QUIRKY SENSATIONS OF MEMORY

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MEMORY UNDER THE SEA (SUBJECTIVE EXPERIENCE OF AGENCY)

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Since the cognitive revolution, computer models of cognition have guided research into the workings of the human mind (Bower, 2000). We view memory, for instance, as a dynamic store of information. Encoding processes allow our minds to save and consolidate new information, and retrieval processes let us access and use existing knowledge (Schwartz, 2018). Those ideas have proved fruitful, setting the foundation for advancements in our understanding of memory.

However, certain human memory phenomena are difficult to explain if we restrict ourselves to the mind-as-machine perspective. Humans, after all, experience emotions, engage in spontaneous creative acts, and, most importantly, possess self-awareness. We have bodies, feel pain, and we make conscious choices that influence the course of our lives and events in the world. On occasion, we also experience odd yet readily identifiable states, such as the déjà vu state (Brown, 2004; Cleary & Claxton, 2018; Wells, O'Connor, & Moulin, 2018), the tip-of-the-tongue (TOT) state (Cleary, 2019; Schwartz, 2006; Schwartz & Metcalfe, 2011), the jamais vu state, and the feeling state associated with insight (Danek & Wiley, 2017; Hedne, Norman, & Metcalfe, 2016). Computers experience none of these things. The influence of such specifically human "quirky" feeling states on the goodness of our memory is difficult to model and understand if researchers restrict themselves to the computer metaphor.

Research suggests that some of these states are associated with enhanced memory. The TOT phenomenon, for example, occurs when a person feels highly confident they can recall fully a piece of information yet cannot do so. It seems to be more than just a feeling of high confidence (Schwartz, 2006). The feeling state associated with TOTs in response to general information questions is associated with enhanced processing and improved recall (Bloom, Friedman, Xu, Vuorre, & Metcalfe, 2018). Such findings raise the question as to whether other human feeling states relate to memory.

One such state is the subjective experience of agency (SEA). Bandura defined agency as the ability to "intentionally make things happen by one's actions" (Bandura, 2001). Research shows that people interpret cues to determine when they are and when they are not agents (Metcalfe, 2013), and that interpretation can result in a metacognitive judgment. Those judgments are associated with feeling states that correspond to the degree of felt control.

Researchers can manipulate SEAs in experimental settings using a variety of tasks. We break down agency into three elements, each of which can be targeted during SEA manipulation: 1) *action choice*—the ability to decide to take productive action rather than remain passive; 2) *action fluency*—the ability to execute actions smoothly and successfully; and 3) *action effectiveness*—the ability to have actions cause effects.

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To illustrate, imagine you are driving a car and you approach a stop sign. You choose to stop the car rather than sit passively and roll through the intersection. The decision to act demonstrates action choice. Once you decide to stop, you step on the brake pedal to carry out your intended action. Your ability to depress the pedal smoothly, without interference from either physical impairments (e.g., paralysis, muscle cramps) or environmental impediments (e.g., stuck pedal), demonstrates action fluency. Finally, your ability to bring the car to a complete stop reveals your action effectiveness; your actions led to the intended effect.

Human beings almost always possess action choice. In most situations, most people can choose whether to take action or remain passive. No matter how hard we may try, however, we are not omnipotent. External factors and forces influence fluency and effectiveness. The effects of these factors and forces determine whether people feel largely in control or out of control while taking action, and we can characterize those feeling states as SEAs. That experience encapsulates a unique internal state that has consequences for human behavior and is thus worth empirical inquiry.

This chapter begins to address two broad question related to that inquiry: What is the nature of SEAs? And how do SEAs affect memory? Our working hypothesis is that the SEA represents a distinct, meaningful internal feeling state. We introduce evidence suggesting that people generally like high SEAs and prefer them to out-of-control situations. Then we review findings showing that SEAs impact memory, and in particular, that merely being the agent is sufficient to enhance memory performance. We discuss how firmly established effects in the memory literature (e.g., generation, testing, enactment) can be viewed through a SEA framework. Finally, we present preliminary evidence suggesting that the effects on memory may be quite nuanced, they may depend on the nature of to-be-remembered information, and that perhaps the more impactful state is in fact the state of feeling out of control, or having a low SEA.

