion) by indicating how strongly they agree with each item on a 7-point scale from 1 (strongly disagree) to 7 (strongly agree). Similar to the temporally extended procedure described in Quoidbach 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.

Social competence scale (Ross and Wilson, 2002). Participants rated their social competence during five life periods: elementary school, high school and the present (as in the original version; Ross and Wilson, 2002), as well as 5 and 10 years from now. For each time period, participants rated themselves on 11 attributes (e.g. popular, lonely) on a 7-point semantic differential scale (e.g. from 1 = unpopular to 7 = popular). Composite social competence scores were calculated by averaging responses across the 11 items of the scale. Participants then indicated the subjective distance of their past/future selves by placing two marks on each of two 190 mm lines to indicate the degree of closeness (first line: 0 = feel very close to my past/future self; 190 = feel very distant from my past/future self) and nearness (second line: 0 = my past/future self feels very near; 190 = my past/future self feels far away) to their current self. Distances were highly correlated (r ranged from 0.50 to 0.72) and thus we derived a single subjective distance (averaged across closeness and nearness) for the past self and for the future self. Lastly, participants were asked to judge objective temporal distance for the two past time periods (as these time periods were not defined as a specific temporal distance) by reporting how long it had really been since the last year of elementary school and high school.

Results

For the Ten Item Personality Inventory (TIPI), the Big Five composite variables (i.e. emotional stability, extraversion, openness, agreeableness, and conscientiousness)¹ were constructed for the past, present and future time periods. Absolute differences between past and present, and between present and future were summed across all traits to quantify the amount of change in personality reported in the past 5 years and anticipated in the next 5 years. The control group reported having changed more in the past 5 years ($M = 13.54$, $s.d. = 6.39$) than they anticipated changing in the next 5 years ($M = 9.54$, $s.d. = 2.92$), $t(23) = 3.01$, $P = 0.006$, $d = 0.61$, 95%CI [1.25, 6.75]. Crawford's t -test for single case studies (Crawford and Howell, 1998) showed that the difference between HC's reported change for the past 5 years and her predicted change for the next 5 years was not significantly different from that of controls (see Fig. 2), $t(23) = 1.35$, $P = 0.189$.

Before comparing social competence judgements in HC to control participants, we first examined these judgements in the control group. The Social Competence Scale (SCS) showed high internal consistency for all time periods ($\alpha > 0.85$). To determine whether control participants perceived improvements in social competence over time, we constructed a mixed model with social competence regressed on time period and with participant as the random intercept (see Table 2). A likelihood ratio test showed that time period accounted for significantly more variance in social competence than the null model, $\chi^2(4) = 18.4682$, $P = 0.001$. Specifically, social competence in elementary school ($M = 4.45$, $s.d. = 1.34$) was rated significantly lower than in the present ($M = 5.06$, $s.d. = 0.95$), 5 years from now ($M = 5.36$, $s.d. = 0.82$), and 10 years from now ($M = 5.28$, $s.d. = 0.91$). This pattern is consistent with a social improvement illusion. However, no differences in social competence ratings were observed between other time periods in the control group, including the predicted increase between high school and

1 TIPI has shown adequate levels of convergence with widely used Big Five measures in self, observer and peer reports; test-retest reliability; patterns of predicted external correlates and convergence between self and observer ratings (Gosling et al., 2003).

Table 2. Model with social competence regressed on time period in controls in Experiment 1

	Social competence			
	<i>b</i>	SE	<i>t</i> (92)	<i>P</i>
Fixed effects				
Elementary school to present	-0.606	0.23	-2.62	0.010
High school to present	-0.174	0.23	-0.75	0.454
Five years from now to present	0.304	0.23	1.31	0.193
Ten years from now to present	0.216	0.23	0.93	0.354
Five years from now to elementary school	0.910	0.23	3.93	<0.001
Ten years from now to elementary school	0.822	0.23	3.55	<0.001
Five years from now to high school	0.478	0.23	2.06	0.042
Ten years from now to high school	0.390	0.23	1.68	0.096
High school to elementary school	0.432	0.23	1.87	0.065
Ten years from now to 5 years from now	-0.08	0.23	-0.38	0.705
Random effects				
	<i>b</i>	<i>s.d.</i>		
Participants				
Intercept error variance	0.397	0.63		
Residual	0.644	0.80		

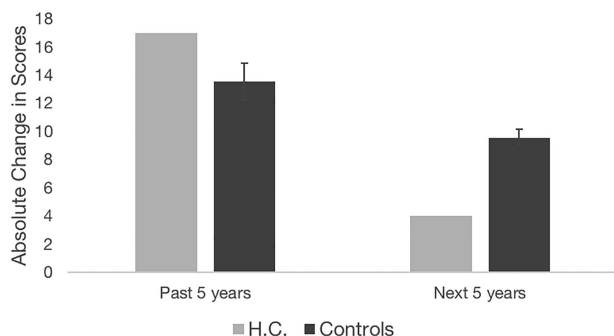


Fig. 2. Self-reported absolute changes in personality scores from 5 years ago to the present (left) and from the present to 5 years from now (right), in Experiment 1. The control group reported having changed more in the past 5 years than they anticipated changing in the next 5 years, constituting the typical temporal personality bias. HC's difference in scores for the past 5 years and for the next 5 years did not significantly differ from that of controls. Error bars represent SE.

the present that is usually evident in neurotypical adults. To examine these data in HC, we compared the change score for each set of time periods to that of controls using Crawford's *t*-test for single case studies. HC showed a different pattern of results (see Fig. 3); specifically, her change in self-appraised social competence from high school to present was significantly greater than that of controls, $t(23) = 2.37, P = 0.027$. Finally, we compared judgements of objective and subjective temporal distance made by HC and control participants and found no significant differences (see Table 3).

