The Capacity of Self-Relevant Long-Term Memories

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Abstract (140 words)

What we know as the self is not just one unified construct, but consists of various self-concepts that are continuously created, revised, and discarded, such as “woman”, “Thai national”, “Northwestern student”, and “true self”. These rich, variegated self-concepts help organize our endeavors throughout the different domains of our lives. How do we store information associated with each of these self-concepts without confusing them in long-term memory? We uncover two mechanisms that support this ability— one that arises from the nature of long-term memory processing, and the other that arises from the nature of self-referential processing. Specifically, people are less likely to confuse memories for self-concepts that are more *distinct*, and they are more likely to remember information for the self than for others. Together, the studies shed light on the mechanisms that support our impressively rich store of self knowledge.

Keywords: self-relevance, self-representation, self-concepts, capacity limits; long-term memory; self-reference

What we know as ourselves is not just tied to one unified construct, but to various self-concepts that are continuously created, revised, and discarded, such as “woman”, “Thai national”, “Northwestern student”, and “true self” (De Freitas, Sarkissian, et al., 2018; Markus & Nurius, 1986; McConnell, 2011; Oyserman & James, 2011). These rich, variegated self-concepts help organize our endeavors. For instance, we remember that we met our old friend at the Thai festival, and that we bought a hamburger at the food cart at Northwestern university. How is information related to our different self-concepts organized in long-term memory without becoming confused, e.g., thinking that we bought the hamburger at the Thai festival? Here we explore two factors that support this organization— one specific to how long-term memory works, and one specific to how self-referential processing works.

Better Memory for Distinct Self-Concepts?

Outside of research on self-relevant memory, a general characteristic of long-term memory is that memories which are more distinct are less confusable (Hunt & Worthen, 2006). As an example, people are more accurate at remembering multiple images that span different categories, like cars and cups, than multiple images that fall within the same category, e.g., different types of cars (Konkle, Brady, Alvarez, & Oliva, 2010). How might this distinctiveness effect come into play when we have to remember information about multiple self-concepts? One possibility is that we are better at remembering information about self-concepts that are conceptually distinct (e.g., your selves at 20 and at 60 years of age) than conceptually similar (your selves at 20 and at 22). We refer to this as the *Self-Distinctiveness Hypothesis*, although we note that such an effect would not be due to anything special about the self-relevant nature of the memories per se, but to their conceptual distinctiveness.

Better memory for the self(ves) than others?

Within research on the self, a robust characteristic of self-relevant processing is that we are more accurate at categorizing or remembering information associated with the self than with others

(Rogers, Kuiper, & Kirker, 1977). In the case of long-term memory, these studies have asked people to associate items with their current selves versus others (Cunningham, Turk, Macdonald, & Macrae, 2008; DeScioli, Rosa, & Gutchess, 2015). How might this standard self-reference benefit come into play when we have to remember information for multiple self-concepts? One possibility is that the benefit grows as the number of self-concepts grows. On this view, if we have to remember information associated with multiple agents, then the more of those agents that are self-relevant, the more accurate our long-term memories about them are. For instance, if we have to remember information relevant to our younger self, older self, and a stranger, then we perform better than if we have to remember information relevant to just our younger self and two strangers. We will refer to this as the *Multiple Self-Allocation* hypothesis, since it claims that multiple self-representations can be allocated toward separately representing each respective self-concept, yielding corresponding self-reference effects for each of the concepts.

An alternative view is that the self-reference effect relies on a limited self-representation that can only confer benefits to one self-concept at a time. On this view people should perform similarly for two self-concepts versus one. When they have to remember information associated with two self-concepts, they only have one self-representation to work with, and so they can only exhibit a self-reference effect for one of the self-concepts at a time. Alternatively, this single self-representation might serially switch between representing the different self-concepts, conferring some amount of self-reference benefit to each concept, but not as much as when it is exclusively allocated to just one self-concept. We refer to this as *Single Self-Allocation* hypothesis, since it suggests that there is a single self-representation that can be allocated to only one self-concept at a time.

