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ADAPTIVE MEMORY: ANIMACY AND THE METHOD OF LOCI

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ADAPTIVE MEMORY: ANIMACY AND THE METHOD OF LOCI

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TABLE OF CONTENTS

Page

Page

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

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A functionalist approach to cognition assumes that people's minds are tuned to process and remember information that benefits our survival or reproduction (Nairne, 2005). One source of information with potentially high fitness value is things that are alive and animate (Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013). The purpose of this dissertation was to explore the effects of using an ancient mnemonic – the method of loci – to examine memory for animate objects. Across four experiments, subjects used the method of loci to remember a list of animate or inanimate objects. I manipulated animacy by using animate or inanimate words (Experiments 1 and 4) or by using animate or inanimate images (Experiments 2, 3, and 4). In Experiment 1, memory for animate and inanimate words was tested in either the method of loci or a pleasantness ratings control condition. Subjects learned a list of words; half of the words were animate and the other half were inanimate. Subjects in both conditions recalled more animate than inanimate words. The animacy effect in the method of loci was smaller relative to the pleasantness condition.

Experiments 2 and 3 were concerned with using imagery to manipulate animacy. In Experiment 2, all subjects were given a list of inanimate words. In the animate condition, subjects were told to imagine the object was alive whereas in the inanimate condition, subjects were given no explicit instructions concerning animacy. There was no animacy effect in this experiment. In Experiment 3, subjects saw inanimate words paired with experimenter-generated descriptions of images, half of which were animate and half of which were inanimate. Subjects recalled more words that were paired with animate images than words that were paired with inanimate images, although this effect was not statistically significant.

Experiment 4 used a combination of animate words and images to examine the animacy effect. I factorially crossed word type (animate vs. inanimate) with image type (animate vs. inanimate) to explore the effect of adding animate and inanimate images to inanimate and inanimate words. There were main effects of word type and image type such that animate words were recalled more than inanimate words (as in Experiment 1) and words associated with animate images were recalled more than words associated with inanimate images (as in Experiment 3). Overall, the results of these four experiments suggest that the animacy effects persist in the method of loci. These results contribute to a growing body of evidence that suggest that animacy is a potent variable in memory.

INTRODUCION

Adaptive Cognition and Memory

A functionalist approach to cognition assumes that cognitive processes are tuned to solve adaptive problems that benefit survival or reproduction. Nature "selects" one physical design over another because that design has fitness value – it helps the organism solve an adaptive problem that in turn increases the chances that the organism will pass the genetic material down to the next generation. In biology the heart is uniquely designed to pump blood, and the kidneys to filter impurities. In the same way, it is likely that nature has shaped the design and function of our cognitive systems (Tooby & Cosmides, 1992). From this perspective it logically follows that our memory system, like our heart and lungs, is also "tuned" to remember things that enhance our fitness (Klein, Cosmides, Tooby, & Chance, 2002; Nairne, 2005; Nairne 2014; Sherry & Schacter, 1987).

In a foundational paper concerned with adaptive memory, Nairne, Thompson, & Pandeirada (2007) offered a functional account of memory that suggested our ability to remember evolved to solve adaptive problems. That is, our memory systems are likely specifically tuned to process information that is relevant to survival. In a typical survival processing paradigm, originally developed by Nairne et al. (2007), subjects process words in an ancestral survival scenario (e.g., “Rate how relevant each of these words would be for your survival if you were stranded in the grassland of a foreign land”) compared to other scenarios (e.g., “Rate how relevant each of these words would be if you were moving to a foreign land”). On a surprise memory test, subjects recall more words that are processed for survival than words that are processed for their relevance to moving (Nairne, et al., 2007; D. J. Burns, Hart, Griffith, & A. D. Burns, 2013), planning a vacation at a resort (Nairne, Pandeirada, & Thompson, 2008; D. J. Burns et al., 2013), or planning a bank heist (Kang, McDermott & Cohen, 2008). Survival processing also produces superior memory than other conditions that are widely accepted as having great mnemonic relevance such as rating words for their pleasantness, imagery or self-reference (Nairne et al., 2008). The effect has also been found using pictures (Otgaar, Smeets, & Van Bergen, 2010). The purpose of this dissertation is to examine the mnemonic value of objects with a potentially high survival value: living (animate) things.

Animacy

Intuitively, it seems as though living things have a special priority in our day-to-day lives. We see faces in the clouds and a man in the moon; our instinct tells us that the thing that goes bump in the night is a predator. We anthropomorphize – attribute human-like characteristics to non-human objects – easily and frequently. Upon coming home, I interpret my dog’s reaction as happiness to see me; it looks as if he pulls back his lips and smiles at me.

Children's media is ripe with examples of the priority of animates. Some of baby's first books teach the sounds animals make and the feel of their fur. Some of the most popular and timeless children's books involve objects or animals that are anthropomorphized, including *Where the Wild Things Are* (Sendak, 1963), *The Very Hungry Caterpillar* (Carle, 1969), *Charlotte's Web* (White, 1952), *Goodnight Moon* (1947), *The Little Engine that Could* (Piper, 1930), and Thomas the Tank Engine from *The Railway Series* (Awdry, 1972). Similarly, many children's movies have a host of objects that have taken on human characteristics such as *The Brave Little Toaster* (Reese, 2003), the dancing brooms in *Fantasia* (Sharpsteen & Disney, 1940), and the whole crew from Disney's *Beauty and the Beast* (1991) including Mrs. Pots, Chip, Lumier, and Cogsworth to name a few. Animates are everywhere, whether or not we are intentionally looking for them.

What is Animacy?

These everyday examples converge with decades of research that suggest we do in fact conceptualize living things differently from non-living things. According to the folk biology literature, there is a ubiquitous taxonomic system in which living things are classified and categorized in a way that objects are not (Berlin, Breedlove, & Raven, 1973, 1974; Medin & Atran, 2004). The classification of living things is typically further divided into additional categories, and these categories often fall into a hierarchy (e.g., humans at the top followed by animals then plants). However, there is often ambiguity surrounding the middle sections of this hierarchy. People from virtually all cultures agree that humans are in a separate category from plants, but the distinction between humans and animals is less clear. Before ages 10 or 11, children typically classify humans as a unique category that is separate from both plants and animals. However, around this age children begin to categorize humans as a type of animal and therefore begin to group humans and animals in the same category (Carey, 1985). Modern American children are not the only people to make a similar human-animal distinction. The separation between humans and other animals dates as far back as pre-Socratic Greece. In this system, living things were classified as either human-like (*biology*) or nonhuman-like (*zoology*). Yet in both systems, living plants fall into a category that is distinctively separate from animals and humans (Dellantonio, Innamorati, & Pastore, 2012). While plants are most certainly living things, they do not enjoy the same special cognitive priority as other living things and have been wrongly categorized by children as nonliving things (Hatano et al., 1993). There is a critical feature absent in most plants that is present in animals and humans. That feature is animacy.

To use an overly simplistic classification scheme, a living thing is animate if it can move on its own and has intentions or goals. A definition of animacy has been conspicuously absent in this manuscript until now because, much like the ambiguity surrounding the perception of living and nonliving things, the line between what is animate and what is not can also be unclear. It is often the case that the animate/inanimate distinction parallels the living/nonliving distinction, although this is not always true. It is easy to come up with examples of objects that defy this sort of simple living/nonliving definition of animacy. The first obvious example mentioned previously is plants. Perhaps plants are uniformly classified differently from other living things (and even considered “nonliving” by children) because plants lack the primary indicators of animacy. This idea is captured in the definition of the word as found in the Merriam-Webster dictionary. The word “animate” is defined along the living/nonliving dimension (definitions 1, 2, and 4); “possessing or characterized by life,” “full of life,” and “referring to a living thing,” but also a distinction is made between plant and animal life in an alternative definition (definition 3); “of or relating to animate life as opposed to plant life”.

To further cloud the already murky conceptualization of animacy, I will argue that it is unclear whether the status of “living” is actually a necessary feature of animacy. Consider a goat that is dead. In this case, the goat shares almost all of the features of a living goat with the exception that it is no longer alive. It seems that this goat no longer is animate. On the other hand, a vampire is also not living, yet shares almost all of the features of other animate, human-like beings. In this case, it would seem as though a vampire is animate. However, at this point these are all speculations because there is no hard line drawn between what is animate and what is inanimate. For the sake of the current dissertation, I am concerned with things that would be important to notice and remember because of their fitness value. It seems that noticing and remembering things that have goals and the ability to act on those goals would provide an advantage to survival relative to things that do not.

The ambiguity surrounding what is animate and what is not may stem from the fact that researchers from across the various fields of psychology have yet to agree upon a unified classification system for separating these two things. Fortunately, that is not to say that we are left empty-handed in this question to understand animacy. There are many characteristics that are used to inform people's perception of animacy. The majority of these characteristics fall primarily into two classes: static/featural and dynamic. There are also other characteristics that do not fall neatly into a static or dynamic classification, such as using empathy to determine how similar an object is to oneself (Langacker, 1991). However, the static/dynamic dichotomy is a useful way to consider animate characteristics.

The static characteristics of animacy are based on unchanging features of an object such as the look or feel of the object. The most reliable static cue for animacy is the presence of a face. Other static features include the presence of legs (as opposed to wheels), skin or fur, sounds, and smells. The categories of static and dynamic characteristics are not mutually exclusive as in the case of a person's static – but also dynamic – gaze (Gao, McCarthy, & Scholl, 2010; Opfer & Gelman, 2011). Often these static clues overlap with characteristics of living things (e.g. a table has legs) and therefore may be good indicators of animacy in combination with other dynamic cues.

Perhaps the most reliable signal of animacy comes from dynamic cues that are based on motion. Animate objects have self-generated and self-sustained movement such as walking or crawling (Opfer & Gelman, 2011). This type of motion is different from other types of Newtonian motions because there is no other external source for the start of the motion (such as an object that is falling because of gravity). This movement must also be biologically plausible such as the pattern of motion inferred from lights that are placed on joints in point light walker displays (Johansson, 1973). A third dynamic characteristic is the perception of goal-directed movement, such as a pattern of movement that can be interpreted as an animal searching for dinner or avoiding becoming another animal's dinner. This ability to differentiate goal-directed movement from other movement starts as early as 3 months (Luo, 2011). Similarly, another characteristic is that animates have contingent behaviors that are related in time to another action (Gergely & Watson, 1999) Examples of these cause-and-effect behaviors might include smiling after receiving a compliment, crying because something sad has happened, or taking an alternative route because an obstacle has been placed in the originally intended route. The majority of images described in this dissertation are based on dynamic actions.

Detecting Animates

There is ample evidence suggesting that people respond differently to animates and inanimates beginning at an early age. There are special ways people in every society think about living things, including tracking the movement of other humans (e.g., recognizing human faces; Carey & Diamond, 1977; Diamond & Carey, 1986). People have developed specific grammar rules and semantic structures for pronouns and proper names (Arnold, Eisenband, Brown-Schmidt, & Trueswell, 2000). Infants as young as 6.5 months old attribute goals to moving shapes. For example, infants pay special attention to a circle that moves around a rectangle to reach another circle relative to a circle that takes the same trajectory without the rectangle (Csibra, Gergely, Bíró, Koós, & Brockbank, 1999). At 12 months, infants associate ordered movement with animate objects and disordered, random movement with inanimate objects (Newman, Keil, Kuhlmeier, & Wynn, 2010). By four years old, children are able to predict and explain whether unfamiliar objects are animate or not (Gelman, 1990). At this age children are also able to differentiate between things that are dead versus sleeping, despite the shared perceptual features (Barrett & Behne, 2005).

This differential treatment of animate objects makes sense from an adaptive memory perspective. If survival depended on rapidly detecting nearby predators, it would be advantageous to have a cognitive system that quickly and easily detected living things with goals and intentions (i.e., animate things). People are thought to have a specialized animacy detection device to determine whether something is alive or is the result of a living thing (J. L. Barrett, 2004). Often this animacy detection device responds quickly and automatically. In change-detection scenarios, people are substantially faster at detecting changes that involve animals relative to other categories of inanimate objects (New, Cosmides, & Tooby, 2007). People are easily able to detect animacy (even the gender of a walker) with only sparse inputs of information in the form of lights placed strategically on various joints on the body (Johansson, 1973). Our detection device is hypersensitive to animate objects, frequently ascribing animacy to a situation when there is none. For this reason, our detection system is often thought of as a *hyperactive* agency detection device (H. C. Barrett, 2005; J. L. Barrett, 2004; Tipper & Weaver, 1998). From an evolutionary perspective, it is more advantageous for a person to detect an animate when there is none than it is to fail to detect an animate, especially a harmful or dangerous one (J. L. Barrett, 2004). A person who mistakenly perceives rustling in the grass to be a poisonous snake when in reality it is the wind is more likely to survive than a person who mistakenly perceives the rustling of a snake to be the wind.

This hyperactive agency detection device perceives animacy in unlikely situations. In a classic paper, Heider and Simmel (1944) showed a brief film in which two triangles and a circle moved around the screen in what appeared to be an ordered, intentional manner. Despite the fact that these were simple, geometric shapes that moved silently around the screen, subjects were quick to attribute intentions and goals to the shapes. Almost all of the subjects produced elaborate stories about the shapes such as a romantic tale about an intricate love triangle complete with character profiles for each shape including fearful, frustrated, and aggressive.

However, not all movement is automatically perceived as animate. Whether or not geometric shapes are perceived as animate depends on the pattern of the movement. In a visual search task, Abrams and Christ (2006) demonstrated that it was the start of motion (i.e., an object that has just begun to move), not motion per se, that captured attention. Furthermore, motion onset is only predictive of animacy if there is no physical explanation. To borrow an example from Scholl and Tremoulet (2000), imagine square “A” moves in a straight line towards square “B.” In one scenario, once “A” reaches “B,” “A” stops moving, and “B” starts moving along the same path. In the other scenario, once “A” has almost reached “B,” “B” moves quickly away from “A” in a random direction until it is a few inches away from “A.” “A” then changes course and moves in the new direction towards “B.” Both cases are examples of motion onset of geometric shapes, but the two scenarios are perceived differently. In the first scenario “A” is seen as the cause for “B”s movement according to the properties of physics, but in the second scenario the squares become alive with potential intentional states or goals (e.g., “A” wants to catch “B”, or “B” is trying to escape from “A”). If an object begins to move with no other explanation than an internal energy source, this object is self-propelled. As mentioned earlier, this ability is a key characteristic of animate objects. Similarly, objects that move randomly and without clear goals (a characteristic of animate objects) capture people’s attention faster than objects that move predictably, as if colliding into one another (Pratt, Radulescu, Guo, & Abrams, 2010).

Remembering Animates

Given the information available about the importance of animacy on a perceptual level, it is reasonable to expect that our memory systems, like our perceptual systems, are tuned to remember animate things. In perhaps one of the first, albeit unintentional, studies to demonstrate the mnemonic value of animacy, Camilleri, Kuhlmeier, and Chu (2010) used geometric shapes to examine the role of intentionality in helping and hindering behavior. Subjects viewed movies of various colored triangles in which the triangles were either perceived as “helping” a red ball up a slope, or hindering the ball’s progress. Importantly, the movement of the triangle could be perceived as intentional (e.g., moving on its own accord) or unintentional (e.g., falling because of gravity). Although animacy was not a dimension of interest to the authors, on a later test subjects recognized the correct color of triangle more often when the triangle’s motion was perceived as intentional rather than unintentional.

Recently, the mnemonic value of animate objects has been directly examined with animate and inanimate stimuli. Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton (2013) had subjects study a list of animate and inanimate words (e.g., “duck” versus “kite”) that were equated along a number of mnemonic-relevant dimensions. Across repeated free recall tests, subjects remembered more animate than inanimate words. In the current dissertation, I will use a modified version of this animate and inanimate word list to examine the mnemonic value of animate objects within the context of the method of loci. In addition, when Rubin and Friendly’s (1986) collection of recall norms were subjected to a multiple regression analysis, animacy was an important predictor of recall. Animacy was actually ranked as high as the three variables Rubin and Friendly reported were the largest determinants of memory: imagery, availability, and emotionality. Bonin, Gelin, and Bugaiska (2014) extended the animacy effect using pictures (Experiment 1), an incidental learning task (Experiment 2) and a final recognition test (Experiment 3).