Discussion

The results of Experiment 1 did not support the hypothesis that self-appraisal of personality and social competence requires a

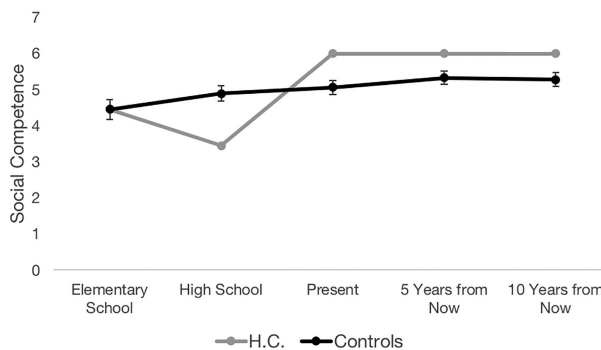


Fig. 3. Self-reported social competence scores across five time periods for HC and controls in Experiment 1. In controls, social competence ratings in elementary school were significantly lower than in the present and future, and self-appraisals were significantly more positive for 5 years from now than for high school. HC's reported social improvement between high school and the present was significantly greater than that reported by controls. Error bars represent SE.

typically developed episodic memory. Specifically, the analyses revealed no significant differences between HC and controls on TIPI over time, providing no evidence to suggest that past and future self-appraisal of personality relies on constructing detailed past or future autobiographical episodes. Surprisingly, the only significant difference between HC and control participants on self-appraisal of social competence was in the opposite direction to our hypothesis. HC exhibited a large change in social competence ratings between high school and the present, consistent with the social improvement illusion, while unexpectedly, control participants did not (although they did exhibit perceived improvement between other time periods). Thus, HC's pattern of responses, unlike that of the control group, was consistent with previous findings in neurotypical controls (Wilson and Ross, 2003). One possible explanation is a difference in self-esteem between HC and the control group, given previous findings that self-esteem moderates self-appraised temporal social competence (Ross and Wilson, 2002).

Therefore, we conducted Experiment 2 to re-examine our original hypothesis while also exploring whether self-esteem could explain the findings of Experiment 1. In an online version of the first experiment, we tested a new, larger control group; we retested HC in this online format, expecting that although she would be unlikely to recall much about the previous testing session, her responses should be consistent. We also included a measure of self-esteem to enable us to examine whether the moderating effect of self-esteem might explain why the control participants in Experiment 1 did not exhibit the social improvement illusion. We predicted that higher self-esteem would be associated with a more negative appraisal of past as compared to present social competence (cf. Ross and Wilson, 2002). Critically, we compared HC's social improvement illusion (i.e. perceived improvement from high school to the present) to a subsample of control participants who matched her high level of self-esteem. If our original hypothesis—that typically developed episodic memory supports social improvement illusion—is correct and we have now accounted for the moderating effect of self-esteem on the social improvement illusion, then this bias should be reduced in HC relative to the matched control group. Finally, if the ability to mentally travel in time contributes to the temporal extension of the self, we hypothesized that episodic memory and future imagining abilities should predict controls' social improvement illusion for the past and the future, respectively.

Table 3. Results of the Crawford t-tests, comparing the judgements of objective and subjective temporal distance between HC and controls across past and future time periods in Experiment 1

Measure	Controls		HC	t(23)*	P
	M	s.d.			
Objective temporal distance					
Elementary school	16.65	3.52	18	0.40	.692
High school	10.91	3.19	12	0.36	.719
Subjective temporal distance					
Elementary school	118.88	45.03	124.50	0.12	.904
High school	102.23	44.22	145.50	0.95	.353
Five years from now	71.81	37.19	44.50	-0.72	.479
Ten years from now	101.21	41.28	49.50	-1.23	.232

Note. *These analyses were conducted using Crawford's t-test for single case studies.

Thus, our online study also included a self-report measure of these episodic abilities.

Experiment 2

Method

Participants. The sample size was determined a priori by conducting a power analysis in G*Power (Faul et al., 2007) with two groups, five measurements, $\alpha = 0.05$, a medium ES $f = 0.25$, and 80% power, $N = 78$. We oversampled and recruited 102 participants, online via Prolific (www.prolific.ac), 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 HC. Two participants were identified as random responders by the conscientious responder scale (Marjanovic et al., 2015) and their data removed from the analysis, yielding a total sample of 100 (98 female) participants, age- ($M = 31.68$, $s.d. = 2.96$) and education-matched ($M = 16.24$, $s.d. = 2.78$) to HC, with no known history of neurological or psychiatric conditions. There were no significant differences in the years of education between HC and controls, $t(99) = -0.80$, $P = 0.42$. HC completed Experiment 2 6 months after she participated in Experiment 1; as expected, her responses on the two administrations were strongly correlated (TIPI: $r = 0.81$, $P < 0.001$; SCS: $r = 0.97$, $P < 0.001$).

Measures

All of the measures used in Experiment 1 were used in Experiment 2, with the addition of the following questionnaires to assess ratings of episodic memory, future imagining and self-esteem.

Survey of autobiographical memory. Participants rated their agreement with each of the 26 items of the Survey of Autobiographical Memory (SAM) (Palombo et al., 2013) on a scale from 1 (strongly disagree) to 5 (strongly agree), indicating their self-reported naturalistic autobiographical memory abilities across four domains: episodic memory, semantic memory, spatial memory and future imagining. A moderate correlation was previously established between the subjective ratings of episodic memory on the SAM and objective measures of episodic memory (Palombo et al., 2013).

Rosenberg self-esteem scale (Rosenberg, 1965). Participants completed this 10-item measure of positive and negative feelings about the self by indicating the degree of agreement with each item from 0 (strongly disagree) to 3 (strongly agree).

Conscientious responder scale. We distributed these five items (e.g. To answer this question, please choose option three, 'neither agree nor disagree'; Marjanovic et al., 2015) throughout the survey to identify random responders.

Procedure. Participants accessed the study online via Qualtrics. After providing informed consent, participants completed the questionnaires in the following order: Rosenberg self-esteem scale (RSES), TIPI, SAM and SCS. As in Experiment 1, the order of time periods for the TIPI and SCS was randomized. Participants received monetary compensation for participating in accordance with the ethics boards of Baycrest Health Sciences and York University.

Results

For the TIPI, the composite variables were constructed as per Experiment 1. The control group, on average, reported having changed more in the past 5 years ($M = 9.36$, $s.d. = 5.49$) than they anticipated changing in the next 5 years ($M = 7.60$, $s.d. = 4.51$), $t(99) = 3.21$, $P < 0.001$, $d = 0.32$, 95%CI [0.67, 2.85], reproducing the results of Experiment 1. The sample size of Experiment 2 was sufficiently large to conduct an order effect regression analysis; the order of presentation of time periods (i.e. past, present and future) had no significant effect on the results, $F(5,94) = 2.18$, $P = 0.062$, $R^2 = 0.10$. HC also reported having changed more in the past 5 years (absolute difference = 14) than anticipated changing in the next 5 years (absolute difference = 4; see Fig. 4). Crawford's t-test showed that the difference between H.C's reported change over the past 5 years and predicted change in the next 5 years was not significantly different from that of the control group, $t(99) = 1.49$, $P = 0.138$, reproducing the findings in Experiment 1.