The Present Studies

The current studies test whether remembering multiple self-relevant memories is facilitated by conceptual distinctiveness and/or multiple self-allocation. Testing the Multiple Self-Allocation

hypothesis, Experiments 1-3 ask whether the self-reference effect in long-term memory grows as the number of remembered self-concepts does. Testing the Self-Distinctiveness hypothesis, Experiments 4-6 explore whether people remember more information associated with self-concepts that are conceptually distinct.

General Procedure across Experiments 1-5

Participants. Participants were recruited from the online crowdsourcing platform, Amazon's Mechanical Turk, to take part in a 10-minute study for \$1.00 compensation. A database kept track of their Turk Ids, to ensure that no participant took part in more than one of the experiments. All studies were approved by the Harvard Internal Review Board. The participant sample size for these experiments was determined by a pilot study which found that one hundred participants per condition provides sufficient power to detect a standard self-reference effect using the long-term memory paradigm we developed for the experiments. Specifically, we found that participants accurately remembered more information for their present self than for an imagined friend or stranger.

Participant exclusions. At the beginning of all experiments, participants answered an attention check (*How many fatal heart attacks have you had?*), and at the end they answered two comprehension questions about the background story used in the paradigm (*What did the images represent? A. Items seen on a trip, B. Items won at a supermarket, C. Items thrown away*) and the particular agents that they were asked to imagine (e.g., *Who were you asked to imagine? A. Future-you1, an enemy named Bob, and a foreigner named Tom, B. Future-you1, a stranger named John, and a stranger named Bill, C. Future-you1, future-you2, and a stranger named John.*; the particular options were modified based on the experiment). In Experiment 4b, participants also answered a comprehension question about a specific distinctiveness manipulation concerning the relative ages of the self-concepts (*How much*

younger was young you? A. 1 month, B. 2 months, C. 3 months, D. 1 year, E. 2 years, F. I don't remember).

Finally, participants answered basic demographics questions: age, gender, native language, and level of science and philosophy education.

Across experiments, we excluded participants for incorrectly answering any of the attention or comprehension checks. We also excluded those who scored lower than 50% accuracy overall (30% = chance), or who reacted quicker than 100ms for more than 50% of trials. These stringent performance-based checks meant that sometimes we excluded more participants than is typical of self-report studies, which only use attention and comprehension checks. But we stuck with these planned exclusions in order to ensure the highest data quality.

Procedure. All experiments included three conditions, each of which featured three agents. The Self #1 condition asked participants to imagine one particular self-concept and two strangers (a stranger named John and another named Bill), the Self #2 condition asked participants to imagine another particular self-concept and the same two strangers, and the Two Selves condition asked participants to imagine both of the self-concepts featured in the Self #1 and Self #2 conditions, in addition to one of the strangers (John).

As illustrated in Figure 1, participants were asked to imagine that all three agents were at a supermarket. To probe long-term memory, we created a modified version of the paradigm from DeScioli et al. (2015). Participants were asked to imagine that each of the agents won several shopping items. After this, we serially showed an image of each shopping item (e.g., an apple, or a bagel) together with the name of the agent who won it (e.g., young-you, old-you, or stranger-john) and asked, *Do you think the person who won the object likes it? Yes, no, or maybe?* We expected that this question would lead participants to consult knowledge specific to the self-concept. After they judged all 30 items, participants were given a surprise recall test, in which they were shown the items in a

newly randomized order and asked to recall who won each one, by pressing one of three keys (Figure 1).

The paradigm included 3 sets of 10 images, with each set of 10 assigned to one of the three agents. This made for six unique set-agent assignments for each of the three self conditions, yielding 18 unique combinations total. These combinations were counterbalanced between-subjects, with the order of images randomized within-subjects. All stimuli were created using a combination of Javascript, html, and css.

