## Single Case Report

# Autobiographical memory unknown: Pervasive autobiographical memory loss encompassing personality trait knowledge in an individual with medial temporal lobe amnesia

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### ARTICLE INFO

### ABSTRACT

Autobiographical memory consists of distinct memory types varying from highly abstract to episodic. Self trait knowledge, which is considered one of the more abstract types of autobiographical memory, is thought to rely on regions of the autobiographical memory neural network implicated in schema representation, including the ventromedial pre-frontal cortex, and critically, not the medial temporal lobes. The current case study introduces an individual who experienced bilateral posterior cerebral artery strokes resulting in extensive medial temporal lobe damage with sparing of the ventromedial prefrontal cortex. Interestingly, in addition to severe retrograde and anterograde episodic and autobiographical fact amnesia, this individual's self trait knowledge was impaired for his current and pre-morbid personality traits. Yet, further assessment revealed that this individual had preserved conceptual knowledge for personality traits, could reliably and accurately rate another person's traits, and could access his own self-concept in a variety of ways. In addition to autobiographical memory loss, he demonstrated impairment on non-personal semantic memory tests, most notably on tests requiring retrieval of unique knowledge. This rare case of amnesia suggests a previously unreported role for the medial temporal lobes in self trait knowledge, which we propose reflects the critical role of this

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neural region in the storage and retrieval of personal semantics that are experience-near, meaning autobiographical facts grounded in spatiotemporal contexts.

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*"Today I feel off, like I just woke up. Something's off."* HML040

## 1.    Introduction

Through autobiographical memory we keep a record of the experiences, places, and people that compose our life story. According to cognitive models (Conway, 2005; Klein, 2012; Prebble et al., 2013), autobiographical memory consists of episodic memories (i.e., autobiographical memories of unique events), and personal semantics, including autobiographical facts (i.e., factual features of our life record) and self trait knowledge (i.e., broad knowledge about one's general demeanor or social behavior). It is believed that these types of autobiographical memory collectively represent one's identity and are retrieved to reflect our past and contemplate our future (Levine et al., 2002; Strikwerda-Brown et al., 2019).

According to cognitive theory, self trait knowledge has many qualities that distinguish it from episodic memories and autobiographical facts (Conway, 2005; Grilli, 2017; Grilli, Bercel, et al., 2018; Klein, 2012; Renoult et al., 2012). Predominant among these qualities is its apparent abstractness. From a cognitive perspective, whereas episodes imprint details of a singular event, autobiographical facts represent specific knowledge, and traits reflect abstract themes that are far less specific to one context or event feature. In other words, traits capture the commonalities of large catalogs of experiences, possibly ranging widely in social and physical context, as well as time. As a result, self trait knowledge is believed to represent life experience at a categorically more abstract level than other types of autobiographical memory.

As support for an abstract characterization of self trait knowledge, cognitive neuroscience findings have associated personality traits with the ventromedial prefrontal cortex (vmPFC), which is believed to support schema-level knowledge (Ghosh & Gilboa, 2014; Gilboa & Marlatte, 2017). For instance, in a meta-analysis of functional magnetic resonance imaging (fMRI) studies evaluating trait judgments, Martinelli et al. (2013) found that ventral and dorsal PFC and anterior cingulate cortex were reliably activated by the retrieval of self traits relative to traits about others. Neuropsychological findings, while based on a few cases, strengthen the idea that the vmPFC has a critical role in representing self trait knowledge, as three individuals with vmPFC damage (not isolated) have been shown to have varying degrees of unreliable and/or inaccurate self trait ratings (Marquine et al., 2016; Philippi et al., 2012; Philippi et al., 2017).

Building on the perspective that self trait knowledge reflects a type of abstract autobiographical memory, cognitive neuroscience research has suggested that the medial temporal lobes (MTLs) may not be critical for self trait knowledge. For instance, Tulving (1993) reported that KC, who had extensive MTL lesions, could reliably rate his own postmorbid traits, which were accurately updated because they were different from his premorbid self as rated by his mother. This sparing occurred in the context of severely impaired episodic memory, along with impaired autobiographical facts for his recent life (Rosenbaum et al., 2005). Additional evidence for single dissociations in neuropsychological data have been reported in three other cases of extensive unilateral or bilateral MTL damage, where self trait knowledge was intact in the face of impaired episodic memory and autobiographical facts (Grilli, Bercel, et al., 2018; Klein et al., 2002; Klein & Lax, 2010). The apparent separation of self trait knowledge from the MTLs has persisted despite growing appreciation that other personal semantics depend on the MTLs (Grilli & Verfaellie, 2014; Renoult et al., 2012). For instance, we have shown that the retrieval of autobiographical facts attached to a spatiotemporal context, which we have termed "experience-near" autobiographical facts, is compromised by MTL damage, whereas the retrieval of experience-far autobiographical facts that are devoid of such contexts does not depend on the MTL (Grilli & Verfaellie, 2016). Though relevant case studies of self trait knowledge are few, these findings are also corroborated by numerous fMRI studies. Critically, relative to judging the personality traits of a close person (e.g., parent, relationship partner) or the semantic features of trait words, self judgments of trait knowledge have not been reliably associated with greater activation in the MTLs (see meta-analysis by Martinelli et al., 2013). In contrast, both episodic memory retrieval and the retrieval of autobiographical facts are related to MTL activation (Martinelli et al., 2013).

### 1.1.    HML040: impaired self trait knowledge in an individual with medial temporal lobe amnesia

In this context, we present the case of HML040, an 80-year-old individual who was working and functioning independently prior to developing profound retrograde and anterograde amnesia secondary to bilateral posterior cerebral artery (PCA) strokes. Available to us at referral, clinical MRI and CT scans revealed extensive bilateral lesions to the hippocampus from the strokes, as well as surrounding MTL regions. The lesions from the strokes extended into inferior temporo-occipital cortex, especially on the left, but critically did not include the vmPFC. In light of these neuroimaging data, we conducted an initial assessment of autobiographical memory in HML040, expecting to find spared self trait knowledge in the face of amnesia for episodic memory and autobiographical facts. Not surprisingly, we found that HML040 had episodic and factual autobiographical amnesia. However, contrary to prior cases of amnesia, we found that HML040 could not reliably or accurately rate his personality traits – neither for who he is now nor for who he was prior to his amnesia.

We subsequently administered a series of experimental tasks to HML040 and a control group to a) explore possible explanations for HML040's poor self trait knowledge performance, and b) better characterize the degree to which his autobiographical memory knowledge base was impoverished. Regarding possible explanations for his impaired self trait knowledge, we considered whether HML040 had degraded semantic knowledge of traits as social concepts, if he was unable to make reliable or accurate judgments of *anyone's* traits, and if he had a global impairment in accessing his self-concept. As we will show in Section 3.2, HML040's performance did not support any of these hypotheses. Instead, the results suggest that, although his impaired trait knowledge was specific to the self, it was not accompanied by broader deficits in the self-concept, and it occurred in the context of extensive disruption of his autobiographical memory knowledge base. As we elaborate in Section 4, HML040 provides insights into the organization and neural substrates of self trait knowledge.

## 2. Description of present case study

### 2.1. Case history

HML040 was an 80-year-old male with 20 years of education when he participated. HML040 experienced sequential bilateral PCA strokes, the second of which involved the left PCA territory and resulted in the onset of his memory impairment approximately one and a half years before our initial evaluation. His previous right PCA stroke was clinically silent. HML040's wife reported that prior to his second stroke, he had no cognitive difficulties, was working full time, and was completely independent in activities of daily living. She also reported that his memory impairment appeared to be stable after his strokes, as opposed to worsening, with no new cognitive difficulties surfacing recently.

