Highlights

- Self-knowledge (SK) is thought to be distinct from semantic and episodic memory (EM)
- SK's relationship to semantic and EM may depend to some extent on time perspective
- LPC amplitude distinguished EM from present but not from past or future SK
- P200, N400 and LPC amplitudes differentiated semantic memory from SK
- The relationship between SK's LPC and episodic memory depends on time perspective

The ERP correlates of self-knowledge: Are assessments one's past, present, and future traits closer to semantic or episodic memory?

1. Introduction

The ancient Greeks' invitation to "Know thyself" resonates to this day in popular culture. Despite this, self-knowledge is rarely integrated into current models of declarative memory. Declarative memory is usually described as consisting of semantic and episodic memory, which are depicted as two branches of a tree diagram (Squire & Wixted, 2015) or two extremes of a continuum (e.g., Jacoby & Craik, 1979; Cabeza & St Jacques, 2007). At one extreme, semantic memory concerns knowledge of facts that are detached from their context of acquisition and shared with other people in the culture (Binder & Desai, 2011; Lambon Ralph, Jefferies, Patterson, & Rogers, 2017). At the other extreme, episodic memory concerns our ability to remember events from our past and related contextual information (Tulving, 2002). Between these two extremes arguably falls *personal semantics*, which (like semantic memory) are factual and limited in spatial/temporal details, but (like episodic memory) are idiosyncratically personal. Personal semantics were broken down into four types in a recent review and taxonomy (Renoult, Davidson, Palombo, Moscovitch, & Levine, 2012). Two of the four types were hypothesized to be closer to episodic memory (i.e., memory for repeated events, autobiographically significant concepts), one as being closer to semantic memory (i.e., autobiographical facts), and one as being relatively distinct from both (i.e. self-knowledge; see Figure 1; Renoult et al., 2012). Recently, we have used ERPs to compare repeated events, autobiographically significant concepts, and autobiographical facts to semantic and episodic memory (Renoult et al., 2015, 2016). Here we turn to the fourth operationalization of personal semantics: self-knowledge.

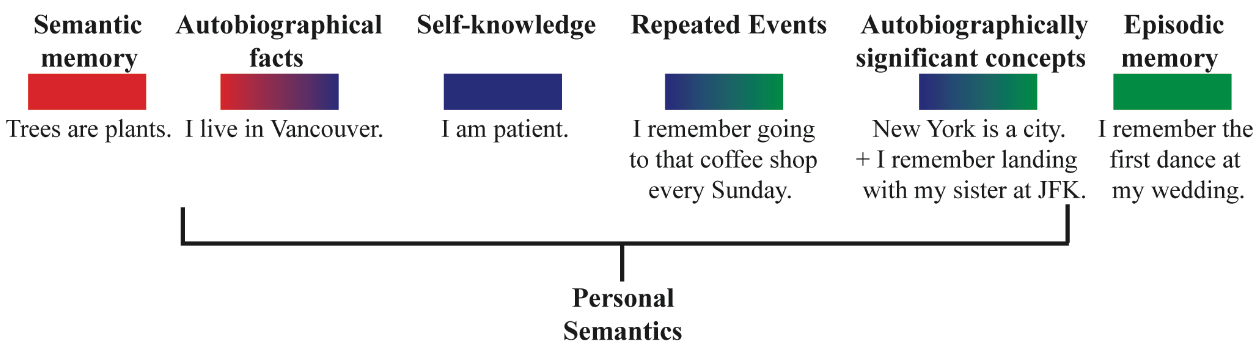

Figure 1. The 4 types of personal semantics in relation to semantic and episodic memory.

1.1 Self-knowledge

Self-knowledge entails evaluative judgments of oneself, and includes knowledge of one's own traits and preferences (Renoult et al., 2012). Self-knowledge is arguably a highly abstract form of knowledge (Grilli & Verfaellie, 2014; Renoult et al., 2012), which in part could explain its apparent independence from episodic and semantic memory impairment (Klein & Gangi, 2010). For example, amnesic patients can describe their post-morbid personality, indicating that self-knowledge can be updated despite episodic memory impairment (Craver, Kwan, Steindam, & Rosenbaum, 2014; Grilli & Verfaellie, 2015). In addition, self-knowledge can remain intact when another kind of personal semantics is impaired [i.e., autobiographical facts: knowledge of facts about oneself that resemble an autobiographical "CV", including jobs, hobbies, diplomas; etc. (Klein, Cosmides, & Costabile, 2003; Klein, Cosmides, Costabile, & Mei, 2002; Renoult et al., 2012; Warrington & McCarthy, 1988)]. The reverse pattern has also been found: A patient with damage to medial prefrontal cortex (mPFC) showed impaired insight into his own traits (i.e. self-knowledge) in the face of accurate knowledge of an acquaintance's traits (Marquine et al., 2016).

1.2 Knowledge of Past, Present and Future Selves

Conceptualizations of self-knowledge usually focus on the present self, but knowledge can extend to past selves and future "possible selves" (Markus & Nurius, 1986) or the "temporally extended self" (Prebble, Addis, & Tippett, 2013). Two perspectives have been taken on the relative contribution of semantic and episodic memory to self-knowledge across time. From the first perspective, several have posited that episodic memory shapes self-knowledge through the elaboration of self-defining events in one's past and future, and contributes to a sense of continuity of one's identity in time (Demblon & D'Argembeau, 2016; Prebble et al., 2013). In these respects, traits are concepts that can acquire a personal significance through events, particularly when considering the past or the future (Demblon & D'Argembeau, 2016; Renoult et al., 2015). Semantic memory is usually argued to be associated with a subjective awareness based in the present, whereas episodic memory is associated with a subjective awareness oriented towards the past and possibly also the future (Tulving, 2001, 2002). This difference in temporal orientation might suggest that present self-knowledge is more similar to semantic memory, whereas past and future self-knowledge are more similar to episodic memory. However, the relationship between temporal orientation and episodic memory lends itself to potential confusion. A case study of amnesic patient KC found that he understood time as a concept, and he could orient to his past, present, and future (that is, he was not "stuck in the present"; Craver et al., 2014). To nuance this perspective, one might consider episodic memory as associated with awareness of oneself in a specific temporal context, including the ever-changing present. If so, the neural correlates of present self-knowledge may be intermediate between semantic and episodic memory (Prebble et al., 2013). Present self-knowledge shares the personal and introspective characteristics of episodic memory that are absent from semantic memory. The (re)construction of self-defining events and the maintenance of a sense of continuity of one's identity may additionally engage episodic memory in the past and the future. Although neuropsychological studies indicate that self-knowledge is independent of episodic memory (Klein & Gangi, 2010), it may become less so when the self-knowledge is accompanied by a spatial or temporal context (for example, the distant past or the future; see Grilli & Verfaellie, 2016).

From the second perspective, however, some have suggested that semantic memory is essential for thinking about the past and future, particularly when events are novel (Irish, Addis, Hodges, & Piguet, 2012; Irish & Piguet, 2013; Wang, Yue, & Huang, 2016; Weiler, Suchan, Koch, Schwarz, & Daum, 2011) . Semantic memory encompasses a variety of knowledge about the world, including knowledge of one's culture's typical "life periods" or "life chapters" and what novel experiences might involve (Thomsen, 2015). For example, young adults could muse about or appraise their future identity in relation to the prototypical life narrative: (*I will graduate from university, obtain a fulfilling job, buy a house, get married, have children*, et cetera). As the case of KC has shown, semantic memory includes knowledge of time as a concept, and we note that he could order his autobiographical facts mostly correctly (Craver et al., 2014). The construal-level theory of psychological distance of Trope & Liberman (2010) stipulates that temporal distance makes us think more abstractly and thus in a more meaning-based (i.e., semantic) than experience-based (i.e., episodic) manner. In a similar logic, La Corte and Piolino (2016) have suggested that thinking about a distant future increases the use of general or semanticized memories (including personal semantics) relative to a closer time. Concordant neuroimaging findings indicate that the neural correlates of thinking about temporally distant selves may be more similar to thinking about other people compared to the present self (D'Argembeau et al., 2008, 2010; see also Palombo, Hayes, Peterson, Keane, &

Verfaellie, in press). Taken together, this second perspective suggests that past and particularly future self-knowledge may rely more on semantic memory than present self-knowledge does.

1.3.The Present Study

Personal semantics are often compared to either semantic or episodic memory alone, but rarely to both. Yet, as seen in the review above, both semantic and episodic memory could be significantly related to self-knowledge. In the present study, we designed a novel task to compare the behavioral and electrophysiological correlates of self-knowledge to semantic and episodic memory in a within-subject design, and tested whether the temporal orientation of the self-knowledge influences the relationship to semantic versus episodic memory. Thus, the study included five closely matched memory conditions: semantic and episodic memory, and past, present, and future self-knowledge. We operationalized self-knowledge as knowledge of one's own personality traits, as this has been the most frequently studied operationalization (Renoult et al., 2012). In the self-knowledge tasks, participants decided whether target words (e.g., *generous*) reflected their past traits, present traits, or future traits. In the semantic memory task, participants indicated whether the words reflected the traits of most people holding a certain occupation. The episodic memory task also involved being shown traits, but deciding whether each trait had been seen previously during the study or not. We used positive (e.g., *generous*) and negative (e.g., *jealous*) traits, which we expected to show a distinct behavioral pattern across time perspectives. People tend to exhibit an optimistic belief that their personality improves through time and will become even "better than average" in the future (D'Argembeau et al., 2010; Kanten & Teigen, 2008; Wilson & Ross, 2001).

1.3.1 Semantic versus Episodic: N400 versus LPC Event-Related Potentials.

We examined the neural correlates of the memory conditions using electroencephalography (EEG). We focused on two ERP components: the N400 and the LPC. The N400 is a negative amplitude ERP component occurring 250 to 500 ms after stimulus onset, maximal over centro-parietal sites (Kutas & Federmeier, 2011). The N400 is sensitive to semantic processing; for example it is larger when words are unexpected or incongruent within the context of a sentence (e.g., “I take coffee with cream and *dog*”; Kutas and Federmeier (2011), but also, importantly, when words violate our knowledge of the world (Hagoort, Hald, Bastiaansen, & Petersson, 2004). In addition to these contextual effects, the N400 is also sensitive to the structure of semantic memory, as demonstrated for example by effects of concreteness, semantic category or semantic richness (reviewed in Renoult, 2016). Its main neural generators are in the left temporal and inferior parietal cortex, consistent with N400’s role in the binding of multimodal conceptual representations (Kutas and Federmeier, 2011; Renoult, 2016). Lesion studies have shown that left temporal-parietal lesions reduce N400 amplitudes and impair semantic comprehension (Friederici, Hahne, & von Cramon, 1998; Hagoort, Brown, & Swaab, 1996; Swaab, Brown, & Hagoort, 1997).

The Late Positive Component (LPC) – also known as “the parietal old new effect” – is a positive amplitude component occurring 500 to 800 ms after stimulus onset, with a posterior parietal scalp distribution (Rugg & Curran, 2007). The LPC is reliably associated with episodic recollection, although it is also sensitive to the “true” status of the memory, and memory strength (Brezis, Bronfman, Yovel, & Goshen-Gottstein, 2016; Friedman & Johnson, 2000; Rugg &

Curran, 2007; Wilding & Ranganath, 2011). Bilateral hippocampal lesions greatly reduce the LPC (Addante, Ranganath, Olichney, & Yonelinas, 2012; Düzel, Vargha-Khadem, Heinze, & Mishkin, 2001; Olichney et al., 2000). Simultaneous EEG-fMRI associate the LPC with activity in the right posterior hippocampus, and parahippocampal and retrosplenial cortices (Hoppstädter, Baeuchl, Diener, Flor, & Meyer, 2015). The LPC may be sensitive to self-relevance as suggested in Coronel & Federmeier (2016), based partly on Fields and Kuperberg (2012), but a recent study indicates that the relationship may depend on various factors (Fields & Kuperberg, 2016; see Renoult et al., 2016). Thus, the N400 and the LPC are neural correlates of semantic and episodic processing, respectively, and they are distinguishable from one another (Düzel et al., 2001; Olichney et al., 2000).

In a recent study, Coronel and Federmeier (2016) compared self-knowledge -- operationalized as knowledge of personal preferences (e.g. do I like to wear pink clothes?) -- to knowledge of people's preferences in general (e.g. do most people like to wear pink clothes?). Self-knowledge was associated with a larger LPC amplitude compared to others' preferences at centro-parietal sites (Coronel & Federmeier, 2016). The N400 tended to be less negative for personal than others' preferences at 26 sites over the scalp (qualitatively), but the scalp distribution, latency, and amplitude were not significantly different. Coronel and Federmeier's (2016) main goal was to compare the N400 of personal semantics and semantic memory, so they did not include a memory condition equivalent to episodic memory (e.g. did I wear pink clothes yesterday?). Other recent studies have demonstrated that personal semantics can be associated to different degrees with the N400 or LPC components (Choi, Cha, Jung, & Kim, 2017; Renoult et al., 2015, 2016).

EEG allows us to test the opposing (but not mutually exclusive) hypotheses about the neural correlates of self-knowledge reviewed in Section 1.2 above (see also Table 1): past and future self-knowledge may involve more semantic processing or more episodic processing, or possibly more of both, relative to present self-knowledge. The last scenario would translate into: 1) A maximal N400 – the index of semantic processing – for semantic memory, followed by past and future self-knowledge, while it would be minimal for episodic memory (and possibly also for present self-knowledge), and 2) a maximal LPC – the index of episodic processing – for episodic memory, followed by past and future self-knowledge, and minimal for semantic memory, with present self-knowledge in the intermediate between semantic and episodic memory. While the above hypotheses for a time-related modulation of the LPC have a solid basis, the direction of a temporal modulation for the N400 lends itself to multiple interpretations. Present self-knowledge shares important conceptual similarities with semantic memory, rendering the opposite hypothesis equally likely (i.e. semantic memory > present self-knowledge > past and future self-knowledge). For instance, present self-knowledge represents best the stable (present/atemporal) portion of personality (Anusic & Schimmack, 2016); that is, the stable traits that are detached from a context of acquisition (or projection). Lastly, in keeping with a vast literature (Friedman & Johnson, 2000; Rugg & Curran, 2007; Wilding & Ranganath, 2011), modulation of the LPC by the old/new effect (i.e., greater amplitude for hits than correct rejections) should be observed for the recognition memory task.

Table 1: Hypotheses for ERP data based on the first or second perspective.