The mnemonic value of animacy has also been demonstrated by attributing animate characteristics to non-words. In this way, subjects were exposed to the same stimuli but were asked to process the stimuli differently. VanArsdall, Nairne, Pandeirada, and Blunt (2013) attributed characteristics to non-words that were either typically associated with animate objects (e.g. “cries when upset”) or with inanimate objects (e.g., “assembled with screws”). On final free recall and recognition tests, non-words that were paired with animate characteristics were recalled and recognized more than non-words that were paired with inanimate characteristics. In the current dissertation, I used a similar method to attribute animate and inanimate characteristics to objects.

Animacy effects have recently been found for animate stimuli in a paired associate task (VanArsdall, Nairne, Pandeirada, & Cogdill, 2015). Animate and inanimate words were randomly paired with Swahili words. Subjects were told to learn the English word associated with each Swahili word (essentially, a foreign language learning paradigm). On a final cued recall test, subjects recalled more of the animate words than inanimate words. However, there may be situations in which animacy effects are not found in paired associate learning. This is the case for paired-associate learning with emotional arousing stimuli (Madan, Caplan, Lau & Fujiware, 2012). In this situation, there is a memory advantage for the individual negative valence words at the cost of the associated words. Perhaps there could be similar situations in which animate words are remembered at the cost of remembering the item associated with the animate object. Research from the perception literature has demonstrated that animates capture attention; therefore, it is possible that during paired associate learning, animate words may capture attention and therefore receive more processing than inanimate words. If this is the case there might be an advantage for animate words on a free recall test but not on a cued recall test.

It is possible, then, that the animacy effect may not appear in an ordered output task. Animate words may increase the specific memory for that item at the cost of information about that item's order. That is, memory for the individual animate items may be greater for animate words, but this memory for the individual items may impair the memory for serial order. This type of dissociation for item and order memory has been demonstrated with the generation effect. Across three experiments, subjects completed word fragments aloud of some words (the generation condition) and simply read aloud the others (the read only condition). As is typically the case (see Slamecka & Graf, 1978), generating the words improved the memory for the individual items. However, generating the words impaired memory for the order of those words as measured by order reconstruction tasks and input-output correspondence measures of recall (Nairne, Riegler, & Serra, 1991). In the present experiments, the effect of animacy was tested in an ordered output task. This ordered output task was the method of loci.

Method of Loci

What is the method of loci? In the popular British Broadcasting Corporation television series based off of Sir Arthur Conan Doyle's classic stories, "Sherlock Holmes", Dr. Stapleton asks the same question when Sherlock Holmes mentally retreats to his "mind palace." Holmes's sidekick, Watson, explains:

> DR. JOHN WATSON: It's a memory technique, a sort of mental map. You plot a...a map with a location - it doesn't have to be a real place - and then you deposit memories there that...theoretically, you can never forget anything. All you have to do is find your way back to it.
>
> DR. STAPLETON: So this imaginary location could be anything - a house, a street...?
>
> DR. JOHN WATSON: Yeah.
>
> DR. STAPLETON: It's a palace. He said it was a palace.
>
> DR. JOHN WATSON: Yeah, well, he would, wouldn't he?
>
> (Gatiss, Moffat, & Doyle, 2012, 1:10:05)

Not only would Sherlock Holmes choose to call his set of internal location cues a palace, but so would many others after him, including many top memory athletes. But before I get into the details about how memory athletes use the method – and what the existent literature says about it – or why it is particularly well-suited for the present study of animacy, I will first provide an accurate explanation of the technique (You were on the right track, Watson!) and provide a brief history.

To use the method of loci, a person creates images of to-be-remembered items and then mentally places these images in distinguishable locations along a path, often in a building such as a house (or, in Holmes's case, a palace). To recall the items, the person mentally retraces his/her steps along the path and virtually "looks" at each location to identify the items that were previously placed there. This technique is not new to the 2012 television show, nor was it new in 1902 at the time when Sir Arthur Conan Doyle published the story quoted above, *The Hound of the Baskervilles.*

A Brief History of the Method of Loci

Legend traces the origins of the method of loci to as early as 500 B.C.E at a banquet given by a nobleman in Ancient Greece. (Yates, 1966). The nobleman hired Simonides of Ceos to deliver a poem in his honor at the banquet, but Simonedes dedicated only half of the poem to honoring the host and the other half to honoring the twin gods, Castor and Pollux. When the nobleman heard the poem, he was enraged that he received only half of the honor and praise he expected and refused to pay Simonides the agreed upon price. Instead, the nobleman offered only half of the payment and insisted Simonides ask Castor and Pollux for the rest of the payment. Soon after, a messenger informed Simonides that two men, later assumed to be Castor and Pollux, were waiting to see him outside of the banquet hall. While Simonides was outside waiting for the two men, an earthquake struck, destroying the banquet hall and killing all the attendees inside the ruins. The damage from the earthquake left the guests unidentifiable even to their family members. To recall who was there for the burials, Simonides imagined the seating arrangement of the guests at the banquet hall. He then mentally walked through the former banquet hall and identified every guest who had attended. But Simonides did not stop there. He realized that this technique could be used to remember other things besides guests, perhaps famous poets, objects, or even poems. And so the method of loci was born (and beware he who dare cross the gods! Cicero 55 B.C.E./1970).

Before external mnemonic devices such as paper or the latest iPhone were readily available, memory was considered to be a critical component of speech. As such, the techniques of remembering were included in every school of rhetoric (Yates, 1966). There are three surviving Latin sources that described this often-called “art of memory” for the aspiring student of rhetoric. The earliest and most informative text, *Rhetorica ad Herennium,* was written around 90 B.C.E. and does not bear the name of the author, only that it was a treatise on rhetoric for a man named Herennius. This anonymous manuscript is the source for the majority of surviving information about how to use the method of loci and was likely the gold-standard of mnemonics in the ancient world. In it the author distinguishes between two types of memory: natural memory and artificial memory – a distinction that remains today (Worthen & Hunt, 2011). Despite two thousand years, the techniques laid out in this book are still largely unchanged, to such an extent that world memory champion Ed

Cooke said of it, “This book is our bible” (Foer, 2011, p. 93). The two later works, Cicero’s 55 B.C.E. *De Oratore* and Quintilian’s 95 C.E. *Instituto de Oratoria,* likely assumed readers were familiar with this book (Yates, 1966) and consist of related information (e.g., the origins story described above from *de Oratore* and Quintillian’s opinion that the method seems rather artificial and unhelpful from *Instituo de Oratoria*). For these reasons, *Ad Herennium* will be the primary ancient source referenced in this manuscript.

By the Middle Ages, the method of loci had fallen out of favor and was replaced with other mnemonics such as the linking-by-story method and general organizational strategies. With the exception of the Puritans, who considered the often off-color use of imagery idolatrous, the method of loci enjoyed another period of popularity during the Renaissance. Several notable individuals who used the method of loci during this time were Peter of Ravenna and Matteo Ricci. Peter of Ravenna (c. 1448-1508) was a lawyer who is best known for his book, *Phoenix seu artificiosa memoria,* in which he described his extensive use of mnemonic techniques like the method of loci (Yates, 1966). Later, the Italian Matteo Ricci (c. 1582–1610) reported using hundreds of churches to hold items in memory during his time as a Jesuit missionary in China. His book is called, *A Treatise on Mnemonics* and is described in the book *The Memory Palace of Matteo Ricci* (Spence, 1985). Worthen and Hunt (2011) speculate that the method of loci, and mnemonics in general, fell out of favor after Ebbinghaus’s 1885 monograph which was concerned with “natural” memory. Five years later, however, William James acknowledges in his foundational 1890 book, *Principles of Psychology,* the benefits of using mnemonic techniques.

Currently, universities no longer focus on rhetoric or memorization, choosing instead to emphasize complex learning and application skills such as logic and critical analysis. The method of loci is now often reduced to just a gimmicky party trick (Worthen & Hunt, 2011). However, the appearance of the method of loci in popular media outlets (including Joshua Foer's *Moonwalking with Einstein* and the BBC's *Sherlock*) has once again aroused some curiosity about the method. Joshua Foer's book provides detailed descriptions of the techniques used by several successful memory champions. For that reason, it will be frequently cited throughout the section about recommendations.

Today, the method of loci is one of the most popular mnemonic techniques used by memory athletes around the world. Last year, 169 people with quite ordinary memory abilities gathered at Haikou, China to compete in a variety of memory competitions. There, these ordinary people accomplished quite extraordinary feats of memory, memorizing in minutes what most of us would only dream of memorizing in weeks or months. According to the World Memory Championship website, notable contestants of last year's competition include 11-year-old Chen Zeqi who memorized 15 decks of playing cards in one hour and 2014 World Memory Champion Jonas von Essen who memorized 95 random words in 5 minutes and 106 historic dates in 5 minutes (World Memory Statistics, 2015). How did Jonas von Essen and Chen Zeqi memorize so many things in so little time? By now it is probably obvious what the answer, or at least part of the answer, is: They used a memory palace. It is important to realize that these memory athletes like *Moonwalking with Einstein* author, Joshua Foer, are not savants born with superior memory abilities. Rather, these are people who have spent hours training to use certain mnemonic techniques like the method of loci. In a recent article aimed at exploring 10 people with extraordinary memory abilities, 9 of the 10 reported using the method of loci (Maguire, Valentine, Widing & Kapur, 2003). Below I will describe recommendations advocated by method of loci experts from both over 2000 years ago and present day; the surprising reality is that the method has changed little since its inception. I will then examine these recommendations through the lenses of a cognitive psychologist and discuss empirical evidence in favor of or against these various recommendations.

How to Build a Memory Palace

Memory athletes such as Joshua Foer and Ed Cooke recommend several techniques to increase the effectiveness of the method of loci. The majority of these recommendations were originally described in the Latin sources, *Ad Herennium* in particular (Foer, 2011). There is not much in the way of empirical evidence that any of these recommendations actually enhance the mnemonic value of the method, although several recommendations capitalize on well-established processes known to improve memory in the cognitive sciences, in particular organization and distinctiveness (Worthen & Hunt, 2008).

A basic component and recommendation of the method of loci is to create images. This recommendation is likely for a good reason. Within cognitive psychology, it is widely accepted that people have an impressive ability to remember images (Crowder, 1976; Paivio & Csapo, 1973). In a two-choice forced recognition test of 68 items, subjects recognized 88.4% of the words, and 96.0% of the pictures (Shepard, 1967). Across 8 hours, Standing, Conezio, and Haber (1970), showed subjects 2560 pictures of family vacations, which included people, cities, and vegetation. On a two-choice recognition test of a sample of 280 of the original pictures, subjects correctly identified about 90% of the pictures. Another group of subjects who viewed 1000 extra pictures scored similarly. People have an impressive ability to recognize images, although these experiments say nothing of a person's ability to recall those images.

In addition to recalling images, the process of creating images has played an important role in memory throughout the history of experimental psychology (Paivio, 1969). As early as 1937, Fernberger described a procedure similar to the peg-word method in which words that rhyme with numbers are used as a framework to organize to-be-remembered items. In this method, an interactive image of the to-be-remembered word is formed with a peg-word. In one of the earliest demonstrations of imagery in modern experimental psychology, Miller, Galanter & Pribram (1960) used a list of 10 peg-words that rhymed with the numerals 1 through 10 (bun, shoe, tree, door, hive, sticks, heaven, gate, wine, and hen). Several years later, Bugelski, Kidd, and Segmen (1968) provided one of the first controlled experiments of the peg-word mnemonic and demonstrated that images can serve as mediators in memory. Subjects created their own images and followed a strict recall strategy during retrieval, much like subjects do when using the method of loci. On these associate recall tasks, it was important whether the to-be-remembered word and peg-word interacted: When people were given instructions to form an interactive image of word pairs, recall performance was much higher both on immediate and delayed tests relative to control subjects who used rote repetition (Bower, 1972; see also Wollen, Weber, & Lower, 1972). Therefore another recommendation from cognitive psychology may be that the method of loci may be most effective when images are created in which objects and locations interact. Many examples given by memory athletes include examples of the to-be-remembered word interacting with the location (Roediger & Dellis, 2014).

Some memory athletes further believe that images rich in sensory features may be more memorable than less descriptive images. A mental image of a cat noisily eating or old and smelly gym socks are thought to be more memorable than only the image of a cat or pair of socks (Bower, 1970; Foer, 2011). Images are also thought to be more memorable if they are funny (Foer, 2011), colorful (Bower, 1970), or sad (Roediger & Dellis, 2014). It is possible that creating richer images is a form of elaboration which could lead to higher levels of recall.

Memory champions advise people who use the method of loci to create images that are distinct (Worthen & Hunt, 2011; Foer, 2011). The author of *Ad Herennium* provided the example that sunrises and sunsets, unlike solar eclipses, are unexceptional – and therefore unmemorable – because they occur so often. Memory champion Ed Cooke explained, “The general idea … is to change whatever boring thing is being inputted into your memory into something that is so colorful, so exciting, and so different from anything you’ve seen before that you can’t possibly forget it” (Foer, 2011 p.99). There is no direct test of this advice within the method of loci, but it is not a stretch to imagine that distinct images would be recalled more than images that are not distinct. Distinctiveness has played a role in cognition since von Restorff’s (1933) experiments in which unique items were recalled more than the remaining items, and distinctiveness has continued to play a key role in many views of memory (Craik & Lockhart, 1972; Hunt & Einstein, 1981; Hunt & McDaniel, 1993; Nairne, 2006). On the other hand, the improved memory for the distinct items may hurt the recall of the remaining items, resulting in no overall change in memory for the entire list. To take it a step further, there could be improved memory for the items but worse memory for order, as is the case with the item-order dissociation seen in the generation effect (Nairne et al., 1991). This impaired order information may be particularly detrimental in the method of loci because the method’s mnemonic benefits are driven largely in part from the availability of the encoding order during retrieval.

Other recommendations have potential adaptive underpinnings such as creating images that are sexual, animate, or disgusting. Following the advice established in *Ad Herennium*, Joshua Foer recommended creating images that are sexual such as an image of Claudia Schiffer swimming in cottage cheese naked (Foer, 2011). Jesuit missionary Matteo Ricci also acknowledged using lewd imagery in his memory palaces (Spencer, 1985). It is reasonable to expect, from a functional memory perspective, that sexual images could be remembered well because of their mating cues (Ryan & Jetha, 2010). The next recommendation is directly related to the topic of this dissertation: Animate images are thought to produce a mnemonic advantage over inanimate images. Joshua Foer wrote of the advice given to him by his memory coach, Ed Cooke: "'Now, anthropomorphizing the bottles of wine is quite a good idea,' Ed suggested. 'Animate images tend to be more memorable than inanimate images.' That advice, too, came from the *Ad Herennium."* (Foer, 2011, p. 101). Motion is also thought to enhance the memorability of images, although whether it is motion per se or motion *onset* (a featural cue for animacy, as discuss earlier) was not described. An example of giving motion to images is hot dogs rolling down the driveway (Bower, 1970). Perhaps the driveway in Bower's mind was slanted and the hot dogs were merely following the laws of gravity. But perhaps the hotdogs were moving of their own accord, maybe rolling to get off the driveway. Bower does not specify. Disfigured images are also advised such as ripe tomatoes splattered on the front door (Bower, 1970) or tomato sauce on a pizza that is made out of rat blood (Roediger & Dellis, 2014). Perhaps these people have unknowingly stumbled across another potentially adaptive feature of memory: Enhanced memory for things that are potentially harmful due to risk of contagion from a disease or illness.