The SAM episodic memory and future imagining subscales showed high internal consistency ($\alpha = 0.86$ and 0.81 , respectively). The full control sample, reported that, on average, they are better at remembering the past ($M = 132.93$, $s.d. = 57.95$) than imagining the future ($M = 126.45$, $s.d. = 48.47$), $t(99) = 4.96$, $P < 0.001$, $d = 0.50$, 95%CI [4.54, 10.59]. On the other hand, HC reported being better at imagining the future (94.32) than remembering the past (80.27). We ran two regressions in the control group to determine whether self-reported episodic memory and future imagining scores predicted changes in personality ratings over the past 5 years and the next 5 years, respectively. Contrary to our hypotheses, neither episodic memory or future imagining scores predicted differences in personality ratings in the past and the present, $b = -0.07$, $SE = 0.04$, $P = 0.068$, $R^2 = 0.03$,

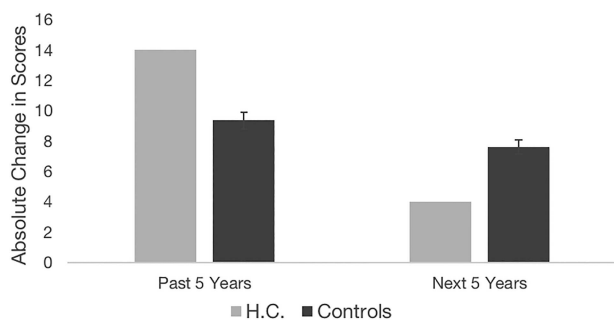


Fig. 4. Self-reported absolute changes in personality scores from 5 years ago to the present (left) and from the present to 5 years from now (right), in Experiment 2. Reproducing results of Experiment 1, HC and controls reported having changed more in the past 5 years than they anticipated changing in the next 5 years. Error bars represent SE.

or the present and the future, $b = -0.002$, $SE = 0.04$, $P = 0.961$, $R^2 = 0.01$, respectively. HC's subjective ratings of her factual memory (total score = 94.74) was not significantly different from controls ($M = 95.65$, $s.d. = 10.07$), $t(99) = -0.09$, $P = 0.93$.

The SCS showed high internal consistency for each time period ($\alpha > 0.88$). A likelihood ratio test showed no significant order effect of time period presentation on the pattern of responses, $\chi^2(20) = 17.32$, $P = 0.632$. RSES showed high internal consistency ($\alpha = 0.89$). We tested the hypothesized moderating effect of self-esteem on control participants' social competence ratings across time periods using a linear mixed-effects analysis in R package lme4 (Bates et al., 2012). Time period (relative to the present, which was the reference condition), self-esteem ratings and their interaction were entered as fixed effects in the model, with social competence ratings as the dependent variable. We included subject as a random intercept in the model. A likelihood ratio test showed that the model (see Table 4) with the self-esteem by time period interaction accounts for significantly more variance in social competence than the null model without the interaction term, $\chi^2(4) = 9.82$, $P = 0.044$. Specifically, individuals with high self-esteem tend to rate themselves significantly more negatively in high school relative to the present than those with low self-esteem.

The regression results above suggest that it is indeed necessary to control for the level of self-esteem when comparing SCS scores between HC who has a high score in self-esteem (scoring 28 out of 30) and control participants who range widely in self-esteem ($M = 19.06$, $s.d. = 4.91$). Thus, we selected a subset of individuals with self-esteem scores equal to or higher than 21.² This high self-esteem subsample was composed of 36 participants with an average age of 32.08 ($s.d. = 3.09$), an average education of 16.36 years ($s.d. = 2.52$), and an average self-esteem rating of 23.86 ($s.d. = 2.52$). Regression analysis (see Table 5) showed that, relative to the present and future time periods (5 and 10 years from now), these high self-esteem participants rated their social competence more negatively in elementary school (replicating Experiment 1) and high school (see Fig. 5). As in Experiment 1, social competence ratings both 5 and 10 years into the future did not show significant differences relative to the present. Crawford's t -test showed that HC's changes in self-appraised social competence did not differ from that of high self-esteem control participants, and importantly, this was the case

2 The self-esteem scores were approximately normally distributed, with a mean of 19.06 ($s.d. = 4.91$) and median of 20.

Table 4. Model with social competence regressed on time period by self-esteem interaction in Experiment 2

	Social competence			
	<i>b</i>	SE	<i>t</i>	<i>P</i>
Fixed effects				
Intercept	2.581	0.46	5.66	<0.001
Elementary school	1.192	0.45	2.63	0.009
High school	1.416	0.45	2.21	0.028
Five years from now	0.779	0.45	1.72	0.087
Ten years from now	1.300	0.45	2.87	0.004
Self-esteem	0.101	0.02	4.35	<0.001
Self-esteem × elementary school	-0.064	0.02	-2.79	0.006
Self-esteem × high school	-0.052	0.02	-2.28	0.023
Self-esteem × 5 years from now	-0.022	0.02	-0.95	0.344
Self-esteem × 5 years from now	-0.040	0.02	-1.75	0.081
Random effects				
	<i>b</i>	<i>s.d.</i>		
Participants				
Intercept error variance	0.646	0.80		
Residual	0.635	0.80		

Note. Present time period was used as the reference condition in this analysis.

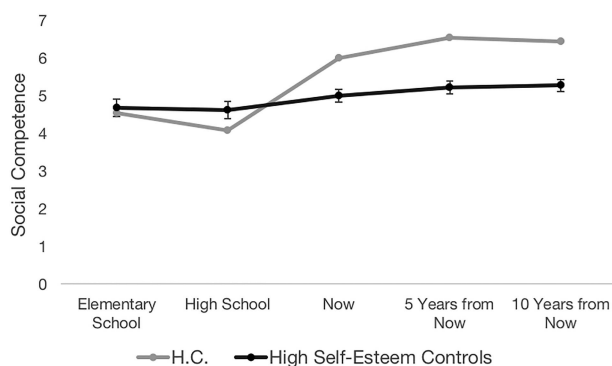


Fig. 5. Social competence scores across five time periods for HC and a high self-esteem subsample of controls in Experiment 2. HC and controls reported lower social competence in elementary and high school relative to the present. No differences were found between other life periods. Error bars represent SE.

for the differences between the present and both past time periods where the control subsample showed significant changes (elementary school and the present, $t(35) = 0.88$, $P = 0.387$; high school and the present, $t(35) = 1.53$, $P = 0.134$). Thus, by controlling for self-esteem, HC's social improvement illusion is not greater than that of control participants as it was in Experiment 1, not because of any change in HC's response patterns across the two experiments (she exhibited the bias in both experiments), but because the high self-esteem control participants in Experiment 2 exhibit the perceived social improvement from high school to the present that is typical in adults (Ross and Wilson, 2002).