Nature of SEAs

To better understand the nature of SEAs, recall a moment in your life when you felt firmly in control. Consider how you felt. If you are like most people, you probably associate feeling in control with positive feelings (Leotti & Delgado, 2011). Maybe you felt more secure or content or like everything was proceeding according to plan. You may have felt calm, confident, or self-assured, or able to breathe more easily.

Now, bring to mind a time when you felt out of control. Consider that experience and how it contrasts with the in-control experience. When out of control, you likely felt stressed and anxious. Your mind may have started to focus on actions that could prevent you from spiraling further out of control. Or perhaps you started to see the world differently, in a way that may have helped restore your sense of control (Kay, Whitson, Gaucher, & Galinsky, 2009). This thought experiment illustrates that SEAs have distinct flavors to them. Certain emotions and feelings arise when we feel firmly in control and others come up when we feel hopelessly out of control. And the consequences of these states may be adaptive such that they focus our minds toward information relevant to survival.

Evidence that people generally like high SEAs (i.e., feeling in control) exists in a variety of forms. For example, when selecting among actions associated with different levels of contingency, people tend to choose high-contingency actions (Karsh & Eitam, 2015). In this context, contingency refers to the probability that an effect causes an action. Karsh and Eitam (2015) programmed a computer to display a red circle that would change color and disappear (effect) after a participant pressed a key (action). Probability of effect occurrence depended on the specific key pressed. They found that participants were more likely to press

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the key associated with the highest probability of causing the effect than the key associated with no effect. That indicates that in certain circumstances, people prefer experiences with high action effectiveness to low action effectiveness.

Evidence that people like SEAs has also emerged from studies using dynamic, motor control paradigms. Such tasks allow researchers to manipulate action fluency and action effectiveness in experimental inquiry of SEAs. Bucknoff and Metcalfe (2015) asked participants to choose between two versions of a videogame-like task (e.g., Metcalfe & Greene, 2007), each associated with different SEAs. In the task, people use a computer mouse to move an on-screen cursor across the bottom of a screen. Xs and Os scroll down the screen, and the objective is to maneuver the cursor to hit Xs and avoid Os. When an X is successfully hit, the player receives visual and auditory performance feedback in the form of the X "popping" and disappearing from the screen.

The task allowed us to manipulate SEAs and ask participants which version of the task they preferred to perform—a version associated with a low SEA or one associated with a high SEA. To create a low-SEA version of the task, we manipulated action fluency by introducing random interference into the cursor behavior such that it failed to respond reliably to mouse movements. The high-SEA task was the standard task with one crucial adjustment. Because SEAs correlate with performance (Metcalfe, Eich, & Castel, 2010; Metcalfe & Greene, 2007), and because we wanted to isolate the effect of the SEA on task preference, we manipulated action effectiveness in the high SEA task to dissociate SEAs and performance. We allowed only 50% of struck Xs to exhibit expected auditory and visual performance feedback. That is, each X struck by the player's cursor had a 50% chance of responding with the expected feedback and a 50% chance of falling through to the bottom of the screen as if nothing happened. Such manipulations permitted participants to choose between a high-SEA and a low-SEA task that were roughly equal in the amount of positive performance feedback received. In each trial, participants performed two versions of the task, made judgments about their SEAs, and indicated which version they would like to perform again. Participants overwhelmingly preferred the high-SEA task.

We conducted two follow-up experiments to investigate whether people persist in choosing high-SEA tasks even when such a choice involves sacrificing positive performance feedback (Bucknoff & Metcalfe, 2016). In the first follow-up study, we introduced two additional versions of the tasks that further reduced the probability of performance feedback. Specifically, we further reduced action effectiveness by introducing a 40% and 30% condition, such that struck Xs only behaved as expected 40% and 30% of the time. The purpose was to examine whether people persist in preferring high SEA tasks even at the expense of positive performance feedback. Again, participants performed pairs of the tasks then expressed their preferences as to which version of the task they wished to perform again. The study forced participants to choose between two versions of the task, one higher in SEA and the other higher in performance feedback. Participants' choices revealed that further withholding performance feedback made no difference. People preferred versions of the task associated with high SEAs even when it means making a trade-off with performance feedback. In that context, they would rather feel in control than experience good things happening.