### 2.2. Neuroimaging data

Information about lesion localization was available from clinical scans. Part A of Fig. 1 shows the location of HML040's strokes based on a CT scan obtained around the time of our initial evaluation (approximately one and a half years after his second stroke) as it provides the best spatial resolution and MTL definition of the PCA infarcts. We also present T2 FLAIR images from a clinical MRI obtained a few days after the second stroke (part B of Fig. 1). Review of the scans revealed that his strokes affected the entire length of the hippocampus and surrounding MTL structures bilaterally. The stroke also extended into inferior temporo-occipital regions bilaterally, but more so on the left. Posterior cortical regions of the autobiographical memory network, including lateral and medial parietal cortex/cingulate, were not directly lesioned by the strokes, nor did the strokes affect the anterior lateral temporal lobes or the prefrontal cortex. There was evidence of left posterior thalamic involvement, but the lesion did not encompass the anteroventral or medial dorsal thalamic nuclei implicated in memory function (Van Der Werf et al., 2003). There was no evidence of age disproportionate cortical

atrophy. In addition, consistent with HML040's history of hypertension, the MRI revealed moderate chronic deep and periventricular white matter ischemic changes, sparing the vmPFC. Based on review of the clinical scans, we observed no obvious changes between the acute stage MRI obtained shortly after the second stroke and the subsequent CT obtained one and half years later, suggesting no intervening clinical incident or development of new pathology.

### 2.3. Case assessment

We obtained informed consent from all participants in this study in accordance with the University of Arizona Institutional Review Board. We report how we determined our sample size, all data exclusions, all inclusion/exclusion criteria, whether inclusion/exclusion criteria were established prior to data analysis, all manipulations, and all measures in the study. The digital testing materials for some experimental tasks, deidentified dataset, and corresponding data analysis code can be found here: https://osf.io/vhtsk/. The conditions of our ethical approval do not permit sharing of the raw neuroimaging data in this study with any individual outside the research team under any circumstances. Stimuli and testing materials for experimental tasks not archived because of copyright or "ownership" restrictions include Autobiographical Memory Interview (Kopelman et al., 1989), Famous Faces Task (current study), Famous Landmarks Task (current study), Social and Non-Social Concepts Task (Pobric et al., 2016), Tennessee Self-Concept Scale, Second edition (TSCS-II; Fitts & Warren, 1996), and Autobiographical Interview (Levine et al., 2002). The Famous Faces and Famous Landmarks Tasks that were developed for the current study are available upon request to the corresponding authors. Stimuli and testing materials for standard neuropsychological tests included in this study are not publicly archived on the open source page due to copyright restrictions and for ethical reasons. This includes the Wechsler Adult Intelligence Scale, Fourth edition (WAIS-IV; Wechsler, 2008), Wechsler Memory Scale, Fourth edition (WMS-IV; Wechsler, 2009), Pyramids and Palm Trees (Howard & Patterson, 1992), Boston Naming Test-II (Kaplan et al., 2001), Cambridge Naming Test (Adlam et al., 2010), verbal phonemic and animal fluency (Benton et al., 1983), and Trail Making Test A & B (Reitan & Wolfson, 1985). The study procedures and analyses were not preregistered.

#### 2.3.1. Neuropsychological and psychological assessment

As part of our initial research work-up, HML040 was administered a battery of standardized neuropsychological tests approximately one and a half years after his second stroke. In terms of premorbid intelligence and functioning, HML040 achieved 20 years of education and worked in a highly demanding career requiring a professional degree. As seen in Table 1, HML040 demonstrated a pattern largely consistent with MTL amnesia, characterized by impaired learning and memory with what appears to be largely, albeit not complete, sparing of intellectual functioning and other cognitive domains. On the WAIS-IV (Wechsler, 2008), HML040 demonstrated low average overall intelligence, with average verbal comprehension and low average perceptual reasoning. Consistent with his educational and occupational
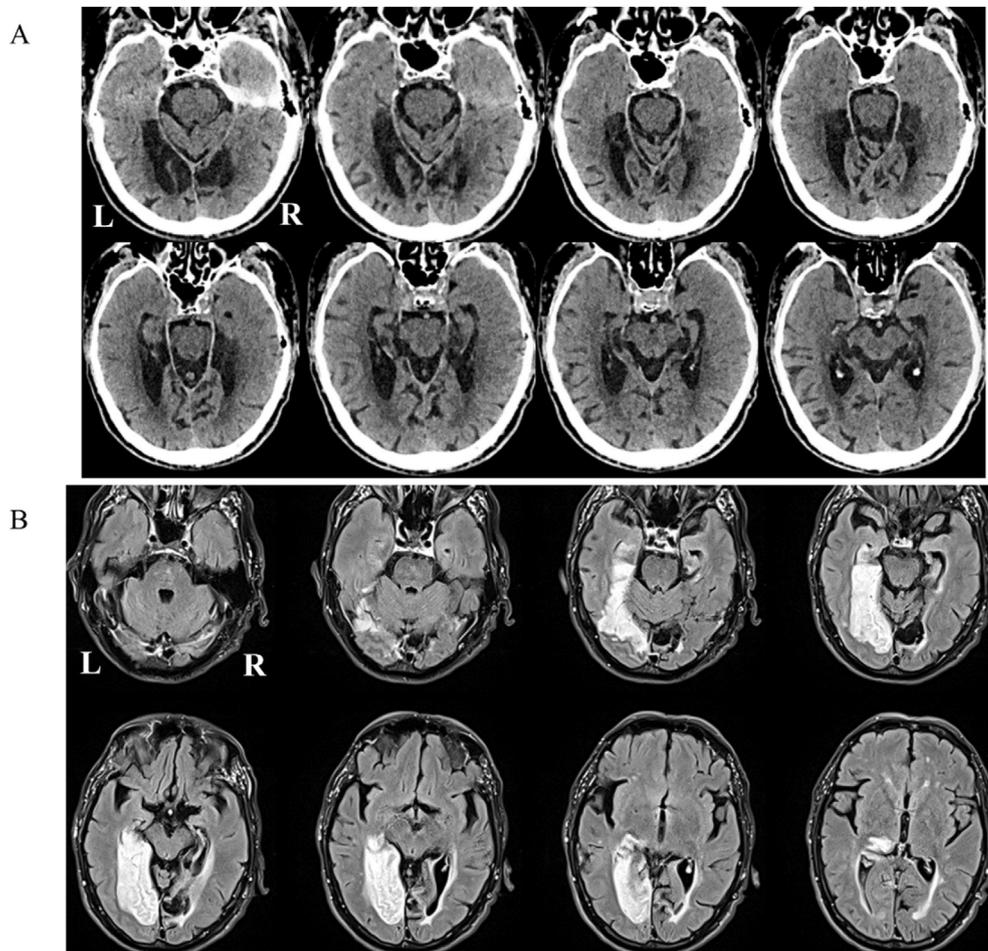
Fig. 1 — Part A includes axial CT images of HML040's lesions approximately 1.5 years after the second PCA stroke. The eight images track the lesion from ventral (top left) regions to those more dorsal (bottom right). Part B shows axial images from the MRI T2 Flair that was obtained a few days after the second stroke. They also track from ventral to dorsal in the same order.

background, his Similarities score was high average, which is correlated with measures of premorbid function in healthy adults (Bright & van der Linde, 2020). However, the Vocabulary and Information subtest scores were in the average range, which may represent a decline from premorbid levels. If these scores do reflect a decline, we suspect it is attributable to a loss of semantic knowledge, which further assessment showed to be an area of difficulty for HML040. HML040 consistently performed near the floor on learning and memory assessed by the WMS-IV (Wechsler, 2009). As a result, his performance was profoundly impaired for verbal and non-verbal memory across multiple subtests, with delayed memory more severely impaired than immediate memory. In regard to language and non-personal semantic memory, or "general semantics" (Renoult et al., 2012), HML040's performance was somewhat mixed. Whereas his performance on a verbal comprehension test of basic semantic knowledge was spared (Pyramids and Palm Trees; Howard & Patterson, 1992), he showed mild to moderate object naming impairment (Boston Naming Test-II, Kaplan et al., 2001; Cambridge Naming Test, Adlam et al., 2010). Verbal fluency was also impaired on generating words for animals. In the executive functioning domain, HML040

showed normal working memory on the WAIS-IV, and his performance was low average on generating words that begin with a particular letter, namely "F", "A", and "S" (Benton et al., 1983). Whereas performance on Trails B was impaired, he was likely hindered by slow mental and psychomotor processing speed as demonstrated by the WAIS-IV tasks and Trails A. Notably, Trails B was normatively similar to Trails A (Reitan & Wolfson, 1985). We also did not observe any clinical signs of frontal lobe impairment in our interactions with HML040.