Based on the SAM scores from the full control sample, we ran a series of mixed models to estimate whether self-reported episodic memory and future imagining abilities in the full control sample predicted past and future appraisals of social competence, respectively, controlling for self-appraisal in the present. These analyses showed that episodic memory was not a significant predictor for participants' ratings of social competence in elementary school, $b = 0.01$, $SE = 0.01$, $t(97) = 1.20$, $P = 0.23$, $R^2 = 0.01$, or high school, $b = -0.01$, $SE = 0.01$, $t(97) = -0.84$, $P = 0.41$, $R^2 = 0.01$.

Table 5. Model with social competence regressed on time period in high self-esteem controls in Experiment 2

Fixed effects	Social competence			
	b	SE	t(140)	P
Fixed effects				
Elementary school to present	-0.322	0.16	-1.99	0.048
High school to present	-0.375	0.16	-2.32	0.022
Five years from now to present	0.224	0.16	1.39	0.168
Ten years from now to present	0.274	0.16	1.69	0.093
Five years from now to elementary school	0.547	0.16	3.38	<0.001
Ten years from now to elementary school	0.597	0.16	3.68	<0.001
Five years from now to high school	0.600	0.16	3.70	<0.001
Ten years from now to high school	0.649	0.16	4.01	<0.001
High school to elementary school	-0.053	0.16	-1.75	0.747
Five years from now to 10 years from now	0.049	0.16	0.31	0.761
Random effects				
	b	s.d.		
Participants				
Intercept error variance	0.606	0.78		
Residual	0.473	0.69		

Table 6. Results of the Crawford t-tests, comparing the judgements of subjective temporal distance between HC and high self-esteem controls across past and future time periods in Experiment 2

Measure	Controls		HC	t(35)	P
	M	s.d.			
Objective temporal distance					
Elementary school	18.94	4.26	20	0.24	0.808
High school	14.47	3.81	13	-.38	0.705
Subjective temporal distance					
Elementary school	120.03	45.87	139	0.41	0.686
High school	115.03	47.53	141	0.539	0.593
Five years from now	85.93	38.92	37	-1.24	0.223
Ten years from now	94.96	43.50	16.5	-1.78	0.084

Although future imagining was not a significant predictor of participants' ratings of their future selves 5 years from now, $b = 0.01$, $SE = 0.01$, $t(97) = 0.82$, $P = 0.42$, $R^2 = 0.01$, it was a significant predictor of future social competence ratings 10 years from now, $b = 0.01$, $SE = 0.01$, $t(97) = 2.18$, $P = 0.03$, $R^2 = 0.02$.

Finally, as in Experiment 1, we examined participants' subjective distance for their past and future selves (see Table 6). The larger sample size of Experiment 2 enabled us to run a regression analysis comparing subjective distances from the present for the past and the future time periods that were most similar in objective distance at the group level, while controlling for differences in objective distance. This varied across participants for the past time period 'high school' ($M = 14.47$ years ago, $s.d. = 3.81$) but was constant for the future time period (5 and 10 years from now). Crawford's t-tests confirmed that HC's ratings of subjective temporal distance for the past and the future time periods were not significantly different from that of control participants (see Table 6), contrary to our original hypothesis but consistent with the findings in Experiment 1.

Discussion

HC showed similar temporal self-appraisal biases when thinking about her past and future selves to those evident in control participants. For the end-of-history illusion, we reproduced the findings of Experiment 1, with both HC and the control group reporting having changed more in the past than they expected

changing in the future. The subsample of controls selected to match HC's high self-esteem showed the same temporal bias as HC did in both experiments, rating themselves more positively in the present than in the past. Importantly, HC's biases in temporal self-appraisal were clearly evident, reflecting her perception of herself changing over time. These biases were present despite impaired episodic memory in HC, and were not predicted by self-reported episodic memory or future imagining abilities in control participants. The findings contribute to cognitive explanations of the temporal self-appraisal theory in particular, and the theoretical link between autobiographical memory and self-appraisal more generally.

General discussion

Using two measures of temporal self-appraisal (personality and social competence), across two experiments that compared the developmental amnesic case HC with independent samples of controls (student and non-student) assessed in distinct testing contexts (laboratory, online), our results did not support the hypothesis that typically developed episodic memory is essential for temporal self-appraisal.

These findings call into question several memory-related explanations for temporal self-appraisal biases. First, Quoidbach et al. (2013) proposed that the end-of-history illusion may reflect the relative ease of remembering past events compared to imagining future events. However, our results suggest that the

ease of episodic retrieval is unlikely to account for people's tendency to report having changed more in the past than they anticipate changing in the future. In Experiment 2, we found that even though control participants reported their episodic memory was better than their future imagining abilities, these scores did not predict control participants' self-appraised personality changes in the past or next 5 years, respectively. Furthermore, HC reported that her future imagining ability is better than her episodic memory, which is opposite to that reported by controls (but accurate with respect to objective assessments of HC's abilities in these domains; Hurley et al., 2011; Kwan et al., 2013). Yet, she, too, showed typical temporal self-appraisal biases, including the end-of-history illusion. Interestingly, control participants' future imagining abilities predicted the degree to which they expected their social competence to have improved 10 years from now. It is possible that being able to imagine the future in detail is necessary for appraising the self in relatively distant future time periods. However, additional research is needed to determine how this finding fits with other research suggesting decreased involvement of concrete information, such as episodic events, as temporal distance increases (e.g. Trope and Liberman, 2003).