While these experiments offer evidence that SEAs are desirable, one key limitation is that the findings could be attributed to interference aversion rather than to SEA preference. It is possible that participants' choices demonstrated a dislike for the dysfluent interference condition (low SEA) rather than a preference for high SEAs. Accordingly, we introduced a new manipulation to create a low SEA task without manipulating action fluency (i.e., introducing interference into the cursor movement). This was a non-contingent version of the task whereby Xs exhibited performance feedback 75% of the time regardless of whether

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they were struck by the cursor. Thus, the person's action had no effect on the proportion of Xs exhibiting performance feedback. When paired with the standard version of the task, the participant had to choose between a high-SEA task associated with low performance feedback and a low-SEA task associated with high performance feedback. People consistently chose the high-SEA task, again at the expense of performance feedback (Bucknoff & Metcalfe, 2016).

Even when performance feedback takes the form of monetary gains, people make sacrifices in favor of high SEAs. Bobadilla-Suarez, Sunstein, and Sharot (2017) gave participants the chance to retain or delegate decision-making authority in a simple choice task. In part one, participants chose one of two shapes, and each shape was associated with a monetary gain or no gain. In part two, participants chose whether to retain or delegate decision-making authority in the shape choosing task. To delegate authority meant to allow the computer to choose. The participants knew the computer's accuracy rate and cost prior to making the delegation decision and that sometimes the computer would be expected to perform better than would they themselves. Surprisingly, the researchers found that people failed to delegate when it was in their best interest (i.e., the expected value of the computer's performance exceeded their own) far more frequently than they failed to retain agency when that was optimal. Furthermore, the researchers found that the point of indifference—the expected value at which probability of delegation was 50%—was higher than it should have been for a rational actor (i.e., a person acting solely to maximize gains). These findings suggest that retaining agency—or enjoying a high SEA—has inherent value, and that people will sacrifice monetary gains for it.

Neuroimaging evidence provides additional support for the notion that the SEA has inherent value. Leotti and Delgado (2011) examined the affective experience of anticipating choice. They used a simple choice task that involved either choosing one of two colored keys or responding to the location of a key that the computer chose. fMRI data showed increased activity in the ventral striatum—a part of the brain associated with reward processing—when participants anticipated the opportunity to choose. In addition, participants were asked which condition they liked better, and people preferred the choice condition. The findings suggest that when a person anticipates a SEA, the brain behaves as if a reward were imminent.

The reverse process may also be true. When a person feels good, the intensity of SEA appears to increase under certain conditions. Kirkpatrick, Metcalfe, Greene, and Hart (2008) examined how methamphetamine use affected judgments of agency in a dynamic metacognition of agency task (e.g., Metcalfe & Greene, 2007). Methamphetamine increases neurotransmission of serotonin, norepinephrine, and dopamine, and such an increase enhances mood and feelings of wellbeing (Sulzer et al., 2005). The researchers found that participants taking methamphetamine recorded higher judgments of agency compared to placebo. The finding reinforces the relation between the SEA and positive affect and suggests a bidirectional causal pathway. When people feel good, they feel more in control, and when people feel more in control, they feel better.

SEAs and Memory

The body of work reviewed above suggests that people generally like high SEAs and are willing to sacrifice positive outcomes to attain them. We now turn to the question of how SEAs impact memory. We know that *merely being the agent* enhances recall and recognition. In certain lines of work, "merely being the agent" refers to making a choice about to-be-remembered information. Cloutier and Macrae (2008) found that selecting positive trait

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words "out of a hat" enhances memory and accessibility relative to a condition where words were assigned to the participant. Participants completed the experiment in pairs and memory was tested for words allotted to the participant and words allotted to the other. Both recall and recognition performance were better for words allotted to the primary participant rather than words allotted to the other. Intriguingly, an interaction showed that the effect held only for words in the selected condition, not the assigned condition. When both people in the room were assigned words, the researchers found no benefit to self-assigned words.