Predictions based on the first perspective (self defined through events)

N400			
Maximal (i.e., most negative)			Minimal (i.e., least negative)
semantic memory task	>/= present self	>/= past and future self	episodic memory task
LPC			
Maximal (i.e., most positive)			Minimal (i.e., least positive)
episodic memory task	>/= past and future self	>/= present self	semantic memory task
Predictions based the second perspective (self-construal theory)			
N400			
Maximal (i.e, most negative)			Minimal (i.e, least negative)
semantic memory task	>/= past and future self	>/= Present self	episodic memory task
LPC			
Maximal (i.e., most			Minimal (i.e.,

positive)			least positive)
episodic memory task	>/= present self	>/= past and future self	semantic memory task

2. Methods

2.1 Participants

Thirty-two participants (15 men) took part in the study. They were aged between 18 and 33 years old (mean age: 20.97 ± 0.66 *SE*; one participant did not report his age), and had completed an average of 14.84 (± 0.39 *SE*) years of education. Undergraduate psychology students at the University of East Anglia were recruited through an online system and awarded partial course credit. Others were recruited through a participant panel at the School of Psychology of the University of East Anglia; they contacted the researcher after obtaining information about the study via email, and received £13 for their participation. Exclusion criteria consisted of a history of head injury with loss of consciousness longer than 5 min, other neurological or medical conditions known to compromise brain function, and active substance abuse. All participants had normal or corrected-to-normal vision, were English native speakers, and were right-handed. Two participants did not meet eligibility criteria, and two were excluded due to a low number of yes responses (< 15), resulting in a sample of 28 participants.

The study received ethics approval from the Research Ethics Committee of the School of Psychology at the University of East Anglia (2016-0195-000370) and the Health Sciences and Science Research Ethics Board of the University of Ottawa (H10-16-20).

2.2 Experimental Tasks

Our study included five memory conditions: semantic memory, episodic memory, and past, present, and future self-knowledge conditions. The inclusion of these self-knowledge conditions was inspired by D'Argembeau et al. (2010). A key difference was that we increased the number of traits from 20 to 80 per condition to adapt the paradigm to EEG.

2.2.1 Stimuli. We retrieved a total of four-hundred words descriptive of people from Dumas, Johnson, & Lynch (2002). From this database, we also retrieved the words' frequency of occurrence in texts (Kučera & Francis, 1967), as well as ratings of familiarity and likability. We obtained valence ratings of the words or their root word (e.g., snob for snobbish) from Warriner, Kuperman, & Brysbaert (2013), when available. Words with a mean valence score below five and a mean score above five were classified as negative and positive, respectively. Five is the neutral point on the self-assessment manikins (Bradley & Lang, 1994), and Warriner et al. (2013) reversed the scale, thus words below 5 were negative, and words above 5 were positive. We excluded the words we judged as ambiguous because their scores were too close to 5, that is, the neutral point [e.g. "nonchalant" (M = 4.58) and "conservative" (M = 4.55)]. 48 of the 400 words were absent from Warriner et al.'s (2013) database and thus we relied on their definition (Cambridge Dictionary, 2015) and likableness scores to classify them as either positive or negative (likeableness and valence are highly correlated; r = .931 in our selection). We generated six lists of 80 words each (40 positive, 40 negative): two lists for the episodic memory condition (target words that were already encountered during the experiment, and new words), one for semantic memory, and one for each of the three self-knowledge conditions. The list of target words for the episodic memory task was formed by randomly selecting 10 positive and 10 negative words from each of the semantic memory and self-knowledge lists. We distributed the original words randomly across the other lists using the randomization excel function and made adjustments as necessary to match lists in word length (i.e. number of letters), familiarity, the words' frequency (Kučera & Francis, 1967), and likableness (all $p \geq .77$; lowest p value obtained with the target words for the recognition memory task included or excluded from the analyses). We also rotated three lists between the three self-knowledge tasks (past, present, future) to obtain six combinations randomized across participants, further reducing the likelihood of a spurious difference between time perspectives. Negative words had significantly lower likableness scores compared to positive words in all lists ($p < .001$). Valence and likableness were strongly correlated ($r = .931$, $p < .001$), and 48 words did not have valence values in the norms that we used (Warriner et al., 2013), thus these analyses focused on the latter.

2.2.2. Experimental Conditions. During the task, participants were shown character traits and they were asked to make decisions about them in five ways. In the "self-knowledge" tasks, participants decided whether the word reflected either past (five years ago), present or future (five years from now) character traits. Five years was modeled on D'Argembeau et al. (2010) who argued that young university students had undergone – and then will undergo – significant changes in life circumstances during that time period. Indeed, a sense of continuity of one's own traits diminishes gradually through time, but changes temper down between 5 to 10 years for young adults (that is, the effect is not proportional with time; Rutt & Löckenhoff, 2016).

In the semantic memory task, participants determined whether the word reflected the character traits of most people holding an occupation (i.e. soldiers, priests, lawyers, scientists). Some traits are easier to associate with occupations. For instance, it is easy to agree that a priest is "solemn", but the same trait would be surprising (and disappointing) in a clown. The traits were assigned to occupations purposefully to ensure traits would vary in relevance, much like the relevance of traits in the self-knowledge task would (see stimuli in Appendix A). Nine additional people, who did not participate in the EEG study, completed a survey on Qualtrics (Qualtrics, Provo, UT) to verify whether traits were associated with the occupations using a 7-point Likert scale (1 = *not at all associated*, and 7 = *highly associated*). Responses 1 to 3 were grouped as "not associated" and responses 5 to 7 were considered to be "associated". We classified words as either associated or not associated when 6 out of 9 people made responses at the same end of the spectrum. 47.5% of the traits were not associated with the occupations (26.25% negative traits, 21.25% positive), 30% were associated with occupations (7.5% negative, 22.5% positive), and 22.5% received mixed responses (16.25% negative, 6.25% positive). For example, when speaking of scientists, "inventive" was thought to be associated, "social" not associated, and responses were mixed for "humorous". After the self-knowledge and semantic memory tasks, participants completed a recognition memory task. In that case, participants indicated whether the words were presented previously (i.e. target words) or if they were new (80 old, 80 new), and how confident they were in their response.

2.2.3. Procedure. Participants sat in front of a computer screen placed about 1 m from their eyes. During cap preparation, the researchers interviewed participants about their life circumstances five years ago, five years from now, and in the present, in this order (adapted from D'Argembeau et al., 2010). The aim of the interview was to allow participants to elaborate past, present, and future life circumstances prior to the task, and to reduce the likelihood of order effects (Cordonnier, Barnier, & Sutton, 2016), and potential discrepancies in cognitive demand between experimental conditions (Weiler et al., 2011) . The semi-structured interview centered on activities (e.g. school, leisure), geographical location and housing. The same topics were addressed in the three time perspectives. Presumably, our participants kept life circumstances in mind when judging whether traits were relevant to a specific life period, but we did not instruct them to do so (unlike D'Argembeau et al., 2010). We reasoned that inviting participants to think of life events during the task could bias self-knowledge towards appearing closer to episodic rather than semantic memory.

E-Prime 2.0 (Psychology Software Tools, Pittsburgh, PA) was used for stimulus presentation. The five experimental conditions (semantic memory, episodic memory, and past, present, future self-knowledge) were presented in blocks (i.e. all stimuli for a condition presented together), so participants could maintain a specific mode of processing when judging the traits. To reduce switching between modes of processing, we also presented randomly semantic memory either before or after the self-knowledge tasks. Following a similar logic, all the traits for a given occupation were presented in a block. The order of the occupations was randomized in E-Prime. The 3 self-knowledge tasks could take 3 orders using the Latin Square method. The 3 orders of the self-knowledge tasks were crossed with the 6 possible combinations of 3 lists with the 3 time perspectives, yielding a total of 18 versions of the task. The assignation of the versions was randomized for the first set of 18 participants, and this order was repeated for the second set. We chose that strategy because most women were recruited in the first half of study inadvertently, and men in the second half. The recognition memory task always ended the study. Finally, the order of the traits was randomized within each block using an E-Prime function. Participants took short breaks between the blocks as necessary.

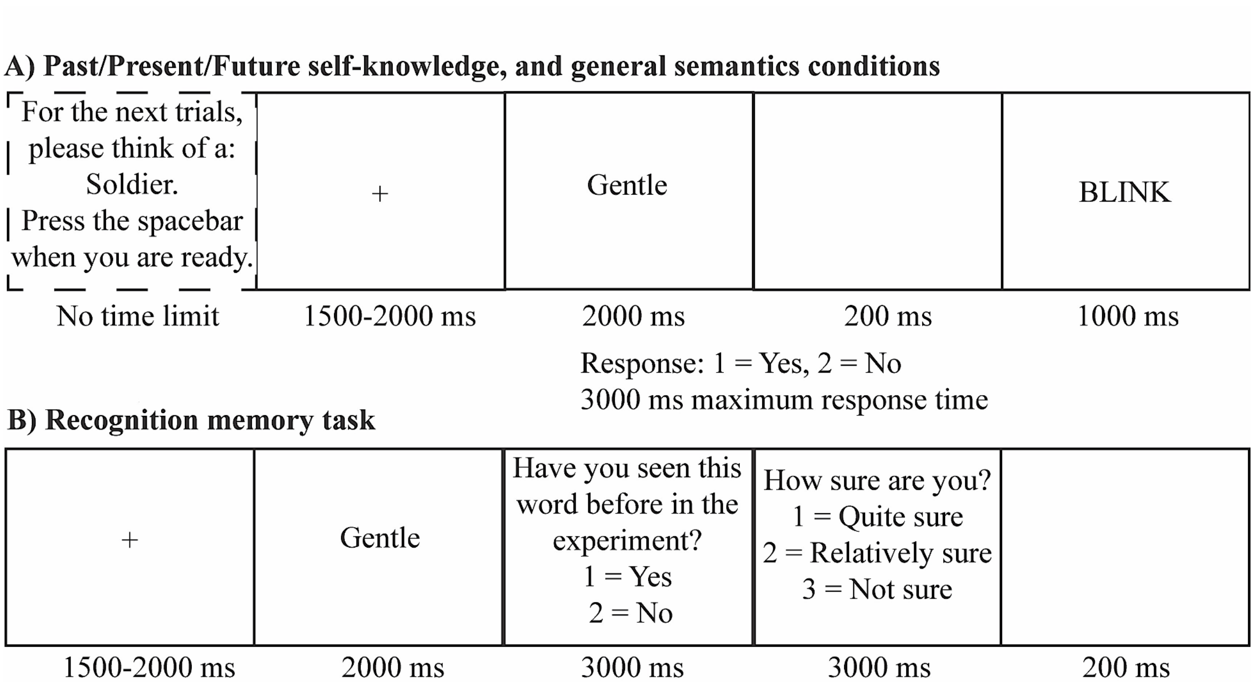

Figure. 2. The structure of A) the self-knowledge and general semantics tasks, and B) the recognition memory task. In A), an additional instruction screen was included to specify an occupation every 20 trials for the general semantics task (surrounded by dotted lines).

As a general rule, each trial started with a fixation cross of a variable duration (1500 to 2000 ms), after which a trait was shown for 2000 ms (see Figure 2). The maximum response time was 3000 ms, during which people could press 1 or 2 to respond. A “1” signified “I think the word reflects my (past/ present/ future) traits” and “2” meant “I think the word does not reflect my (past/present/future) traits”. Similarly, in the semantic memory task, a “1” represented agreement with the statement "I think the word reflects the traits of most people holding the occupation", and a "2" showed a disagreement. A white screen followed the trait screen for 200 ms, and this sequence of events ended with a blink screen for 1000 ms (inviting participants to blink).

We adapted the stimulus presentation of the semantic and episodic memory tasks in a few ways. In the case of semantic memory, additional instructions were shown every 20 trials to specify in relation to what occupation the judgements on traits should be made. These instructions, like those introducing each task, were self-paced. The differences in the episodic memory task lay in the response screens. The options for the recognition memory task (i.e. 1 = old, 2 = new) were displayed after the trait screen. Subsequently, participants were shown the options for the confidence rating (1 = Quite sure; 2 = Relatively sure; 3 = Not sure; based on Renoult et al., 2015). For both the old/new and the confidence screens, participants had up to 3000 ms to respond. A response ended the screen and triggered the onset of the next screen. Participants could blink when making the responses in this case, thus we did not include a "blink" screen during the recognition memory task.

2.3 EEG acquisition and pre-processing

The Electroencephalogram (EEG) was recorded with a 63-channel active electrode system (Brain Products GmbH) embedded in a nylon cap (10/10 system extended). An additional electrode was placed under the left eye in order to monitor vertical eye movements (lower EOG). The continuous EEG signal was acquired at a 500 Hz sampling rate using an FCz reference. The high filter was set at 250 Hz and the time constant was 10 s. The impedance was kept below 20 kΩ. A vertical EOG was reconstructed offline as the difference between the lower EOG and FP1 activity. A horizontal EOG was constructed by subtracting FT9 from FT10 activity.

Offline analyses were conducted using Brain Vision Analyzer 2.1. Manual visual inspection was performed to remove excessive movement artifacts or drifts. High and low band-pass filter half-amplitude cutoffs were set at 0.01 and 30 Hz (12 db/oct), respectively. We removed components representing eye movement and blinks with an automatic ICA ocular correction (Jung et al., 2000). Noisy channels were interpolated using spherical interpolation. An average reference was computed offline and used for all analyses. The EEG was segmented into epochs of 1 s (from -200 ms prior to, to 800 ms after the onset of the words). Trials were rejected after a 200 ms baseline correction: 1) if the absolute difference of two contiguous sampling points was larger than 75 µV, 2) if the difference between the minimal and maximal voltage was larger than 150 µV within a 200 ms interval, 3) if the voltage was above 100 µV or below -100 µV, or 4) if the difference between the minimum and maximum voltage was less than 0.5 µV for 100 ms.

The percentage of rejected trials followed by a *yes*/*no* response was: Semantic Memory: *Yes M* =7.08 % ± 1.68 *SE*/ *No M* = 6.87% ± 1.65 *SE*; Past self-knowledge: *Yes M* = 5.67% ± 1.02 *SE* / *No M* = 5.64% ± 1.32 *SE*; Present self-knowledge: *Yes M* = 4.57% ± 0.93 *SE*/ *No M* = 4.18% ± 0.86 *SE*; Future self-knowledge: *Yes M* = 5.56% ± 1.18 *SE*/ *No M* = 6.7% ± 1.36 *SE*; Episodic Memory: (high confidence hits) *M* = 3.34% ± 0.69 *SE*/ (correct rejections) *M* = 3.49% ± 0.67 *SE*. This resulted in the following average number of trials: Semantic Memory: *Yes M* = 30.25 ± 1.23 *SE*/ *No M* = 40.25 ± 1.27 *SE*; Past self-knowledge: *Yes M* = 33.04 ± 1.19 *SE*/ *No M* = 39.68 ± 1.36 *SE*; Present self-knowledge: *Yes M* = 33.96 ± 1.39 *SE*/ *No M* = 39.57 ± 1.42 *SE*; Future self-knowledge: *Yes M* = 33.21 ± 1.05 *SE*/ *No M* = 39.75 ± 1.19 *SE*; Episodic Memory:

(high confidence hits) *M* = 45.71 ± 2.4 *SE/* (correct rejections) *M* = 50.39 ± 1.79 *SE*. The small difference in the number of trials does not affect our analyses, because mean amplitude is little influenced by noise (Tavakoli & Campbell, 2015).