Second, it has been previously proposed that an 'illusion of change' in self-appraisal (e.g. social improvement illusion) from the past to the present might be explained by people's reconstructions of their memories of self (Conway and 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). However, our results do not support the notion that one has to '(re)construct' past and future selves in order to appraise the attributes of these selves. Although individuals with episodic amnesia may retain their narrative construction abilities, provided that relevant story details are made available to them (Keven et al., 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 and Addis, 2007). It is possible that HC uses her present self as a prototype for constructing a more negative version of herself in the past. Indeed, her perceived improvement in social competence over time was similar to control participants who, like HC, hold their present self in high esteem, consistent with evidence that self-esteem moderates this social improvement illusion (Ross and Wilson, 2002). Nevertheless, we view the possibility that HC uses her present self as a prototype as unlikely because her past self-appraisal was only weakly to moderately correlated with her present self-appraisal, yet her appraisals of her past self were strongly correlated between the two testing sessions that occurred 6 months apart.

We extended previous research on the present self in individuals with amnesia (e.g. Tulving, 1993; Klein et al., 2002; Picard et al., 2013) by assessing knowledge of past and future selves, and found that in addition to being able to describe her traits in the present, HC was also able to reflect on what she was like in the past and how she might change in the future. The findings are consistent with a model of the self in which the temporally extended self-concept is supported primarily by semantic autobiographical memory (D'Argembeau et al., 2008, 2010; Prebble et al., 2013), and with recent reports that even in conditions characterized by episodic memory impairment, such as Alzheimer's disease, strong beliefs in the continuity of the self are maintained by semantic knowledge, such as cultural life scripts (Tippett et al., 2018). These results further support the notion that despite her episodic memory deficit, HC has likely developed the capacity to construct a semantic temporal

chronology (Grilli et al., 2018) of her life chapters. Nevertheless, if both past and future self-appraisal rely on semantic memory, then personality changes may take longer to incorporate into self-appraisals in individuals with developmental amnesia than healthy controls, akin to their delayed updating of other forms of semantic knowledge (Gardiner et al., 2008).

Because we were assessing the hypotheses that the end-of-history illusion and social improvement illusion rely on episodic memories, we had to consider the possibility that without specific memories on which to base self-ratings, HC's ratings may not be stable over time. HC was tested on both self-appraisal tasks (personality ratings and social competence ratings) on two separate occasions spaced 6 months apart, and her ratings were highly correlated across time. If individuals with amnesia have a consistent and stable sense of self, it may explain why they show the same benefit as controls on some tasks (e.g. describing future events involving self) that draw on self-knowledge (i.e. beliefs about one's attributes, whether or not those beliefs are accurate by objective standards) to a greater degree than other tasks (e.g. describing future events involving familiar others; Verfaellie et al., 2019). Our findings may also contribute to refining the Self Memory System model (Conway et al., 2004) by demonstrating that stability of self-knowledge can be achieved even in the face of impaired episodic memory.

Findings that HC's temporal sense of personality and social competence appear to be intact, and her appraisals are consistent across testing sessions despite her deficient episodic memory, raise the possibility that HC's residual episodic memory is sufficient to support her temporally extended self-concept. However, this seems unlikely when the nature of her lifelong episodic memory impairment is considered. Like other developmental amnesic cases, HC's episodic learning and memory is largely atypical, not reaching the levels attained by age- and education-matched counterparts (Kwan et al., 2010; Rosenbaum et al., 2014). Data from two independent labs have demonstrated that HC's episodic memory is significantly worse than that of control participants on multiple laboratory and real-world (autobiographical) measures, both in terms of number of details retrieved and quality of memories (Vargha-Khadem et al., 2003; Rosenbaum et al., 2011). A more likely explanation is that her intact semantic abilities are sufficient to support her temporally extended self-concept. However, it is important that an episodic contribution to these biases cannot be completely ruled out solely on the basis of HC's performance not being significantly different from that of the two control groups. We note that Crawford's t-test for case studies is necessarily conservative (to account for the absence of across-subject variance when comparing a single case to a control group that naturally has variance). Thus, possibility remains that HC's temporal self-appraisals, while not statistically different from those of control participants, may not be typical. There is evidence to suggest that some aspects of HC's self-appraisals are compromised by her lack of rich episodic memories. For example, when asked to describe herself in her own words after formal testing, she reported her traits (e.g. friendly, empathic) without contextualizing them. By contrast, neurotypical adults tended to contextualize their traits (e.g. 'introverted, especially in new situations'; e.g. Addis and Tippett, 2004), thought to rely on the ability to recall specific autobiographical events and remember how they demonstrated their traits in those situations. This finding is consistent with work showing that individuals with hippocampal amnesia experience deficits in generating episodic-near autobiographical facts that provide spatiotemporal context to their narratives (Grilli and Verfaellie, 2016). It also supports a tenet of Prebble et al.'s (2013) model

that abstract conceptual self-knowledge does not rely on episodic memory, but that episodic memory may afford a more nuanced and contextualized self-understanding by providing the necessary detail. Notably, although the SCS used more specific contexts (e.g. elementary school) than the TIPI, neither task used here required retrieval of specific memories or concrete exemplars of trait-relevant behaviour in order to complete the self-ratings.

Taken together, our results do not provide support for the hypothesis that a richly detailed episodic memory is necessary for appraising how the self changes and improves over time, contrary to many theories implicating a role for episodic memory in the temporally extended self-concept. Our findings that, despite a lifelong episodic memory impairment, HC exhibits the same temporal biases as other adults her age indicate that she is able to represent past and future self-knowledge. Moreover, this self-knowledge appears to be relatively stable over a period of 6 months. Nevertheless, these results cannot fully rule out episodic contributions to the temporally extended self. Further research should explore whether a normally functioning episodic memory is necessary for more subtle qualities of the temporally extended self. These might include grounding trait self-knowledge in the experiences of past and future selves, and the efficient updating of the self-concept with changes to personality and other attributes and abilities as one moves through life.

Acknowledgements

The authors wish to thank HC for her continued participation and dedication to science. R.S.R. acknowledges the support of a Vision: Science to Applications (VISTA) York Research Chair and a Natural Science and Engineering Research Council (NSERC) Grant. D.R.A. is supported, in part, by funding from the Canada 150 Research Chairs Program.

Conflict of interest. The authors declare no conflict of interest.

Funding

Research reported in this manuscript was funded by the Natural Science and Engineering Research Council (NSERC) Discovery Grant (RGPIN-04238-2015) to R.S.R.