We administered additional semantic memory tests that assessed HML040's ability to retrieve unique information from several categories of non-personal knowledge including famous people (names and facts), landmarks, and historical facts (see supplemental materials for full task descriptions). Our motivation for administering these tasks was to assess non-personal semantics at a more unique level akin to autobiographical memory assessment (Grilli, Bercel, et al., 2018). HML040 was consistently impaired across these tests. Additionally, we stratified the results of the Famous Faces and Historical Events tasks to examine whether a temporal gradient was present in HML040's performance. Although there was no discernible temporal pattern for his Historical

**Table 1 — HML040's neuropsychological performance.**

|  | Raw Score | Standardized Score | Interpretation |
|---|---|---|---|
| **WAIS-IV** | | | |
| Similarities | 30 | 14 | High average |
| Vocabulary | 45 | 12 | Average |
| Information | 11 | 8 | Average |
| Block design | 20 | 7 | Low average |
| Matrix reasoning | 8 | 8 | Average |
| Visual puzzles | 6 | 6 | Low average |
| Digit span | 21 | 8 | Average |
| Arithmetic | 11 | 8 | Average |
| Symbol search | 4 | 2 | Impaired |
| Digit symbol coding | 15 | 3 | Impaired |
| Full scale IQ | | 83 | Low average |
| Verbal comprehension index | | 107 | Average |
| Perceptual reasoning index | | 82 | Low average |
| Working memory index | | 89 | Low average |
| Processing speed index | | 59 | Impaired |
| **WMS-IV** | | | |
| Logical memory I | 11 | 4 | Impaired |
| Logical memory II | 0 | 1 | Impaired |
| Verbal paired associates I | 3 | 3 | Impaired |
| Verbal paired associates II | 0 | 1 | Impaired |
| Visual reproduction I | 14 | 4 | Impaired |
| Visual reproduction II | 0 | 2 | Impaired |
| Symbol span | 10 | 8 | Average |
| Auditory memory index | | 51 | Impaired |
| Visual memory index | | 58 | Impaired |
| Immediate memory index | | 60 | Impaired |
| Delayed memory index | | 43 | Impaired |
| **General Semantics** | | | |
| Animal fluency | 9 | −2.5 | Impaired |
| Boston naming test-II | 36 | −2.4 | Impaired |
| Cambridge naming test | 49 | −11.59 | Impaired |
| Pyramids and Palm trees (words) | 48 | 92.31% | WNL |
| Famous faces task | 37 | −3.74 | Impaired |
| Semantic knowledge of famous persons | 13 | −8.78 | Impaired |
| Famous landmarks task | 4 | −7.51 | Impaired |
| Historical events task | 5 | −5.36 | Impaired |
| **Processing speed/executive function** | | | |
| Trails A | 90.9″ | −2.9 | Impaired |
| Trails B | >300″ | <−3 | Impaired |
| F + A + S | 38 | −.3 | Average |

*Note.* Standardized scores from the subtests and indices of the WAIS-IV and WMS-IV are scaled scores and index scores, respectively, and derived from the published norms. z-scores are reported for all general semantic (except Pyramids and Palm Trees) and executive function tests. Both fluency tests, Boston Naming Test-II, and Trails z-scores were based on norms from Heaton et al., 2004. The z-scores for the last four general semantic tasks were calculated from HML040's matched control group described in Section 3. The z-score for Cambridge Naming Test was calculated using a different, unpublished control sample of healthy middle age and older adults (N = 32). For Pyramids and Palm Trees, percent correct is reported in the standardized score column and a score of >90% is considered within normal limits (WNL) per published norms. WAIS-IV = Wechsler Adult Intelligence Scale, Fourth edition, WMS-IV = Wechsler Memory Scale, Fourth edition.

Events performance (all z-scores ≤ −2.11), knowledge for Famous Faces in earlier decades was better preserved than for later decades (1940s—1950s z-score = −.69, 1960s—1970s z-score = −1.85, 1980s—1990s z-score = −5.16, 2000s—2010s z-score = −4.40).

As part of our work up, we also reviewed HML040's psychological history. Per medical records, HML040 had a history of chronic depression and was on antidepressant medication at the time of testing. Clinical depression was not formally assessed because depression questionnaires require individuals to make subjective judgments about the recent past (e.g., the past week), which would likely be difficult for HML040 considering his severe anterograde amnesia. Our

behavioral observations were that he was in good spirits overall, but when testing became more difficult or when he was more aware of his difficulties, he appeared down.

### 2.3.2. Initial autobiographical memory assessment

HML040 was administered two tests of autobiographical memory as part of the initial research battery. The first was the Autobiographical Memory Interview (AMI; Kopelman et al., 1989), which assesses episodic memory and personal semantics and was completed in a single session. The second was a personality trait questionnaire that we have used before (Grilli, Bercel, et al., 2018; Marquine et al., 2016) and for which we have in-lab normative data available on a group of older

**Table 2 — HML040's autobiographical memory performance.**

| Autobiographical memory assessment | Normative sample | | HML040 | |
|---|---|---|---|---|
| | Mean | Standard deviation | Raw score | z-score |
| Autobiographical memory interview (N = 34) | | | | |
|     Personal semantic childhood | 18.41 | 2.71 | 4.50 | −5.13 |
|     Personal semantic young adult | 19.24 | 1.92 | 8.50 | −5.59 |
|     Personal semantic recent | 20.29 | .95 | 5.00 | −16.09 |
|     Autobiographical incidents childhood | 7.35 | 1.56 | 2.00 | −3.43 |
|     Autobiographical incidents young adult | 7.31 | 1.53 | .00 | −4.78 |
|     Autobiographical incidents recent | 7.65 | 1.06 | .00 | −7.22 |
| Personality trait self rating reliability (N = 21) | .84 | .07 | | |
|     Anterograde | | | .466 | −5.45 |
|     Retrograde | | | .651 | −2.74 |

*Note.* The normative sample for the Autobiographical Memory Interview (N = 34) comes from Kopelman et al., 1989, whereas the normative sample for the personality trait ratings (N = 21) comes from our lab. Personality trait rating scores are represented as intraclass correlation coefficients.

adults (N = 21, mean age = 73) collected prior to the current study. For the personality trait questionnaire, on two occasions separated by one week, HML040 was asked to rate the degree to which 84 traits describe his current personality, using a four-point scale ranging from "not at all" to "definitely me." Though the traits were the same at both assessments, they were presented in a different order. Half of the traits were identified as positive and half as negative (Marquine et al., 2016) utilizing likableness ratings (Anderson, 1968). In addition to judging his current or anterograde personality, HML040 completed a version that assessed retrograde personality (i.e., "before your strokes"). We also had his wife complete the questionnaire describing HML040's personality, enabling an assessment of HML040's accuracy (our normative sample does not include accuracy data). Reliability was calculated with one-way intraclass correlation coefficients (ICCs), single measure, between the first and second ratings of participants' self-ratings (for both retrograde and anterograde rating sets in HML040), as well as other person ratings. Accuracy was calculated with two-way mixed ICCs, absolute agreement, between HML040 and his wife's ratings of his retrograde and anterograde personality traits.

HML040 exhibited profound impairment for all three types of autobiographical memory. The results, shown in Table 2, demonstrate that both remote and recent episodic and personal semantic memory were severely impaired, as was retrograde and anterograde self trait knowledge reliability when compared to our in-lab normative sample. The accuracy of HML040's self-trait ratings was also poor when compared with his wife's ratings of his personality.

## 3. Follow-up assessment prompted by HML040's impaired self trait ratings

To better understand the cause of HML040's impaired self trait knowledge, in Parts 1 and 2, we administered established and novel tasks to test several hypotheses related to this pattern of results. In both series, HML040 was compared to a group of six controls. We determined this sample size was adequate because it is a slightly larger ratio of controls to patients in

comparison to a similar study using the same statistical approach (Robin et al., 2019). The control participants (4 females and 2 males) were matched to HML040 in age (M = 76.5, SD = 3.02), p > .10, and level of education (M = 18.67, SD = 2.42), p > .10, according to a single patient-to-group Bayesian t-test approach (Crawford & Garthwaite, 2007; Makowski, 2018; R Core Team, 2019). Given the age range of our controls, they were assessed using a brief neuropsychological battery to rule out cognitive impairment (Grilli, Wank, Bercel, et al., 2018). Control participants received the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977) to rule out clinical depression.