Because the to-be-remembered materials were trait adjectives, participants may have associated the words with themselves more when they chose them. Objectively, the words were not necessarily self-relevant because they were chosen randomly. But participants may have associated traits with themselves during the random selection procedure. To address the self-relevance concern, Murty, DuBrow, and Davachi (2015) used a more extreme manipulation where it was unlikely that a link between the to-be-remembered information and the self played a role. They also found that minimal choice led to memory enhancement. In their work, participants either chose locations on a screen where to-be-remembered images (unrelated to personality traits) would appear, or the locations were fixed. Crucially, the researchers used occluding symbols to mask the to-be-remembered images while the participants chose the location. People performed better on a recognition task for items in the choice condition. The findings suggest that the simple act of choosing, even if the choice is uniformed and not related to the to-be-remembered items, improves memory.

Cloutier and Macrae (2008) offered an attentional explanation for the memory enhancing effects of choice. They proposed that self-initiated action (e.g., selecting trait words) heightens attention. Increased attention, then, strengthens encoding and leads to better memory. However, Murty et al. (2015) controlled for attentional differences between the choice and fixed conditions and discovered that differences in viewing times failed to account for the effect. Instead, they argued that choice enhances the "perceived sense of agency" over the learning environment and that felt state leads to memory improvement. (The researchers also suggested an interaction between striatal and hippocampal activity as a neurological mechanism. Details regarding the neural basis of the effect, however, are beyond the scope of this chapter.) For all intents and purposes, their "perceived sense of agency" is analogous to the SEA. Their work, therefore, supports the notion that SEAs enhance memory.

Simple choice paradigms are not the only settings where we observe memory-enhancing effects of SEAs. In the classic generation effect paradigm, for instance, researchers compare memory performance in a passive, read-only condition to an active, generate condition. The generate condition presents participants with a cue paired with a portion of a target (e.g., rapid—f___), and they generate the target word. The control condition presents participants with both words (e.g., rapid—fast). Memory assessed at test is better for items presented in the generate condition (Bertsch, Pesta, Wiscott, & McDaniel, 2007; Slamecka & Graf, 1978).

Prominent explanations for the generation effect include mental effort, selective rehearsal displacement, and study-test processing match (Bertsch et al., 2007). Others have proposed alternative accounts (cf. McDaniel, Waddill, & Einstein, 1988), and while each enjoys some favorable evidence, none fully explain the effect. Like Murty et al. (2015), we propose a parsimonious explanation. Specifically, *merely being the agent*—taking productive action in pursuit of a goal—is sufficient to enhance memory and to contribute to the effect. In the generate condition, participants take action by generating their best guess as to the target word. In contrast, in the read-only condition, they study material presented to them passively rather than produce a response through their own action. That crucial difference in agency enhances the SEA during generation and may, in part, account for enhanced memory.

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Of course, we acknowledge that agency also exists in the read-only condition. Reading is, in fact, an action and is not the same as doing nothing. However, it seems very likely that the SEA is stronger in the generate condition. The required action is more complex and necessitates more self-involvement. It results in a product—something in the world that did not exist prior to the person's action (i.e., their best guess as to the target word). Reading, in contrast, does not result in a product. It is also a simpler action, requires less effort, and needs less involvement of the self.

Differences in SEAs may account for other memory effects, such as testing and enactment effects. The testing effect refers to the finding that testing previously learned information enhances memory relative to restudying (McDaniel, Roediger, & McDermott, 2007). It is not much of a leap to infer that SEAs are higher during testing than while restudying. Testing involves generating responses, so the processes at play are similar to those activated in generate conditions. Differences between testing and restudying mirror contrasts between generate and read-only conditions. Most importantly, test-takers *produce responses* through their own action. Those in the restudy condition merely reread or review information *without productive action*. That distinction enhances the SEA in the testing condition, which may explain improved memory performance.