Perhaps the most popular recommendation is to create images that are bizarre. It may also be the recommendation about which cognitive psychology has the most to say. The idea that, when using the method of loci, images should be bizarre is as old as the method itself. It has been advocated by ancient Romans (*Ad Herennium*), memory champions (Foer, 2011; Roediger & Dellis, 2014), modern self-help authors (Lorayne & Lucas, 2012), and educators (Tess, Hutchinson, Treloar, & Junkins, 1999). The mnemonic value of bizarre imagery is not intuitive and was a source of considerable debate among experimental psychologists for decades.

Considerable attention has been devoted to understanding the conditions under which bizarre images are more memorable than ordinary images. When bizarreness first captured the attention of memory researchers, it was assumed that bizarre images were more memorable than ordinary images (e.g., Roth, 1961). However, in an experiment examining recall of word pairs, Wollen et al. (1972) called into question this pervasive assumption. Wollen et al. (1972) demonstrated that it was not bizarreness per se that enhanced recall, but rather it was the interaction of the two word pairs. For example, to remember the word pair “piano-cigar”, the bizarre image of the piano smoking the cigar was equally memorable as the ordinary image of the cigar resting on the piano. They proposed that creating an interaction of the two words often lead people to create bizarre images (such as the piano smoking the cigar), which lead to the superstition that it was bizarreness, rather than interactivity, that improved memory for those pairs. (As an aside, it would also be interesting to further examine these interactive images for another potential confound: animacy. The words could be examined individually to see if bizarre images that are animate, such as the piano smoking the cigar, are more memorable than bizarre images that are inanimate, such as a cigar burning at both ends). By the late 1970s, bizarre imagery was generally considered to provide no extra mnemonic advantage (Crowder, 1976; Postman, 1975). However, the case against the mnemonic value of bizarre imagery was not closed. Shortly after Crowder's and Postman's remarks, several demonstrations of the mnemonic advantages of bizarre imagery reappeared (Merry, 1980; Webber & Marshall, 1978; Wollen & Cox, 1981a, 1981b). By the mid-1980s the literature was ripe with evidence supporting both viewpoints.

A decade after Postman's and Crowder's seemingly conclusive statements, McDaniel and Einstein (1986) demonstrated across five experiments that bizarre images may be more memorable than ordinary images but only under certain conditions. In their incidental learning tasks, subjects were asked to rate the vividness of mental images created for three underlined words that were embedded in sentences. The context of the sentence was either bizarre (e.g., "The <u>dog</u> rode the <u>bicycle</u> down the <u>street."</u>) or ordinary (e.g., "The <u>dog</u> chased the <u>bicycle</u> down the <u>street</u>.") On a surprise recall test, subjects recalled more words from sentences from bizarre contexts than words from ordinary contexts, but only when the list of sentences contained both bizarre and ordinary sentences (that is, a mixed design). The bizarreness effect occurred when the initial imagery task was self-paced or experimenter-paced, but did not appear on a recognition test. Kroll and Tu (1988) found a similar pattern of results on both an immediate and delayed recall test: Across six experiments, bizarre imagery improved memory only in a mixed list design. Many others have since found similar bizarreness effects in which bizarreness only improves memory in mixed list designs (Campos, Gómez-Juncal, & Pérez-Fabello, 2008; Macklin & McDaniel, 2005; McDaniel, Einstein, DeLosh, May & Brady, 1995). McDaniel and Einstein (1986) proposed the now largely accepted idea that bizarre imagery enhances memory in mixed lists designs because bizarre images are more distinct.

This prevailing explanation of the bizarreness effect is that bizarre images are easier to access but once accessed fail to provide a boost in the recovery of the information within that image. In McDaniel and Einstein's (1986) experiments, this meant that the bizarre contexts were recalled more than the ordinary contexts, but the individual words within the sentence were not recalled more. Kroll and Tu (1988) found similar evidence: On average, words in the bizarre sentences were recalled more, but the average number of underlined words recalled per sentence was higher in the ordinary sentences. The subject may have recalled that *something* odd was riding a bike *somewhere* but were unable to recall that it was a dog riding the bike down the street. It is generally thought that the bizarreness effect is therefore due to the retrievability of the image rather than the discriminability of the individual items within the image. Said another way, bizarre images help retrieve the image, but it is at the cost of recalling the specific items within the image.

When people use the method of loci, the mental path provides them with a retrieval strategy, or retrieval context. It is then up to the user to discriminate what object was placed in that location/context. The experiments by McDaniel and Einstein (1986) showed that when the context was given back to subjects in a recognition test, bizarre words were not recovered more frequently than non-bizarre words. It would be unlikely, then, that bizarre imagery in the context of the method of loci would be more memorable than ordinary imagery. There are similar findings with cued recall; Wollen and Cox (1981a) found an advantage of bizarre imagery on a free recall test, but not on a cued recall test.

While some early assumptions were made about the necessity of bizarre images in the method of loci, the majority of cognitive psychologists seemed to have dismissed this assumption. However, there has yet to be an empirical demonstration one way or the other. Over 40 years ago, the belief that bizarre imagery was a key ingredient was assumed among several researchers who were examining the method of loci, (Crovitz, 1971; Briggs, Hawkins, & Crovitz, 1970). At the same time, however, Gordon Bower concluded that the notion was “entirely negative” (Bower, 1970, p. 501). To support his evaluation, Bower (1970) described a series of 4 experiments relayed to him in a personal communication, yet the experiments he described appeared to only address the issue of whether bizarre images are more memorable than ordinary images, which we now know from the previous section depends on several additional factors such as list composition and the way in which memory for those images is tested. Bower's described experiments do not speak directly to whether or not bizarre images are more memorable in the context of the method of loci. Briggs, Hawkins, & Crovitz (1970) assumed bizarre imagery was critical and reported providing subjects with a location in capital letters followed by a description of a bizarre image. Yet it is unclear if they actually used bizarre imagery in their experiment and they did not provide any measure (objective or subjective) of bizarreness. Glancing at the images, some intuitively seem less bizarre than others (e.g., NURSERY. Picture the nursery children playing the game 'ring around the rosey'" versus "BOOK SHOP. Picture a tongue being used as a bookmark."). In perhaps the best controlled demonstration of the method of loci, Roediger (1980) dismisses the notion that bizarre imagery enhances memory in the method of loci and, like Bower (1970), cites work from classic imagery experiments (Wollen et al., 1972). However, he notes that there really is no empirical evidence one way or the other.

While much attention has been paid to the process of creating images, far less attention has been devoted to describing the ideal conditions for the locations. Yates (1966) described several recommendations, drawing primarily from *Ad Herennium*. The best locations are thought to be isolated, solitary, and free of people. Each location should be distinct from one another so the locations are not confused with one another (e.g., numerous identical columns in a temple). The locations should be well-lit and moderately-sized so that the images are identifiable. If the memory palace is too small, then images will be crowded; if the palace is too large than the images will be lost. German memory champion and journalist Florian Dellé, who has written numerous articles describing mnemonic techniques to beginners interested in competing themselves or just interested in learning the tricks of the trade, also provides some recommendations about the locations. In addition to the advice laid out in *Ad Herennium*, he advises people to use the first location that comes to mind when mentally traveling along the path. He also advises people to place images every 10 feet along the path and consistently move along the path in either a clockwise or counter-clockwise order (Dellé, n. d.).

There is no empirical research to confirm or reject these ideas about the locations, but the process of creating the path provides people with an organizational strategy that is used during encoding and retrieval. Decades of research in cognitive science has demonstrated that organized information is easier to remember than unorganized information (Jenkins and Russell, 1952; Bower, Clark, Lesgold, & Winzenz, 1969; Mandler, 1967). By placing items along an ordered set of locations, subjects are organizing the to-be-remembered items. Additionally, when subjects retrace the path during retrieval, they are possibly reinstating the original spatial context, which results in distinct cues during retrieval that match the cues during encoding (Tulving & Thomson, 1973). When subjects wish to recall the items, the predetermined familiar set of locations is as readily available to subjects as they were during encoding. Each location serves as a distinct retrieval cue to a particular item that provides subjects with a clear retrieval strategy (Bower, 1970). Therefore, the items placed in the locations are more accessible during recall (Groninger, 1971). Furthermore, because the locations are fixed and each item is associated to a location and not another item, forgetting one item should not disrupt the recall of other items (Roediger, 1980). The organization used in the method of loci may have particular mnemonic value because it makes use of spatial navigation, which likely played an important role in the evolution of our cognitive functions. Additionally, the method of loci may capitalize on people's superior navigation in the presence of familiar landmarks (Maguire, Burgess, & O'Keefe, 1999; Siegal & White, 1975; Ruddle, Payne, & Jones, 1997).

Empirical Evidence for the Method of Loci

In the previous section, I discussed how the method of loci is used, along with specific recommendations from people who have used it. When possible, I provided evidence from psychological research to support or dismiss these recommendations. The bulk of the experiments described, however, were not directly concerned with the method of loci, and specific comments that I cited were often not the topic of those researchers' experiments. More importantly, I have not established the effectiveness of the method of loci through empirical demonstrations. In this section I review the available empirical evidence in support of the effectiveness of the method of loci.

Although controlled experiments examining the method of loci are rare, the results can be quite impressive (Bower, 1970). In perhaps one of the earliest demonstrations of the method of loci, Ross and Lawrence (1968) taught five subjects a path with 52 locations that were later used across four successive days to learn 40 words that were viewed at the subjects' own pace (about 14 seconds per word). On an immediate recall test, subjects recalled on average 38 words; on a test a day later subjects recalled 34 of the 40 words. In one of the first experiments to compare the method of loci to a control condition, Roediger (1980) demonstrated that mnemonic techniques (imagery, the link method, peg-word method, and the method of loci) produced a mnemonic advantage relative to rehearsal. In particular, the method of loci and peg-word method were especially useful when the order of the items was important. Massen & Vaterrodt-Plünnecke (2006) replicated these findings with categorized lists and also showed that the locations can be reused with minimal proactive interference. Lee and Ewards (1981) demonstrated that students who used the method of loci remembered more than students who used verbal elaboration. De Beni and Cornoldi extended the basic findings with word lists to word triplets (e.g., *KEY-PARADE-FLY*); subjects recalled more word triplets using the method of loci compared to an image only control (De Beni & Cornoldi, 1985). The method has also been used often in combination with other techniques to improve memory in older adults (Verhaeghen & Kliegl, 2000; Yesavage & Rose, 1983). In a meta-analysis aimed at examining the effects of various mnemonic techniques on older adults, the method of loci was reported to have a Cohen's *d* of 0.80 [0.58, 1.02] (Verhaeghen, Marcoen, & Gosseens, 1992).

The basic procedures of the method of loci have largely remained unchanged for over two thousand years, but the mnemonic device does appear to be flexible in how it is used. For example, often people were asked to first memorize a set of locations, usually in a separate session (e.g., De Beni & Cornoldi, 1985; Roediger, 1980). However, this does not appear to be necessary. Crovitz (1969) provided subjects with a map of an imaginary street with various locations (e.g., "electric company," "gas station," "florist"). On a final recall test, subjects were given back the locations and recalled an average of 34 out of 40 words in the correct order. It is difficult to interpret the effectiveness of this method because the author reports that 2 of the 12 subjects missed 19 and 29 words, respectively. On one hand, the average number of words recalled may be near ceiling for the majority of subjects. On the other hand, it appears as though 10% of the subjects were unable to successfully use the method. Briggs, Hawkins, & Crovitz (1970) extended this idea and also provided subjects with the locations and images (e.g., "Electric company: picture a PLOW cutting an underground cable. The word is PLOW," "Gas station: Picture the attendant angrily driving a NAIL into your tire. The word is NAIL.") When given the locations and images by the experimenter, subjects recalled an average of 17 out of 20 words. This procedure has also been used with subjects as young as 9 and as old as 78 years old (Brehmer, Li, Muller, Oertzen, and Lindenberger, 2007; see also Lee & Edwards, 1981).

However, in all of these cases it is unknown how many words subjects in a self-generated condition might have recalled had such a condition existed. It is possible that recall performance may have been higher in a condition in which subjects created their own images.

Similarly, Legge, Madan, Ng, & Caplan (2012) used a computer-generated virtual reality environment in place of familiar locations. It is possible that people do not need to create their own locations, but there has yet to be enough controlled comparisons to make this claim. In addition, in their recent book, *Mnemonology: Mnemonics for the 21st Century*, Worthen and Hunt (2011) concluded that self-generated mnemonics (not specifically the method of loci) are more effective than other-generated mnemonics when the mnemonic is easier to use (Ironsmith & Lutz, 1996; Jamieson & Schimpf, 1980) but not when mnemonics are difficult such as the phonetic mnemonic system (Patton, D'Aaro, & Gaudette, 1991). Whether the method of loci is an easy to use mnemonic or a difficult mnemonic is up for debate.

Up until now, the method of loci has been described to remember simple one-word materials, typically objects. The method has also been used with complex materials. The mnemonic improved high school students' recall of lengthy passages compared to students who used rehearsal (Bellezza, 1981) and may be more beneficial when the text is heard out loud rather than read silently (Cornoldi & De Beni, 1991; De Beni, Moe, & Cornoldi, 1997; Moe & De Beni, 2005). Medical students who used the method of loci to learn about the endocrine system performed better on a final multiple choice test than did students who learned the same information in lecture format (Qureshi, Rizvi, Syed, Shahid, & Manzoor, 2014).

Up to this point, I described what the method of loci is and have shown that it was not only a popular tool among ancient orators, but that it also remains in use today as one of the foundational techniques used during memory competitions worldwide. I also discussed recommendations of how to use it and, when possible, discussed what the literature from cognitive science says about those recommendations. Finally, I reviewed the available literature concerning the method, which is rather limited. The present experiments will use the method of loci to answer questions concerning the mnemonic value of animacy and will also address some unresolved questions about the method of loci, specifically concerning bizarre imagery and the lack of a control condition for comparison.

Experiments

The following experiments were aimed at exploring the mnemonic effects of animacy in the method of loci – a context that provides people with a pre-existing organization structure. There are several reasons why the method of loci was used in the present experiments. As mentioned in a previous section, the primary reason is concerned with animacy. In the current experiment, the method provided a salient organizational strategy during encoding that was then available again during retrieval. As a result, the recall test was not a free recall test that relied on subjects' unique output strategy, but rather the test held the output strategy constant across subjects so that the recall test was primarily a measure of item-specific information. If these experiments used a typical free recall test, I would expect an effect of animacy such that animate words and images would be recalled more than inanimate words and images. However, the current experiment did not use a traditional free recall task. Instead, subjects were provided with an explicit output strategy that relied heavily on the encoding order. It is unclear whether the animacy effect would persist in such a context and, if so, whether the effect would be smaller relative to a control condition that did not rely on output order (e.g., making pleasantness ratings).

Furthermore, it could be argued that the animacy effect occurs not because animates are innately more memorable, but because they belong to the same category and therefore can be categorized at output. Despite researchers' best attempts to equate the animate and inanimate word pairs along various important cognitive dimensions including category size and instance, if the animacy effect is due to categorization during retrieval, an organizational strategy like the method of loci should eliminate the effect. I do not predict that the animacy effect is due to categorization during retrieval.

Finally, in the present experiments subjects associated images of words to specific locations, a task that may have similarities to a paired associate task. Animates may capture attention or be more memorable at the cost of the paired associate (as was the case with negative valence words in Madan et al., 2012). If this is the case, then the location associated with the animate image may have been forgotten resulting in worse performance for animate words because the mnemonic strategy would be unavailable during recall (i.e., the locations would not be available to cue the retrieval of the animate words).

A secondary reason for using the method of loci in the present experiment was to examine the method in controlled experiments. In the first experiment, the method of loci was compared to a control condition (pleasantness ratings) that is traditionally considered one of the best deep, encoding tasks (e.g., Packman & Battig, 1978). If the claims of memory champions are to be believed, then subjects who used the method of loci should vastly outperform subjects who did not.