References

- Addis, D.R., Tippett, L.J. (2004). Memory of myself: autobiographical memory and identity in Alzheimer's disease. *Memory*, *12*(1), 56–74. <http://dx.doi.org/10.1080/09658210244000423>.
- Addis, D.R., Tippett, L.J. (2008). The contributions of autobiographical memory to the content and continuity of identity: a social-cognitive neuroscience approach. In: Sani, F., editor. *Self continuity: individual and collective perspectives*, New York, NY: Psychology Press, pp. 71–84 Chapter xv, 273 Pages.
- Arnould, A., Rochat, L., Azouvi, P., van der Linden, M. (2018). Self-appraisals and episodic memory: different psychological factors related to patient versus informant reports of apathy in severe traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology*, *40*(7), 650–62. <http://dx.doi.org/10.1080/13803395.2017.1411468>.
- Bates, D., Maechler, M., Bolker, B. (2012). *lme4: Linear mixed-effects models using Eigen and Eigenfaces* (R Package). doi: <http://cran.r-project.org/web/packages/lme4/index.html>
- Blumenthal, A., Duke, D., Bowles, B., et al. (2017). Abnormal semantic knowledge in a case of developmental amnesia. *Neuropsychologia*, *102*, 237–47.
- Bouizegarene, N., Philippe, F.L. (2016). Episodic memories as building blocks of identity processing styles and life domains satisfaction: examining need satisfaction and need for cognitive closure in memories. *Memory*, *24*(5), 616–28. <http://dx.doi.org/10.1080/09658211.2015.1034138>.
- Cameron, J.J., Wilson, A.E., Ross, M. (2004). Autobiographical memory and self-assessment. In: Beike, D.R., Lampinen, J.M., Behrend, D.A., editors. *The self and memory; the self and memory*, New York, NY: Psychology Press, pp. 207–26 Chapter x, 268 Pages.
- Carson, N., Rosenbaum, R.S., Moscovitch, M., Murphy, K.J. (2018). Self-reference effect and self-reference recollection effect for trait adjectives in amnesic mild cognitive impairment. *Journal of the International Neuropsychological Society*, *24*(8), 821–32. <https://doi.org/10.1017/S1355617718000395>.
- Charlesworth, L.A., Allen, R.J., Havelka, J., Moulin, C.J.A. (2016). Who am I? Autobiographical retrieval improves access to self-concepts. *Memory*, *24*(8), 1033–41. <http://dx.doi.org/10.1080/09658211.2015.1063667>.
- Conway, M., Ross, M. (1984). Getting what you want by revising what you had. *Journal of Personality and Social Psychology*, *47*(4), 738–48. <http://dx.doi.org/10.1037/0022-3514.47.4.738>.
- Conway, M.A., Singer, J.A., Tagini, A. (2004). The self and autobiographical memory: correspondence and coherence. *Social Cognition*, *22*(5), 491–529. <http://dx.doi.org/10.1521/so.co.22.5.491.50768>.
- Craver, C., Kwan, D., Steindam, C., Rosenbaum, R.S. (2014). Individuals with episodic amnesia are not stuck in time. *Neuropsychologia*, *57*, 191–5.
- Crawford, J.R., Howell, D.C. (1998). Comparing an individual's test score against norms derived from small samples. *The Clinical Neuropsychologist*, *12*(4), 482–6. <http://dx.doi.org/10.1076/cli.n.12.4.482.7241>.
- D'Argembeau, A., Feyers, D., Majerus, S., et al. (2008). Self-reflection across time: cortical midline structures differentiate between present and past selves. *Social Cognitive and Affective Neuroscience*, *3*(3), 244–52. <http://dx.doi.org/10.1093/scan/nsn020>.
- D'Argembeau, A., Stawarczyk, D., Majerus, S., Collette, F., Van, d.L., Salmon, E. (2010). Modulation of medial prefrontal and inferior parietal cortices when thinking about past, present, and future selves. *Social Neuroscience*, *5*(2), 187–200. <http://dx.doi.org/10.1080/17470910903233562>.
- D'Argembeau, A., Jedidi, H., Baiteau, E., Bahri, M., Phillips, C., Salmon, E. (2012). Valuing one's self: medial prefrontal involvement in epistemic and emotive investments in self-views. *Cerebral Cortex*, *22*(3), 659–67. <http://dx.doi.org/10.1093/cercor/bhr144>.
- Darwin, C.R. (1859). *On the origin of species by means of natural selection, or, the preservation of favoured races in the struggle for life*, London: J. Murray.
- Eustache, F., Viard, A., Desgranges, B. (2016). The MNESIS model: memory systems and processes, identity and future thinking. *Neuropsychologia*, *87*, 96–109. <http://dx.doi.org/10.1016/j.neuropsychologia.2016.05.006>.
- Faul, F., Erdfelder, E., Lang, A., Buchner, A. (2007). G*power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, *39*(2), 175–91.
- Gardiner, J.M., Brandt, K.R., Baddeley, A.D., Vargha-Khadem, F., Mishkin, M. (2008). Charting the acquisition of semantic