Test type moderates the testing effect, which further supports the idea that the SEA may explain memory benefits. The testing effect is strengthened when recall rather than recognition is tested and when short-answer instead of multiple choice exams are administered (McDaniel, Roediger, & McDermott, 2007). Recall and short-answer responses require more productive action than do recognition and multiple-choice tests, so SEAs are greater in the former cases.

The enactment effect refers to the finding that memory for action events (e.g., "lift the pen," "put on the ring") is enhanced when a person acts out the event through gestures (Cohen, 1989; Nyberg, 1993). Cohen (1981) compared memory performance for action events among many study conditions. In one condition, people enacted events. In another, they listened to an experimenter read descriptions of events. Recall was superior in the enactment condition. Like generation and testing, enactment requires productive action. Enactors produce physical portrayals of the to-be-remembered action by making appropriate gestures. In contrast, those in the instruction condition listen passively to the events read aloud by the experimenter. SEAs are likely enhanced in the enactment condition and may contribute to the effect.

Cohen (1981) used another condition where the participant observed another person enacting the action event. Recall in that condition was comparable to the self-enactment condition and thus superior to instruction-only. In some circumstances, therefore, observing another acting as the agent enhances the observer's memory. It is possible that people can infer the experienced agency of others, so inferred SEA may also improve memory in certain situations. This phenomenon may vary across domains. Metcalfe & Xu (2017) found memory benefits only for *self-produced* corrected errors to general knowledge questions compared to *other-produced* corrected errors. That finding suggests that memory benefits from observing others acting as agents may be unique to enactment contexts.

Limitations and Ongoing Research

While we know that SEAs influence memory, the existing work is limited in three key ways. First, the experimental paradigms discussed above allow only for manipulation of action choice. Participants either take action (e.g., make a choice, generate a response) or remain passive. Recall that agency has three distinct components—action choice, action fluency, and

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action effectiveness. Manipulation of the latter two may result in unique memory effects, but the existing work does not address that question.

Second, all SEA manipulations in the existing work are connected in some way to the memory task. Participants make a choice that affects the content or presentation of to-be-remembered stimuli, or they take an action directly related to the stimuli (e.g., generation). However, because the SEA is an internal state, it is theoretically possible that SEAs generated *independent* of the memory task may carry over to influence memory. For example, people could perform a task for a few minutes over which they feel some degree of control. The experimenter could manipulate the task such that in certain trials it generates a high SEA and in others it generates a low SEA. Then, the participant could view to-be-remembered stimuli, and the experimenter could examine whether SEA strength affects memory performance.

Finally, much of the existing work is content agnostic. Researchers have shown little interest into whether and how the nature of to-be-remembered stimuli interact with SEAs to influence memory. But research into the cognitive and perceptual consequences of low control suggests that the nature of to-be-remembered information may affect what we remember and what we forget. According to the compensatory control hypothesis, people's SEAs affect perceptions and beliefs in such a way as to restore or maintain an equilibrium sense of control. For example, lacking control (i.e., having a low SEA) increases illusory pattern perception, enhances endorsement of government intervention, and strengthens belief in a controlling God (Kay et al., 2009). Therefore, it is possible the degree of SEA may bias memory toward certain information that maintains or restores control equilibrium. The compensatory control literature is limited to perceptions and beliefs, however, so the role of memory in that framework is unknown.

On the other hand, existing work on the relevance of a representation suggests a different hypothesis (Eitam & Higgins, 2010). A person's motivational state may bias cognition toward certain information and away from others. When a person feels out of control, their minds may tune to information in the environment that might be particularly threatening. Already in a low SEA, the person might scan for information that may further threaten their SEA. They may be motivated to preserve and protect the small amount of agency they are experiencing. Such ideas are consistent with "weapon focus" in the memory and stress literature (Loftus, Loftus, & Messo, 1987) and would make different predictions about SEAs and memory.