EXPERIMENT 1

The primary goal of this experiment was to determine if the animacy effect existed in recall with a fixed or predetermined output order as in the method of loci, and if so, whether the effect was similar for the method of loci and the pleasantness control condition. Subjects learned a list of words; half of the words were animate and the other half were inanimate. These words were matched along 10 memory-relevant dimensions (see Nairne et al., 2013; VanArsdall et al., 2015). In one condition, subjects were taught to use the method of loci to memorize a list of words for a later free recall test. In an incidental learning control condition, subjects rated the pleasantness of each word – a task that draws attention to the unique characteristics of an item and is traditionally considered to be one of the best deep encoding tasks (e.g., Packman & Battig,1978). If this experiment was a typical free recall experiment, I would expect that memory for animate objects would be better than memory for inanimate objects because animate objects hold a privileged place in our adaptive memories. For this reason, I expected an animacy advantage in the pleasantness condition. However, the following experiment was unlike the free recall experiments in which adaptive memory is typically examined. Here, the method of loci provided subjects with an encoding and output strategy that emphasized the temporal order of the words. If animate objects increase memory for the animate item but reduce memory for order or the associated location, the mnemonic effects of animacy would be lessened or nonexistent in the method of loci condition relative to the pleasantness control condition. A second goal of Experiment 1 was to demonstrate the mnemonic superiority of the method of loci relative to a control. If the method of loci is truly a powerful mnemonic technique, then subjects who used the method of loci should recall more words than subjects who made pleasantness ratings.

Method

Subjects

One hundred and fifty-four subjects (94 female, 60 male) were recruited online via a Human Intelligence Task (HIT) posted on Amazon Mechanical Turk. An additional 27 subjects were tested and excluded from data analysis for the following reasons: 1 subject indicated cheating on the task, 9 subjects reported computer/user errors, and 16 did not comply with instructions during the method of loci task (9 subjects left more than 6 responses blank during study, 3 subjects retyped the word instead of creating an image, and 4 subjects were determined to be completely off task which included responding to words with memories from childhood or writing various locations across the world). Subjects were restricted to people who were located in the United States, had a 95% HIT acceptance rate, and had completed at least 1000 HITs. Demographic information (age, gender, native-language) was collected at the beginning of the study (see Table 1), and additional information about the workers' environment, whether they cheated, and computer specifications were collected in a post-experiment questionnaire. The mean age of the subjects was 36.7 years (*SD* = 12.13, range = 18-69). Subjects were paid $1.50 to complete the task, which lasted about 20 - 25 min.

Design

This experiment used a 2 (word type: animate, inanimate) x 2 (condition: method of loci, pleasantness) repeated measures design with word as a within-subjects factor and condition as a between subjects factor. There were 77 subjects in the pleasantness condition and 77 in the method of loci condition. Number of words recalled on an immediate recall test was the dependent variable.

Materials

A list of 30 words[1], of which 15 were animate and 15 were inanimate, were selected from Nairne et al. (2013; note that 6 additional words were added to the original 24 words to create a list of 30). The two sets of word types (animate and inanimate) were matched along 10 relevant dimensions: age of acquisition, category size, category typicality, concreteness, familiarity, imagery, written frequency, meaningfulness, number of letters, and

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[1] Due to a program error that occurred with the first 120 subjects, only 14 inanimate words appeared, resulting in a total of 29 words instead of the intended 30 words. The program error was fixed and an additional 17 subjects were then included in both the pleasantness and method of loci conditions for a total of 34 additional subjects. These additional 34 subjects who were shown all 30 words showed the same pattern of results as the original 120 subjects. Therefore, the results are reported with all 154 subjects.

relatedness. For additional information about these dimensions and a complete list of words, see Appendix C.

Procedure

After workers accepted the HIT, electronically signed the informed consent, and completed the demographic information, the experiment began. Subjects were randomly assigned to either the method of loci condition or the pleasantness ratings condition. All subjects then took a final recall test followed by a post-experiment questionnaire.

In the method of loci condition, the subjects were first given basic instructions. They were told they would learn a list of words by imagining placing items along a familiar path, such as a childhood home. On a later test, they would be asked to mentally retrace their steps to recall the items placed in each location. Subjects were also given examples of how the method of loci might be used to remember a couple practice words (e.g., “imagine that the PEACH is so large that it is blocking you from the driveway”). For the complete instructions used in Experiment 1, see Appendix D.

The to-be-remembered words were presented in a random order one at a time for each subject. After the presentation of each word, subjects typed in a box labeled “Location” the location where they imagined placing the word and typed in a box labeled “Image” a brief description of the image. The task was self-paced, and subjects spent on average 10.8 min in total for this task. After the final word was presented, subjects were asked to recall the words by mentally walking through their house and remembering the objects they placed there. Subjects were given 4 min for this task.

In the pleasantness condition, subjects rated the pleasantness of each word on a 5-point scale, with 1 being very offensive and 5 being very pleasant. Although the instructions for the pleasantness rating task did not explicitly mention a final recall test, the description for the HIT informed subjects that they would be asked to memorize a list of 30 words. The task was self-paced, and subjects spent an average of 2.5 min in total for this task. After the final word was rated, subjects were asked to recall as many of the words as they could in 4 min.

Results

Initial Method of Loci and Pleasantness Performance

A preliminary analysis eliminated subjects who did not appear to complete the method of loci task. To do this, I developed a list of minimum requirements for inclusion based on subjects' image and location responses. Subjects' were included if their responses: (1) have no more than 6 blanks, (2) consist of more than the retyped word and, perhaps most importantly, (3) contain locations rather than random memories associated with each item[2] or

[2] For example, for the word "journal" a subject wrote "during my college days" for the location and "me myself serving one among the editorial member of college journal" for the image; for the word "rake" the subject wrote "during trekking" for the location and "As bachelors we used to rake frequently for trekking and other adventurous activities" for the image.

free associations to the item that do not resemble anything like a path[3]. As stated in the previous section, 16 out of 77 people (9 of whom were eliminated for leaving more than 6 blanks) did not meet these criteria and were replaced. Subjects in the pleasantness condition were eliminated if they made the same rating for all words or left more than 6 ratings blank. This never happened.

A 2 X 2 mixed ANOVA was used (with condition as a between-subjects factor and word type as a within-subjects factor) to analyze the time subjects took to complete the pleasantness and method of loci tasks. Subjects took longer to complete the method of loci task than to make the pleasantness ratings, *M*s = 21.6 s vs 5.1 s per word, $F(1, 152) = 118.34$, $\eta^2 = .44$, $p < .001$. Reaction times for animate and inanimate words were similar, *M*s = 13.5 s vs 13.2, $F(1, 152) = 0.27$, $\eta^2 = .00$, $p = .61$. There was no interaction, $F(1, 152) = 0.39$, $\eta^2 = .00$, $p = .53$.

Recall Performance

Figure 1 shows the performance on the recall test. A 2 X 2 mixed ANOVA was used to analyze recall performance[4]. Overall, recall was higher in the method of loci condition, *M*s = .68 vs .38, $F(1, 152) = 99.30$, $\eta^2 = .40$, $p < .001$, which demonstrated that a brief period of instructions in the method of loci was sufficient to produce large mnemonic benefits. Additionally, animate

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[3] For example, for the word “violin” a subject wrote “concert” for the location and “Atlanta” for the image; for the word “soldier” the subject wrote “Afghanistan” for the location and “military” for the image.

[4] Due to the large range of subjects, age was entered as a covariate for all experiments, and the pattern of results was the same. Also an analysis with gender as a between subjects factor indicated that there were no differences between genders so the results have been collapsed across this variable.

words were recalled more than inanimate words, *M*s = .60 vs .45, $F(1, 152) = 124.60$, $\eta^2 = .45$, $p < .001$. This advantage for animate words was quite robust: Out of 154 subjects, 112 recalled more animate words than inanimate words, 24 recalled more inanimate than animate words, and 18 recalled the same amount of both words. However, these main effects were qualified by an interaction such that the animacy effect was smaller in the method of loci condition than in the pleasantness condition, $F(1, 152) = 18.89$, $p < 0.001$. A post-hoc analysis indicated that the animacy effect persisted both in the method of loci, $t(76) = 5.25$, $d = 0.60$ [0.35, 0.84] and pleasantness condition, $t(76) = 10.20$, $d = 1.16$[0.87, 1.45].

Reaction time data was not recorded for one subject in the method of loci condition, so the results are reported with 153 subjects. Because the method of loci provided subjects with an output strategy during retrieval (i.e., mentally retracing the path), it would be unsurprising if subjects spent less time per word during the recall in this condition. Indeed, this was the case: Subjects in the method of loci condition recalled words faster than did subjects in the pleasantness condition, $M = 9.2$ s vs 12.1 s per word, $t(152) = 3.71$, $d = 0.60$, 95% CI [0.27, 0.92].

Table 2 reports the average number of words recalled that were not on the list. The mean number of intrusions per subject was low for both groups, but overall, more intrusions occurred in the method of loci group (*M*s = 0.64 vs 0.47). Intrusions were further classified in two ways. First, when intruded words were a synonym of a list word (e.g. the subject recalled “dad” when the list word was “father,” or “diary” instead of “journal”), the intrusion was labeled as a “synonym.” When the intruded word had no clear similarity to a list word, it was labeled as “other intrusions.” This was done because synonyms were fairly common in the method of loci group relative to the pleasantness group (*M*s = 0.47 vs 0.12). This is likely because subjects recalled images rather than the exact word, per se. The total number of intrusions is therefore the sum of both the synonyms and intrusions. Because the primary concern of this experiment was the mnemonic value of animacy, intrusions were further classified as either animate or inanimate[5]. To use the previous example of a subject who intruded “dad,” this synonym would be further categorized as an animate, as would the intrusion “frog.” Overall, the pattern of synonyms follows the pattern of recall performance: More animate than inanimate synonyms for list words were recalled in both the method of loci group (*M*s = 0.35 vs 0.12) and pleasantness group (*M*s = 0.09 vs 0.03). It is unsurprising that the pattern of results with these synonyms mirrors the pattern of results with the list words, given that they can be considered as words that were *almost* correctly recalled, but not quite. The pattern was reversed for other intrusions: More inanimate intrusions were recalled than animate intrusions in both the method of loci group (*M*s = 0.12 vs. 0.05) and pleasantness group (*M*s = 0.23 vs 0.12).

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[5] Note that this analysis is independent of the within-subject independent variable because intrusions in a within-subjects design cannot be calculated along this variable.

Recall Output Order

I also analyzed the organization of subjects' recall responses. One goal was to measure whether subjects who used the method of loci relied on a temporal organization to recall the words. If the method of loci provided subjects with a temporal organization strategy during encoding and retrieval, then those subjects would likely have a higher-than-chance measure of temporal output order and also likely have a higher temporal measure than subjects in the pleasantness control condition. To measure temporal output order, I calculated input-output correspondence (Asch & Ebenholtz, 1962) and temporal factor (Polyn, Norman, & Kahana, 2009) for each subject. The Asch-Ebenholtz input-output correspondence was calculated in the following way: Imagine that a student recalled, in order, words 1, 2, 8, 6, and 3 from the list. If neighboring words are considered as pairs, then the student recalled four pairs (1-2, 2-8, 8-6, 6-3). In this case, two of the four pairs (1-2 and 2-8) show the correct sequence, resulting in an overall proportion of correctly ordered words of 0.50 (chance performance). The temporal factor described by Polyn et al. also measures output order but it provides a more general temporal order by taking into account the temporal order of not only immediate neighboring words but also other nearby words.

Overall, subjects who used the method of loci were more likely to recall the words in serial order relative to subjects who made pleasantness ratings. This was true when temporal order was measured using the Asch-Ebenholtz (1962) input output correspondence, *M*s = 0.63 vs. 0.46, $t(152) = 6.36$, $d =$

1.02, 95% CI [0.69, 1.36], and the Polyn et al. temporal factor measure, *M*s = 0.65 vs. 0.57, *t* (152) = 2.57, *d* = 0.42, 95% CI [0.09, 0.74]. This suggests that subjects in the method of loci condition relied on temporal order more than did subjects in the pleasantness condition, whose serial output scores were around chance.

These temporal measures also provided an opportunity to glimpse into whether subjects' who recalled more animate than inanimate words relied more or less on serial order. First, I calculated the difference between the number of inanimate words from the number of animate words subjects recalled. This served as a measure of the subjects' animacy effect. I then calculated the correlation of this difference with the subjects' temporal score to determine the extent to which subjects who recalled more animate words depended on serial order. A large negative correlation would mean that subjects who demonstrated a larger animacy effect depended less on serial order. While there was no significant difference in the correlations for each group individually, when combined across both groups, the difference scores were negatively correlated with the input-output scores, $r(151) = -.17$, $p = .03$, and a non-significant trend with the temporal factor, $r(151) = -.08$, $p = .35$. In combination with the interaction that was observed in the recall performance, these data suggest that using temporal order as an output strategy may decrease the animacy effect.

I also analyzed the semantic organization of subjects' recall responses. This is of particular interest because it is possible that the animacy effect occurs, at least in part, because subjects notice that animate words fall under a general category of “living things.” Knowing this category cue could then aid the retrieval of words in that category. If this were the case, I would expect subjects to cluster their recall around things with similar semantic features in both the method of loci and pleasantness conditions. To do this, I calculated the semantic factor for each subject. Semantic factor uses Latent Semantic Analysis (or LSA) to measure the relatedness of words. As with temporal factor, a semantic factor of .50 indicates chance semantic grouping Sederberg, Miller, Howard, & Kahana, 2010). The semantic factors for the method of loci and pleasantness conditions were not significantly different than chance (M = .50), M = .53, $t(75) = 1.14$, p =.26 and M =.51, $t(76) = 1.97$, p=.053 respectively, which indicates no semantic grouping in either condition. This is unsurprising in the method of loci condition because subjects were instructed to mentally retrace their steps through their memory palace during recall and the results of the previous temporal analyses indicate that, for the most part, subjects did recall in order. In addition, in both conditions the animate words were carefully selected to belong to a matched number of categories as the inanimate words. The semantic factor calculated here provides additional evidence that animate objects were memorable because they were animate objects, not because of their membership in a category.

Discussion

The results of Experiment 1 showed that the mnemonic advantage for animate words relative to inanimate words persisted when subjects used the method of loci which relied on order information. However, the animacy effect in the method of loci was smaller relative to the pleasantness control condition which did not rely on order. This may have occurred because animate objects are more memorable on an item-level at the cost of order information. The negative correlation between the difference scores and temporal output scores provide similar evidence: Subjects who had a larger animacy effect relied less on temporal order. The correlation was small and is not causal but shows the same pattern as the interaction between the animacy effect and condition (method of loci versus pleasantness ratings).

The results of Experiment 1 also highlight the mnemonic value of the method of loci. Overall, subjects who used the method of loci recalled almost twice as many words as subjects in the pleasantness condition (*M*s = .68 vs. .38). One subject who used the method of loci recalled all 30 words on the list. By contrast the highest scoring subject in the pleasantness condition recalled only 25 words. It is interesting to note that this high level of performance was achieved with minimal instructions. Given the range of training techniques and instructions provided to subjects in previous studies involving method of loci, it is useful to know that subjects can learn to use the method after only a brief period of instructions. The results of this experiment suggest that extensive training is not required in order to experience mnemonic benefits of the method of loci. Experiment 2 was carried out as a further investigation of animacy effects with the method of loci.

EXPERIMENT 2

In Experiment 1, animate words were remembered better than inanimate words, even when the words were used in an ordered task such as the method of loci. Do animate images show the same pattern? To borrow an example from Joshua Foer, does imagining the wine bottles as living beings, talking amongst themselves make the wine bottles more memorable? To examine this, subjects in Experiment 2 saw only inanimate words and were either given the same instructions for the method of loci as in Experiment 1 (the inanimate control condition) or they were explicitly told to create animate images (e.g., “is laughing”) of the otherwise inanimate objects (e.g., “coin”). It is noteworthy that by doing this, subjects in both conditions viewed the exact same stimuli. The difference, then, was in how the words were processed (as animates or inanimates). Because the animacy manipulation occurred in the instructions, the most straightforward approach was to use a between-subjects design. This allowed me to keep all other aspects of Experiment 2 the same. That is, subjects were given one set of instructions at the onset of the experiment and they were uninterrupted while they created their memory palaces. I predicted Joshua Foer and other memory athletes were correct: creating animate images would produce a memory boost. Therefore, I predicted that subjects who created animate images would recall more words than subjects who did not create animate images.