### 3.1. Approach to data analysis for parts 1 and 2

Many of our experimental cognitive tests in Parts 1 and 2 did not produce normally distributed data in controls. For this reason, we chose to calculate descriptive statistics to examine HML040's performance, which is consistent with prior research comparing single cases to controls on tests for which cognitively unimpaired performance is not normally distributed (Robin et al., 2019). On each test, we calculated z-scores for HML040 based on the group performance of matched controls. The following classification was used for z-score qualifiers reported below: z-scores < −2 standard deviations were identified as impaired, −2 < z-scores < −1.4 standard deviations were borderline, −1.4 < z-scores < −.7 standard deviations were low average, and −.7 > z-scores > +1.4 standard deviations above were average to high average. To determine reliability between first and second personality trait ratings in controls, as we did with HML040, one-way intraclass correlation coefficients (ICCs), single measure, were calculated. When a measure of accuracy was needed (i.e., between HML040 and his wife's ratings of her personality traits), we calculated two-way mixed ICCs, absolute agreement. We also conducted reliability analyses for tests that required scoring of episodes, episodic details, autobiographical facts, and general, or non-personal, semantic knowledge (described in Sections 3.2.1 and 3.3.1 and Supplemental Materials). All analyses and data visualization were conducted in RStudio (R Core Team, 2019), using the ggplot2 (Wickham,

2016), reshape2 (Wickham, 2007), ggrepel (Slowikowski, 2020), and ggpubr (Kassambara, 2020) packages.

### 3.2. Part 1: investigation of HML040's trait and self-concept knowledge

In an attempt to understand HML040's impaired knowledge of his personality traits, we first considered three hypotheses: 1) Was HML040's impairment in judging his own personality traits reflective of a general deficit in understanding the meaning of traits as social concepts, 2) Was HML040's impairment related to an inability to apply knowledge of traits to specific individuals (self or other), or 3) Was HML040 unable to bring to mind a conceptualization or schema of himself (i.e., self-concept), affecting his ability to judge his own traits?

#### 3.2.1. Part 1 methods and materials
Before addressing our hypotheses, we assessed whether HML040's self-trait ratings were similarly impaired when we compared his performance to his age and education matched controls by calculating a reliability z-score derived from reliability ICCs of the six controls.

To investigate HML040's general knowledge of personality traits (Hypothesis 1), we administered the Social and Non-Social Concepts Task, which assessed the precision of abstract semantic knowledge for the relationship between social and non-social concepts. The task was taken from Pobric et al. (2016) where participants were presented with a probe word, a target word, and a distractor word on a computer screen. They were instructed to make a judgment of whether the target or distractor was more closely related in meaning to the probe. In the original study, there were a total of 160 items where half were social words, including words referring to personality traits (e.g., probe: respected, distractor: wicked, target: admired) and other social scenarios (e.g., probe: refuge, distractor: novelty, target: sanctuary), whereas the other half were non-social abstract words (e.g., probe: frequency, distractor: edition, target: occurrence). We randomly selected five social and five non-social words to use as practice. Participants were provided with accuracy feedback during practice. They then cycled through a randomized presentation of 75 triads of social words and 75 triads of non-social words, recording their responses using corresponding keyboard buttons. The correct answer for both word types (social and non-social) was presented on the left and right sides of the screen equally. The outcomes of interest were accuracy for social, non-social, and total items. To more specifically assess for HML040's trait knowledge, we conducted a follow-up analysis for which we separated 26 of the 75 social items that assessed trait knowledge (i.e., the probe, target, and distractor words were all traits) and calculated accuracy scores for trait and non-trait items.

We also examined whether HML040 was reliable and accurate in judging personality traits of an individual other than himself (Hypothesis 2). Another version of the 84-item personality trait questionnaire (Grilli, Bercel, et al., 2018; Marquine et al., 2016) was administered twice (t1 and t2), separated by about one to two weeks, to participants who were asked to rate the traits of a personally known individual (for HML040, this was his wife). We also asked HML040's wife

to rate her own personality to measure HML040's ability to accurately judge another person's traits. Other person accuracy was not assessed in controls as we did not collect trait ratings from the identified person. Notably, we instructed our participants that they needed to select a person whom they were very close to and felt that they could most accurately rate, and not that the other person could or would be willing to participate in research.

A third potential source of HML040's impaired self trait knowledge is that he has a fundamental deficit in the ability to access his self-concept (Hypothesis 3), which we assessed with four tasks. The Twenty Statements Test has been commonly used in prior studies of amnesia and related memory disorders as a basic measure of self-concept access, or identity strength (Addis & Tippett, 2004). In our use of the Twenty Statements Test, participants were given a sheet of paper with 20 "I Am _____" statements and asked to complete as many statements as they could with a word or short phrase describing their identity. Consistent with prior research using this task to assess self-concept strength in individuals with memory disorders (Addis & Tippett, 2004; Ben Malek et al., 2018; Philippi et al., 2017), our primary outcome of interest was the total number of self-statements completed by HML040 relative to the controls.

In another assessment of self-concept, we asked whether HML040 was able to generate related autobiographical memories for self-defining I Am statements. In an adaptation of a task developed by Rathbone et al. (2009), the Self-Defining Memory Task asked participants to select six I AMs from the Twenty Statements Test, and then to provide six memories supporting each statement. Participants were asked for memories one at a time, and responses were audio recorded. Consistent with prior work, we assessed whether the memories were episodes, "experience-near" or episodic-like autobiographical facts (i.e., facts associated with a spatiotemporal context), or "experience-far" or more abstract autobiographical facts (Grilli & Verfaellie, 2015; 2016). Our primary outcome of interest was whether HML040 was able to provide as many memories as controls to ground his most defining features of his self-concept, and whether he relied on a qualitatively similar profile of memories. Two trained raters scored data from all participants. z-scores were calculated from averaging the two raters' scores for each memory type. Excellent reliability was achieved for experience-near and experience-far facts (Cronbach's alpha range = .91–.94). Although reliability was low for episodic memories generated (Cronbach's alpha = .17), this was because there were very few occurrences, aligning with prior research (Grilli, 2017; Grilli & Verfaellie, 2015).
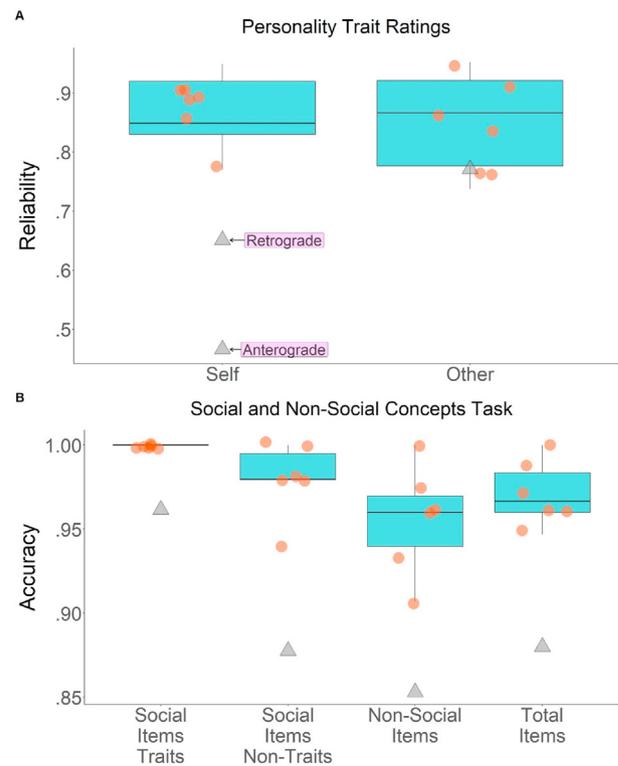
The TSCS-II (Fitts & Warren, 1996) is designed to measure three components of the self-concept, namely identity (e.g., "I am an honest person"), satisfaction (e.g., "I understand my family as well as I should"), and behavior (e.g., "I take good care of myself physically"), across five domains of life, including personal, family, social, moral, and physical. The first of two metrics that were our focus was an inconsistency score, which is how stably one evaluates their own preferences, behavior, and beliefs (i.e., rating these statements similarly: "I am a friendly person" and "I get along well with other people"). Nine pairs of statements were included in this

score that was calculated by summing the absolute value of the differences between the two ratings for each pair of statements. Second, we summed the number of Identity sub-scale questions given a vague self-descriptiveness score, meaning a score of "3" or "partly true and partly false" on a scale from 1 to 5. According to Addis and Tippett (2004), vague responses on this measure can be viewed as a measure of self-concept uncertainty.