The amplitudes of the N400 and the LPC were measured as the mean of all data points between 250 to 500 ms and 500 to 800 ms, respectively. The N400 is typically studied at sagittal or parasagittal sites, and the LPC at the posterior parietal sites. The sagittal subset included the electrodes FCz, Cz, CPz, and PZ, the parasagittal subset included C1/C2, C3/C4, Cp3/Cp4, and the posterior parietal subset included P1/2, P3/4, and PO3/4 (see Figure 3). Our key hypotheses and core analyses focus on the N400 and LPC at their typical maximal sites (see Table 1, and sections 3.1.2, 3.1.3 below). Moreover, we included frontal sites in preliminary and exploratory analyses for comparability with our other ERP studies on personal semantics (Renoult et al., 2015, 2016). The frontal subset included the electrodes F1/F2, F3/F4, FC3/FC4. A visual inspection of the grand average ERPs upon suggestion by a reviewer (see Figure 4) prompted the addition of an earlier time window, because a P200 effect of memory type may precede the N400 effect. The P200 time window was defined as ranging from 150 to 250 ms, and studied over all regions of interest, as P200 effects often have an anterior and central distribution, but posterior effects are also observed (Luck & Kappenman, 2012).

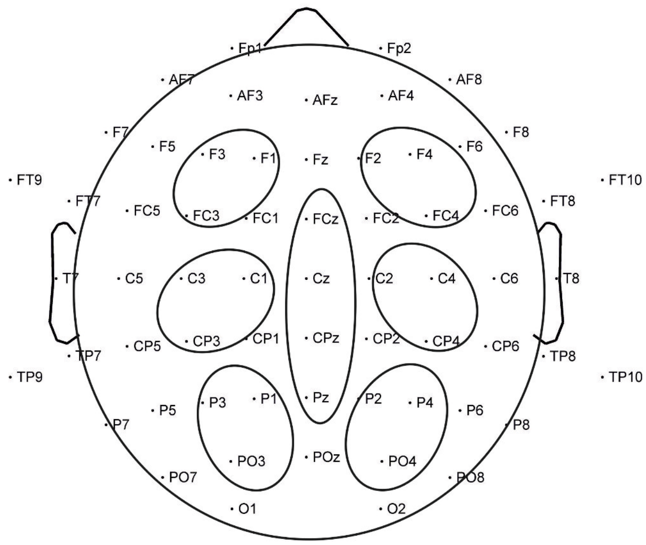

Figure 3. Circles surround the frontal, sagittal, parasagittal, and posterior parietal region of interests (ROI).

2.4 Statistical analyses

We ran repeated-measures ANOVAs on behavioral and electrophysiological data. Only "yes" responses were retained for these ERP analyses as these suggest participants were sufficiently confident in the presence of a memory trace. Further, we operationalized episodic memory as correct recognition of old items with high confidence (Rugg & Curran, 2007). Daselaar, Fleck, and Cabeza (2006), and Yonelinas (2002) consider that high confidence hits derive from recollection.

The Greenhouse & Geisser (1959) procedure was used to compensate for violations of the sphericity assumption, when appropriate. In this case, the original degrees of freedom are reported together with the epsilon (E) and the corrected probability level.

For both behavioral and ERP data, partial eta-squared (η_p^2) is indicated as a measure of effect size.

3. Results

3.1 Electrophysiological Data: Core Analyses

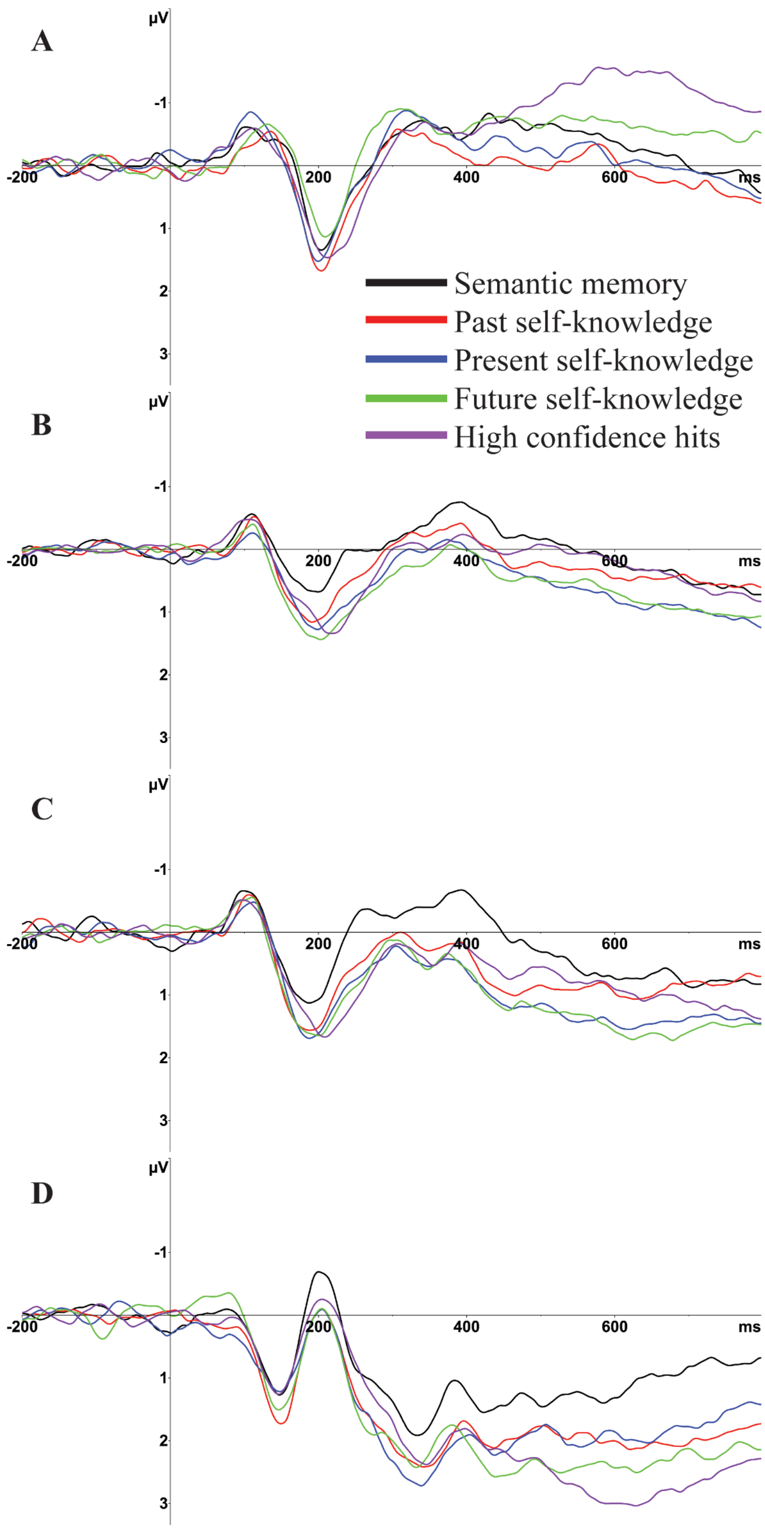

Figure 4. Grand average ERPs (*N* = 28) of yes responses for semantic memory and personal semantics, and high confidence hits for episodic memory, over A) frontal, B) parasagittal, C)

sagittal, and C) posterior parietal sites. Negative voltage is plotted upwards. A low pass filter of 20hz was applied on the grand averages.

3.1.1 P200 time window (150-250 ms)

We tested whether a difference between the 5 memory types (semantic memory, past self-knowledge, present self-knowledge, future self-knowledge, and episodic memory) emerged early, prior to the onset of the N400. The P200 scalp maps (episodic memory subtracted from semantic memory and self-knowledge subtracted from semantic memory) showed a large distribution on central sites extending to frontal and posterior parietal sites (see Figure 5). We conducted separate repeated-measures ANOVA for frontal, sagittal, parasagittal, and posterior parietal subsets (see Figure 4), with Electrode as a factor for all subsets, and Hemisphere as an additional factor for the frontal, parasagittal and posterior parietal subsets. The main effect of Memory was not significant at the frontal subset, $F(4, 108) = 1.03$, $p = .395$, $\eta_p^2 = .04$, nor the sagittal subset, $F(3.12, 84.22) = 2.14$, $p = .098$, $\eta_p^2 = .07$, or the posterior parietal subset, $F(2.78, 75.16) = 1.05$, $p = .373$, $\eta_p^2 = .04$. The main effect of Memory interacted with electrodes at the posterior parietal subset, F(3.22, 87) = 3 = p = .032, η_p^2 = 1. Follow-up analyses showed the Memory effect was nearly significant at P2, $F(4, 108) = 2.37$, $p = .057$, $\eta_p^2 = .08$, and no other sites were significant. Present self-knowledge had the maximal positive amplitude at the electrode P2.

The main effect of Memory was significant at the parasagittal subset, $F(2.89, 77.95) = 3.59$, $p = .019$, $\eta_p^2 = .12$. Semantic memory was less positive than present self-knowledge, $p =$

.012, future self-knowledge, p = .001, and episodic memory, p <.001, but not past self-knowledge, p = .07. The main effect of Memory was only a statistical trend over the sagittal site (p = .098). However, it is worth noting that post-hoc tests also revealed a less positive mean amplitude for semantic memory compared to all other memory types, $p \leq .048$. No other of the two-way interactions between Memory and Electrode or Memory and Hemisphere, or three-way interactions, were significant.

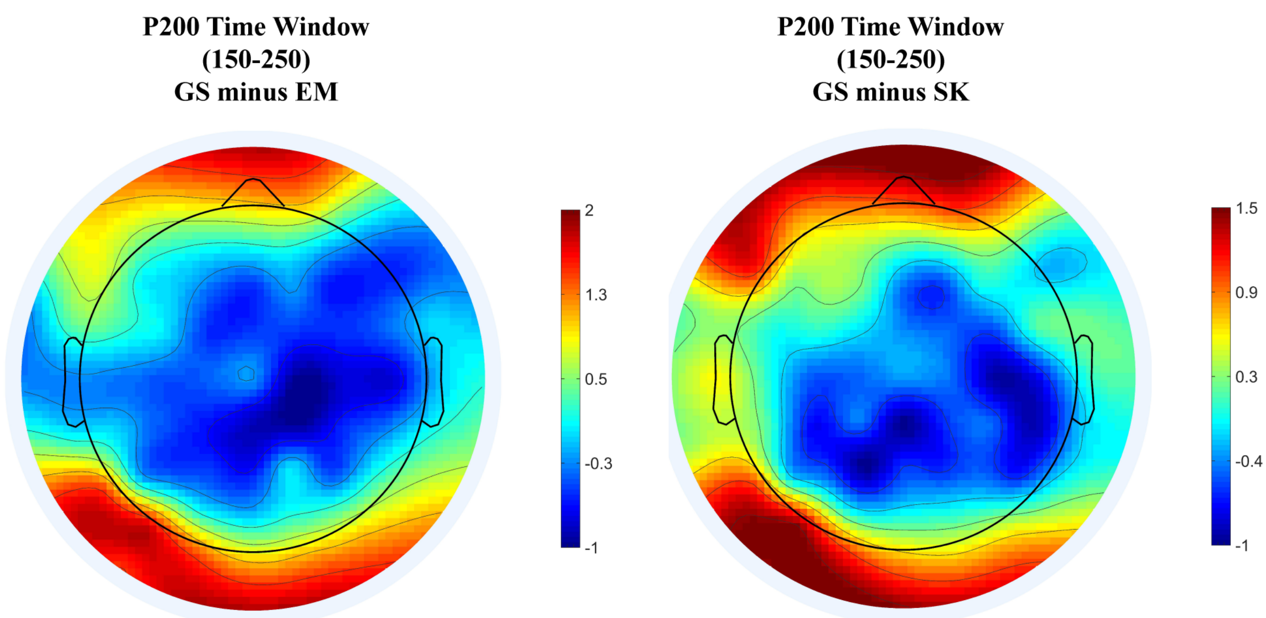

Figure 5. Spline interpolated isovoltage maps of semantic memory (SM, yes responses) minus high confidence hits (EM) at the left, and semantic memory (SM, yes responses) minus the average of all self-knowledge conditions (SK; yes responses) at the right from 150 to 250 ms. Scalp maps were prepared in EEGLAB (Delorme & Makeig, 2004).

3.1.2 N400 time window (250-500 ms). We examined whether the 5 memory types had a different mean voltage amplitude over the sagittal and parasagittal subsets as outlined in Table 1 (see Figure 4 panel A & B, and Figure 6). The N400 scalp maps (episodic memory subtracted from semantic memory and self-knowledge subtracted from semantic memory) showed a classic centro-parietal N400 distribution (see Figure 6). The main effect of Memory was significant, $F(4, 108) = 2.8$, $p = .029$, $\eta_p^2 = .09$ over the sagittal subset. Semantic memory produced more negative amplitudes compared to all other memory conditions (past self-knowledge, $p = .033$, $\eta_p^2 = .16$; present self-knowledge, $p = .015$, $\eta_p^2 = .2$; future self-knowledge, $p = .007$, $\eta_p^2 = .24$; episodic memory, $p = .009$, $\eta_p^2 = .23$; see Table 2). The main effect of Memory type was not significant over the parasagittal subsets, $F(2.52, 67.93) = 1.8$, $p = .162$, $\eta_p^2 = .06$. At both sagittal and parasagittal sites, Memory did not interact with other factors [sagittal: Memory and Electrodes: $F(7.11, 192) = 1.03$, $p = .413$, $\eta_p^2 = .04$; parasagittal: Memory and Electrodes: $F(5.1, 137.61) = 1.07$, $p = .388$, $\eta_p^2 = .04$; Memory and hemisphere: $F(4,108) = .74$, $p = .567$, $\eta_p^2 = .03$; Memory, electrodes and hemisphere: $F(5.28, 142.46) = .73$, $p = .612$, $\eta_p^2 = .03$].