We recently began a line of research that addresses these limitations (Bucknoff & Metcalfe, submitted). To address the action choice and task relatedness limitations, we use the dynamic motor task used in the agency choice work described above to manipulate SEAs. That task allows us to manipulate SEAs by manipulating action fluency. The introduction of interference into the movement of the cursor disrupts action fluency and leads to reliably lower SEAs. Furthermore, the task itself has nothing to do with learning and memory. But we can use the task to manipulate SEAs and interleave a memory task. To address the content agnostic limitation, for the to-be-remembered information we use vignettes that describe behavior across a spectrum of morality.

Preliminary results support the relevance hypothesis. In low SEA conditions, we have found differences in recall for moral acts and moral violations such that recall is enhanced for moral violations and impaired for moral acts (Bucknoff & Metcalfe, submitted). Interestingly, only when people experienced a low SEA were they more likely to recall moral violations than moral acts. In high SEA conditions, the reverse appears to be true. When people feel more in control, they are more likely to remember moral acts than violations. Follow-up experiments are underway.

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Conclusion

The SEA is a meaningful internal state with consequences for memory. SEAs can be manipulated experimentally by influencing any of the three components of agency—action choice, action fluency, and action effectiveness. Much of the existing research explores action choice manipulations, but some work is beginning to investigate the consequences of fluency and effectiveness. Also, none of the existing work has used the SEA explicitly as a construct. Rather, researchers have investigated the effects of choice, productive action (e.g., generation), or other agentic circumstances on memory performance. Some researchers have suggested the *perceived sense of agency* as the possible mechanism, which is quite similar to the SEA (Murty et al., 2015). However, according to the literature, the *sense of agency* refers to a specific metacognitive experience that results from the output of a comparator model (Haggard & Chambon, 2012). We prefer the SEA as an organizing construct to highlight the felt internal experience that may be common to all agentic circumstances, and we posit that the effects on memory may be attributed to that internal state.

We know that people generally like SEAs and will make choices to increase their likelihood of experiencing them. In certain contexts, SEAs boost memory. It appears that SEAs influence memory, both when they are generated with actions directly related to the memory task and when they are transferred from an unrelated task. SEAs seem to interact with the content of to-be-remembered stimuli to impact memory performance. Specifically, preliminary research suggests that low SEAs may boost recall for negative or threatening information and impair memory for positive or benign stimuli. The reverse may be true for high SEAs—enhanced memory for the positive and impaired memory for the negative. More research is necessary that uses different and novel SEA manipulations in attempt to find converging evidence that supports preliminary findings. We also encourage researchers to consider the type of to-be-remembered information as a variable with consequences for the effects of SEAs on memory.

The effects of SEAs on memory have important theoretical and practical implications. From a theoretical standpoint, the construct may help explain and unify previously disparate bodies of work. For example, the reason generation enhances memory may be the same as the reason why choice enhances memory. Both enhance SEAs. In addition, the construct reminds us of the importance of integrating bodily states into the study of memory. The embodied cognition movement discovered that perception and cognitive performance can depend on physical states and stimuli (Glenberg, Witt, & Metcalfe, 2013). It seems likely that the sphere of embodied cognition research can be extended to include SEAs. To better justify the characterization of SEAs as a bodily state, more research needs to investigate the nature of SEAs and their potential physical correlates.

From a practical standpoint, experimental work on SEAs and memory can inform curriculum and classroom design. Teachers can design coursework in ways that optimize students' action choice, action fluency, and action effectiveness (and, thus, their SEAs). Doing so may have long-term positive consequences for student learning. To justify such applications, more research is needed to examine the long-term effects of SEAs on memory.

Of course, laboratory research is not required for us to know that human beings value agency. A perusal of nearly any history book teaches us that. Wars have been waged and revolutions fought in the name of attaining greater self-determination. History tells us, therefore, that asserting our agency can have profound implications for our political systems. We believe that psychology can deepen our understanding of the consequences of agency and reveal important insights about our cognitive systems.

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