1. Instructions

Imagine that the younger you 20 years ago is in a particular isle of a supermarket, searching for something. We will refer to this past version of yourself as **young-you**.

Now imagine the older you 20 years from now is in the same isle of the supermarket, searching for something. We will refer to this future version of yourself as **old-you**.

Now imagine that, when in the supermarket, **young-you**, **old-you** and a **stranger named John** each win some shopping items.

You will be shown who wins each item, and asked whether you think the person likes it.

2. Encoding

*Do you think the person who wins the object likes it?
Please select YES, NO, or MAYBE below,
then hit 'enter' to proceed.*

old-you

- ☐ Yes
- ☐ No
- ☐ Maybe

3. Surprise recall

*Who won this object?
Press 'q' for young-you, 'w' for old-you,
and 'e' for stranger-john*

Figure 1. Task structure of the long-term memory paradigm, using the specific self-concepts from Experiment 2 as an example.

Experiments 1-3: Testing the Multiple Self-Allocation Hypothesis

Experiments 1-3 tested whether participants perform better overall when they have to store information for two self-concepts (Two Selves condition) than for either of the self-concepts presented in isolation (the Self #1 and Self #2 conditions). If participants consistently perform better in the Two Selves condition, then this supports the Multiple Self-Allocation hypothesis, in which long-term memory for multiple self-concepts is facilitated by a self-reference effect that grows as the number of selves grows. A secondary aim was to test whether the standard self-reference effect would occur *at all* for these imagined self-concepts when presented in isolation (in the Self #1 and Self #2 conditions), since previous work has only investigated self-reference effects in memory for the present self. We tested these questions for multiple self-concepts, including alternative selves (Experiment 1), past and future selves (Experiment 2), and true and surface selves (Experiment 3). Below we summarize the main differences between Experiments 1-3, together with the number of participants recruited in each.

Methods, Experiments 1-3

Experiment 1: Alternative Selves. We recruited 298 participants (~100 per self condition), and excluded 133 for failing any of the strict attention, comprehension, and performance checks, yielding a final sample of 165 participants ($M_{\text{age}} = 35$, 44% female).

The Self #1 condition asked participants to imagine one future self (*Imagine an activity that you could do in 2 hours from now*, labeled as *future-you1*) and two strangers (a stranger named John and a stranger named Bill, labeled *stranger-john* and *stranger-bill*). The Self #2 condition asked participants to imagine two self-concepts (*...now imagine a different activity that you could do instead in 2 hours from now*, labeled *future-you2*), but to only imagine that the second self was in the supermarket with the two strangers; Future-you1 played no role in the rest of the procedure. Finally, the Two Selves condition asked participants to imagine future-you1, future-you2, and stranger-john

Experiment 2: Past and Future Selves. We recruited 300 participants, and excluded 112 for failing any of the checks, yielding a final sample of 188 participants ($M_{\text{age}} = 37$, 51% female). The procedure was the same as in Experiment 1, except that we contrasted the past self (*the younger you 20 years ago*) and future self (*the older you 20 years from now*).

Experiment 3: True and Surface Selves. We recruited 301 participants, and excluded 117 for failing any checks, yielding a final sample of 184 participants ($M_{\text{age}} = 37$, 60% female). We contrasted the true self (*who you truly are deep down*) and surface self (*those things that you picked up from society rather than who you truly are deep down*).

Results, Experiments 1-3

Across experiments, we generally found self-reference effects in the Self #1 and Self #2 conditions: participants performed better for the single self-concept than for the two strangers (Figure 2). We also generally found indistinguishable performance between the two self-concepts in the Two Selves condition. The only exception was Experiment 3, in which participants performed better for the true self than the surface self. Perhaps they identified preferentially with the true self, given its positive valence and higher known importance in folk intuitions of personal identity (De Freitas, Cikara, Grossmann, & Schlegel, 2017, 2018). These results confirm that standard self-reference effects do occur for these imagined self-concepts when presented in isolation.