The P200 may have contributed to the N400 effect. Semantic memory was less positive compared to other memory types from 150 to 250 ms, this effect being statistically significant at the parasagittal site, and a statistical trend at the sagittal site. We adopted a peak-to-peak approach to compare the N400 between memory types while taking into account the preceding P200 amplitude. The data was filtered a second time with a low pass cut-off of 10 hz (12 db/oct) allowing clear peaks to emerge. We selected the maximal positive peak from 150 to 250 ms (P200) and the maximal negative peak from 250 to 500 ms (N400), using the Analyzer software. We then subtracted the N400 voltage from the P200 voltage and entered this peak-to-peak measurement in a repeated measures ANOVA including the 5 memory types and the 4 electrodes of the sagittal site (where the N400 effect of Memory was significant with the mean amplitude data). The main effect of Memory was non-significant, $F(4, 108) = .23$, $p = .922$, $\eta_p^2 = .01$, nor was the Memory and Electrode interaction, $F(6.07, 163.79) = 1.03$, $p = .422$, $\eta_p^2 = .04$. This analysis thus revealed that the N400 effect cannot be dissociated from the preceding P200 effect at these electrode sites.

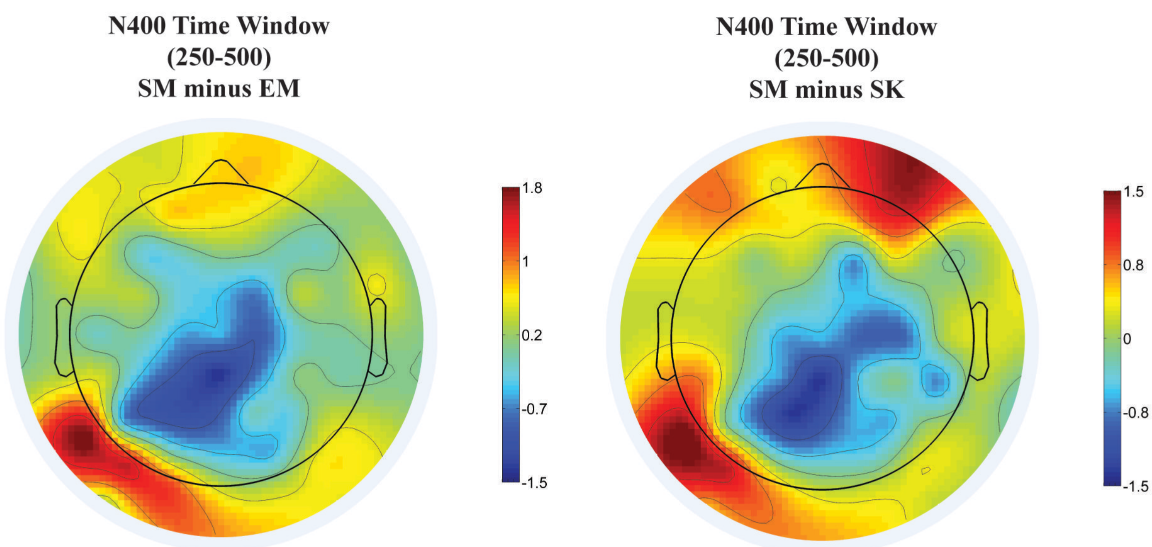

Figure 6. Spline interpolated isovoltage maps of semantic memory (SM) minus episodic memory (EM; left) and semantic memory (SM) minus the average of all self-knowledge conditions (SK; right) from 250 to 500 ms. Scalp maps were prepared in EEGLAB (Delorme & Makeig, 2004).

Table 2: Comparisons between memory types over the sagittal subset in the N400 time window.

Multiple Comparisons					
Dir.	**SM *vs* Past SK**	**Dir.**	**SM *vs* Present SK**	**Dir.**	**SM *vs* Future SK**

>	$F(1,27) = 5.07$, $p = .033$, $\eta_p^2 = .16$	>	$F(1,27) = 6.75$, $p = .015$, $\eta_p^2 = .2$	>	$F(1,27) = 8.68$, $p = .007$, $\eta_p^2 = .24$
Dir.	**EM *vs* Past SK**	**Dir.**	**EM *vs* Present SK**	**Dir.**	**EM *vs* Future SK**
ns	$F(1,27) = .01$, $p = .939$, $\eta_p^2 < .01$	*ns*	$F(1,27) = .58$, $p = .452$, $\eta_p^2 = .02$	*ns*	$F(1,27) = .42$, $p = .521$, $\eta_p^2 = .02$
Dir.	**Past SK *vs* Present SK**	**Dir.**	**Past SK *vs* Future SK**	**Dir.**	**Present *vs* Future SK**
ns	$F(1,27) = .54$, $p = .468$, $\eta_p^2 = .02$	*ns*	$F(1,27) = .3$, $p = .588$, $\eta_p^2 = .01$	*ns*	$F(1,27) = .01$, $p = .95$, $\eta_p^2 < .01$
Dir.	**SM *vs* EM***				
>	$F(1,27) = 7.94$, $p = .009$, $\eta_p^2 = .23$				

Note: > = "more negative"; < = "less negative", *ns* = non-significant. *Two-way interaction between memory and electrodes. SK = self-knowledge, SM = semantic memory.

3.1.3 LPC time window (500-800 ms). We tested whether the 5 memory types have a different mean voltage amplitude over the posterior parietal sites (see Table 1 for the hypotheses). The main effect of Memory was significant, $F(4, 108) = 5.19$, $p = .001$, $\eta_p^2 = .16$.

As can been observed in Figure 4 panel D, at one extreme, episodic memory was associated more positive amplitudes compared to present self-knowledge, p = .049, η_p^2 = .14, and semantic memory, but not past self-knowledge, p = .102, η_p^2 = .1, or future self-knowledge, p = .338, η_p^2 = .03 (see Table 3). The three self-knowledge conditions were not statistically different from one another (past *vs* present: p = .719, η_p^2 < .01; past *vs* future: , p = .292, η_p^2 = .04; present *vs* future: p = .217, η_p^2 = .06; see Table 3). All personal types of memory had greater positive amplitudes compared to semantic memory: (past self-knowledge, p = .021, η_p^2 = .18; present self-knowledge, p = .031, η_p^2 = .16, future self-knowledge, p = .001, η_p^2 = .33, episodic memory, p < .001, η_p^2 = .43). The Memory factor did not interact with Hemisphere, $F(4, 108) = .75$, p = *.562,* η_p^2 = .03, Electrode, F(4.51, 121.71) = 1.29, p = .274, η_p^2 = .046, and there was no three-way interaction, F(4.96, 133.85) = 1, p = .422, η_p^2 = .04. The LPC for episodic memory relative to semantic memory had a left-sided posterior parietal scalp distribution (see Figure 7). The LPC for episodic memory relative to present self-knowledge had a more posterior scalp distribution with maximal amplitudes at left posterior parietal sites, extending to parietal-occipital sites.

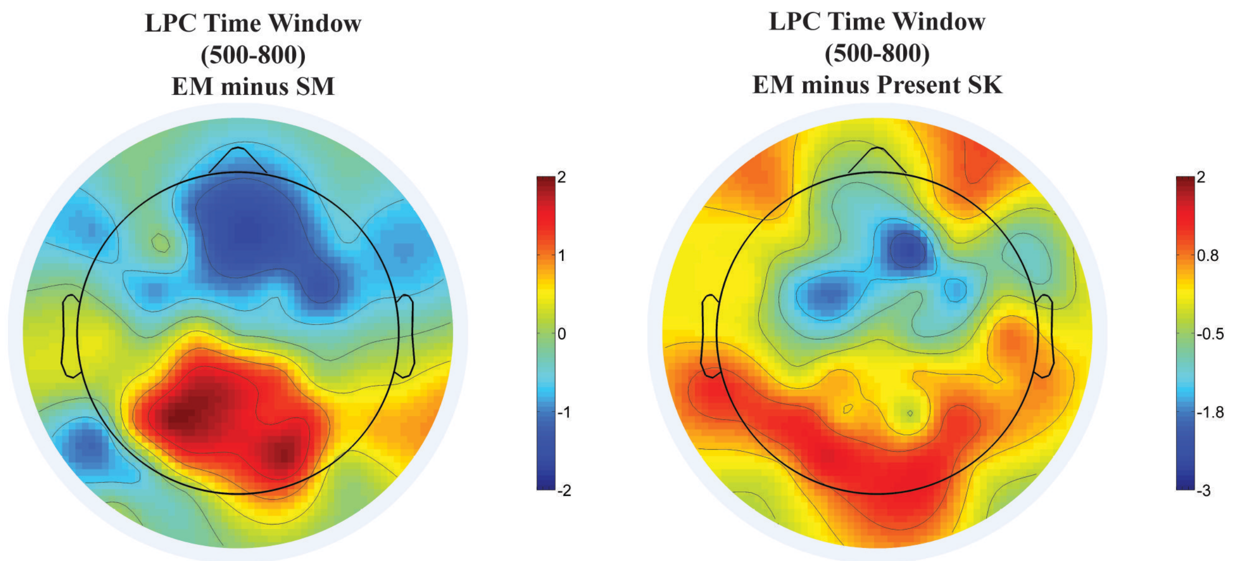

Figure 7. Spline interpolated isovoltage maps of high confidence hits (EM) minus semantic memory (SM; yes responses) at the left and high confidence hits (EM) minus present self-knowledge (SK; *yes* responses) at the right during the 500 to 800 ms time window. Scalp maps were prepared in EEGLAB (Delorme & Makeig, 2004).

Table 3: Paired comparisons between memory types over the posterior parietal subset in the LPC time window.

Multiple Comparisons					
Dir.	**EM *vs* Past SK**	**Dir.**	**EM *vs* Present SK**	**Dir.**	**EM *vs* Future SK**
ns	$F(1,27) = 2.87$, $p = .102$, $\eta_p^2 = .1$	>	$F(1,27) = 4.26$, $p = .049$, $\eta_p^2 = .14$	*ns*	$F(1,27) = .95$, $p = .338$, $\eta_p^2 = .03$
Dir.	**Past SK *vs* SM**	**Dir.**	**Present SK *vs* SM**	**Dir.**	**Future SK *vs* SM**

>	$F(1,27) = 6, p = .021, \eta_p^2 = .18$	>	$F(1,27) = 5.16, p = .031, \eta_p^2 = .16$	>	$F(1,27) = 13.05, p = .001, \eta_p^2 = .33$
Dir.	**Past SK *vs* Present SK**	**Dir.**	**Past SK *vs* Future SK**	**Dir.**	**Present *vs* Future SK**
ns	$F(1,27) = .13, p = .719, \eta_p^2 < .01$	*ns*	$F(1,27) = 1.16, p = .292, \eta_p^2 = .04$	*ns*	$F(1,27) = 1.6, p = .217, \eta_p^2 = .06$
Dir.	**EM *vs* SM**				
>	$F(1,27) = 20.25, p < .001, \eta_p^2 = .43$				

Note: > = "more positive"; < = "less positive"; *ns* = non-significant.

3.2 Electrophysiological Data: Manipulation Checks and Exploratory Analyses

3.2.1 N400 time window (250-500 ms). The N400 is a well-established ERP component that typically displays larger negative amplitude over centroparietal sites for a semantically incongruent words (e.g. "I take coffee with cream and *dog*") compared to a semantical congruent word (e.g. "I shaved off my mustache and *beard*") in specific sentential or prime-target contexts (examples taken from Kutas & Federmeier, 2011). If we consider *no* responses as signifying that the trait is “incongruent” with an occupation or the self-concept, its mean N400 amplitude might be more negative than when people respond *yes*.

To test this hypothesis, we conducted separate repeated-measure ANOVAs for the sagittal and parasagittal subsets of electrodes with Memory condition (4 levels: semantic memory, past self-knowledge, present self-knowledge, future self-knowledge), Response (*yes, no*), Electrode and Hemisphere (for the parasagittal subset) as factors. We focus on the main effect of Response, interactions between Response and Memory, and three- or four-way interactions including Response, Memory as factors for these preliminary analyses. Over the sagittal site, *no* responses resulted in a more negative amplitude (M = 0.13 µV ± 0.21 SE) compared to *yes* responses (M = 0.38 µV ± 0.21 SE), $F(1,27) = 5.02$, $p = .033$, $\eta_p^2 = .16$ (see Figure 8). The main effect of Response did not reach significance over the parasagittal sites, $F(1,27) = 2.83$, $p = .104$, $\eta_p^2 = .1$. None of the interactions were significant, thus they are presented in Table 4 for simplicity.

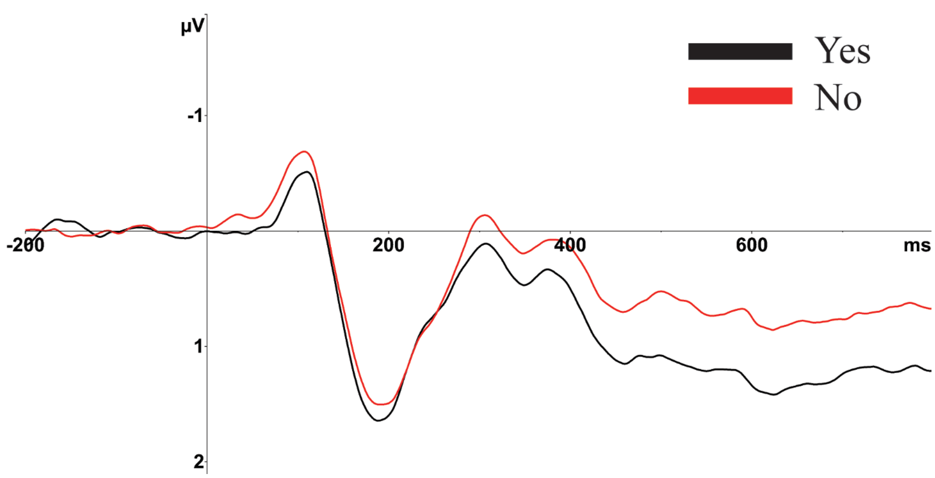

Figure 8. Grand average ERPs (N = 28) of the three self-knowledge conditions over sagittal sites. Negative voltage is plotted upwards. A low pass filter of 20hz was applied on the grand averages.

Table 4: Interactions between Response (*yes, no*) and Memory types, and other factors (i.e. Hemisphere, Electrode).

Interactions with Response				
	Dir.	***Mem**	**Dir.**	***Mem*Elec**
Sagittal Subset		$F(3, 81) = 1.3$, $p = .281$, $\eta_p^2 = 05$		$F(9, 243) = .82$, $p = .595$, $\eta_p^2 = .03$
	Dir.	***Mem**	**Dir.**	***Mem*Elec**
Para-sagittal Subset		$F(3, 81) = .61$, $p = .612$, $\eta_p^2 = .02$		$F(4.13, 111.53) = .49$, $p = .748$, $\eta_p^2 = .02$
	Dir.	***Mem*Hem**	**Dir.**	***Mem*Elec*Hem**
Para-sagittal Subset		$F(3, 81) = .76$, $p = .518$, $\eta_p^2 = .03$		$F(3.9, 105.47) = .92$, $p = .454$, $\eta_p^2 = .03$

Note: *ns* = non-significant, Mem = memory, Hem = hemisphere, Elec = electrode.