Method

Subjects

One hundred and twenty subjects (52 female, 62 male, and 6 people who did not identify their gender) were recruited online via a Human Intelligence Task (HIT) posted on Amazon Mechanical Turk. An additional 6 subjects were tested and excluded for the following reasons: 1 subject completed the experiment on a smartphone, 3 subjects reported computer/user errors, and 2 subjects were determined to be completely off task which included responding to words with memories from childhood or writing various locations across the world. None of the subjects in Experiment 2 had participated in Experiment 1. The mean age of the subjects was 33.9 years (*SD* = 10.0, range = 20-74). The demographic information collection, post survey questionnaire, and worker restrictions used in Experiment 2 were the same as Experiment 1 (see Table 1). Subjects were paid $2.00 to complete the task, which lasted about 20 – 25 min.

Design

This experiment used a between-subjects design with two conditions: animate and inanimate imagery. There were 60 subjects in each condition. The number of words recalled on an immediate recall test was the dependent variable.

Materials

Thirty unrelated, inanimate nouns (e.g., “coin,” “diamond”) were drawn from the extended Pavio norms (Clark & Pavio, 2004). All words were between three and seven letters long and were high in concreteness (M = 6.90), familiarity (M = 6.13), and imagery (M = 6.54). For a list of words used in Experiment 2, see Appendix C.

Procedure

The method of loci procedure from Experiment 1 was the same in Experiment 2 with the exception that subjects in the animacy condition were specifically told to imagine that the objects were alive. As in Experiment 1, subjects were given two examples. In the inanimate condition the examples were the same as Experiment 1 (e.g., “imagine that the PEACH is so large that it is blocking you from the driveway”). However, in the animate condition the examples included features of animate objects (e.g., “imagine that the PEACH is angrily trying to block you from the driveway”). Subjects spent an average of 13.2 min in total for this task. Subjects were then given 4 min to recall the words.

Results

Initial Method of Loci Performance

Using the same criteria as Experiment 1, 2 out of 120 subjects were eliminated for freely associating random locations or memories rather than creating a path. Reaction times for animate and inanimate images were similar, Ms = 28.3 vs. 24.5 ms per word, $t(118) = 1.17$, $d = 0.21$, 95% CI [-0.15, 0.57].

Categorization of Animate Responses: How do Subjects Conceptualize Animacy?

In this experiment subjects were asked to animate inanimate objects. It is therefore interesting to examine how subjects conceptualized animacy. What characteristics did subjects assign to the inanimate objects in order to animate them? Did subjects imagine the objects as self-propelled and with intentions? To do this, I determined whether certain animate characteristics were present in the images. The initial inspiration for these characteristics was drawn from the literature concerned with defining animacy, but I also created additional characteristics that did not easily fit into any previously nominalized characteristic of animacy. Each image response often had multiple characteristics. For example "playing a tuba" is an example of both self-generated movement and human-like behavior.

The top of Table 3 shows the animate characteristics that were given to animate the objects in order of most frequent to least frequent. The second column from the right also shows the proportion of responses that included a given characteristic. For example, the most common characteristic was self-generated movement: The proportion of animate images that included self-generated movement was 0.26. This means that about 1 out of every 4 images included this characteristic. Responses ranged from short one-word answers with only one animate characteristic such as "hiding" (in this case the animate characteristic is planning or pursuing a goal) to up to 5 characteristics in one response such as "On my bed, is a piece of burnt toast, with a scowling face, thrashing around trying to get to sleep on my bed." In this second case the animate characteristics include self-generated movement (thrashing around), human-like behavior/emotions (scowling), has a face, and has a goal (trying to sleep).

Recall Performance

Figure 2 shows performance on the immediate recall test. Overall, there was no clear benefit for processing words as animates over processing words as inanimates, *M*s = 0.68 vs 0.67, $t(118) = 0.33$, $d = 0.06$, 95% CI [-0.30, 0.42]. Reaction time data did not save for three subjects, so the results are reported with 117 subjects. Reaction times for animate and inanimate words were almost identical, *M*s = 9.7 vs. 9.6 s per word, $t(115) = 0.003$, $d = 0.00$, 95% CI [-0.36, 0.37].

Table 4 reports the average number of words that were recalled that were not on the list. All of the intrusions were inanimate objects. The mean number of intrusions per subject was low for both groups, but overall more intrusions occurred in the animate group than inanimate group (*M*s = 0.70 vs 0.55). Intrusions were again further classified into synonyms and other intrusions as in Experiment 1. Overall, the pattern of synonyms followed the pattern of recall performance: There was no difference between the number of synonyms recalled in the animate group compared to the inanimate group (*M*s = 0.35 vs 0.32). The pattern was similar for other intrusions: Although very small, subjects in the animate group intruded slightly more than subjects in the inanimate group (*M*s = 0.35 vs 0.23).

Recall Output Order

The overall input-output correspondence and temporal factor in Experiment 2 were similar as Experiment 1 for both the animate and the inanimate conditions, (Input-output correspondence, *M*s = 0.60 vs. .64; temporal factor, 0.67 vs. 0.68) which demonstrated that subjects were relying on some sort of temporal organization during retrieval. The semantic factor was around chance for both the animate and inanimate conditions, $M = .54$, $t(59) = 3.05$, $p = .003$ and $M = .54$, $t(59) = 4.96$, $p = .000$, indicating that subjects may have relied on semantic categories during recall.

Despite the instructions to animate the objects, not every image explicitly included animate characteristics. These responses were also coded and are represented in the bottom half of Table 3. It is interesting to note that a large proportion of responses did not explicitly include animate characteristics (38%). Of the 60 subjects in the animate condition, 17 did not include any animate characteristics in their responses. Therefore, their responses make up 14% of the 38% of inanimate responses which means that the remaining 21% percent of inanimate responses were from subjects who included a mix of animate and inanimate characteristics. It is difficult to know in these cases whether the animacy of the objects was implied in the subjects' minds or whether the objects remained truly inanimate. For example, a subject wrote, "coffee spilling on the floor." It is unclear what the cause of the spill is here. The coffee may have revolted against the mug and may be escaping to the floor or the coffee pot may have been unattended resulting in coffee dripping from a pot into an overflowing mug and onto the floor. It is not possible to know from the brief descriptions. For this reason, I included all responses from subjects regardless of their inanimate characteristics.

Additionally, an exploratory analysis was done to determine whether certain animate characteristics resulted in higher recall. It is possible that certain characteristics are stronger markers of animacy than other characteristics (such as self-generated movement) which may lead to higher levels of recall. The far right column of Table 3 shows the recall performance for words that were given the associated animate characteristics. Generally, the recall performance was consistent across characteristics, both animate and inanimate: Certain animate characteristics did not produce greater or worse memory for the associated word. I hesitate to draw strong conclusions about the recallability of certain animate characteristics because of the exploratory and conditional nature of this analysis (and the ambiguity of the actual image the subject created as in the case of the spilled coffee). It is possible that certain characteristics such as self-generated movement and pursuing a goal may be more memorable than other characteristics such as growing.

In addition to analyzing the type of characteristic, another analysis was aimed at exploring recall differences based on the number of characteristics. Perhaps the animate words in Experiment 1 readily brought to mind an array of animate characteristics whereas the images subjects created in Experiment 2 could bring to mind only a limited number of characteristics. For example, for the animate word “judge,” there is an array of animate characteristics that could easily come to mind. We know that judges can walk on their own, use language, have emotions, have faces, were once children (and therefore grow), have wishes, and desires, etc. When subjects are tasked with animating a word with only a single phrase, such as “bouncing on the walls,” the number of animate characteristics – and inferences about what that object may do – is limited. In this example, perhaps the only animate characteristic is self-generated movement. Likewise, the phrase mentioned previously about the thrashing burnt toast contains 5 characteristics. In the present experiment, a logistic regression analysis was used to predict recall using the number of animate characteristics associated with each word as predictors. The number of characteristics was not a significant predictor (chi squared = 0.82, $p = .37$ with $df = 1$). The EXP(B) value indicated that for every additional animate characteristic subjects included, subjects were no more likely to recall the associated word, EXP(B) = 0.92, or 0.92 times as likely. As with the type of animate characteristic, the number of characteristics may be related to an item’s recallability, but these differences are not detectable under the conditions of this experiment.

Bizarre and Imagery Ratings

In this experiment subjects were asked to take inanimate objects and either transform them into animate objects or keep them inanimate. In the first situation, it is reasonable to expect that the resulting image would be more bizarre or difficult to imagine. In typical free recall experiments, bizarre imagers are more memorable than ordinary images, but only in mixed list designs.

To obtain bizarreness and imagery ratings, 52 Mechanical Turk workers who had not participated in Experiment 2 rated how normal or bizarre the images were; 52 different subjects rated how difficult or easy it was to create an image of the word-image pairs. Because the current experiment was between subjects, half of the subjects in each group rated the images from the animate condition and the other half rated images from the inanimate conditions. Rating all possible word and image combinations (3600 images in total) was not practical so a random subset of 50 of the pairs was selected for each subject. Subjects saw the word and image phrase (e.g., “DOLLAR: Resting and snoring”) and were asked to rate how bizarre each image was on a scale of 1-5 where 1 was very normal and 5 was very bizarre. Subjects who made imagery ratings were asked to rate how difficult or easy it was to create an image in which 1 was very difficult to image and 5 was very easy to image. Ratings were self-paced and subjects were instructed to make the ratings based only on the image and not on grammatical errors.

As expected, the images created in the animate condition were rated as more bizarre than the images created in the inanimate condition, *M*s = 3.28 vs. 2.63, $t(50) = 6.38$, $d = 1.77$ 95%CI [1.12, 2.41]. Animate images were also rated as more difficult to image than the images created in the inanimate condition, *M*s = 2.88 vs. 3.62, $t(50) = 5.90$, $d = 1.70$ 95%CI [1.04, 2.35]. This is unsurprising given that bizarre images tend to be more difficult to imagine (McDaniel & Einstein, 1986).

Discussion

When subjects were asked to process objects as either animate or inanimate in a between-subjects design, there was no animacy effect. There are several possible explanations for why this may be the case. The first possibility is that animacy effects are only found with animate and inanimate words. VanArsdall et al. (2013) demonstrated the animacy effect with nonwords that were paired with phrase. In that case, nonwords had no prior characteristics, animate or inanimate. In the current experiment, all words were inanimate and half of the subjects were asked to add animate characteristics to inanimate words. Perhaps the inanimate characteristics of the words cannot be "overridden" with animate images. This seems unlikely given the pervasiveness of animated inanimate objects in everyday life (e.g., the examples from earlier such as Mrs. Pots from *Beauty and the Beast*). A related possible explanation is that this task was too difficult for subjects to do. Perhaps it was too difficult to create both 30 unique locations and also 30 examples of animate images. Possible evidence for this is that 38% of images did not explicitly contain animate imagery. In Experiment 3, I avoided this by providing subjects with the images. A third possible explanation is that the animacy effect does not appear in between-subjects designs. To my knowledge, there have been no between-subjects manipulations of animacy. In Experiment 3, I returned to a within-subjects design.

In Experiment 2, subjects were asked to create animate images of inanimate objects, resulting in a rather large list of animate images. These images provide a starting point for an empirical classification system of animate characteristics. Of particular interest was the frequency with which subjects attributed animacy to objects by including self-generated movement. Self-generated movement is generally considered one of the primary dynamic cues of animacy and may be the characteristic that comes to mind most easily. At this point, any conclusions based on this experiment are speculation. Additional, controlled experiments aimed specifically at examining this issue are needed.

This experiment also provided additional information about the method of loci. As in Experiment 1, the method of loci was an effective mnemonic strategy despite minimal instructions. With no extensive training on the method or additional study, subjects recalled on average 20 out of 30 words. The results from Experiment 2 also shed light on existing speculation regarding the use of bizarre images in the method of loci. Frequent users of the method often promote creating bizarre images to facilitate later recall, yet this experiment suggests that turning every image on a list into a bizarre one will not provide a mnemonic benefit.

Experiment 3 was designed to continue investigating the mnemonic effects of animate images of inanimate words using the method of loci. In this experiment, images were provided to subjects and were presented in a mixed list resulting in a within-subjects design. Providing subjects with the images also ensured that animate words truly were processed as animates.

EXPERIMENT 3

In the second experiment, the task of animating objects was up to the subjects and was carried out in a between-subjects design to keep the task straightforward and the instructions consistent for each subject (i.e., subjects either received the special instructions to animate the objects or they did not). However, 38% of the images subjects created in the animate condition did not explicitly contain animate characteristics. Although these words were not recalled any differently than images that did explicitly contain animate characteristics, a goal of Experiment 3 was to remove this ambiguity by pairing words with predetermined images that were either animate or inanimate. By providing subjects with the images, I was also able to reintroduce a within subjects design. In the current experiment, subjects were again instructed to mentally place the target words along a path such as a childhood home. However, unlike the previous experiments, I provided the images, half of which were animate (e.g., “playing tennis”) and half of which were inanimate (e.g., “made of wood”). Subjects were told to imagine the object and create a location for it along their path. I predicted that providing subjects with images that are clearly either animate or inanimate and returning to a within subjects design would produce an animacy effect.

Method

Subjects

Sixty subjects (32 female, 24 male, and 4 people who did not identify their gender) were recruited online via a Human Intelligence Task (HIT) posted on Amazon Mechanical Turk. An additional 2 subjects were tested and excluded from the experiment because 1 subject reported computer/user errors, and 1 subject was determined to be completely off task, which included freely associating words to writing various locations across the world. None of the subjects in Experiment 3 had participated in either Experiment 1 or 2. The mean age of the subjects was 36.9 years (*SD* = 11.6, range = 19 - 65). The same demographic information collection, post survey questionnaire and worker restrictions from Experiments 1 and 2 applied in Experiment 3 (see Table 1). Subjects were paid $2.00 to complete the task, which lasted about 25 min.

Design

This experiment used a within-subjects design with two conditions: animate and inanimate imagery. Half of the words from the list were paired with animate images (e.g., “playing tennis”) and the other half were paired with inanimate images (e.g., “made of wood”). Image and word pairings were counterbalanced such that each word was paired with an animate image in one version and an inanimate image in another. The number of words recalled on an immediate recall test was the dependent variable.

Materials

The same words in Experiment 2 were used in Experiment 3 with 4 exceptions: The words *apple, flower, lemon,* and *potato* were removed because, although not animate, they are living things. The replacement words were also drawn from the extended Pavio norms (Clark & Pavio, 2004). All words were between three and seven letters long and were high in concreteness (M = 6.90), familiarity (M = 6.13), and imagery (M = 6.54). For a list of words and images used in Experiment 3, see Appendix C.

Procedure

The method of loci procedure of Experiment 1 was the same in Experiment 3 with the main exception that subjects were given an image rather than creating one themselves. In addition, Experiment 3 instructions were modified to reduce the number of people who did not create a clear path. Also, pilot data suggested that recall performance and output order were quite low when subjects were instructed to write only the locations of the images along their path. These pilot subjects reported focusing on identifying 30 locations in their house rather than imagining placing the objects in those locations. Therefore, the instructions in Experiment 3 were modified to emphasize that the goal of the task was to imagine the given object interacting with the subjects' chosen location. The instructions also emphasized the importance of creating a path. See Appendix D for the complete instructions. Subjects spent on average 9.0 min in total for this task. Subjects were then given 4 min to recall the words.

Results

Initial Method of Loci Performance

Reaction times for animate and inanimate words were similar, *M*s = 9.3 s vs. 8.8 s per word, $t(59) = 1.79$, $d = 0.23$, 95% CI [-0.03, 0.49].

Recall Performance

Figure 3 shows performance on the immediate recall test. Overall, there was a numerical benefit for processing words as animates over processing words as inanimates, *M*s = 0.50 vs 0.46, $t(59) = 1.54$, $d = 0.20$, 95% CI [-0.06, 0.45], although this was not statistically significant.