But did participants perform better overall in the Two Selves condition than in the Self #1 and Self #2 conditions, in line with the Multiple Self-Allocation view? To test this question, we summed performance across each of the three agents, comparing this overall performance level between the Two Selves condition and each of the Self #1 and Self #2 conditions (see the gray bars of Figure 2). In all but one of the experiments, participants performed no better overall for two selves than for one. Therefore, insofar as the self-reference effect is meant to arise from simply

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associating an item with the self, the majority of experiments indicated that increasing the number of selves did not by itself amplify the effect into a *selves*-reference effect, contra the Multiple Self-Allocation hypothesis. Rather, the studies provided more evidence for the Single Self-Allocation hypothesis, which says that there is a single self-representation that can only represent one self-concept at a time, conferring a self-reference benefit that is limited to that concept.

Figure 2. Performance on the long-term memory tasks in Experiments 1-3. The gray bars represent summed performance across each of the agent categories for the Self #1, Self #2, and Two Selves conditions, from left to right. Error bars depict standard error of the mean. *ns* = not-significant, $\dagger < .10$, $* p < .05$, $** p < .01$, $*** p < .001$.

Experiments 4-5: Effects of Self-distinctiveness

Next, we explored the exception that we found for Experiment 2, in which participants *did* perform better when they associated images with both their younger and older selves, rather than with just their younger or older self. One possibility is that, of all the self-concepts that participants were asked to imagine in the previous experiments, the younger and older selves were the most *distinct* pair. Since previous work on long-term memory finds that people are better at remembering items that are conceptually distinct, perhaps associating items with distinct selves similarly provides distinct encoding contexts that prevents confusion of these self-relevant memories. Thus, Experiments 4-5 tested the potential role of self-distinctiveness, by deliberately manipulating the extent to which a pair of self-concepts was distinct.

We took two different approaches to this question. Experiments 4a-4b tested whether we can *eliminate* the benefit we saw in Experiment 2 by making the same younger and older selves *less* distinct, whereas Experiments 5a-5b tested whether we can *create* a benefit for an experiment that did not previously show one (Experiment 1), by making the self-concepts *more* distinct. We summarize the details of these experiments below, together with the number of participants recruited in each.

Methods, Experiments 4-5

Experiment 4: Similar (E4a) and Distinct (E4b) Past & Future Selves. Experiment 4a recruited 298 participants, and excluded 86 for failing any of the checks, yielding a final sample of

212 participants ($M_{\text{age}} = 35$, 53% female), whereas Experiment 4b recruited 296 participants, and excluded 81 for failing any of the checks, yielding a final sample of 215 participants ($M_{\text{age}} = 36$, 49% female).

Experiments 4a-b held the type of self-concepts constant (young vs. old), while manipulating whether they were similar (one month younger or older than one's current self; Experiment 4a) or distinct (18 year old and 60 year old; Experiment 4b). The aim of these experiments was to test whether making the self-concepts used in Experiment 2 less distinct *eliminates* the unexpected performance benefit that we found in that experiment. Experiments 4a-b used a completely new set of images, to ensure that the original effects generalize across various images.

Experiment 5: Similar (E5a) and Distinct (E5b) Alternative Selves. Experiment 5a recruited 298 participants, and excluded 117 for failing any of the checks, yielding a final sample of 181 participants ($M_{\text{age}} = 35$, 43% female), whereas Experiment 5b recruited 303 participants, and excluded 121 for failing any of the checks, yielding a final sample of 182 participants ($M_{\text{age}} = 34$, 55% female).