3.2.2 LPC time window (500-800 ms). Another established finding in ERP research is the parietal old/new effect: LPC amplitude is more positive for hits compared to correct rejections over posterior parietal sites (Rugg & Curran, 2007). We ran a repeated-measures ANOVA with Memory performance (2 levels: high confidence hits, correct rejection), Hemisphere, Electrode as factors on the mean amplitude between 500 to 800 ms. As expected, the amplitude of hits was more positive (M = 2.71 μV ± 0.42 SE) compared to correct rejections (M = 2.07 μV ± 0.39 SE), $F(1,27) = 16.26$, $p < .001$, $\eta_p^2 = .38$ (see Figure 9). However, the type of memory response did not interact with Hemisphere, $F(1, 27) = .05$, $p = .83$, $\eta_p^2 < .01$, or Electrodes, $F(2, 54) < .01$, $p = .996$, $\eta_p^2 < .01$, and the three-way interaction was not significant, $F(2, 54) = .37$, $p = .692$, $\eta_p^2 = .01$. The LPC had a posterior parietal distribution, with local maxima at left posterior parietal sites and right centro-parietal sites (see Figure 10).

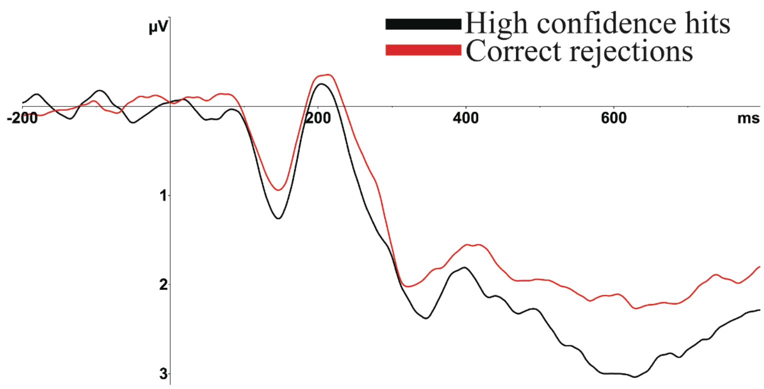

Figure 9. Grand average ERPs (N = 28) of high confidence hits and correct rejections over posterior parietal sites. Negative voltage is plotted upwards. A low pass filter of 20hz was applied on the grand averages.

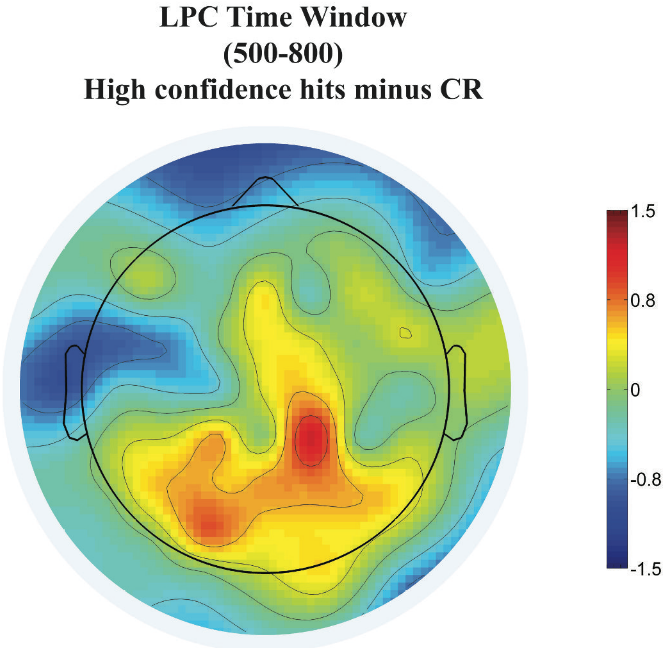

Figure 10. Spline interpolated isovoltage maps of high confidence hits minus correct rejections from 500 to 800 ms. Scalp maps were prepared in EEGLAB (Delorme & Makeig, 2004).

3.2.3 Frontal ROI. We investigated the main effect of Memory over the frontal subset during the N400 and LPC time window (see 3.1.1 for P200). The FN400, or the midfrontal old/new effect, is commonly thought to index familiarity in recognition, often used as the counterpart to the LPC, or the parietal old/new effect, which indexes recollection (Rugg & Curran, 2007).

As preliminary check, the FN400 effect was not observed on frontal site when comparing high confidence hits and correct rejection, $F(1, 27) = .14$, $p = .71$, $\eta_p^2 = .01$. Response Type did not interact with Electrode, $F(2, 54) = .2$, $p = .816$, $\eta_p^2 = .01$, or Hemisphere, $F(1, 27) = .23$, $p = .639$, $\eta_p^2 = .01$, Electrode and Hemisphere, $F(2, 54) = .4$, $p = .673$, $\eta_p^2 = .02$, which are also included in this set of analyses.

Next, we considered whether the 5 memory conditions differed over frontal sites during the N400 time window, and they did not, $F(3.39, 91.65) = .73$, $p = .552$, $\eta_p^2 = .026$. Memory did not interact with Electrode, $F(8, 216) = 1.02$, $p = .425$, $\eta_p^2 = .04$, or hemisphere, $F(4, 108) = .6$, $p = .667$, $\eta_p^2 = .02$, and there was no three-way interaction, $F(5.13, 138.57) = .77$, $p = .577$, $\eta_p^2 = .03$. Lastly, we tested if the 5 memory types differed in the later time window over the frontal subset, that is, from 500 to 800 ms. Indeed, the main effect of Memory was significant, $F(4, 108) = 4.73$, $p = .001$, $\eta_p^2 = .15$. Episodic memory was more negative than general semantics, $p = .002$, past self-knowledge, $p = .001$, present self-knowledge, but not future self-knowledge, $p = .084$. Future self-knowledge was also more negative than past self-knowledge, $p = .014$. Memory did not interact with Electrode, $F(8, 216) = 1.35$, $p = .223$, $\eta_p^2 = .05$, or Hemisphere, $F(4, 108) = .88$, $p = .481$, $\eta_p^2 = .03$, and there was no three-way interaction, $F(5.15, 139.04) = 1.14$, $p = .343$, $\eta_p^2 = .04$. This effect is likely due to the use of the average reference, consistent with findings of FN400 and LPC effects of opposite polarity when using this reference (Curran & Friedman, 2004; e.g., Curran, Tanaka, & Weiskopf, 2002; Renoult et al., 2015).

3.3 Behavioral Data: Preliminary analyses and manipulations checks

3.3.1 Behavioral data: Reaction Times

We tested whether the memory conditions differ in their mean reaction times (this section) or responses (next section). Through these analyses, we aimed to verify if our study replicates previous findings of an optimism bias (D'Argembeau et al., 2010; Kanten & Teigen, 2008; Wilson & Ross, 2001). We tested whether mean Reaction Time (RT) differed between Valence (2 levels: positive, negative), Response (2 levels: *yes*, *no*), and the Memory conditions (4 levels: semantic memory, past, present, and future self-knowledge), and whether these factors interacted (see Figure 11). Participants made recognition responses after trait presentation (rather than during presentation) for the episodic memory condition, thus there was no reaction times to analyze for this condition.

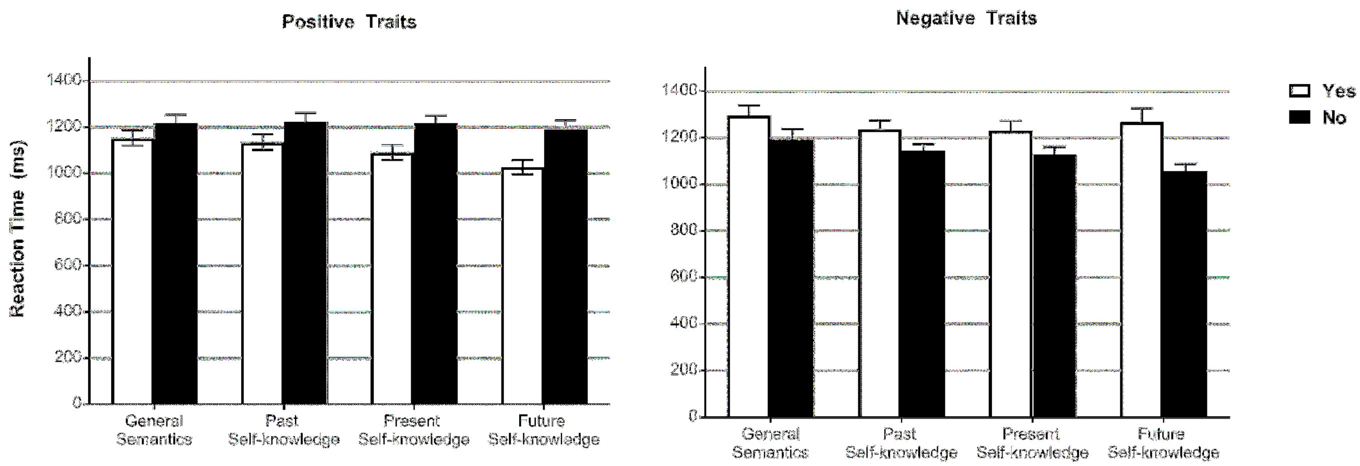

Figure 11. Mean RTs for positive traits (left) and negative traits (right) for *yes* and *no* responses in each of the memory conditions. Error bars represent ± 1 *SE*.

The repeated-measures ANOVA revealed a main effect of Memory, $F(3, 81) = 3.89$, $p = .012$, $\eta_p^2 = .13$, and a main effect of Valence, $F(1, 27) = 12.27$, $p = .002$, $\eta_p^2 = .31$. Memory, Valence, and Response interacted, $F(3, 81) = 6.98$, $p < .001$, $\eta_p^2 = .21$. We ran separate repeated-measures ANOVAs for positive and negative traits to follow-up on this three-way interaction. Memory and Response interacted for positive traits, $F(3, 81) = 3.07$, $p = .032$, $\eta_p^2 = .1$, and negative traits, $F(2.23, 60.14) = 3.55$, $p = .031$, $\eta_p^2 = .12$. The most important finding (given that we emphasized *yes* responses in our ERP analyses) was that, for positive traits, the main effect of Memory was significant, $F(2.24, 60.46) = 7.86$, $p = .001$, $\eta_p^2 = .23$. Participants were faster to respond *yes* in the future self-knowledge condition compared to past self-knowledge ($p < .001$,

η_p^2 = .44), present self-knowledge (p = .008, η_p^2 = .23), and semantic memory (p < .001, η_p^2 = .39). Participants were also faster to respond *yes* for present compared to past self-knowledge (p = .046, η_p^2 = .14; see Table 5). The rapidity of *no* responses to positive traits did not differ between memory conditions, F(3, 81) = .47, p = .706, η_p^2 = .02. For negative traits, RTs to *yes* responses were not significantly different between memory types, F(2.2, 59.47) = 1.22, p = .305, η_p^2 = .04. However, the main effect of Memory was significant for *no* response to negative traits, F(2.07, 55.9) = 6.33, p = .003, η_p^2 = .19. Participants were significantly faster to respond *no* for future self-knowledge compared to past self-knowledge (p = .001, η_p^2 = .33), present self-knowledge (p = .011, η_p^2 = .22), and semantic memory (p = .001, η_p^2 = .36). Thus, participants were faster to endorse positive traits and reject negative traits when they pertained to the future relative to the past or present selves, or other people.

Table 5: Comparisons of the RT between Memory types as a factor of Response (*yes or no*).

Multiple Comparisons					
Positive Traits			Negative Traits		
Response	**Dir.**	**Future SK *vs* SM**	**Response**	**Dir.**	**Future SK *vs* SM**
Yes	<	F(1, 27) = 17.03, p < .001, η_p^2 = .39	**No**	<	F(1, 27) = 15.19, p = .001, η_p^2 = .36

Response	Dir.	Future SK *vs* Past SK
Yes	<	$F(1, 27) = 21.38, p < .001, \eta_p^2 = .44$

Response	Dir.	Future SK *vs* Past SK
No	<	$F(1, 27) = 12.98, p = .001, \eta_p^2 = .33$

Response	Dir.	Future *vs* Present SK
Yes	<	$F(1, 27) = 8.23, p = .008, \eta_p^2 = .23$

Response	Dir.	Future *vs* Present SK
No	<	$F(1, 27) = 7.38, p = .011, \eta_p^2 = .22$

Response	Dir.	Past SK *vs* Present SK
Yes	>	$F(1, 27) = 4.38, p = .046, \eta_p^2 = .14$

Response	Dir.	Past SK *vs* Present SK
No	*ns*	$F(1, 27) = .42, p = .523, \eta_p^2 = .02$

Response	Dir.	SM *vs* Past SK
Yes	*ns*	$F(1, 27) = .28, p = .605, \eta_p^2 = .01$

Response	Dir.	SM *vs* Past SK
No	*ns*	$F(1, 27) = 2.16, p = .154, \eta_p^2 = .07$

Response	Dir.	SM *vs* Present SK
Yes	*ns*	$F(1, 27) = 3.41, p = .076, \eta_p^2 = 11$

Response	Dir.	SM *vs* Present SK
No	*ns*	$F(1, 27) = 2.27, p = .144, \eta_p^2 = .08$

Note: > = "slower"; < = "faster", *ns* = non-significant, SK = self-knowledge, SM = semantic memory

3.3.2 Behavioral data: Percentage of Yes Responses

We ran a repeated-measures ANOVA on the percentage of *yes* responses with Valence and Memory conditions (4 levels: semantic memory, past, present, and future self-knowledge) as within-subject factors. The percentage of *yes* responses did not differ between Memory types when averaging responses to positive and negative traits together, $F(3,81) = 1.75$, $p = .164$, $\eta_p^2 = .06$ (see Figure 12).