All the intrusions, except for 2 words, were inanimate objects. The mean number of intrusions was higher in this experiment ($M = 1.03$ intrusions per subjects), but it was rare that subjects recalled a synonym of a word in place of the actual word ($M = 0.08$ words per subject).

As in Experiment 2, another analysis was aimed at exploring recall differences based on the number of animate characteristics of the images. However, in the present experiment each subject did not create their own animate images, but rather all subjects viewed the same 30 images, 15 of which were animate. In the absence of a standardized norm of animate characteristics, I used the same category of characteristics that were present in the 1800 responses in Experiment 2 (listed in Table 2) to quantify the number of animate characteristics of the images in Experiment 3. I then correlated the average recall for the words associated with the 15 animate images with the number of characteristics of the images. An increase in number of categories was associated with an increase in recall performance, but the result was not significant *r*(14) = .23, *p* = .40.

Recall Output Order

The overall input-output correspondence and temporal factor in Experiment 3 were similar as previous experiments, (*M*s = 0.68, 0.65, respectively) which demonstrate that subjects were indeed relying on some sort of temporal organization during retrieval. The within-subject design allowed me to perform an analysis similar to Experiment 1 to determine whether subjects who recalled more animate than inanimate words relied more or less on serial order. A large negative correlation between the subjects' difference scores and temporal scores would mean that subjects who demonstrated a larger animacy effect depended less on serial order. As in previous experiments, there were nonsignificant negative correlations with the Asch-Ebenholtz input-output correlation, *r*(59)= -.24, *p* = .07 and the Polyn temporal factor, *r*(59) = -.18, *p* = .18. In combination with results from Experiment 1, these data suggest that using a temporal order may decrease the animacy effect. As in previous experiments, the semantic factor was not statistically different than chance, *M* = .48, *t*(59) = 0.97, *p* = .34, indicating that subjects likely did not rely on animacy as a category cue during recall.

Bizarre Ratings

In Experiment 2 subjects created their own animate images which were later rated as more bizarre and more difficult to imagine than inanimate images. In the current Experiment, I created fixed images for subjects. To assess how bizarre and easy to imagine the images were, 60 subjects who had not participated in Experiment 3 rated the bizarreness of the word-image pairs and a separate 60 subjects rated the imagability of the word pairs. Each subject rated all 30 words from either counterbalanced version. The rating procedures were identical to Experiment 2. In typical free recall experiments, bizarre images are more memorable than ordinary images, but only in mixed list designs. However, in this experiment subjects were given a retrieval strategy during encoding and retrieval and the subject was tasked with retrieving the specific item. The prevailing explanation for the bizarreness effect is that bizarre images enhance the retrievability of the specific item but not the accessibility or discriminability of the individual items within the image (McDaniel & Einstein, 1986). If that is the case, then it would be surprising if bizarreness affected recallability of the words within the method of loci.

As in Experiment 2, the images created in the animate condition were rated as more bizarre than the images created in the inanimate condition, *M*s = 3.83 vs. 2.89, $t(59) = 7.37$, $d = 0.95$, 95%CI [0.64, 1.25]. The reverse pattern was found for imagery ratings: The animate images were rated as more difficult to imagine than the images in the inanimate condition, *M*s = 2.57 vs. 3.76, $t(59) = 11.12$, $d = 1.43$ 95%CI [1.07, 1.79].

Discussion

In Experiment 3 subjects were given a mixed list of animate and inanimate descriptions of objects and were asked to use the method of loci to place the objects. In this within-subjects design, subjects recalled numerically more words associated with animate images than words associated with inanimate images, yet this difference was not statistically significant. When imagery was used to manipulate animacy, the animacy effect persisted. This experiment also provides additional evidence that the animacy effect may be decreased when subjects' encoding strategy is restricted. Correlations between subjects' difference scores and output order were negative which suggests that subjects who relied more on a temporal output order during retrieval had a smaller animacy effect.

Objects associated with more animate characteristics may be more memorable than objects associated with less animate characteristics, but these differences were not detectable in this experiment, nor was this experiment designed to detect such a difference. However, the results of the current experiment trend in that direction. In fact, the phrase associated with the highest recall ("crying because she is lonely") had the highest number of animate characteristics (4) and the phrase associated with the lowest recall ("running in circles") had only 1 characteristic.

The bizarre and imagery ratings from Experiment 3 replicated the pattern found in Experiment 2. On one hand, bizarre images are typically recalled more than ordinary objects in a mixed-list, free recall design. On the other hand, imagability is another dimension that is considered one of best predictors of recall performance (Rubin and Friendly, 1986). In the present experiment, animate objects were both more bizarre and more difficult to imagine.

The results of Experiment 3 also allow for a brief comment about the method of loci as a mnemonic tool. Looking across the free recall data from all three experiments, the method of loci was less effective when subjects were given the images and only asked to create locations. It is possible that part of the benefit of the method of loci comes from creating images of the to-be-remembered words.

Thus far, I have reported one experiment (Experiment 1) that demonstrated the potent value of animacy as a mnemonic variable and two experiments that provided weak evidence (Experiment 3) to no evidence (Experiment 2) of the mnemonic value of pairing inanimate words with animate images. Across these experiments, I have examined word type (animate vs. inanimate) without directly stating the type of image that should be created, and I have examined image type (animate vs. inanimate) with only inanimate words. Experiment 4 was carried out as a further investigation of the animate/inanimate word-image conditions previously used and also included a fourth condition (animate words paired with inanimate images) that has not yet been tested.

EXPERIMENT 4

In Experiment 4, I first sought to conceptually replicate the effect of animate words found in Experiment 1 and the smaller effect of animate images found in Experiment 3. In addition, the previous experiments (Experiments 2 and 3) were concerned with the mnemonic benefits of *adding* animate characteristics to inanimate words. In Experiment 4, I added a condition to examine the mnemonic effects of *removing* animate characteristics from animate words (see Figure 4 for an example from each condition). Specifically, in this condition I paired animate words with inanimate images. Thus in Experiment 4, I factorially crossed word type (animate vs. inanimate) with image type (animate vs. inanimate). The procedure was identical to Experiment 3: I provided subjects with images, half of which were animate and half of which were inanimate. In contrast to Experiment 3, half of the associated words were animate words and the other half were inanimate words. Subjects were again told to image the word and associated characteristic and to imagine placing the image along a path. Based on the results from the previous experiments, I predicted a main effect of word and image type such that more animate words and words that were paired with animate images would be recalled than inanimate words and words paired with inanimate images. However, based on the results of Experiment 3, I predicted that the effect of image type would be smaller than the effect of word type.

Method

Subjects

To determine the number of subjects, I performed a power analysis[6] with the effect size from Experiment 3. Two hundred subjects (117 female, 77 male, and 6 people who did not identify their gender/reported “other”) were recruited online via a Human Intelligence Task (HIT) posted on Amazon Mechanical Turk. An additional 33 subjects were tested and excluded for the following reasons: 2 subjects indicated cheating on the task, 1 subject left more than 6 study response blank, 3 indicated using a smartphone, 9 subjects reported computer/user errors, and 18 did not comply with instructions during the method of loci task (1 subject retyped the word instead of creating an image, 16 subjects were determined to be completely off task which included responding to words with various locations across the world or putting all of the words in the same location, and 1 subject reported being distracted by the TV during the experiment and failed to understand the instructions). None of the subjects in Experiment 4 had participated in the previous experiments. The mean age of the subjects was 35.0 years (*SD* = 10.8, range = 19 - 67). The same demographic information collection, post survey questionnaire and worker restrictions from previous experiments were used (see Table 1).

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[6] Experiment 3 was chosen for the power analysis here because Experiment 4 contains a direct replication of Experiment 3.

Design

A 2 (word type: animate vs. inanimate) X 2 (image type: animate vs. inanimate) within-subjects design was used. Half of the words from the list were paired with animate images (e.g., “trying to escape”) and the other half were paired with inanimate images (e.g., “made of chocolate”). In addition, half of the words were animate (e.g., “father”) and half were inanimate (e.g., “kite”). There were 7 words in each of the 4 word-image conditions: (a) animate-word/animate-image, (b) animate-word/inanimate-image, (c) inanimate-word/animate-image, and (d) inanimate-word/inanimate-image. (See Figure 4 for the design and an example word-image pair for each condition.) Image and word pairings were counterbalanced such that each word was paired with an animate image in one counterbalance version and an inanimate image in another. The number of words recalled on an immediate recall test was the dependent variable.

Materials

Twenty-eight of the 30 words used in Experiment 1 were selected for Experiment 4. This was done to create an equal number of words per condition. For a list of words and images used in Experiment 4, see Appendix C. Prior to Experiment 4, several pilot studies were done to create a set of materials that had more similar bizarreness and imagery ratings than in Experiment 3. The rating results from the 40 subjects who rated the bizarreness (20 per version) and the 40 subjects who rated the imagery (20 per version) are reported in Table 5.

Procedure

The procedure was identical to Experiment 3 with the exception that the materials were different. Subjects spent on average 7.9 min in total for this task. Subjects were given 4 min to recall the words.

Results

Initial Method of Loci Performance

A 2 X 2 repeated measures ANOVA was used to analyze the reaction time. Subjects were faster at creating the location for animate words relative to inanimate words, *M*s = 16290 vs 17417, $F(1, 196) = 4.03$, $\eta^2 = .02$, $p = .05$. Reaction times for animate and inanimate images were almost the same, *M*s = 16.4 s vs 17.2 s, $F(1, 196) = 1.21$, $\eta^2 = .01$, $p = .27$. There was no interaction, $F(1, 196) = 1.10$, $\eta^2 = .01$, $p = .30$.

Final Recall Performance

Figure 5 shows the performance on the immediate recall test. A 2 X 2 repeated measures ANOVA was used to analyze recall performance. Overall there was a main effect of word type, *M*s = .54 vs .48, $F(1, 199) = 21.27$, $\eta^2 = .10$, $p < .001$, and image type, *M*s = .52 vs .49, $F(1, 199) = 7.31$, $\eta^2 = .04$, $p = .007$, such that animate images were recalled better than inanimate images. There was no interaction, $F(1, 199) = 0.20$, $\eta^2 = .00$, $p = .66$, indicating that the effect of animate images did not differ when the images were paired with animate words versus inanimate words.

Table 6 reports the average number of words recalled that were not on the list. The mean number of intrusions was higher in Experiment 4 (*M* = 1.42

intrusions per subject) than in previous experiments. More inanimate words were intruded than animate words, *M* = 0.90 vs. *M* = 0.54. The majority of intrusions were images (e.g., the subject recalled "chocolate") most of which were inanimate images, *M* = 0.55, whereas less were animate images, *M* = 0.06. Intrusions were further classified as synonyms of target words. Overall, the pattern of these synonym intrusions followed the pattern of recall performance: More animate synonyms were intruded than inanimate synonyms, *M* = 0.18 vs. 0.10, and more synonyms associated with animate images were intruded than synonyms associated with inanimate phrases, *M* = 0.17 vs. *M* = 0.11). In sum the higher intrusion rates in Experiment 4 were likely due to a large number of image intrusions, the majority of which were unexpectedly inanimate intrusions. Unsurprisingly, the intrusion pattern of synonyms of target words followed the same pattern as the target word recall performance.

Recall differences were again examined based on the number of animate characteristics, collapsed across word type, of the images with a correlation. However in this experiment, there was no relation between recall and number of characteristics. If anything, an increase in number of categories was associated with a slight *decrease* in recall performance, $r(13) = -.15$, $p = .61$.

Bizarre/Imagery Ratings

The words and images used in Experiment 4 were rated in advance to equate bizarreness and imagery across conditions. However, because there were still small differences across conditions, these variables were correlated with the average recall score for each word-image pair. There was a weak, non-significant correlation between bizarre ratings and recall such that word-image pairs that were rated as more bizarre were recalled less than words that were rated as ordinary, $r(54) = -0.06$, $p = .65$. There was also a negative, yet insignificant, correlation between image ratings and recall such that word-image pairs that were rated as easier to image were recalled more than words that were more difficult to image, $r(54) = -0.15$, $p = .26$. Bizarre imagery was not associated with higher recall performance.

Recall Output Order

The overall input-output correspondence and temporal factor in Experiment 4 were similar as previous experiments, (*M*s = 0.66, 0.69) which demonstrates that subjects were indeed relying on some sort of temporal organization during retrieval. While there were no significant correlations between the difference between animate and inanimate recall scores and the output orders, there was a consistent negative trend for both words (Asch-Ebenholtz: $r = -0.05$, $p = .16$; Temporal Factor: -0.05, $p = .15$) and images (Asch-Ebenholt: $r = -0.09$, $p = .19$ Temporal Factor: -0.12, $p = .08$). In combination with results from Experiments 1 and 3, these data suggest that using a temporal order may decrease the animacy effect, although this was a very small effect. As in the previous experiments, the semantic factor was at chance, $M = .50$, $t(196) = .353$, p = .73, indicating subjects did not cluster their recall responses based on semantic relatedness.

Discussion

The results of Experiment 4 replicate the findings from Experiment 3 with inanimate words and extended the findings to include animate words. In Experiment 4 subjects used the method of loci to learn a mixed list of animate and inanimate words that were paired with either animate or inanimate images. Subjects recalled more animate than inanimate words and recalled more words that were paired with animate images than with inanimate images.

The results showed that manipulating the animacy of target words produced a larger animacy effect than did manipulating the animacy of images. When subjects processed an animate object as something that was inanimate (e.g., “A minister sketched in pencil hangs over the doorway”) the animacy characteristics still persisted. These objects were remembered just as well, numerically even a bit better, than inanimate objects that acted like animates (e.g., “The drum dances to its own beat in the shower”).

There was no obvious relationship between the number of animate characteristics associated with each phrase and the recallability of the words paired with those phrases. In fact, the phrase associated with the highest recall (“trying to escape”) only had 1 animate characteristic whereas the phrase associated with the lowest and second lowest recall (“dancing to music” and “singing a song”) had 2 and 3 characteristics, respectively.

These data also provide additional insights into the usefulness of the method of loci as a mnemonic device. The results provide support for the idea expressed in Experiment 3 that the method of loci is more effective when people create their own images than when people are given images. In Experiment 4, subjects recalled on average 51% (roughly 14 out of 28) words whereas in Experiment 1, in which subjects were to create images however they chose, subjects who used the method of loci recalled 68% (roughly 20 out of 30) words. In addition to lower levels of recall performance, subjects in Experiment 4 had higher intrusion rates and reported that it was difficult to keep the images and words straight or that they focused too much on creating location. One subject said, “I can remember something was writing a novel at the kitchen table but not what exactly. Maybe it was a dove?” (It was not). Here the subject successfully recalled part of the image (“writing a novel”), but failed to remember the rest of the image (the target word “pencil”). Another subject reported a similar confusion that was caused by the images, “I think if it wasn't for the phrases, I would've been able to remember many more words.” Another concluded, “If I do this type of thing again, I will ignore any given extra info and only concentrate on word I need to remember and create images I need by myself.”

GENERAL DISCUSSION

The reported experiments used the method of loci to explore the mnemonic effects of animacy. The method of loci provided a salient organizational strategy during encoding that was available again during retrieval. As a result, output strategy was held constant across subjects so that the recall test was a relatively pure measure of item information. In Experiment 1, memory for animate and inanimate words was tested in either the method of loci or a pleasantness ratings control condition. Subjects learned a list of words; half of the words were animate and the other half were inanimate. Subjects in both conditions recalled more animate than inanimate words. However, the animacy effect in the method of loci was smaller relative to the pleasantness condition. These results demonstrated that the animacy effect was smaller when subjects were given an ordered encoding and retrieval structure, but animacy is still a potent variable in memory. In addition, subjects in the method of loci condition recalled more words than did subjects in the pleasantness control condition. Note the magnitude of this effect was rather large, d = 1.60, 95%CI [1.24, 1.97].