Experiments 5a-b took the opposite approach to Experiments 4a-b, testing whether we could *create* a performance benefit for an earlier experiment that did not find one. To test this, we returned to the task of imagining two possible versions of oneself in the future (Experiment 1). It is reasonable to assume that participants imagined these self-concepts as being very similar, since they were merely meant to be two different activities that the participant could be doing in 2 hours. Experiment 5a used these same instructions to keep the selves similar (i.e., it was a direct replication of Experiment 1), whereas Experiment 5b made the self-concepts more distinct by asking people to imagine one self as healthy-minded (*imagine a time in your life in which you have been very health conscious, wanting to eat only healthy foods*) and the other as unhealthy-minded (*Now imagine a time in your life in which*

you have been much less health conscious, eating whatever you want). Although this manipulation varies several factors other than just distinctiveness, our main goal was to make the selves as distinct as possible. Experiments 5a-b used another fresh set of images.

Results, Experiments 4-5

In both the similar and distinct experiments, participants exhibited self-reference effects for the Self #1 and Self #2 conditions (Figure 3, first two columns). They also generally exhibited indistinguishable performance between the two selves in the Two Selves condition (Figure 3, third column). The one exception was Experiment 5b, in which they performed better for healthy-you than unhealthy-you. Perhaps they preferentially identified with healthy-you because of its positive valence.

But did the manipulations of self-distinctiveness affect overall performance levels in the Two Selves condition versus the Self #1 and Self #2 conditions? Experiments 4a-b found that when the self-concepts were similar (E4a) participants performed better overall for Two Selves than Self #2, but no better for Two Selves than Self #1. Yet when the selves were distinct (E4b), they performed much better for Two Selves than for both Self #1 and Self #2 (Figure 3, right-most column), consistent with the self-distinctiveness hypothesis and with the results of Experiment 2. Experiment 5a-b found that when the self-concepts were similar, participants showed no evidence of performing better for Two Selves than either of the single self conditions (if anything, they performed *better* for Self #1 than Two Selves). When the selves were distinct, however, they performed better overall for Two Selves than for Self #1 but not for Self #2, although this second difference was still in the predicted direction. These results are again largely consistent with the self-distinctiveness hypothesis. Further, the fact that participants tended to only perform better for Two Selves than one self when the self-concepts were distinct underscores our earlier results showing that the self-reference effect

does not grow as the number of self-concepts does— if it did, we would have seen a performance benefit for Two Selves in all experiments, not just some of them.

Figure 3. Performance on the long-term memory tasks in Experiments 4-5. The gray bars represent summed performance across each of the agent categories for the Self #1, Self #2, and Two Selves conditions, from left to right. Error bars depict standard error of the mean. *ns* = not-significant, † < .01, * $p < .05$, ** $p < .01$, *** $p < .001$.

Experiments 6: The Role of Self Distinctiveness Across Experiments

In order to get a better handle on the extent to which self-distinctiveness affects memory performance, we determined how distinct the different self-concepts seemed to participants, then tested whether these impressions predicted performance for two selves vs. one self across all the experiments. To do this, we ran a separate norming study in which participants provided distinctiveness ratings for each pair of selves across the experiments, presented in a randomized order. We then correlated these ratings with the performance differences for Two Selves vs. the single selves across experiments.

Participants

To determine the perceived distinctiveness of the different self-concepts, we recruited 99 participants in a norming study, excluding 17 for failing the attention check at the beginning of the experiment or either of two comprehension questions at the end of the experiment (*1. According to the questions, you were asked to imagine different versions of...A. Others, B. You, C. Objects, D. Kites; For each question, how many versions did you compare? A. Zero, B. One, C. Two, D. Three, E. Four*), yielding a final sample of 82 ($M_{\text{age}} = 35$, 50% female).