We also considered the possibility that making self trait judgments at least in part requires what has been termed "introspective computation," reflecting the ability to rate personality traits using a behavioral simulation when relevant autobiographical memories are unavailable (Juskenaite et al., 2016). It has been proposed that relying on introspective computation may explain the sparing of personality trait judgments in patients with severe autobiographical memory loss (Juskenaite et al., 2016). We adapted a task from Ruby et al. (2007) that assessed the ability to project oneself into imagined social scenarios and judge how one would feel. Specifically, we created 36 novel social scenarios and asked participants to imagine how they would feel in each scenario (e.g., "Imagine you are at work, when your manager announces the company has decided to promote you. Do you feel suspicious [distractor], carefree [distractor], excited [target], or I cannot imagine how I would feel?"). To reduce demands on naming or self-generation/fluency, which might disadvantage HML040, participants were given three emotions to choose from for each scenario, with one of the choices more probable than the two distractor emotions based on consensus between two researchers. Critically, to evaluate the ability to self-project into the scenario, participants were given the fourth choice of "I cannot imagine how I would feel". There were six sets of answer choices (i.e., one set included one target emotion, two distracter emotions, and "I cannot imagine" option) that were each repeated six times throughout the task for a total of 36 scenario-answer choice combinations. These sets were quasi-randomized such that each would not appear more than three times in a row and each emotion choice was the target (i.e., most probable answer) twice throughout the task. The critical outcome was the number of "I cannot imagine how I would feel" answers selected by the participants, but we also reported the total number of correctly identified probable answers. One control participant received a version of the task missing the "I cannot imagine how I would feel" answer choice and therefore this comparison is based on performance from five controls.

### 3.2.2. Part 1 results

Consistent with the initial comparison to our normative data represented in Table 2, HML040's reliability rating his self trait knowledge relative to his age and education matched controls was impaired for anterograde, $z = -5.76$, and retrograde, $z = -3.08$, traits (see Fig. 2). Examining positive and negative traits separately, we found that HML040 had poor reliability

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[1] A binary coding of whether a trait was endorsed yielded strikingly similar results. In this analysis, ratings of 1 meant the trait was not endorsed, whereas the remaining ratings were classified as endorsed.

Fig. 2 — Plot (A) shows personality trait ratings for the self and a close other person. Circles: control reliability data. Triangles: HML040 reliability data. Plot (B) shows accuracy performance for social (trait and non-trait items separately), non-social, and total items on the Social and Non-Social Concepts Task. Circles: controls. Triangles: HML040. Lines within boxplots represent medians, horizontal edges represent first and third quartiles, and whiskers represent 1.5 standard deviations above the upper quartile and below the lower quartile.

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for anterograde and retrograde ratings of positive traits (anterograde ICC = −.002, retrograde ICC = .274), as well as for anterograde ratings of negative traits (ICC = −.14). He exhibited fair reliability for retrograde negative traits (ICC = .525).[1] When comparing HML040's and his wife's ratings of his personality, his accuracy describing anterograde self traits was poor based on conventional cutoffs for ICC analyses (Cicchetti, 1994), $ICC_{t1} = -.149$, $ICC_{t2} = -.171$, and poor to fair for his retrograde ratings, $ICC_{t1} = .429$, $ICC_{t2} = .52$. Of note, these low reliability and accuracy scores occurred in the context of HML040 showing a strong positivity bias of endorsed traits for anterograde ($z_{t1} = 3.04$, $z_{t2} = 2.75$), and retrograde ($z_{t1} = 1.89$, $z_{t2} = 1.42$) self trait ratings when comparing the proportion of positive traits endorsed out of total traits endorsed to those of controls.

Addressing Hypothesis 1, HML040 demonstrated impaired accuracy on the Social and Non-Social Concepts Task for social concepts ($z = -5.48$), non-social concepts ($z = -3.17$), and overall ($z = -4.64$). Critically, in our follow-up analysis of social concepts that tested trait knowledge, HML040 missed only one item (accuracy = 96%), but we were unable to calculate a
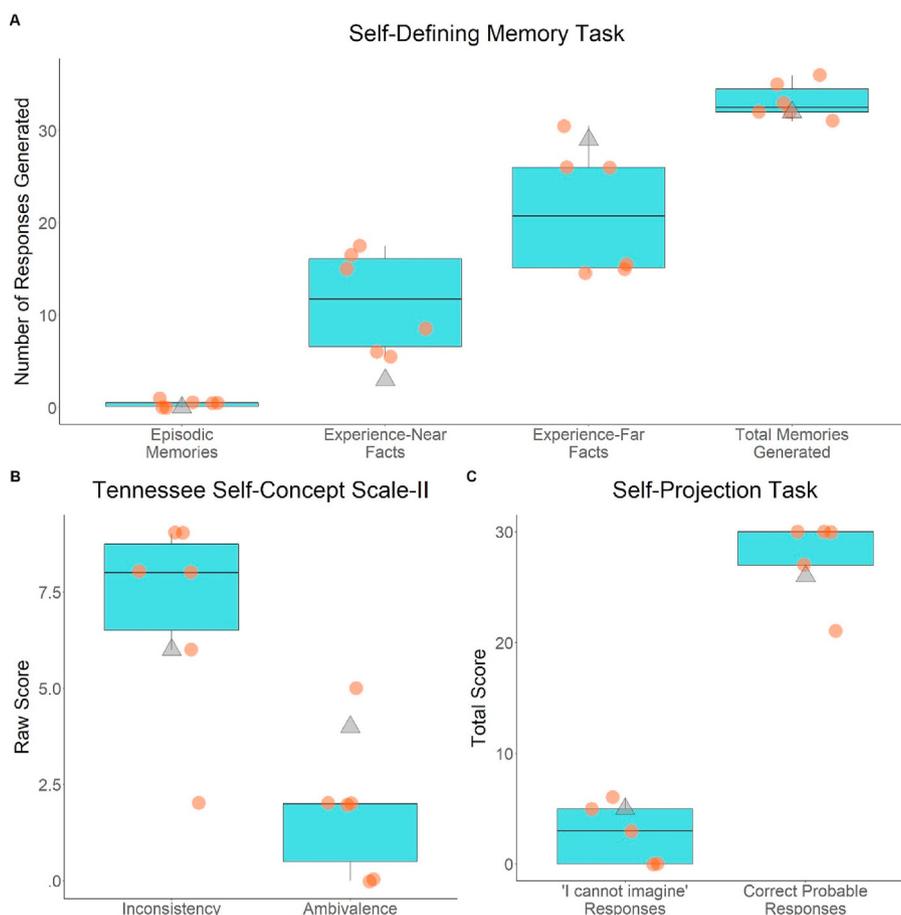
Fig. 3 — Plot (A) shows the total memories or facts generated on the Self-Defining Memory Task. Plot (B) includes the inconsistency and ambivalence raw scores from the Tennessee Self-Concept Scale-II. Plot (C) shows the total "I cannot imagine" and total correct probable responses on the Self-Projection Task. Control group N = 5 for the Self-Projection Task because one control received an older version of the task without "I cannot imagine" response. For all plots, Circles: controls; Triangles: HML040. Lines within boxplots represent medians, horizontal edges represent first and third quartiles, and whiskers represent 1.5 standard deviations above the upper quartile and below the lower quartile.

z-score given that all controls were 100% accurate. For non-trait social concepts, HML040's accuracy was impaired in comparison to controls, $z = -4.56$. All data in this section are represented in Fig. 2.