Experiment 2 was designed to test whether the animacy effect persisted when inanimate words were imagined as animate. All subjects were given a list of inanimate words. In the animate condition, subjects were told to imagine the object was alive. In the inanimate condition, subjects were given no additional instructions. In this between-subject design, there was no animacy effect. It is unclear why there was no animacy effect in this experiment. Some possible explanations include the between-subjects design, the difficulty of the task, or the possibility that the animacy effect is limited to animate words and does not extend to animate images. Given the results of the third and fourth experiments, this last possibility is unlikely. These explanations will be discussed in further detail below.

In Experiment 3, subjects saw inanimate words paired with experimenter-generated images, half of which were animate and half of which were inanimate. Subjects recalled numerically more words that were paired with animate images than words that were paired with inanimate images, although this effect was not statistically significant. A replication of Experiment 3 with more subjects was carried out in Experiment 4. In addition, I added a condition to examine the mnemonic effects of *removing* animate characteristics from animate words by pairing animate words with inanimate images. Thus, in Experiment 4, I factorially crossed word type (animate vs. inanimate) with image type (animate vs. inanimate). There was a main effect of both word type and image type such that animate words were recalled more than inanimate words (as in Experiment 1) and words associated with animate images were recalled more than words associated with inanimate images (as in Experiment 3). The results of Experiment 4 demonstrate that imagining objects as animates, even if they are inanimate objects, produced an animacy effect. Likewise, imagining animate objects as inanimate reduced the mnemonic value of that word.

Why was there no advantage for animate imagery in Experiment 2? The first obvious difference between Experiment 2 and Experiments 3 and 4 was the use of a between-subjects design. To my knowledge, animacy effects have yet to be seen in a pure list, between-subjects design. Certain memory phenomena, such as the bizarreness or generation effects mentioned in this manuscript, are only observed in mixed-list designs. It is possible that animacy is another phenomenon that is only found in a mixed-list design. The bizarreness and generation effects are thought to occur only in mixed list designs because they either enhance the retrievability of the item at the cost of the memory for the specific item or vice versa. In the generation effect, words that are generated are presumably recalled more because those individual words become more memorable at the cost of memory for the order information. In a mixed-list, the order information of the restudied words is also impaired due to the presence of the generated words within the list. In this case, the order of both the generated and restudied words is impaired. In a pure-list design, generating the words improves the item memory for the words but impairs the order information. Restudying the words does not provide the extra mnemonic boost at the individual item level, but it also does not impair the order memory for the words, either. Thus, no generation effect is found in a pure-list design (Nairne et al., 1991). Bizarreness is thought to improve memory for the opposite reasons. Words that are more bizarre are thought to improve the retrievability of item at the cost of the memory for the specific item (McDaniel & Einstein, 1986). Perhaps animacy is another phenomenon that does not appear in a pure list design.

Another explanation of the null results in Experiment 2 is that the animacy effect is not found with animate images of inanimate words. Across three experiments, images were used to manipulate the animacy of objects and Experiment 2 was the only experiment in which no effect was found although in Experiment 4, the effect of imagery, $d = .19$, 95% CI [0.05, 0.33], was smaller than the effect of animate words, $d = .33$, 95% CI [0.19, 0.47]. In Experiment 2 a large proportion of animate images did not explicitly contain animate imagery. Perhaps the combination of an already small imagery effect and a large proportion of inanimate images included in the animate imagery condition were sufficient to eliminate the animacy effect. Perhaps subjects in Experiment 2 needed additional instructions or examples to learn how to use the method of loci *and* create images a specific way.

In Experiment 4, creating animate images produced an animacy effect, but this effect was smaller than the effect with animate words. When words were paired with animate images, they were recalled more than when they were paired with inanimate images and vice versa. It appears as though pairing an animate word with an inanimate phrase reduced the mnemonic value of that word relative to pairing the same word with an animate phrase. However, animate words that were paired with inanimate images were still recalled more than inanimate words that were paired with animate images. There must be something about animate words that is innately more memorable that cannot be stripped away even if the animate characteristics of that word have been stripped away.

Why was the animacy effect smaller with images relative to words? One idea may be related to the number of animate characteristics in the image. This is a possibility, but across all the experiment manipulating imagery type (Experiments 2 - 4) there was no consistent relationship between the number of animate characteristics associated with each phrase and the recallability of the words paired with those phrases. In Experiment 2 the phrase associated with the most characteristics, “crying because she is lonely”, was associated with the highest recalled word but in Experiment 2, the words associated with this phrase fell in the middle of the recall distribution. I think it is quite possible that, in a separate and controlled experiment designed specifically to explore this idea, objects with more animate characteristics or features may lead to better recall. Such an experiment might pair more images (along the magnitude of hundreds) that have been normed for the number of characteristics with inanimate objects that are then tested on a final recall test. It is quite possible that under these controlled and highly powered conditions, more animate characteristics would predict higher recall scores. However, this is not a pattern I have identified in the present experiments. Perhaps there are certain types of animacy cues that may be more memorable than other cues. The exploratory analysis in Experiment 2 did not reveal any support for this conclusion either, but again, I hesitate to dismiss the idea based on a conditional analysis of an experiment with null results.

What mechanisms underlie the animacy effect? It is most likely that animacy does not enhance exclusively item information or order information. One possible explanation was that animates may capture attention and be more memorable at the cost of the paired associate. The results of the present experiments do not provide conclusive evidence one way or the other. On one hand, these experiments provided a small amount of evidence that people with larger animacy effects relied less on order (as seen from the consistently negative correlations between subjects' animacy effects and output order). This fits with the idea that animates may have captured attention at the cost of the associated location. During retrieval the locations associated with the animate objects could have been less available than the locations associated with the inanimate objects. This might explain the reduced output order for subjects with larger animacy effects. On the other hand, the animacy effect persisted in the method of loci, which means any impairment the location suffered was not enough to eliminate the animacy effect. Importantly, the fact that the animacy effect appeared in the method of loci at all suggests that the animacy effect is due, at least in part, to memory for the items. Whether animates affect the accessibility or order information of words is not fully known. The persistence of the animacy effect in the method of loci also suggests it is unlikely that the animacy effect occurs because subjects use “animate” and “inanimate” (or “living” and nonliving”) as category cues during retrieval.

Method of Loci

The use of the method of loci throughout these experiments allows for some comments to be made about its effectiveness. While the primary goal of this dissertation was not to examine the effectiveness of the method of loci per se, there are several observations made across four experiments that are worth noting. First, subjects in the method of loci condition recalled almost twice as many words as subjects in the pleasantness control condition (Experiment 1). Of course, these results are confounded by the total time on task because subjects in the method of loci condition also spent about four times as long for the initial encoding task. Nevertheless, the method of loci produced impressive recall performance. Also, the goal of the present experiments was to examine differences in memory for animate versus inanimate objects. Therefore, I was not hoping for ceiling performance in the method of loci conditions so that differences in the variable of interest would be detectable. There are several changes that could be made that may boost performance. One such change is that subjects in the present experiments received relatively brief instructions. The memory athletes mentioned in this manuscript have spent months, if not years, developing their method of loci techniques. The subjects in this dissertation spent only minutes. Perhaps performance would have been higher had subjects been given additional instructions or practice opportunities. In previous studies examining the method of loci, subjects participated in an entire session devoted to creating a path for future use of the method. Currently, it is unknown whether a single session would improve performance or not, but I suspect it might. Additionally, performance may improve if subjects are told explicitly to create an interactive image with the to-be-remembered object and the location. Preliminary pilot data suggest that this may improve performance. These interactive instructions were intentionally excluded in Experiments 1 and 2 to keep performance from ceiling.

Looking across all four experiments, it appears that method of loci performance was best when subjects created their own images. In Experiments 1 and 2, subjects created their own images. In Experiments 3 and 4, subjects viewed experimenter-created images. Comparing across these experiments, method of loci performance was about 15% - 20% higher when subjects created their own images. There were obvious differences across conditions besides whether or not subjects created their own imagery, but there are reasons to expect that self-generated images would be more memorable than experimenter-generated images. Worthen and Hunt (2011) reviewed several mnemonics and conclude that in general, self-generated mnemonics are more effective than other-generated mnemonics. Perhaps with additional training, people could learn to generate animate images themselves that would be particularly memorable.

Finally, the results of these experiments do not provide overwhelming evidence that bizarreness provides a mnemonic boost in the method of loci. Bizarreness was not a factor of interest in these studies, but inanimate images that were animated were consistently rated as more bizarre. This provided an opportunity to make some brief comments about bizarreness. In Experiment 2, there were clear differences in bizarreness between the animate and inanimate conditions yet no differences in performance. In Experiment 4, bizarreness differences were minimized relative to Experiment 3 yet the same pattern of recall was observed. It is unlikely that the animacy effect in these experiments was driven by bizarre imagery.

Conclusion

The purpose of this dissertation was to examine the animacy effect in the method of loci. Across four experiments, there was evidence that the animacy effect persisted in the method of loci both when animacy was manipulated by the words themselves and with the imagery associated with the words. However, the mnemonic effect of animacy was decreased in the method of loci relative to a control (Experiment 1). Also, the animacy effect was larger when the animacy manipulation occurred at the word level than when it occurred at the image level. These results demonstrate that animacy is a potent variable in memory.

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APPENDICES

Appendix A

Table 1

Demographics of Subjects in All Experiments

	Males (*N*)	Females (*N*)	Gender Not Reported (*N*)	Age Range (years)	Average Age (years)
Experiment 1					
Method of Loci	30	47	-	18 - 66	36.6 (12.3)
Pleasantness	30	47	-	18 - 69	37.7 (11.9)
Experiment 2					
Animate	30	29	1	20 - 74	34.9 (10.6)
Inanimate	32	24	4	20 - 61	32.9 (9.4)
Experiment 3	24	32	4	19 - 65	36.9 (11.6)
Experiment 4	77	117	6	19 - 67	35 (10.8)

Note. Demographics are shown for subjects in all between group comparisons.

Table 2

Average Number of Intrusions Per Subject in Experiment 1

	Synonyms		**Intrusions**	
	Animates	Inanimates	Animates	Inanimates
Method of Loci	0.35	0.12	0.05	0.12
Pleasantness	0.09	0.03	0.12	0.23

Note. “Synonyms” are intrusions that were synonyms from the to-be-remembered list (e.g. “dad” when the list word was “father” or “diary” instead of “journal”). “Intrusions” are extra list intrusions that had no clear similarity to a list word. Intrusions were also classified as either animate (e.g., “frog”) or inanimate (e.g. “candle”). The pattern of synonyms was the same as the pattern of recall performance. The opposite pattern was found for extra list intrusions: More inanimates were intruded than animates.

Table 3

Classification of Animate Descriptions

	Example Response	Proportion of Animate Images	Recall Performance
Self-generated movement	*"tap dancing"; "turning its own pages"; "rocking himself slowly"*	0.26	0.66
Planning or pursuing a goal	*"looking for bugs in the dirt"; "trying to cook itself on the heat radiating up from the asphalt"; "trying to keep cool"*	0.22	0.67
Human-like behavior	*"Playing a tuba all night long"; "Sweeping the lint off an old sweater"; "Doing push-ups"*	0.15	0.60
Using language	*"hitting on the lemon with corny pick up lines"; "calling everyone names"; "saying, 'Look! It's rock and bowl!!'"*	0.05	0.70
Emotion	*"crying"; "Potato sprouting with pride"; "feeling crowded"*	0.04	0.68
Has a face	*"A huge, man sized flower, a daisy with a face"; "the apple is squinting and wearing an eye patch"; "Sitting at the vanity, tweezing it's eyebrows"*	0.02	0.63

(*table continues*)

	Example Response	Proportion of Animate Images	Recall Performance
Contingent behavior (cause and effect)	*"crying because no one here really love him"; "… [the pencils] start laughing at me because I'm wearing a dress"; "holding the dollar down so he doesn't blow away"*	0.02	0.70
Other animate	*"being smothered under the vaccuum"; "Metal snakes"; "dripping with sweat."*	0.006	0.73
Growing	*"growing itself"; "growing though the cracks on the ground"*	0.004	0.38
Not animate/ambiguous	*"purple and covering the whole step"; "a rose, crushed on the floor and trampled"; "I look at the top of the fridge and see an old, yellowed, dried apple. Hhmm.. better throw that away."*	0.38	0.68
Acted on by an animate	*"My dress clings to my body as I stroll through my house"; "tripped over slipper"; "I grab my wallet and a ticket stub falls out "*	0.11	0.71
Physical movement	*"My rock waterfall trickles water down into my pool"; "Coffee spilling on floor"; "falling off the edge"*	0.06	0.73

Note. Characteristics of animate objects from responses in the Animate condition. Characteristics are in order from most common (self-generated movement) to lease common (growing). The proportion of recall associated with each characteristic is in the far right column.

Table 4

Average Number of Intrusions Per Subject in Experiment 2

	Synonyms	**Intrusions**
Animate	0.35	0.35
Inanimate	0.32	0.23

Note. All intrusions were inanimate words. “Animate” and “Inanimate” here designate the image condition (whether subjects were instructed to create animate images or not). The pattern of synonyms was the same as the pattern of recall performance. Subjects in the Animate condition intruded more than did subjects in the Inanimate condition.

Table 5

Bizarreness and Image Ratings for Experiments 2-4

	Animate Image	Inanimate Image
Experiment 2		
Bizarreness	3.28 (0.05)	2.63 (0.09)
Imagery	2.88 (0.10)	3.62 (0.07)
Experiment 3		
Bizarreness	3.83 (0.12)	2.89 (0.06)
Imagery	2.57 (.14)	3.76 (0.08)
Experiment 4		
Bizarreness		
Animate Word	3.23 (0.07)	3.03 (0.09)
Inanimate Word	3.56 (0.14)	3.30 (0.10)
Imagery		
Animate Word	3.33 (0.13)	3.30 (0.15)
Inanimate Word	2.96 (0.15)	3.08 (0.14)

Note. Bizarreness ratings were made by independent raters on a scale from of 1-5 where 1 was very normal and 5 was very bizarre. Imagery ratings were made on a scale from 1-5 where 1 was very difficult to image and 5 was very easy to image.

Table 6

Average Number of Intrusions Per Subject in Experiment 4

	Synonyms	
	Animate Words	Inanimate Words
Animate Images	0.11	0.06
Inanimate Images	0.07	0.04
	Intrusions	
	Animates	Inanimates
Word Intrusions	0.30	0.25
Image Intrusions	0.06	0.55

Note. The pattern of synonyms was the same as the pattern of recall performance. Extra list intrusions were also classified as word intrusions that had no similarity to the to-be-remembered list and image intrusions which were intrusions of images that were associated with the to-be-remembered words. The most common intrusion of this sort were inanimate images (e.g., recalling “chocolate” which was part of the image “made of chocolate”).