Methods

Participants were asked to provide distinctiveness ratings for each pair of selves across the experiments, as well as for a few more self-concepts that we were testing in a parallel project, all presented in a randomized order to each participant. Specifically, participants were told that *Each*

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question below asks you to imagine two versions of yourself. For each question, please rate the extent to which you think the two versions of yourself are only a little different or extremely different. They then rated the distinctiveness of 7 items on a scale ranging from 1 (A little different) to 9 (Extremely different):

- Two versions of you in the past and future: The younger you 20 years ago and the older you 20 years from now.*
- Two versions of you in the past and future: Your younger self 1 month ago, and your older self 1 month in the future.*
- Two versions of you: A time in your life in which you have been very health conscious, wanting to eat only healthy foods, and a time in your life in which you have been much less health conscious, eating whatever you want.*
- Two possible versions of you 2 hours in the future: one searching for something in a particular isle of a supermarket, and another searching for something in a different isle of the supermarket.*
- Two versions of you: Your true self (who you are deep down) and your surface self (those things that you picked up from society, rather than who you truly are deep down).*
- Two versions of you in a hypothetical future where it is possible to create perfect copies of people: The original you and an identical copy of you.*
- Two versions of you in the past and future: Your 18-year old self and 60-year old self.*

Results

We averaged these ratings across participants for each item, and correlated them with the average performance difference between the Two Selves condition and each of the single self conditions. Since each of Experiments 1-5 included two conditions featuring a single self (Self #1 and Self #2), our measure of performance was the average of the differences between the Two Selves condition and each of the Self #1 and Self #2 conditions, i.e., $((\text{Two Selves} - \text{Self \#1}) + (\text{Two Selves} - \text{Self \#2}))/2$.

We found that self-distinctiveness significantly predicted the performance differences across experiments: the more distinct the selves were, the more information people remembered in the Two Selves versus single self conditions ($r = 0.86, p = .006$; Figure 4). Note that since both Experiments 2 and 5a asked people to imagine future selves in 2 hours from now, the norming study only asked people to rate the distinctiveness of these selves once, although we plot the rating twice in order to correlate it with the performance levels in each of Experiments 2 and 5a.

Fig. 4. The performance difference for two selves versus one across all long-term memory experiments, plotted as a function of the rated distinctiveness of the two selves used in each experiment. The color gradient of the of plotted points characterizes the correlation by plotting the first principal component of the two correlated variables.

General Discussion

Every day we juggle information about the various self-concepts associated with the different domains of our life. How are memories related to these self-concepts organized in long-term memory without becoming confused with one another? Across eight experiments, we found that this ubiquitous ability is supported by mechanisms from both long-term memory and self-referential processing. Specifically, we found a self-distinctiveness effect, whereby people were more accurate at remembering information for multiple self-concepts that were conceptually distinct, and a self-reference effect, whereby people were more accurate at remembering information for a self-concept than a stranger. As a caveat, the self-reference effect did not grow as the number of to-be-remembered self-concepts grew, suggesting that there is an upper limit on how many self-concepts can benefit from the self-reference effect at once.

These findings reveal that self-relevant long-term memories are both limited and flexible. They are limited because the self-reference benefit only occurs for one self-concept at a time. Perhaps this is because only one self-concept can be represented as *the* self at a time, resulting in a benefit that is limited to the particular self-concept that is being represented as the self. This view is consistent with work showing that self-reference effects are supported by an extensive neural network dedicated to self-relevance (Sui, Rotshtein, & Humphreys, 2013); perhaps the costs of replicating this network are too great. Self-memories are flexible because long-term memory continues to improve so long as the self-concepts it is storing are sufficiently distinct from each

other. Perhaps this effect occurs because distinct self-concepts occupy more spaced-out positions within a high dimensional feature representation within long-term memory. Notably, this distinctiveness effect is not specific to self-referential processing per se, but is known to be a general property of long-term memory. The distinction between these limited and flexible factors might also correspond to the everyday distinction between feeling that we are only ever one self at a time, while having a rich store of experiences associated with each of the self-concepts that we ‘switch out’. Luckily for us, even when a particular self-concept is not being actively represented as the self, both its self-referential and conceptual structure facilitate our ability to remember it the next time we need it.

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