With respect to Hypothesis 2, despite being consistently impaired in his ability to rate his personality traits, HML040 made reliable and accurate trait judgments of his wife. Specifically, he demonstrated low average reliability, $z = -.89$ (ICC = .771; Fig. 2), and excellent accuracy, $ICC_{t1} = .783$ and $ICC_{t2} = .728$, based on conventional cutoffs for ICC.

Relevant to Hypothesis 3, HML040 demonstrated normal access to his self-concept via the Twenty Statements Test, as he was able to generate 20 "I Am" statements, like controls (a z-score cannot be calculated as there was no variability in the control group). For the Self-Defining Memory Task, HML040 showed a seemingly normal ability to support his core self-concept with autobiographical memories, $z = -.60$. However, consistent with prior research (Grilli & Verfaellie, 2015; 2016), HML040 showed an experience-far shift in the types of autobiographical memories used to ground his self-concept. Specifically, relative to the controls,

the number of episodic memories HML040 generated was low average, $z = -1.11$, the number of experience-near facts was borderline, $z = -1.56$, and the number of experience-far facts was high average, $z = 1.10$. On the TSCS-II, HML040's spared ability to reliably access his self-concept in a broader way than for rating trait knowledge was evidenced by average performance on the inconsistency score, $z = -.37$, and high average performance on the number of vague self-descriptiveness responses (Identity sub-scale questions), $z = 1.18$. The Self-Projection Task, assessing HML040's ability to project his sense of self to a specific, contextualized scenario and introspect on how he might feel showed that he provided an average number of "I don't know how I would feel" responses, $z = .79$, and an average number of correct probable responses, $z = -.41$. All results under Hypothesis 3 can be found in Fig. 3.

### 3.2.3. Part 1 summary

HML040 had impaired reliability and accuracy of retrograde and anterograde self trait knowledge, encompassing both positive and negative traits. Though impaired overall on the

Social and Non-social Concepts Task, HML040 exhibited near perfect performance for the trials that tested trait concepts specifically (i.e., 96% correct). More conclusively, HML040 performed within normal limits in rating his wife's personality traits, suggesting that not only did HML040 have access to personality trait knowledge, he implemented this knowledge to make reliable and accurate trait judgments of a familiar other. Lastly, HML040 demonstrated normal performance on tasks evaluating his ability to access his self-concept and engage in self-reflection. In summary, the overall findings from these tasks suggest that HML040's deficit in rating his own traits is not likely explained by a lack of basic trait knowledge, a general difficulty in making judgments about the traits of specific individuals, or an inability to self-reflect.

### 3.3. Part 2: deeper exploration of HML040's autobiographical memory knowledge base

At first glance, the sparing of the vmPFC and self-concept makes HML040's unreliable and inaccurate judgments of his personality both unexpected and unique. However, according to Gilboa and Marlatte's (2017) model of schema representation, the vmPFC does not operate alone. Rather, the instantiation of a schema, such as the self-schema, may involve vmPFC temporarily binding together long-term memory representations stored in other neural regions. HML040's impaired self trait knowledge, therefore, may reflect a limited pool of autobiographical facts (with episodic memories potentially also playing a minor role) to support self trait judgments, rendering some judgments less accurate and reliable. Although the AMI hinted at the severity of HML040's impairment, we aimed to provide a more extensive evaluation of his autobiographical memory, and a more precise characterization of the integrity of experience-near and experience-far autobiographical facts, by administering tasks that evaluate his ability to recall unique personal episodes and to describe his life story.

### 3.3.1. Part 2 methods and materials

To assess his ability to describe unique personal events, we had HML040 and controls complete the Autobiographical Interview (Levine et al., 2002), an empirically-supported measure of richness (i.e., amount of detail) of memories of unique life events. This task was administered on a different day than the AMI for HML040. Participants were asked to retrieve one memory from each of the following time periods that targeted HML040's retrograde memory: (1) Before age 18, (2) Between ages 18 and 30, (3) Between ages 31 and 64, and (4) Between ages 65 and 75. We attempted to gather three anterograde memories from HML040 (i.e., from the past year or so), but he was not able to do so. Participants were given 5 min to describe their memory, with one general prompt (i.e., can you tell me more?) if they stopped prior to the time limit. These unique event memories were scored using an adapted version of the original Autobiographical Interview scoring protocol. Specifically, we used the standard "internal" or episodic detail categories and the standard "external" detail categories, which include semantic details, other language features (e.g., meta-comments and editorializing), repetitions,

and narration of events unrelated to the target autobiographical memory. We further divided personal semantic details into experience-near and experience-far facts, according to a recently established scoring protocol (Acevedo-Molina et al., 2020).
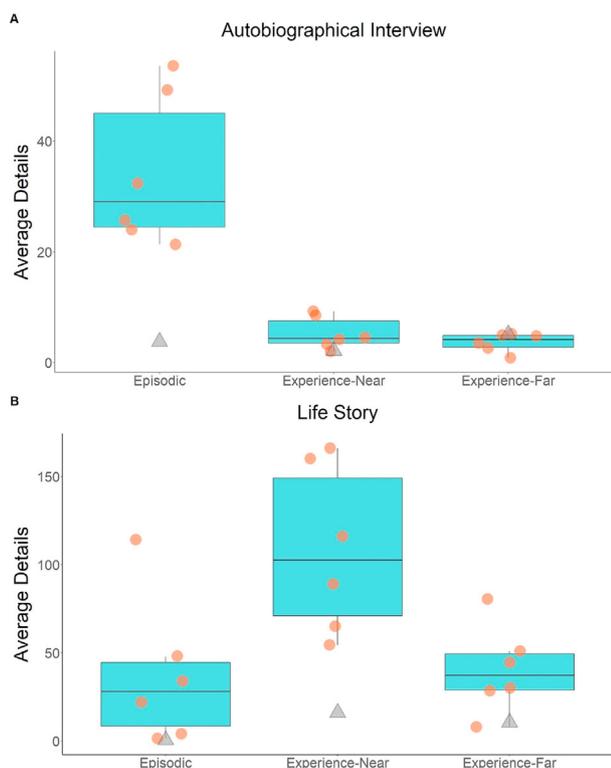
Given that the Autobiographical Interview is most directly a test of the integrity of episodic autobiographical memory, to better understand HML040's access to personal semantics in his autobiographical memory knowledge base, we also had HML040 and the controls describe their life story. We used a protocol we developed, which instructs participants to tell the story of their life, from the beginning until the present day (Grilli, Wank, & Verfaellie, 2018). There was no time limit, but participants were encouraged to take at least 15 min. To further encourage participants to be thorough and to help guide them through the process, participants were told when 5, 10, and 15 min passed. No other prompting or cueing was provided, with the exception of briefly reorienting HML040 when needed. Similar to the Autobiographical Interview, we scored for episodic details, experience-near and experience-far facts, general semantic details, metacomments, and repetitions.

For these two autobiographical memory tasks, two trained raters scored all participants' narratives. Averages of the two raters were calculated and used for z-score calculations. Excellent reliability was achieved for episodic, personal semantic, other, and total details from the Autobiographical Interview (Cronbach's alpha range = .90—.99). Average general semantic details had lower reliability (Cronbach's alpha = .18) because there were very few occasions where these details were scored. On the Autobiographical Interview, good reliability was found for experience-near (Cronbach's alpha = .86) and experience-far details (Cronbach's alpha = .82). Good to excellent reliability was achieved for total episodic, total experience-near, and total experience-far details in the Life Story Task (Cronbach's alpha range = .80—.90).

### 3.3.2. Part 2 results

Results for the following tasks are found in Fig. 4. On the Autobiographical Interview, HML040 showed impaired performance in generating autobiographical details overall, $z = -2.05$. As expected, the majority of details for controls were episodic (Levine et al., 2002), and HML040 demonstrated impaired performance on average episodic details produced, $z = -2.23$, with borderline episodic detail scores for three of the memories (i.e., before age 18, between ages 18 and 30, and between ages 31 and 64) and impaired episodic detail score for the most recent time period (i.e., between ages 65 and 75). He also had low average performance on experience-near factual details produced, $z = -1.07$, and high average performance on experience-far factual details produced, $z = .91$. For all memories but one, HML040 did not provide more specific details (i.e., episodic) after the general probe, and instead gave more experience-far or experience-near facts.