- knowledge in a case of developmental amnesia. *Neuropsychologia*, **46**(11), 2865–8. <http://dx.doi.org/10.1016/j.neuropsychologia.2008.05.021>.
- Gosling, S.D., Rentfrow, P.J., Swann, W.B., Jr. (2003). A very brief measure of the big five personality domains. *Journal of Research in Personality*, **37**, 504–28.
- Green, J.L., Weston, T., Wiseheart, M., Rosenbaum, R.S. (2014). Long-term spacing effect benefits in developmental amnesia: case experiments in rehabilitation. *Neuropsychology*, **28**(5), 685–94. <http://dx.doi.org/10.1037/neu0000070>.
- Grilli, M.D. (2017). The association of personal semantic memory to identity representations: insight into higher-order networks of autobiographical contents. *Memory*, **25**(10), 1435–43. <http://dx.doi.org/10.1080/09658211.2017.1315137>.
- Grilli, M.D., Verfaellie, M. (2016). Experience-near but not experience-far autobiographical facts depend on the medial temporal lobe for retrieval: evidence from amnesia. *Neuropsychologia*, **81**, 180–5. <http://dx.doi.org/10.1016/j.neuropsychologia.2015.12.023>.
- Grilli, M.D., Wank, A.A., Verfaellie, M. (2018). The life stories of adults with amnesia: insights into the contribution of the medial temporal lobes to the organization of autobiographical memory. *Neuropsychologia*, **110**, 84–91. <http://dx.doi.org/10.1016/j.neuropsychologia.2017.03.013>.
- Habermas, T., Köber, C. (2015). Autobiographical reasoning in life narratives buffers the effect of biographical disruptions on the sense of self-continuity. *Memory*, **23**(5), 664–74. <http://dx.doi.org/10.1080/09658211.2014.920885>.
- Haslam, C., Jetten, J., Haslam, S.A., Pugliese, C., Tonks, J. (2011). I remember therefore I am, and I am therefore I remember: exploring the contributions of episodic and semantic self-knowledge to strength of identity. *British Journal of Psychology*, **102**(2), 184–203. <http://dx.doi.org/10.1348/000712610X508091>.
- Hassabis, D., Kumaran, D., Vann, S.D., Maguire, E.A. (2007). Patients with hippocampal amnesia cannot imagine new experiences. *PNAS Proceedings of the National Academy of Sciences of the United States of America*, **104**(5), 1726–31.
- Hurley, N.C., Maguire, E.A., Vargha-Khadem, F. (2011). Patient HC with developmental amnesia can construct future scenarios. *Neuropsychologia*, **49**(13), 3620–8. <http://dx.doi.org/10.1016/j.neuropsychologia.2011.09.015>.
- Keven, N., Kurczek, J., Rosenbaum, R.S., Craver, C.F. (2018). Narrative construction is intact in episodic amnesia. *Neuropsychologia*, **110**, 104–12. <http://dx.doi.org/10.1016/j.neuropsychologia.2017.07.028>.
- Kim, A.S.N., Saberi, F.M., Wiseheart, M., Rosenbaum, R.S. (2018). Ameliorating episodic memory deficits in a young adult with developmental (congenital) amnesia. *Journal of the International Neuropsychological Society*, **24**, 1003–12.
- Klein, S.B., Lax, M.L. (2010). The unanticipated resilience of trait self-knowledge in the face of neural damage. *Memory*, **18**(8), 918–48. <http://dx.doi.org/10.1080/09658211.2010.524651>.
- Klein, S.B., Loftus, J., Kihlstrom, J.F. (1996a). Self-knowledge of an amnesic patient: toward a neuropsychology of personality and social psychology. *Journal of Experimental Psychology: General*, **125**(3), 250–60. <http://dx.doi.org/10.1037/0096-3445.125.3.250>.
- Klein, S.B., Sherman, J.W., Loftus, J. (1996b). The role of episodic and semantic memory in the development of trait self-knowledge. *Social Cognition*, **14**(4), 277–91. <http://dx.doi.org/10.1521/soco.1996.14.4.277>.
- Klein, S.B., Rozendal, K., Cosmides, L. (2002). A social-cognitive neuroscience analysis of the self. *Social Cognition*, **20**(2), 105–35. <http://dx.doi.org/10.1521/soco.20.2.105.20991>.
- Kwan, D., Carson, N., Addis, D.R., Rosenbaum, R.S. (2010). Deficits in past remembering extend to future imagining in a case of developmental amnesia. *Neuropsychologia*, **48**(11), 3179–86. <http://dx.doi.org/10.1016/j.neuropsychologia.2010.06.011>.
- Kwan, D., Craver, C.F., Green, L., Myerson, J., Rosenbaum, R.S. (2013). Dissociations in future thinking following hippocampal damage: evidence from discounting and time perspective in episodic amnesia. *Journal of Experimental Psychology: General*, **142**(4), 1355–69. <http://dx.doi.org/10.1037/a0034001>.
- Lengen, C., Timm, C., Kistemann, T. (2019). Place identity, autobiographical memory and life path trajectories: the development of a place-time-identity model. *Social Science & Medicine*, **227**, 21–37. <http://dx.doi.org/10.1016/j.socscimed.2018.09.039>.
- Lin, Y. (2018). Visual perspectives in episodic memory and the sense of self. *Frontiers in Psychology*, **9**, 7. <http://dx.doi.org/10.3389/fpsyg.2018.02196>.
- Lind, M., Thomsen, D.K. (2018). Functions of personal and vicarious life stories: identity and empathy. *Memory*, **26**(5), 672–82. <http://dx.doi.org/10.1080/09658211.2017.1395054>.
- Locke, J. (1689). *An essay concerning human understanding*, 2nd edn, Oxford: Oxford University Press.
- Marjanovic, Z., Holden, R., Struthers, W., Cribbie, R., Greenglass, E. (2015). The inter-item standard deviation (ISD): an index that discriminates between conscientious and random responders. *Personality and Individual Differences*, **84**, 79–83. <http://dx.doi.org/10.1016/j.paid.2014.08.021>.
- Markus, H., Nurius, P. (1986). Possible selves. *American Psychologist*, **41**(9), 954–69. <http://dx.doi.org/10.1037/0003-066X.41.9.954>.
- Olsen, R.K., Palombo, D.J., Rabin, J.S., Levine, B., Ryan, J.D., Rosenbaum, R.S. (2013). Volumetric analysis of medial temporal lobe subregions in developmental amnesia using high-resolution magnetic resonance imagining. *Hippocampus*, **23**(10), 855–60. <http://dx.doi.org/10.1002/hipo.22153>.
- Palombo, D.J., Williams, L.J., Abdi, H., Levine, B. (2013). The survey of autobiographical memory (SAM): a novel measure of trait mnemonics in everyday life. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior*, **49**(6), 1526–40. <http://dx.doi.org/10.1016/j.cortex.2012.08.023>.
- Picard, L., Mayor-Dubois, C., Maeder, P., et al. (2013). Functional independence within the self-memory system: new insights from two cases of developmental amnesia. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior*, **49**(6), 1463–81. <http://dx.doi.org/10.1016/j.cortex.2012.10.003>.
- Prebble, S.C. (2014). In: University of Auckland, editor. *Autobiographical Memory and Sense of Self* (PhD thesis, Auckland).
- Prebble, S.C., Addis, D.R., Tippett, L.J. (2013). Autobiographical memory and sense of self. *Psychological Bulletin*, **139**(4), 815–40. <http://dx.doi.org/10.1037/a0030146>.
- Quoidbach, J., Gilbert, D.T., Wilson, T.D. (2013). The end of history illusion. *Science*, **339**(6115), 96–8. <http://dx.doi.org/10.1126/science.1229294>.
- Rabin, J.S., Carson, N., Gilboa, A., Stuss, D.T., Rosenbaum, R.S. (2013). Imagining other people's experiences in a person with impaired episodic memory: the role of personal familiarity. *Frontiers in Psychology*, **3**, 10.
- Race, E., Keane, M.M., Verfaellie, M. (2011). Medial temporal lobe damage causes deficits in episodic memory and episodic future thinking not attributable to deficits in narrative construction. *The Journal of Neuroscience*, **31**(28), 10262–9. <http://dx.doi.org/10.1523/JNEUROSCI.1145-11.2011>.
- Race, E., Keane, M.M., Verfaellie, M. (2015). Sharing mental simulations and stories: hippocampal contributions to discourse integration. *Cortex: A Journal Devoted to the Study of the Nervous*