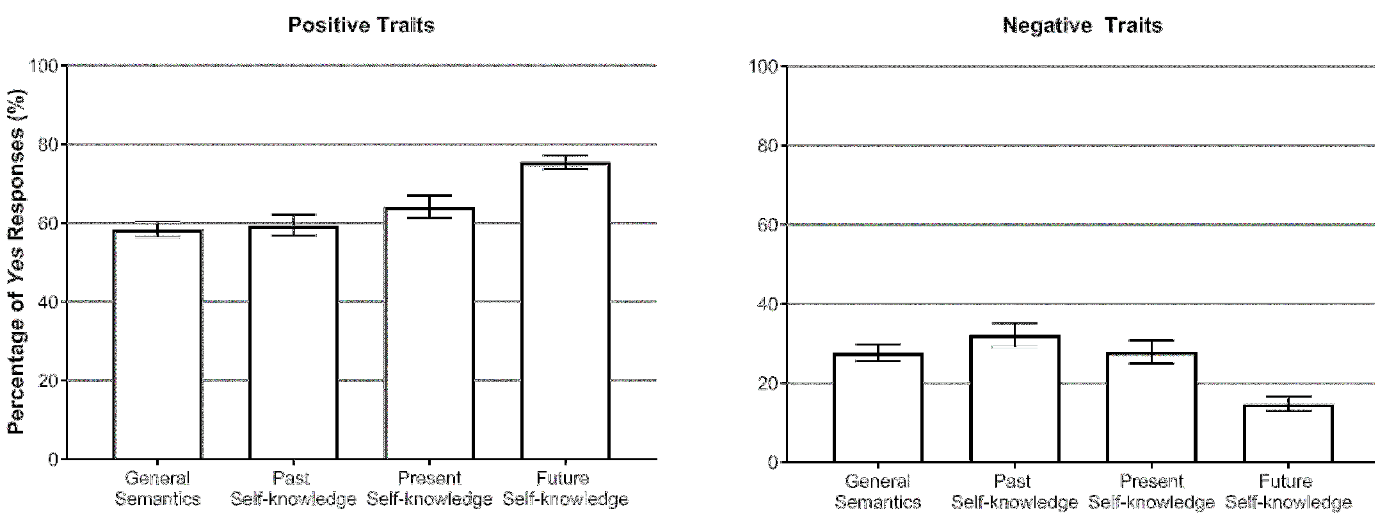

Figure 12. Mean percentage of *yes* responses for positive traits (left) and negative traits (right) in each of the memory conditions. Error bars represent ± 1 *SE*.

Overall, participants made a greater percentage of *yes* responses for positive than negative traits, $F(1, 27) = 241.57$, $p < .001$, $\eta_p^2 = .9$. Memory types and Valence interacted, $F(3, 81) = 20.15$, $p < .001$, $\eta_p^2 = .43$. The percentage of *yes* responses to positive traits was higher for future self-knowledge compared to all other conditions (semantic memory: $p < .001$, $\eta_p^2 = .73$; past self-knowledge: $p < .001$, $\eta_p^2 = .54$; present self-knowledge: $p < .001$, $\eta_p^2 = .45$, see Table 6). In addition, participants endorsed a higher percentage of positive traits in present self-knowledge relative to the positive traits they attributed to other people (semantic memory), $p = .047$, $\eta_p^2 = .14$. The mirrored effect was observed for negative traits: the percentage of *yes* responses was lower for future self-knowledge compared to all others conditions (semantic memory: $p < .001$, $\eta_p^2 = .48$; past self-knowledge: $p < .001$, $\eta_p^2 = .55$; present self-knowledge: $p < .001$, $\eta_p^2 = .41$).

Table 6: Comparisons of the percentage of *yes* responses between memory types.

Multiple Comparisons			
Positive Traits		**Negative Traits**	
Dir.	**Future SK *vs* SM**	**Dir.**	**Future SK vs. SM**
>	$F(1, 27) = 73.78$, $p < .001$, $\eta_p^2 = .73$	<	$F(1, 27) = 24.44$, $p < .001$, $\eta_p^2 = .48$
Dir.	**Future SK *vs* Past SK**	**Dir.**	**Future SK *vs* Past SK**

>	$F(1, 27) = 31.05$, $p < .001$, $\eta_p^2 = .54$	<	$F(1 ,27) = 33.29$, $p < .001$, $\eta_p^2 = .55$
Dir.	**Future *vs* Present SK**	**Dir.**	**Future *vs* Present SK**
>	$F(1, 27) = 22.48$, $p < .001$, $\eta_p^2 = .45$	<	$F(1, 27) = 18.59$, $p < .001$, $\eta_p^2 = .41$
Dir.	**Past SK vs Present SK**	**Dir.**	**Past SK vs Present SK**
ns	$F(1,27) = 2.24$, $p = .146$, $\eta_p^2 = .08$	*ns*	$F(1, 27) = 3.2$, $p = .085$, $\eta_p^2 = .11$
Dir.	**SM vs Past SK**	**Dir.**	**SM vs Past SK**
ns	$F(1, 27) = .16$, $p = .692$, $\eta_p^2 = .01$	*ns*	$F(1, 27) = 2.36$, $p = .136$, $\eta_p^2 = .08$
Dir.	**SM vs Present SK**	**Dir.**	**SM vs Present SK**
<	$F(1, 27) = 4.34$, $p = .047$, $\eta_p^2 = .14$	*ns*	$F(1, 27) < .01$, $p = .995$, $\eta_p^2 < .01$

Note: > = "higher percentage"; < = "lower percentage", *ns* = non-significant, SM = semantic memory, SK = self-knowledge

3.3.3 Behavioral data: Recognition Memory Task

We compared the rapidity of the correct recognition responses (2 levels: hits and correct rejections) with Valence as an additional factor. Participants were slower to make correct rejections (M = 629.78ms ± 34.56SE) compared to hits (M = 503ms ± 23.22SE), $F(1, 27) = 25.04$, $p < .001$, $\eta_p^2 = .48$. The interaction between the response time of Response Type and Valence approached the level of significance, $F(1,27) = 4.13$, $p = .052$, $\eta_p^2 = .13$. Participants were faster to make hits than correct rejections for both positive and negative words ($p \leq .001$), however this effect seemed stronger for positive words. The main effect of Valence was not significant, $F(1,27) = .35$, $p = .56$, $\eta_p^2 = .01$.

For recognition performance, we compared the percentage of correct responses between Response Type (2 levels: hits and correct rejections) and Valence. Participants were more accurate in their recognition of target words (M = 81.56 ± 1.93 SE) than new words overall (M = 66.79 ± 2.49 SE), $F(1,27) = 17.65$, $p < .001$, $\eta_p^2 = .4$. There was no effect of Valence, $F(1, 27) = .03$, $p = .862$, $\eta_p^2 < .01$, but Memory and Valence interacted, $F(1,27) = 23.62$, $p < .001$, $\eta_p^2 = .47$. Participants produced more hits when traits were positive (M = 83.93% ± 2.02 SE) than when they were negative (M = 79.2% ± 2.1SE), $F(1, 27) = 10.89$, $p = .003$, $\eta_p^2 = .29$. Conversely, participants were more accurate to reject new items when traits where negative (M = 69.38% ± 2.5 SE) than positive (M = 64.2% ± 2.78 SE), $F(1, 27) = 8.28$, $p = .008$, $\eta_p^2 = .24$. Next, we considered whether differences between positive and negative traits were attributable to a change in sensitivity (*d’*) or to a bias towards a certain response (*c*). Positive and negative traits did not differ in sensitivity, $F(1, 27) = .35$, $p = .56$, $\eta_p^2 = .01$. Participants were significantly more biased towards a *yes* response for positive traits (M = -.37 ± .07 SE) than they were for negative traits (M = -.14 ± .06 SE), $F(1, 27) = 28.68$, $p < .001$, $\eta_p^2 = .52$.

4. Discussion

The goal of the present study was to compare the event-related potential (ERP) correlates of self-knowledge to both semantic and episodic memory, focusing on N400 and LPC as proxies for semantic and episodic processing, respectively. We also considered time perspective of the self-knowledge judgements (past, present, and future), because thinking about one's past and future selves may engage semantic and episodic memory to differing degrees (Irish & Piguet, 2013; Prebble et al., 2013).

Behavioral results revealed that participants endorsed more positive traits and fewer negative traits as reflecting their future selves, and did so faster, compared to their past and present selves (D'Argembeau et al., 2010; Wilson & Ross, 2001). The participants also rated themselves as "better-than-average": Their own current and future personalities were perceived as containing more positive traits than other people's personalities (similar to: Kanten and Teigen (2008)).

ERP results indicated that mean N400 amplitude at sagittal sites was larger for semantic memory than for all time perspectives of self-knowledge (note also that, as one might expect from the literature (Kutas & Federmeier, 2011), the *no* responses on the self-knowledge and semantic memory tasks were associated with a larger N400 compared to *yes* responses). Of note, we found a larger P200 for self-knowledge conditions relative to semantic memory at these same electrode sites. The N400 memory effect was in tandem with the preceding P200, thus the N400 effect may not be solely attributable to a difference in semantic processing (see 4.3 for a discussion of this finding). Also commensurate with the existing literature, on the recognition memory task the LPC was larger for high confidence hits compared to correct rejections at posterior parietal sites. On the self-knowledge task, the amplitude of the LPC associated with knowing one's current self fell intermediately between semantic and episodic memory, whereas the LPC for knowledge of past and future selves was closer to episodic memory. This modulation of the time perspective is noteworthy in that it is related to only a slight variation in the instructions (i.e. past vs. present vs. future).

4.1 Time perspective and Self-knowledge

Some have considered that temporally distant selves are similar to other people (e.g. Pronin & Ross, 2006). Using a similar logic, D'Argembeau et al. (2010) reported that the neurocognitive processes involved in thinking about distant past or the future selves relative to the present self shares similarities with thinking of other people. Knowledge of unknown or a generic group of people belongs to the domain of semantic memory (Binder & Desai, 2011; Lambon Ralph et al., 2017), thus such perspectives and findings can be gathered as further support that past and future self-knowledge recruits semantic processing. Our study shows the value of including conditions of semantic and episodic memory rather than extrapolating relationships solely on the basis of neural correlates associated with semantic and episodic memory (and the self). Regarding the N400, we had considered the possibility of a closer relationship between semantic memory and present self-knowledge because of their conceptual similarity. This expectation was based on the idea that present self-knowledge implies awareness in the present, like semantic memory. Moreover, present self-knowledge might reflect mostly stable (atemporal) characteristics of one's personality (Anusic & Schimmack, 2016). A recent meta-analysis estimated the stable portion of our personality to be 83% (at *M* age = 32 years old; Anusic & Schimmack, 2016). Likewise, semantic memory is conceptualized as devoid of temporal context. Contrary to these expectations, we found that time perspective did not modulate the N400. In fact, when considering the P200/N400 and LPC, the current study suggests that present self-knowledge shares greater similarity with past and future self-knowledge than with semantic memory. As D'Argembeau et al. (2008) pointed out, the qualifier "present" in "present" self-knowledge might instead refer to an extended period (e.g. as a life chapter or "repeated/general" events). In addition, personality can change with context (Roberts, 2007), even within a single life period. Most participants in the present study were university students and the experimental context (i.e. at the University) might have reinstated the relevance of that context for the current self-identity (e.g. I am calm as a student, but wild when with friends). Awareness of oneself through different temporal contexts is a hallmark of episodic memory (Tulving, 2001, 2002). To investigate the neural correlates of the stable/atemporal aspects of self-knowledge, the instructions in a future study could insist on participants' processing the words according to whether they reflect stable characteristics of one's personality (e.g. I have always been independent).

The mean LPC of past and future self-knowledge was less positive than, but not significantly different from, episodic memory. The LPC is associated with recollection, and possibly also with self-relevance (Fields & Kuperberg, 2016; Rugg & Curran, 2007, Renoult et al., 2015). The trials from the three self-knowledge conditions were all judged to be self-relevant by our participants (i.e., we focused on the "yes" trials in the ERP analyses), therefore the LPC difference is unlikely to be explained by this factor. However, it will be interesting to disambiguate how self-relevance, demands on scene construction, and/or mental time travel (Palombo et al., in press) may each contribute to LPC differences across past, present, and future time perspectives. Alternatively, our findings suggest that self-knowledge could be conceptualized as falling on a continuum ranging from "experience-near" (e.g. I was very friendly as a salesperson) to the "experience-far" (e.g. I am always a cheerful person; Grilli & Verfaellie, 2016; Renoult et al., 2016). This distinction has proven to be useful for autobiographical facts, another type of personal semantics. For example, amnesic patients are more impaired when autobiographical facts are judged to be close to experience (e.g. I adopted my cat in a shelter in Ottawa) than they are for facts removed from experience (e.g. I speak French; Grilli & Verfaellie, 2016). Self-knowledge might similarly be organized in an experience-near versus experience-far manner.

On the basis of the self-construal account we can deduce that the requirements in semantic processing (i.e. the N400) of past and future self-knowledge will be closer to general semantics than to present self-knowledge, because distant events include more general facts and less episodic details (Trope & Liberman, 2010). If we extend this logic, past and future self-knowledge may require accessing general knowledge about typical life narratives and changes in personality to a greater extent than present self-knowledge. Temporal orientation of self-knowledge did not modulate the N400, contrary to this interpretation of the self-construal account. The alternative account highlights the role of events to define identity, as well as the close interrelationships between past or future thinking and episodic memory. This last account offers a better fit for our findings: the LPC of past and future self-knowledge was not significantly different from episodic memory, while present self-knowledge was intermediate, and differed from semantic and episodic memory. Our results support the perspective that recollection or simulation of personal events shape self-knowledge for all temporal orientation, although knowledge of past and future selves increases demands on episodic processing. This pattern of results for the LPC, with past and future self-knowledge being less similar to semantic memory relative to present self-knowledge was not mirrored in the N400. The N400 and LPC thus showed distinct modulations by time perspective and memory types. Time perspective produced a strong LPC effect, but weak (or absent) N400 effect. Similarly, in one of our previous studies, the LPC, but not the N400, distinguished high autobiographically significant concepts from concepts with low autobiographical significance (Renoult et al., 2015).