In the Life Story Task, HML040 demonstrated borderline performance generating autobiographical details overall, $z = -1.52$. More specifically, HML040's total experience-near fact generation was borderline, $z = -1.96$, episodic detail generation was low average, $z = -.88$, and experience-far fact production was low average, $z = -1.32$.

**Fig. 4 — Autobiographical memory tests. Plot (A) shows the average number of details generated for each detail category in the Autobiographical Interview. Plot (B) represents the same averages for the Life Story Task. For both plots, Circles: controls; Triangles: HML040. Lines within boxplots represent medians, horizontal edges represent first and third quartiles, and whiskers represent 1.5 standard deviations above the upper quartile and below the lower quartile.**

### 3.3.3. Part 2 summary

HML040's performance across two autobiographical memory tests revealed that he had limited episodic memory and experience-near personal facts, with spared experience-far personal facts.

## 4. General discussion

According to current cognitive models, of all the information stored in autobiographical memory, perhaps none is more abstract and schema-like than self trait knowledge (Conway, 2005; Klein, 2012). This cognitive framing of autobiographical memory has been used to explain why fMRI findings and neuropsychological case studies suggest that self trait knowledge depends on the vmPFC for retrieval, as opposed to the MTL, which is necessary for episodic memories and experience-near (i.e., spatiotemporal specific) autobiographical fact knowledge. In the present study, we introduced HML040, an individual who has extensive bilateral MTL damage from two PCA strokes that spared vmPFC, and yet demonstrated impaired self trait knowledge. This impairment occurred in the context of intact conceptual knowledge of

traits, reliable and accurate judgments about the traits of another close individual, and preserved ability to access his self-concept in a variety of ways. HML040's impaired trait knowledge, therefore, seems to be specifically autobiographical in nature, and is accompanied by an impoverished episodic and experience-near autobiographical memory knowledge base.

### 4.1. Knowing one's personality: a role for experience-near autobiographical facts and the medial temporal lobe?

Impaired self trait judgments in the context of spared ratings of a close other's traits renders HML040's profile particularly unique. On the one hand, the notion that either self or other trait knowledge could be selectively impaired is not without precedent (D.B. showed sparing of self ratings; Klein & Lax, 2010; Klein et al., 2002; while J.S. had spared other ratings; Marquine et al., 2016). Relatedly, functional neuroimaging studies suggest that whereas self and other trait ratings activate a common neural network, they do so in subtly distinct ways (Martinelli et al., 2013; Northoff et al., 2006; van der Meer et al., 2010). On the other hand, based on current cognitive (Klein, 2012) and cognitive neuroscience models (Renoult et al., 2012), an individual with largely isolated MTL lesions should have spared abstract personal semantics, of which self trait knowledge is believed to be one type. In fact, at least one form of abstract personal semantics, namely experience-far autobiographical facts, was largely preserved in HML040 and was relied on when drawing on autobiographical memory.

One way to try to understand this unexpected trait knowledge outcome is to consider how self trait knowledge judgments are made, and why under certain circumstances, accessing experience-near autobiographical facts may be useful. On a personality trait questionnaire, an individual will likely have to judge many traits, some of which may have a stored representation in long-term memory, and others must be inferred. Abstract personal semantic knowledge may be sufficient to reliably and accurately judge the self-reflectiveness of many of these traits by either accessing a stored abstract representation of the traits or, consistent with a schema-instantiation perspective (Gilboa & Marlatte, 2017), making a decision by using related experience-far autobiographical facts (e.g., I'm kind because I've always cared about people). However, some traits may depend more on context because of how they have evolved over time or how they differ by social situations. These traits may not be stored in an abstract form, and a person's ability to judge these sorts of traits presumably could not rely on abstract autobiographical knowledge, as doing so runs the risk of capturing an inconsistent or inaccurate picture of these traits' reflectiveness. Rather, such trait judgments should require drawing upon spatiotemporal knowledge that grounds and contextualizes these traits, such as particular lifetime periods (e.g., lately I've been more patient) or repeated events (e.g., I'm jovial when with friends). By this logic, we suggest that knowing one's traits is not entirely the purview of abstract personal semantic memory. Instead, experience-near autobiographical facts have a role.

According to our interpretation, the MTL should have a graded involvement in all forms of autobiographical memory,

dropping from episodic memories, to autobiographical facts, to personality traits — reflecting a shift in the relative episodic/experience-near to abstract/experience-far nature of the knowledge base. HML040's performance supports such a conclusion, as revealed by his z-scores across these types of autobiographical memory. Recent event-related potential evidence from Renoult, Tanguay, and colleagues also can be viewed as further evidence in favor of this interpretation (Renoult et al., 2016; Tanguay et al., 2018). These studies have shown that repeated events/autobiographical facts and self trait knowledge retrieval elicit an event-related potential late positive component (LPC), an electrophysiological signal that is believed to reflect episodic processes (Brezis et al., 2016; Friedman & Johnson, 2000; Rugg & Curran, 2007; Wilding & Ranganath, 2011). One of these studies also indicated that the LPCs associated with autobiographical facts and present self trait knowledge are diminished relative to episodic memory, but more prominent than in tasks involving non-personal, conceptual trait knowledge based on social stereotypes (i.e., traits of a soldier; Tanguay et al., 2018). Future studies can examine whether *self* trait knowledge, relative to knowledge about the traits of other personally known individuals, is unique in the degree to which it remains grounded in experience-near personal semantic memory (i.e., more context specific), as this could explain why HML040 was able to reliably and accurately judge his wife's personality (Tanguay et al., 2018, 2020).

In line with our experience-near hypothesis, prior work has also hinted at the idea that some aspects of self trait knowledge may depend on experience-near and episodic autobiographical memories. For instance, Grilli and Verfaellie (2015; 2016) showed that individuals with MTL amnesia shift from trait to role based self-defining statements while describing their identity, and they ground their self-defining statements largely with experience-far autobiographical facts. We speculate that this subtle drop in use of trait self-statements may reflect a decline in access to experience-near personality trait knowledge. Interestingly, Charlesworth et al. (2016) provided some support for this position in cognitively normal young adults by showing that relative to retrieving general semantic memory, retrieving episodic memories results in more fluent access to self trait statements, but not roles or physical traits. Prior work has also suggested that personality traits may fall on a spectrum of category breadth, with some traits being more "narrow" or context specific (e.g., charitable) and others more "broad" and context independent (e.g., kind; Hampson et al., 1987). Similarly, there also is evidence that individuals are inclined to view many of their present personality traits as situational, meaning varying across contexts, as opposed to dispositional or stable (Pronin & Ross, 2006). From this viewpoint, narrow or situational traits may be more likely to require recall of one's demeanor in particular spatiotemporal contexts and therefore draw on experience-near autobiographical factual knowledge reliant on MTL structures. Future research could test this possibility directly.

On the whole, we believe that our findings, along with related evidence (Charlesworth et al., 2015; Grilli & Verfaellie, 2015; 2016; Hampson et al., 1987; Renoult et al., 2016; Tanguay et al., 2018), suggest that a completely abstract

characterization of self trait knowledge is overly simplistic. Yet, if self trait knowledge is supported by a subset of experience-near autobiographical facts that are MTL dependent, why have no prior cases of amnesia demonstrated a reduction in self trait knowledge reliability and accuracy? Here, we think it is noteworthy that HML040's personal semantic impairment appears to be more severe than that for other amnestic patients in whom self trait knowledge was studied (Grilli, Bercel, et al., 2018; Klein et al., 2002; Rosenbaum et al., 2005; Tulving, 1993). In fact, personal semantic knowledge was relatively intact according to the AMI in these earlier cases. Another notable aspect of HML040's profile is that his personal semantic memory impairment also stretches back to childhood, which is rare for MTL amnesia (Grilli, Bercel, et al., 2018; Klein et al., 2002; Rosenbaum et al., 2005; Tulving, 1993). Intriguingly, the remote epoch on the AMI overlaps with the period of time during which, according to some prior work (Rathbone et al., 2008, 2011), much of one's self trait knowledge may emerge. Our findings, therefore, may indicate that remote, experience-near autobiographical facts are particularly important for maintaining much of an individual's self trait knowledge base (also see Addis & Tippett, 2004).