- System and Behavior, 63, 271–81. <http://dx.doi.org/10.1016/j.cortex.2014.09.004>.
- Rose, N.S., Olsen, R.K., Craik, F.I.M., Rosenbaum, R.S. (2012). Working memory and amnesia: the role of stimulus novelty. *Neuropsychologia*, 50(1), 11–8. <http://dx.doi.org/10.1016/j.neuropsychologia.2011.10.016>.
- Rosenbaum, R.S., Carson, N., Abraham, N., et al. (2011). Impaired event memory and recollection in a case of developmental amnesia. *Neurocase*, 17, 394–409.
- Rosenbaum, R.S., Gao, F., Honjo, K., et al. (2014). Congenital absence of the mammillary bodies: a novel finding in a well-studied case of developmental amnesia. *Neuropsychologia*, 65, 82–7. <http://dx.doi.org/10.1016/j.neuropsychologia.2014.09.047>.
- Rosenberg, M. (1965). *Society and the adolescent self-image*, Princeton, NJ: Princeton University Press.
- Ross, M., Wilson, A.E. (2002). It feels like yesterday: self-esteem, valence of personal past experiences, and judgments of subjective distance. *Journal of Personality and Social Psychology*, 82(5), 792–803. <http://dx.doi.org/10.1037/0022-3514.82.5.792>.
- Sacks, O. (1970). *The man who mistook his wife for a hat*, New York: Touchstone.
- Schacter, D.L., Addis, D.R. (2007). On the constructive episodic simulation of past and future events. *Behavioral and Brain Sciences*, 30(3), 331–2. <http://dx.doi.org/10.1017/S0140525X07002178>.
- Singer, J.A., Blagov, P., Berry, M., Oost, K.M. (2013). Self-defining memories, scripts, and the life story: narrative identity in personality and psychotherapy. *Journal of Personality*, 81(6), 569–82. <http://dx.doi.org/10.1111/jopy.12005>.
- Sokol, Y., Conroy, A.K., Weingartner, K.M. (2017). The cognitive underpinnings of continuous identity: higher episodic memory recall and lower heuristic usage predicts highest levels of self-continuity. *Identity: An International Journal of Theory and Research*, 17(2), 84–95. <http://dx.doi.org/10.1080/15283488.2017.1303384>.
- Squire, L.R., Kandel, E.R. (1999). *Memory: from mind to molecules*, New York: Henry Holt & Company, LLC.
- Stanley, M.L., Henne, P., Iyengar, V., Sinnott-Armstrong, W., De Brigard, F. (2017). I'm not the person I used to be: the self and autobiographical memories of immoral actions. *Journal of Experimental Psychology: General*, 146(6), 884–95. <http://dx.doi.org/10.1037/xge0000317>.
- Symons, C. S., & Johnson, B. T. (1997). The self-reference effect in memory: A meta-analysis. *Psychological Bulletin*, 121(3), 371–94. <https://doi.org/10.1037/0033-2909.121.3.371>.
- Tippett, L.J., Prebble, S., Addis, D.R. (2018). The persistence of the self over time in mild cognitive impairment and early Alzheimer's disease. *Frontiers in Psychology*, 9, 94. doi: 10.3389/fpsyg.2018.00094.
- Trope, Y., Liberman, N., editors (2003). Temporal construal. *Psychological Review*, 110, 403–21. doi: 10.1037/0033-295X.110.3.403.
- Tulving, E. (1972). Episodic and semantic memory. In: Tulving, E., Donaldson, W., editors. *Organization of memory*, Oxford, England: Academic Press.
- Tulving, E. (1993). Self-knowledge of an amnesic individual is represented abstractly. In: Srull, T.K., Wyer, R.S., Jr., editors. *Advances in social cognition*, Vol. 5. *The mental representation of trait and autobiographical knowledge about the self* (p. 147–156), Lawrence Erlbaum Associates, Inc.
- Tulving, E. (2002). Episodic memory: from mind to brain. *Annual Review of Psychology*, 53(1), 1–25. <http://dx.doi.org/10.1146/annurev.psych.53.100901.135114>.
- Vargha-Khadem, F., Gadian, D.G., Mishkin, M. (2002). Dissociations in cognitive memory: the syndrome of developmental amnesia. In: Baddeley, A., Aggleton, J.P., Conway, M.A., editors. *Episodic memory: new directions in research* (pp. 153–63, Chapter x, 294 Pages), New York, NY: Oxford University Press. doi: <http://dx.doi.org/10.1093/acprof:oso/9780198508809.003.0009>
- Vargha-Khadem, S., Watkins, F., Gadian, M. (2003). Developmental amnesia: effect of age at injury. *Proceedings of the National Academy of Sciences*, 100(17), 10055–60. doi: 10.1073/pnas.1233756100.
- Verfaellie, M., Wank, A.A., Reid, A.G., Race, E., Keane, M.M. (2019). Self-related processing and future thinking: distinct contributions of ventromedial prefrontal cortex and the medial temporal lobes. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior*, 115, 159–71. <http://dx.doi.org/10.1016/j.cortex.2019.01.028>.
- Wilson, A.E., Ross, M. (2003). The identity function of autobiographical memory: time is on our side. *Memory*, 11(2), 137–49. <http://dx.doi.org/10.1080/741938210>.
- Zimbardo, P.G., Boyd, J.N. (1999). Putting time in perspective: a valid, reliable individual-differences metric. *Journal of Personality and Social Psychology*, 77(6), 1271–88. <http://dx.doi.org/10.1037/0022-3514.77.6.1271>.