4.2 Self-knowledge and Other Types of Personal Semantics

Personal semantics have been argued by Renoult et al. (2012) to come in 4 types, all of which fall between semantic and episodic memory as “intermediate types of declarative memory”, but are their neural and behavioral correlates all “intermediate” in the same way? The Renoult et al. (2012) review of the existing literature suggested that the answer is “no;” two of the 4 types of personal semantics (i.e., memory for repeated events, and autobiographically significant concepts) may be closer to episodic memory, one type (i.e., autobiographical facts) may be closer to semantic memory, and the last type (i.e. self-knowledge; see Figure 1; Renoult et al., 2012) may be relatively distinct from both – although as seen in the present paper self-knowledge’s relation to semantic and episodic memory appears to vary as a function of time perspective. Yet, the question of how similar or dissimilar these 4 different types of personal semantics are to one another can only be answered tentatively at present, because most types of personal semantics have not been compared to one another, or to the same kind of semantic and episodic memory “control” conditions, within the same study. The ERP correlates of personal semantics appear to vary. For instance, a first study (Renoult et al., 2015) compared the ERP correlates of concepts from a single experimental condition by sorting them according to whether the concepts had high or low autobiographical significance (self-reported by each participant after the task). High autobiographically significant (AS) concepts were theorized to be personal semantics, whereas low autobiographical significance concepts were taken to predominantly reflect semantic memory. The N400 was not significantly different between these two kinds of concepts, but the mean LPC was more positive for the highly autobiographically significant concepts than for the less-autobiographically significant ones. Conversely, in a separate study on two other kinds of personal semantics – namely, autobiographical facts and memory for repeated events (Renoult et al., 2016) -- the N400 for autobiographical facts (e.g. I am vegetarian) and for repeated events (e.g. I remember cleaning the windows every spring) was less negative than for general facts at sagittal and posterior parietal sites. Other findings appear to be more consistent across various subtypes of personal semantics in this nascent literature. Across several recent publications, all types of personal semantics were associated with larger LPC amplitudes than semantic memory (Coronel & Federmeier, 2016; Renoult et al., 2015, 2016). In contrast, in the Renoult et al. (2016) report, autobiographical facts and repeated events were less distinguishable from episodic memory, similar to our findings in the present study regarding future and past self-knowledge (Renoult et al., 2016). The effect sizes that we have reported here can be used to generate the hypothesis that past self-knowledge (η_p^2 = .03) and future self-knowledge (η_p^2 = .1) are less different from episodic memory than are autobiographical facts (η_p^2 = .18), memory for repeated events (η_p^2 = .26), and present self-knowledge (η_p^2 =.14). A unique characteristic of self-knowledge as compared to other types of personal semantics may be modulation of the

P200, as such modulation was not observed for memories of autobiographical facts, repeated events or for autobiographically significant concepts (Renoult et al., 2015, 2016).[1]

A main interest of Coronel and Federmeier (2016) and Choi et al. (2017) was to investigate the characteristics of the incongruency effect of personal semantics, if at all present (i.e. larger N400 for a word incongruent with its context vs. congruent). These researchers collected personal information prior to the experimental tasks to elaborate the stimuli, unlike Renoult et al. (2015; 2016), and this study. Thus, the statements were either consistent or inconsistent with the facts or the preferences the participants had shared. The N400 was larger for statements conflicting with one's preferences (i.e. self-knowledge) and for false autobiographical facts compared to congruent statements. Likewise, in our study, *no* responses, signifying that traits do not reflect oneself or other people, were associated with a larger N400 than *yes* responses at sagittal sites. The effect did not interact with memory type (i.e. personal

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[1] In other studies of this group the mean N400 was extracted 300-500 ms post-stimulus onset including centro-parietal sites, and the mean LPC was extracted from 500 to 700 ms post-stimulus onset, including posterior parietal sites. We selected a time window of 250 to 500 ms in this study. Each offers a comparable outcome. That is, when using a 300 to 500 ms time window, the main effect of Memory was significant over the sagittal site, $F(4, 108) = 2.61$, $p = .039$, $\eta_p^2 = .09$, and it was not significant over the parasagittal site, $F(2.58, 69.75) = 1.62$, $p = .198$, $\eta_p^2 = .06$. Pairwise comparisons showed that semantic memory was more negative compared to all other memory conditions over the sagittal site (past self-knowledge, $p = .04$; present self-knowledge, $p = .023$; future self-knowledge, $p = .01$; episodic memory, $p = .04$). All these effects were also significant from 250 to 500 ms, and no other effects were significant.

semantics versus semantic memory). Visual inspection of the data suggests that the effect only became evident when all memory conditions were considered together, and the effect was not significant at parasagittal sites. Contrary to Choi et al. (2017), and Coronel and Federmeier (2016), the stimuli in our personal semantics and semantic memory tasks do not possess a truth or false value *per se*. Rather, traits are likely to range on a continuum of how well they match one's personality or other people's personality (e.g. I have a moderate sense of humour, priests have a moderate sense of humour). Future studies could record responses on a scale from the *completely congruent* to the *completely incongruent* (instead of the dichotomous yes/no response) to investigate how the level of agreement modulates the N400.

4.3 Future Directions

We found that the amplitude of the P200 was less positive for semantic memory than for the other conditions. The P200 is sometimes thought to index high order perceptual processes, as in visual feature analysis (Evans & Federmeier, 2007; Luck & Hillyard, 1994). However, we do not think that differences due to selective attention to visual features are likely to explain any P200 effects in our study. Indeed, our stimuli were matched in number of letters, frequency, familiarity, and likableness (similar to emotional valence). Moreover, stimulus presentation was identical across conditions (i.e. same duration, font, colour, location on the screen), and a similar yes/no response was required in all conditions. Interestingly, a large body of research links P200 to emotion via its possible effects on attention or early lexico-semantic processing (Hajcak, Weinberg, MacNamara, & Foti, 2012; Kotz & Paulmann, 2011; Trauer, Kotz, & Müller, 2015). In these studies, the P200 is larger for emotional than neutral stimuli (Carretié, Hinojosa, Martín-

Loeches, Mercado, & Tapia, 2004; Kanske & Kotz, 2007; Kotz & Paulmann, 2011). Even though the stimuli of our memory conditions were matched in likableness (or emotional valence), thinking about the words in relation to oneself may have increased their emotional salience compared to thinking about a group of people. Our findings would thus be reminiscent of those of Trauer et al., (2015) who interpreted their larger P200 and smaller N400 for emotional words compared to neutral words as *"*enhanced lexico-meaning access" (P200) and "facilitate[d] (….) integrative semantic processing*"*. Other studies have found a larger P200 but smaller N400 for positive compared to neutral words (Kanske & Kotz, 2007) and smaller N400 for positive words about self relative to positive words about others (Fields & Kuperberg, 2015). Fields and Kuperberg (2015) interpreted their findings in the context of a positivity bias: the attribution of a positive outcome is more expected for oneself than for others, and we could add that it requires less semantic processing for oneself. Indeed, our "yes" responses include mostly positive words from each condition, and a positivity bias is observed in the behavioural data. The component process view of personal semantics proposes, among other things, that emotional valence would be increased for self-knowledge relative to semantic memory (Renoult et al., 2012). Therefore, processing words in relation to one's self rather than in relation to others might increase the emotional salience of the words in a way that transpires in the P200 (possibly via attentional processes).

It is worth noting that there may be qualitative gaps when comparing personal with general semantics, as typically operationalized. Self-knowledge is often more emotional than general knowledge (Renoult et al., 2012; Sui & Humphreys, 2015). Similarly, a general semantics judgement may be less specific or may rely on a smaller amount of information that a self-judgement (e.g., I know what the word student means *versus* I know that I am a student;

Klein & Loftus, 1993). Moreover, general semantics is very often looked at with typicality judgements of culturally-shared knowledge (what most people think/do, what is true in general, as in semantic categorisation tasks); this by definition concerns a group, whereas the self by definition is specific to one individual. To try to circumvent these problems, one might consider instead contrasting knowledge of just one individual (e.g., a close family member) with self-knowledge, but the former would not be a typical semantic memory condition because semantic memory is most often defined as general, culturally-shared knowledge (and, thus, detailed knowledge of a close other may be instead another type of personal semantics; Binder & Desai, 2011; Hart et al., 2007; Martin, 2001). For these reasons, when we compared personal to general semantics, we chose to contrast judgements of one's own traits to judgements of a category of people. Nonetheless, because of these potential qualitative gaps between typical operationalizations of personal and general semantics, it will be worthwhile in future studies to study some of these factors further (e.g., investigate how emotional semantic knowledge compares to self-knowledge; compare the neural substrates of knowledge of groups to knowledge of individuals, etc.).

It is also important to note that, in the present study, episodic memory was operationalized as high confidence recognition memory hits (Diana, Yonelinas, & Ranganath, 2007) and not as rich episodic re-experiencing, as is commonly done in autobiographical memory studies (Cabeza & St Jacques, 2007). This is because such slow re-experiencing recollection experiences are typically associated with complex task demands and longer processing time (e.g., 5-10 s per trial, Conway, Pleydell-Pearce, Whitecross, & Sharpe, 2002; Svoboda, McKinnon, & Levine, 2006) as compared to semantic memory tasks (0.8-1.5s, Chang, 1986). High confidence recognition memory is thus a better comparison in this context as it relies on more comparable task demands (Renoult et al., 2016), yet is thought to derive from recollection (Daselaar, 2006; Diana & Ranganath, 2011; Yonelinas, 2002b). The present episodic memory condition may rely to a greater extent on the 1st recollection stage of the model of Moscovitch (2008), reflecting fast ecphory (i.e., automatic interaction between the word cue and a corresponding memory trace) than on the second stage reflecting conscious and effortful re-experiencing. It would be interesting in future studies to develop complex semantic memory tasks that could be used as comparison for these slower and more elaborative recollection processes.

Our design could be modified easily to compare the brain regions associated with self-knowledge, and semantic and episodic memory, and to investigate the effects of time perspective, with functional Magnetic Resonance Imaging (fMRI). fMRI would also allow to assess the component process view of personal semantics (Renoult et al., 2012). That is, the 4 putative types of personal semantics (along with semantic and episodic memory themselves) may involve different weightings of such components as self-reflection, spatial and temporal processing, executive functions, emotions, and so forth. Of foremost interest regarding personal semantics, and perhaps regarding self-knowledge in particular, is the mPFC. Lesion to it impairs traits knowledge (Marquine et al., 2016), consistent with multiple fMRI studies linking this region to self-referential processing (particularly the ventral mPFC; Denny, Kober, Wager, and Ochsner, (2012); Qin et al. (2012)). The mPFC is activated when judging one's own traits, but less so when the decision is made in relation to the past and to the future than in present (e.g., D'Argembeau et al., 2010). Instead, past and future self-knowledge are associated with more activation of the right inferior parietal cortex compared to present self-knowledge (D'Argembeau et al., 2010). Brain regions associated with semantic and episodic memory would also be of key interest [e.g. medial temporal, anterior and inferior temporal, lateral parietal, retrosplenial, and several prefrontal regions (Lambon Ralph et al., 2017; Renoult et al., 2012; Spaniol et al., 2009)]. Additionally, differential activation to semantic and episodic or time perspective could help to generate hypotheses about patterns of impairment/preservation in neurological disorders.

fMRI would complement our findings with ERPs, but this does not imply that all possible questions have already been addressed with ERPs. Rather, the present study highlights ERPs' potential for studying the factors – or components – that make personal semantics appear closer to either semantic or episodic memory. We found that the frequent and classical operationalization of self-knowledge, knowledge of present traits, can be differentiated from semantic memory by the P200/N400 and the LPC. Interestingly, the LPC of present self-knowledge suggests that it is intermediate to semantic and episodic memory. Yet the simple distinction of thinking of past and future traits rather than present traits pushed the LPC to be closer to episodic memory. Some open questions would benefit from the use of ERPs, including the possible influences on the present paradigm of scene construction (Palombo et al., in press), the closeness and similarity of the "other" people being considered (Lee & Atance, 2016), and taking a first vs. a third person perspective on oneself (Grossmann & Kross, 2014). In the meantime, the ancient Greeks' invitation to "Know thyself" continues to resonate with us. The present study suggests that past, present, versus future time perspectives can influence the brain correlates of self-knowledge. Incorporating time perspective into our models may help us develop a more comprehensive understanding of personal semantics and perhaps, even more broadly, of declarative memory.

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Appendix A

The stimuli

Task	Word	Task	Word
Self-knowledge List 1	depressed	Self-knowledge List 2	soft-spoken
Self-knowledge List 1	bossy	Self-knowledge List 2	logical
Self-knowledge List 1	rash	Self-knowledge List 2	attentive
Self-knowledge List 1	irrational	Self-knowledge List 2	caring
Self-knowledge List 1	trustworthy	Self-knowledge List 2	lovable
Self-knowledge List 1	indifferent	Self-knowledge List 2	invincible
Self-knowledge List 1	flamboyant	Self-knowledge List 2	impulsive
Self-knowledge List 1	self-centered	Self-knowledge List 2	angry
Self-knowledge List 1	casual	Self-knowledge List 2	genuine
Self-knowledge List 1	easygoing	Self-knowledge List 2	terrible
Self-knowledge List 1	inquisitive	Self-knowledge List 2	joyful
Self-knowledge List 1	quick-witted	Self-knowledge List 2	resistant
Self-knowledge List 1	philosophical	Self-knowledge List 2	sluggish
Self-knowledge List 1	old-fashioned	Self-knowledge List 2	worried
Self-knowledge List 1	fashionable	Self-knowledge List 2	inefficient
Self-knowledge List 1	dishonest	Self-knowledge List 2	zestful
Self-knowledge List 1	discreet	Self-knowledge List 2	nasty
Self-knowledge List 1	driven	Self-knowledge List 2	dynamic
Self-knowledge List 1	robust	Self-knowledge List 2	blunt
Self-knowledge List 1	finicky	Self-knowledge List 2	sloppy
Self-knowledge List 1	sarcastic	Self-knowledge List 2	enterprising
Self-knowledge List 1	neat	Self-knowledge List 2	agreeable
Self-knowledge List 1	charming	Self-knowledge List 2	cultured
Self-knowledge List 1	cautious	Self-knowledge List 2	manipulative
Self-knowledge List 1	orderly	Self-knowledge List 2	alert
Self-knowledge List 1	gleeful	Self-knowledge List 2	inaccurate
Self-knowledge List 1	vigilant	Self-knowledge List 2	courteous
Self-knowledge List 1	modest	Self-knowledge List 2	spontaneous
Self-knowledge List 1	merry	Self-knowledge List 2	playful
Self-knowledge List 1	pretentious	Self-knowledge List 2	courageous
Self-knowledge List 1	vulgar	Self-knowledge List 2	oversensitive
Self-knowledge List 1	incompetent	Self-knowledge List 2	hasty
Self-knowledge List 1	demanding	Self-knowledge List 2	grim
Self-knowledge List 1	listless	Self-knowledge List 2	self-righteous
Self-knowledge List 1	anxious	Self-knowledge List 2	harsh
Self-knowledge List 1	persuasive	Self-knowledge List 2	excitable
Self-knowledge List 1	considerate	Self-knowledge List 2	jubilant