### 4.2. A subjective self without self trait knowledge?

Self trait knowledge has held a prominent role in the notion that the self-concept may depend on autobiographical memory (Conway, 2005; Prebble et al., 2013; Rathbone et al., 2015). It is therefore interesting that HML040 appears to provide evidence that fundamental access to the self can be spared in the face of impairment to self trait knowledge. For instance, although it is unknown whether the 20 I Am statements he provided reflect an accurate or representative view of himself, HML040 ultimately produced a version of himself with these statements. Additionally, he was able to access the basic features of a typical self-concept because he was not overly uncertain or unreliable about his preferences and identity on the TSCS-II, and because he not only could engage in the Self-Projection Task and imagine his feelings in specific scenarios, but he also produced prototypical answers. Overall, we take our findings to suggest that the absence of reliable or accurate access to self trait knowledge does not preclude a person from engaging in other forms of self-reflection or self-projection.

### 4.3. Connection between non-personal semantics and the medial temporal lobe

Based on our neuropsychological testing of non-personal semantic memory (reported in Section 2.3.1), HML040's performance was mixed on traditional neuropsychological tests, but clearly impaired on our experimental tests of semantic knowledge that required the retrieval of facts about unique entities. This was evident regardless of whether we examined HML040's knowledge of famous people, landmarks, or historical events, and extended beyond a simple anomia for proper names. His semantic memory impairment, therefore, was extensive, encompassing personal semantics and non-personal semantics that have a higher degree of specificity, while preserving some forms of more abstract knowledge in both domains (e.g., experience-far autobiographical facts and

basic or category-level semantic knowledge as assessed by Pyramids and Palm Trees).

There has been recent appreciation for the possibility of hippocampal, or more broadly MTL, involvement in retrieval of unique non-personal semantic memory. A few studies have suggested that the MTL might facilitate the retrieval of details from well-known stories and unique semantic associates of words (Klooster & Duff, 2015; Rosenbaum et al., 2009; Verfaellie et al., 2014). Other cases of amnesia have also shown impairment in identification of famous faces and recollection of details of public or historical events (Cermak & O'Connor et al., 2001; Cipolotti et al., 2001; Damasio et al., 1985; Kartsounis et al., 1995; Klein et al., 2002; Rempel-Clower et al., 1996; Rosenbaum et al., 2005), consistent with some fMRI studies reporting recruitment of MTL regions in these tasks (Bernard et al., 2004; Douville et al., 2005; Leveroni et al., 2000; Nielson et al., 2010; Ross & Olson, 2012). Relatedly, a recent study found that making judgments of semantic similarity for famous people and places activated anterior temporal and posterior medial networks, respectively, and there was evidence of functional connections between these networks and the hippocampus (Morton et al., 2021). Therefore, there may be unique knowledge from both personal and non-personal domains for which the MTLs are necessary; however, this may be overlooked when only tests of category-level semantic knowledge are administered where patients may perform within normal range (Duff et al., 2020; Klooster & Duff, 2015). We suggest that future research should attempt to compare personal and non-personal semantics using similar tasks, because doing so might reveal that they follow comparable organizational principles and depend on largely overlapping neural networks (Irish & Vatansever, 2020).

### 4.4. Additional considerations

HML040's strokes caused bilateral, but predominantly left-sided, inferior temporo-occipital cortical damage. Prior cases of left inferior temporo-occipital damage following PCA strokes have been associated with non-personal semantic memory impairment, which tends to be greater for naming, with milder deficits in comprehension (Antonucci et al., 2004, 2008; Roberts et al., 2013, 2015). These patients also were shown to be impaired on one test assessing unique semantic knowledge (famous faces), but our ability to compare HML040 with these cases is limited given the absence of more extensive testing for unique non-personal semantic knowledge and autobiographical memory. Thus, although we cannot completely rule out the possibility that left posterior temporo-occipital damage contributed to HML040's non-personal semantic memory deficit, we believe that it is unlikely to explain his severe impairment in retrieving both personal and non-personal semantic information.

HML040's MRI also revealed evidence of chronic deep and periventricular white matter ischemic changes. Consistent with chronic subcortical white matter damage, on neuropsychological testing HML040 exhibited slowed mental processing speed, and possibly some mild executive dysfunction (although the latter may be confounded by processing speed). We believe that this aspect of HML040's clinical profile is unlikely to account for his impaired self trait knowledge. First, the ischemic pathology was chronic and clinically asymptomatic at the time of his second PCA stroke and there was no evidence of substantial lesion burden in vmPFC. Second, the personality trait questionnaire was untimed and was in a forced choice recognition format, obviating demands on processing speed and executive functions. If processing speed and/or executive functions had a role, it is not clear why HML040's performance on the personality trait task for his wife would not be similarly impacted.

Given HML040's age, it is important to consider the possibility of a neurodegenerative process affecting cognition. We think this is unlikely for two reasons. First, there were no obvious structural changes between the clinical brain scans done at the time of his second stroke and those done around the time of his evaluation in our laboratory. Second, his wife reported that he was fully independent and working prior to the second stroke, and there had been no additional cognitive decline beyond the acute change associated with the stroke.

In regard to autobiographical memory, while we measured reliability and accuracy of self trait knowledge, we did not similarly measure reliability of episodic memory or autobiographical facts. We do, however, know that his wife's report raised no concerns that he might be confabulating. Also, some of our autobiographical memory testing involved free responses, with limited probing for more detail or information. Therefore, we cannot say for sure whether some of our findings, such as HML040's Autobiographical Interview performance, underrepresent his fund of memory. This critique does not apply to our personality trait judgment task, which entailed force-choice recognition.

Lastly, it is important to consider HML040's history of depression and current use of antidepressant medication in the context of possible alterations of self-perception in individuals with depression. Prior research suggests individuals with depression have a more negative self-view or a lower positive self-bias (Lou et al., 2019). Also, depression (and possibly antidepressant use) has been linked with subtle structural and functional disruption to prefrontal cortical regions (Kaiser et al., 2015; Lou et al., 2019; Mulders et al., 2015; Rive et al., 2013), which our clinical neuroimaging and neuropsychological testing might not have detected in HML040. Despite these points, in the current study, HML040 did not appear to show self-knowledge effects associated with depression, as there was no evidence for a negativity bias or reduced positivity bias in his trait ratings. Moreover, the literature does not appear to suggest a connection between depression and lower reliability and/or a more inaccurate sense of self. In fact, individuals with severe depression appear to have a stable evaluative schema, similar to nondepressed individuals, though theirs is negative (Ruehlman et al., 1985). Combining these results with our behavioral observations of HML040 being in good spirits, it is less likely, then, that his history of depression had a significant impact on these results.

### 4.5. Conclusion

In the current study, an individual with bilateral MTL damage resulting in severe amnesia for personal (episodes and facts)

memory and non-personal semantic memory demonstrated a unique pattern of impairment. Despite having intact conceptual knowledge of personality traits, ability to rate the personality of a familiar other, and access to his self-concept, he was unable to accurately and reliably rate his own personality traits. These findings suggest that the self concept is not beholden to intact self trait knowledge, and they reveal a potential connection between self trait knowledge and experience-near autobiographical facts. More broadly, they highlight the role that single case studies can play in the advancement of cognitive neuroscience models of memory and the self.

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## Author contribution statement (CRediT)

**Aubrey A. Wank:** Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Visualization, Writing − original draft, Writing − review & editing. **Anna Robertson:** Data curation, Investigation. **Sean C. Thayer:** Data curation. **Mieke Verfaellie:** Conceptualization, Writing − review & editing. **Steven Z. Rapcsak:** Conceptualization, Methodology, Resources, Supervision, Writing − review & editing. **Matthew D. Grilli:** Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing − original draft, Writing − review & editing.

## Declaration of competing interest

None.

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## Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cortex.2021.11.013.

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