Self-knowledge List 1	neighborly	Self-knowledge List 2	candid
Self-knowledge List 1	bitter	Self-knowledge List 2	ultra-critical
Self-knowledge List 1	talkative	Self-knowledge List 2	disrespectful
Self-knowledge List 1	self-sufficient	Self-knowledge List 2	aggressive
Self-knowledge List 1	narrow-minded	Self-knowledge List 2	eccentric
Self-knowledge List 1	mathematical	Self-knowledge List 2	liar
Self-knowledge List 1	grave	Self-knowledge List 2	sympathetic
Self-knowledge List 1	suspicious	Self-knowledge List 2	rational
Self-knowledge List 1	discourteous	Self-knowledge List 2	sophisticated
Self-knowledge List 1	rebellious	Self-knowledge List 2	tense
Self-knowledge List 1	sexy	Self-knowledge List 2	brave
Self-knowledge List 1	assertive	Self-knowledge List 2	opinionated
Self-knowledge List 1	complaining	Self-knowledge List 2	brisk
Self-knowledge List 1	cynical	Self-knowledge List 2	broad-minded
Self-knowledge List 1	vengeful	Self-knowledge List 2	well-mannered
Self-knowledge List 1	regretful	Self-knowledge List 2	observant
Self-knowledge List 1	envious	Self-knowledge List 2	grateful
Self-knowledge List 1	offensive	Self-knowledge List 2	hard-hearted
Self-knowledge List 1	conceited	Self-knowledge List 2	combative
Self-knowledge List 1	subtle	Self-knowledge List 2	tidy
Self-knowledge List 1	overcritical	Self-knowledge List 2	self-conscious
Self-knowledge List 1	mediocre	Self-knowledge List 2	cheeky
Self-knowledge List 1	sentimental	Self-knowledge List 2	thoughtful
Self-knowledge List 1	self-assured	Self-knowledge List 2	reckless
Self-knowledge List 1	energetic	Self-knowledge List 2	greedy
Self-knowledge List 1	disruptive	Self-knowledge List 2	obnoxious
Self-knowledge List 1	tolerant	Self-knowledge List 2	idealistic
Self-knowledge List 1	possessive	Self-knowledge List 2	stupid
Self-knowledge List 1	violent	Self-knowledge List 2	pushy
Self-knowledge List 1	nosy	Self-knowledge List 2	mischievous
Self-knowledge List 1	humorless	Self-knowledge List 2	careless
Self-knowledge List 1	peaceful	Self-knowledge List 2	egotistical
Self-knowledge List 1	decent	Self-knowledge List 2	anguished
Self-knowledge List 1	polite	Self-knowledge List 2	smug
Self-knowledge List 1	restless	Self-knowledge List 2	dignified
Self-knowledge List 1	inconsistent	Self-knowledge List 2	bubbly
Self-knowledge List 1	fearful	Self-knowledge List 2	insolent
Self-knowledge List 1	peppy	Self-knowledge List 2	absentminded
Self-knowledge List 1	quarrelsome	Self-knowledge List 2	outspoken
Self-knowledge List 1	jealous	Self-knowledge List 2	stern

Self-knowledge List 1	industrious	Self-knowledge List 2	sad
Self-knowledge List 1	realistic	Self-knowledge List 2	quiet
Self-knowledge List 1	spirited	Self-knowledge List 2	touchy
Self-knowledge List 3	mean	Semantic Memory - Priest	amusing
Self-knowledge List 3	sneaky	Semantic Memory - Priest	informal
Self-knowledge List 3	impolite	Semantic Memory - Priest	hilarious
Self-knowledge List 3	punctual	Semantic Memory - Priest	versatile
Self-knowledge List 3	superficial	Semantic Memory - Priest	vigorous
Self-knowledge List 3	whiny	Semantic Memory - Priest	clumsy
Self-knowledge List 3	temperamental	Semantic Memory - Priest	snobbish
Self-knowledge List 3	apprehensive	Semantic Memory - Priest	immature
Self-knowledge List 3	hateful	Semantic Memory - Priest	lazy
Self-knowledge List 3	impractical	Semantic Memory - Priest	crude
Self-knowledge List 3	grouchy	Semantic Memory - Priest	overcautious
Self-knowledge List 3	prudent	Semantic Memory - Priest	solemn
Self-knowledge List 3	short-tempered	Semantic Memory - Priest	scornful
Self-knowledge List 3	comical	Semantic Memory - Priest	intolerant
Self-knowledge List 3	perceptive	Semantic Memory - Priest	meddlesome
Self-knowledge List 3	extravagant	Semantic Memory - Priest	dependable
Self-knowledge List 3	comforting	Semantic Memory - Priest	conscientious
Self-knowledge List 3	noisy	Semantic Memory - Priest	hopeful
Self-knowledge List 3	insincere	Semantic Memory - Priest	amiable
Self-knowledge List 3	wise	Semantic Memory - Priest	forgiving
Self-knowledge List 3	open-minded	Semantic Memory - Soldier	defenseless
Self-knowledge List 3	overconfident	Semantic Memory - Soldier	compulsive
Self-knowledge List 3	materialistic	Semantic Memory - Soldier	irresponsible
Self-knowledge List 3	cooperative	Semantic Memory - Soldier	helpless
Self-knowledge List 3	accurate	Semantic Memory - Soldier	weak
Self-knowledge List 3	tactless	Semantic Memory - Soldier	hot-headed
Self-knowledge List 3	cordial	Semantic Memory - Soldier	cruel
Self-knowledge List 3	resentful	Semantic Memory - Soldier	tormented
Self-knowledge List 3	troublesome	Semantic Memory - Soldier	inexperienced

Self-knowledge List 3	sensible	Semantic Memory - Soldier	cranky
Self-knowledge List 3	pompous	Semantic Memory - Soldier	giggly
Self-knowledge List 3	agitated	Semantic Memory - Soldier	entertaining
Self-knowledge List 3	loud	Semantic Memory - Soldier	loyal
Self-knowledge List 3	seductive	Semantic Memory - Soldier	studious
Self-knowledge List 3	optimistic	Semantic Memory - Soldier	inoffensive
Self-knowledge List 3	daring	Semantic Memory - Soldier	disciplined
Self-knowledge List 3	decisive	Semantic Memory - Soldier	fearless
Self-knowledge List 3	reliable	Semantic Memory - Soldier	vivacious
Self-knowledge List 3	cowardly	Semantic Memory - Soldier	responsive
Self-knowledge List 3	explosive	Semantic Memory - Soldier	level-headed
Self-knowledge List 3	hesitant	Semantic Memory - Lawyer	confused
Self-knowledge List 3	innocent	Semantic Memory - Lawyer	indecisive
Self-knowledge List 3	clownish	Semantic Memory - Lawyer	inattentive
Self-knowledge List 3	cheerful	Semantic Memory - Lawyer	dull
Self-knowledge List 3	progressive	Semantic Memory - Lawyer	hypochondriac
Self-knowledge List 3	pessimistic	Semantic Memory - Lawyer	wordy
Self-knowledge List 3	high-spirited	Semantic Memory - Lawyer	boastful
Self-knowledge List 3	sparkling	Semantic Memory - Lawyer	hostile
Self-knowledge List 3	cool-headed	Semantic Memory - Lawyer	deceitful
Self-knowledge List 3	likable	Semantic Memory - Lawyer	malicious
Self-knowledge List 3	contented	Semantic Memory - Lawyer	humble
Self-knowledge List 3	ethical	Semantic Memory - Lawyer	generous

Self-knowledge List 3	naive	Semantic Memory - Lawyer	truthful
Self-knowledge List 3	crafty	Semantic Memory - Lawyer	daydreamer
Self-knowledge List 3	pleasant	Semantic Memory - Lawyer	tactful
Self-knowledge List 3	congenial	Semantic Memory - Lawyer	ambitious
Self-knowledge List 3	opportunist	Semantic Memory - Lawyer	witty
Self-knowledge List 3	thrifty	Semantic Memory - Lawyer	intelligent
Self-knowledge List 3	affectionate	Semantic Memory - Lawyer	theatrical
Self-knowledge List 3	rude	Semantic Memory - Lawyer	bold
Self-knowledge List 3	tiresome	Semantic Memory - Scientist	foolish
Self-knowledge List 3	mellow	Semantic Memory - Scientist	negligent
Self-knowledge List 3	strict	Semantic Memory - Scientist	gullible
Self-knowledge List 3	ingenious	Semantic Memory - Scientist	frantic
Self-knowledge List 3	submissive	Semantic Memory - Scientist	tearful
Self-knowledge List 3	hot-tempered	Semantic Memory - Scientist	downcast
Self-knowledge List 3	efficient	Semantic Memory - Scientist	wasteful
Self-knowledge List 3	timid	Semantic Memory - Scientist	thoughtless
Self-knowledge List 3	outgoing	Semantic Memory - Scientist	bleak
Self-knowledge List 3	obstinate	Semantic Memory - Scientist	antisocial
Self-knowledge List 3	exuberant	Semantic Memory - Scientist	frisky
Self-knowledge List 3	artistic	Semantic Memory - Scientist	fortunate
Self-knowledge List 3	critical	Semantic Memory - Scientist	sociable
Self-knowledge List 3	neurotic	Semantic Memory - Scientist	expressive
Self-knowledge List 3	vain	Semantic Memory - Scientist	humorous

Self-knowledge List 3	moody	Semantic Memory - Scientist	inventive
Self-knowledge List 3	soft-hearted	Semantic Memory - Scientist	competent
Self-knowledge List 3	argumentative	Semantic Memory - Scientist	meticulous
Self-knowledge List 3	disobedient	Semantic Memory - Scientist	persistent
Self-knowledge List 3	imaginative	Semantic Memory - Scientist	precise
Episodic Memory - New	coercive	Episodic Memory - Old	depressed
Episodic Memory - New	foolhardy	Episodic Memory - Old	bossy
Episodic Memory - New	frivolous	Episodic Memory - Old	rash
Episodic Memory - New	defiant	Episodic Memory - Old	irrational
Episodic Memory - New	deceptive	Episodic Memory - Old	indifferent
Episodic Memory - New	stingy	Episodic Memory - Old	self-centered
Episodic Memory - New	radical	Episodic Memory - Old	old-fashioned
Episodic Memory - New	spiteful	Episodic Memory - Old	dishonest
Episodic Memory - New	overbearing	Episodic Memory - Old	finicky
Episodic Memory - New	fidgety	Episodic Memory - Old	sarcastic
Episodic Memory - New	fault-finding	Episodic Memory - Old	flamboyant
Episodic Memory - New	fussy	Episodic Memory - Old	casual
Episodic Memory - New	gloomy	Episodic Memory - Old	easygoing
Episodic Memory - New	preoccupied	Episodic Memory - Old	inquisitive
Episodic Memory - New	distrustful	Episodic Memory - Old	quick-witted
Episodic Memory - New	insecure	Episodic Memory - Old	philosophical
Episodic Memory - New	shallow	Episodic Memory - Old	fashionable
Episodic Memory - New	disagreeable	Episodic Memory - Old	discreet
Episodic Memory - New	dissatisfied	Episodic Memory - Old	driven
Episodic Memory - New	uptight	Episodic Memory - Old	robust
Episodic Memory - New	skeptical	Episodic Memory - Old	impulsive
Episodic Memory - New	crabby	Episodic Memory - Old	stern
Episodic Memory - New	desperate	Episodic Memory - Old	angry
Episodic Memory - New	hyperactive	Episodic Memory - Old	terrible
Episodic Memory - New	withdrawn	Episodic Memory - Old	touchy
Episodic Memory - New	arrogant	Episodic Memory - Old	resistant
Episodic Memory - New	gossipy	Episodic Memory - Old	sluggish
Episodic Memory - New	irritable	Episodic Memory - Old	worried
Episodic Memory - New	cold	Episodic Memory - Old	nasty
Episodic Memory - New	messy	Episodic Memory - Old	enterprising
Episodic Memory - New	selfish	Episodic Memory - Old	agreeable

Episodic Memory - New	threatening	Episodic Memory - Old	attentive
Episodic Memory - New	boring	Episodic Memory - Old	caring
Episodic Memory - New	impatient	Episodic Memory - Old	lovable
Episodic Memory - New	nervous	Episodic Memory - Old	invincible
Episodic Memory - New	forgetful	Episodic Memory - Old	genuine
Episodic Memory - New	jovial	Episodic Memory - Old	joyful
Episodic Memory - New	prosocial	Episodic Memory - Old	zestful
Episodic Memory - New	methodical	Episodic Memory - Old	dynamic
Episodic Memory - New	upright	Episodic Memory - Old	careless
Episodic Memory - New	diligent	Episodic Memory - Old	whiny
Episodic Memory - New	maternal	Episodic Memory - Old	temperamental
Episodic Memory - New	ecstatic	Episodic Memory - Old	apprehensive
Episodic Memory - New	cunning	Episodic Memory - Old	hateful
Episodic Memory - New	refined	Episodic Memory - Old	impractical
Episodic Memory - New	righteous	Episodic Memory - Old	grouchy
Episodic Memory - New	moderate	Episodic Memory - Old	short-tempered
Episodic Memory - New	sharp-witted	Episodic Memory - Old	noisy
Episodic Memory - New	glowing	Episodic Memory - Old	insincere
Episodic Memory - New	resourceful	Episodic Memory - Old	overconfident
Episodic Memory - New	perfectionist	Episodic Memory - Old	cordial
Episodic Memory - New	heroic	Episodic Memory - Old	prudent
Episodic Memory - New	constructive	Episodic Memory - Old	comical
Episodic Memory - New	prompt	Episodic Memory - Old	perceptive
Episodic Memory - New	glorious	Episodic Memory - Old	extravagant
Episodic Memory - New	carefree	Episodic Memory - Old	comforting
Episodic Memory - New	inspired	Episodic Memory - Old	wise
Episodic Memory - New	gifted	Episodic Memory - Old	open-minded
Episodic Memory - New	outstanding	Episodic Memory - Old	cooperative
Episodic Memory - New	tender	Episodic Memory - Old	accurate
Episodic Memory - New	calm	Episodic Memory - Old	foolish
Episodic Memory - New	obedient	Episodic Memory - Old	hot-headed
Episodic Memory - New	respectful	Episodic Memory - Old	confused
Episodic Memory - New	gentle	Episodic Memory - Old	cruel
Episodic Memory - New	protective	Episodic Memory - Old	downcast
Episodic Memory - New	passionate	Episodic Memory - Old	negligent
Episodic Memory - New	lively	Episodic Memory - Old	tormented
Episodic Memory - New	supportive	Episodic Memory - Old	defenseless
Episodic Memory - New	talented	Episodic Memory - Old	clumsy
Episodic Memory - New	sincere	Episodic Memory - Old	inexperienced
Episodic Memory - New	lucky	Episodic Memory - Old	entertaining

Episodic Memory - New	adventurous	Episodic Memory - Old	humble
Episodic Memory - New	confident	Episodic Memory - Old	frisky
Episodic Memory - New	helpful	Episodic Memory - Old	inventive
Episodic Memory - New	belligerent	Episodic Memory - Old	witty
Episodic Memory - New	stubborn	Episodic Memory - Old	fortunate
Episodic Memory - New	exceptional	Episodic Memory - Old	dependable
Episodic Memory - New	romantic	Episodic Memory - Old	disciplined
Episodic Memory - New	ill-tempered	Episodic Memory - Old	sociable
Episodic Memory - New	hopeless	Episodic Memory - Old	competent