Appendix B

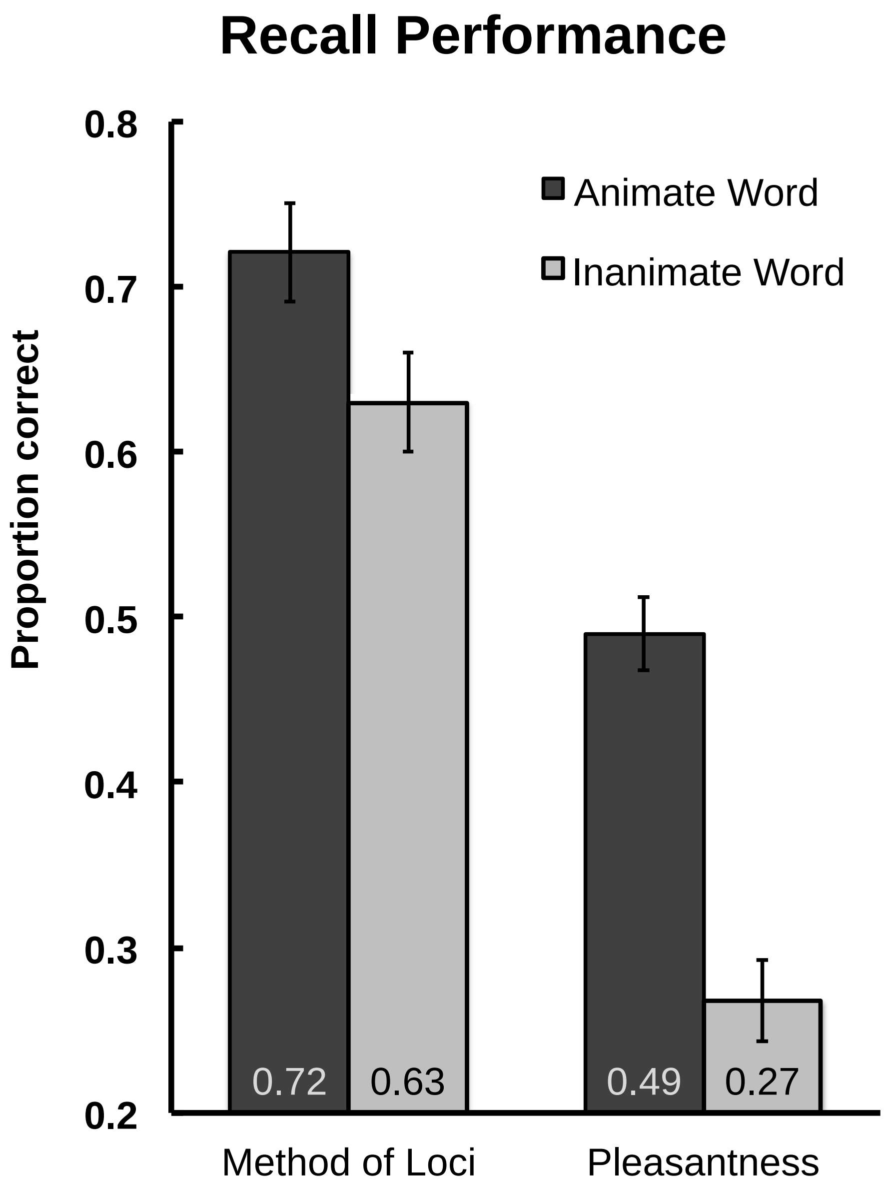

Figure 1. Recall performance in Experiment 1. Animate words were recalled more than inanimate words. Subjects in the method of loci condition recalled more than did subjects in the pleasantness ratings condition. Error bars are standard error of the mean.

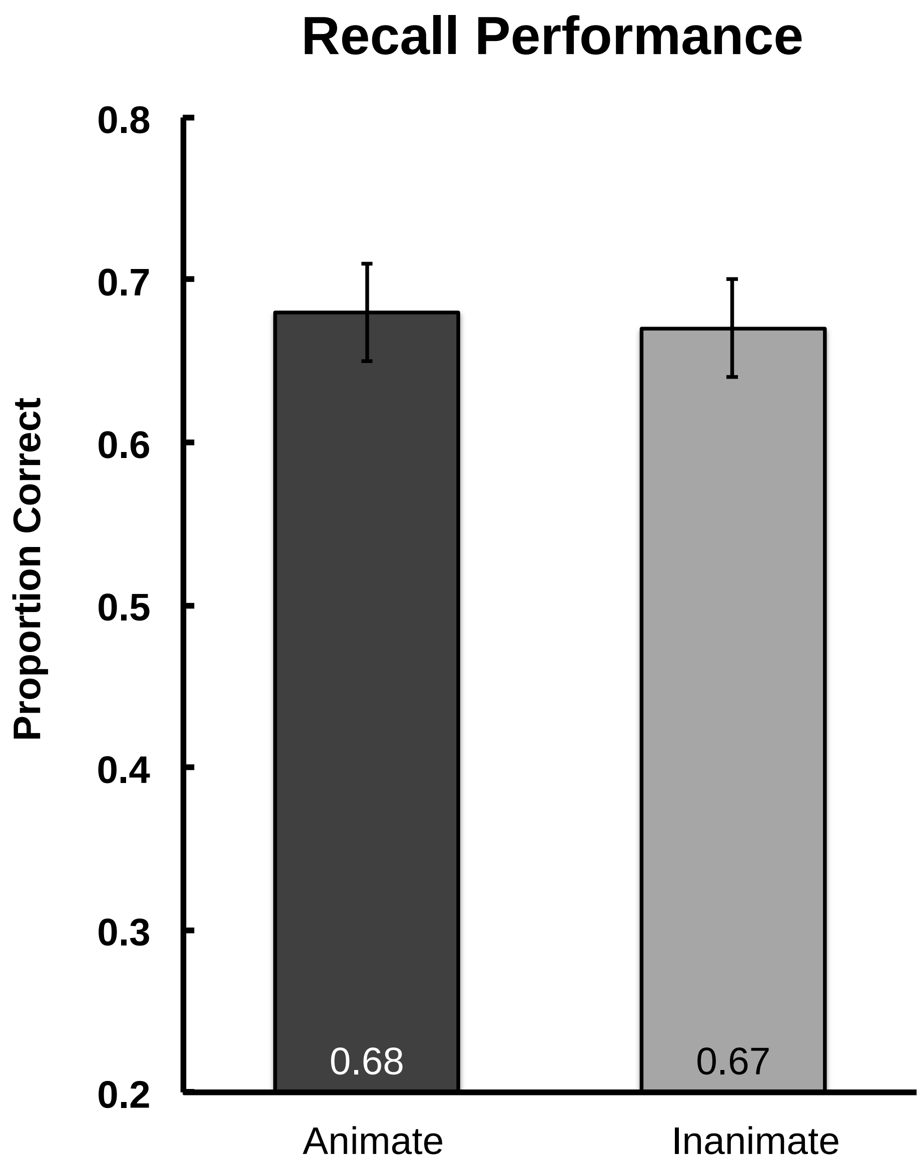

Figure 2. Recall performance in Experiment 2. There was no clear benefit for processing words as animates over processing words as inanimates. Error bars are standard error of the mean.

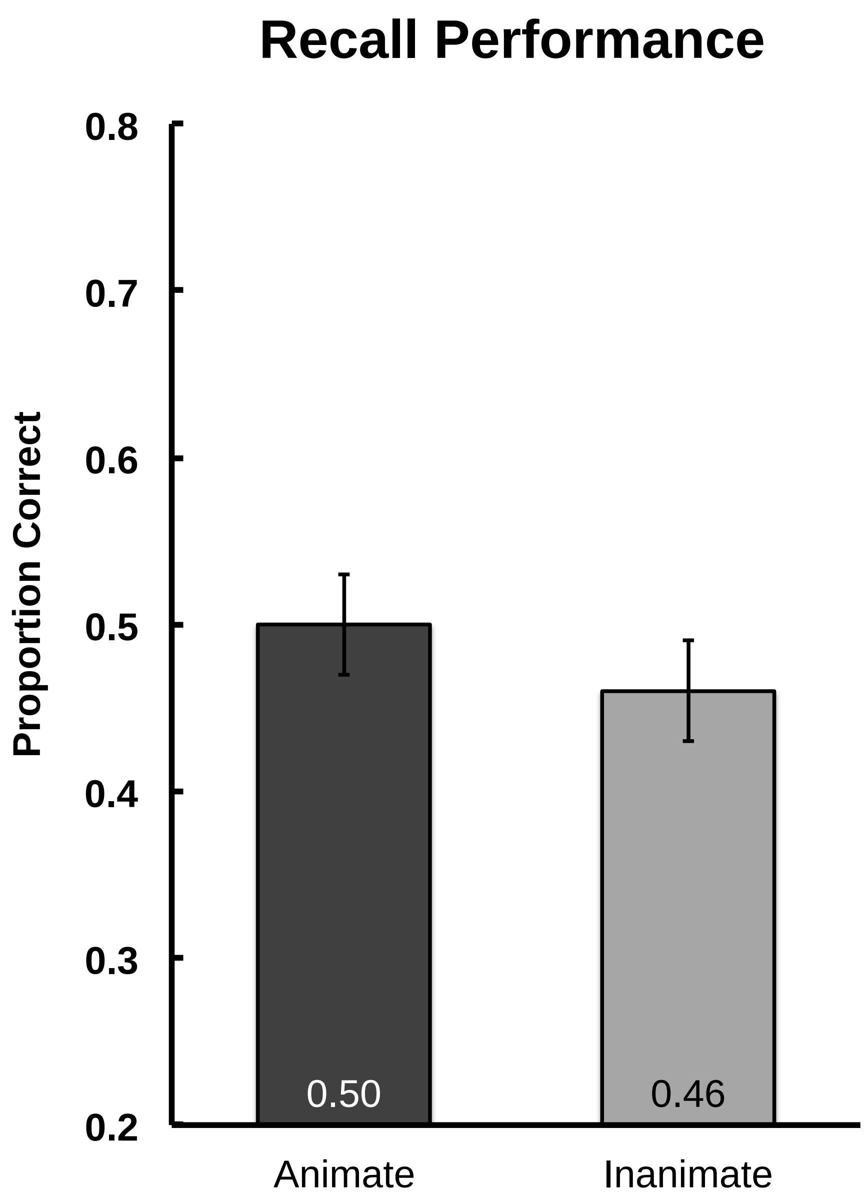

Figure 3. Recall performance in Experiment 3. Words associated with animate images were recalled more than words associated with inanimate images. Error bars are standard error of the mean.

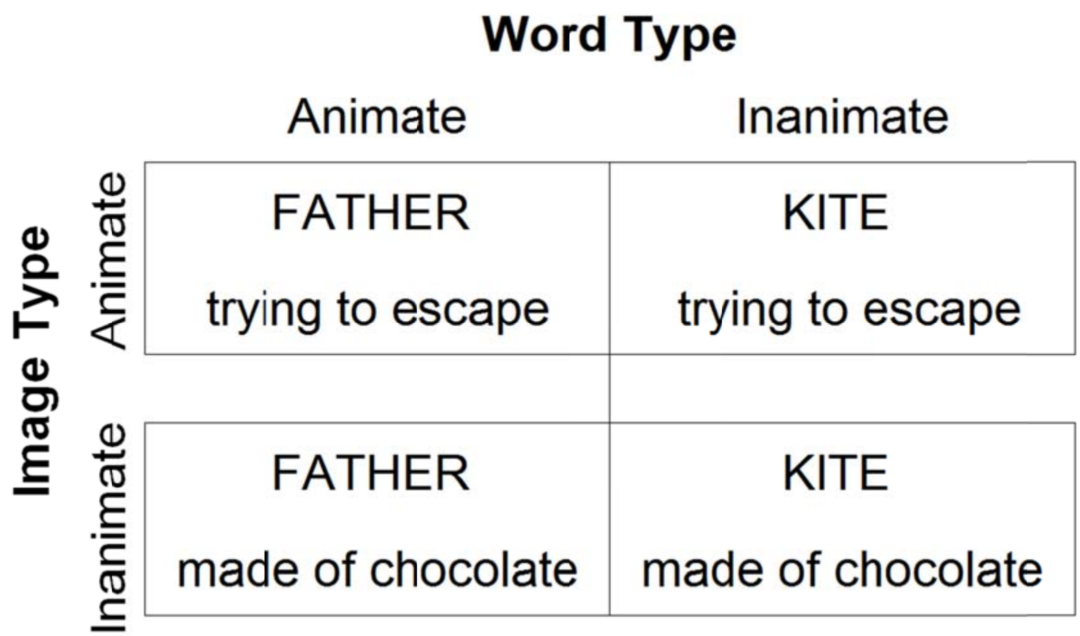

Figure 4. Design used in Experiment 4 and example materials from each -condition.

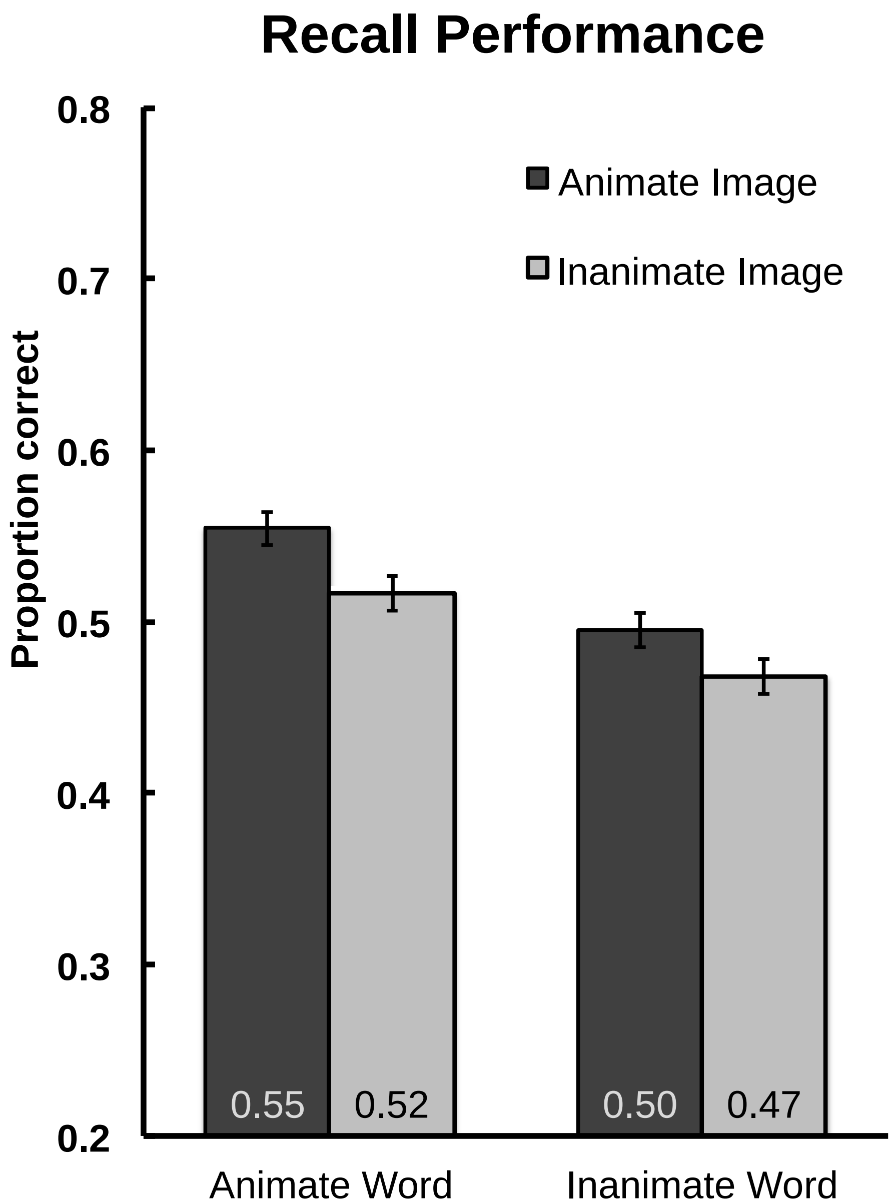

Figure 5. Recall performance in Experiment 4. Animate words and words associated with animate images were recalled more than inanimate words and words associated with inanimate images. Error bars are standard error of the mean.

Appendix C

Materials Used in Experiments

Experiment 1

Animate	**Inanimate**
baby	doll
bee	drum
duck	hat
engineer	journal
father	kite
goat	nickel
judge	pearl
minister	pencil
owl	purse
python	rake
soldier	slipper
spider	stove
trout	tent
turtle	violin
wolf	whistle

	Animate	Inanimate
Familiarity	510 (67)	516 (38)
Imagery	590 (37)	580 (28)
KF-Freq	35.1 (48)	16.5 (16)
No.Letters	5.27 (1.6)	5.13 (1.3)
Meaning-C	452 (58)	435 (31)
Concreteness	590 (36)	594 (16)
Category Size	21.7 (6.1)	22.1 (5.8)
Typicality	.224 (.21)	.235 (.17)
AoA	277 (97)	288 (99)
Relatedness	.106 (.24)	.123 (.24)

Experiment 2

wine
toy
toast
ticket
star
slipper
ship
rock
potato
pipe
pencil
nail
lemon
jelly
gold
fork
flower
dress
dollar
diamond
coin
coffee
cigar
car
candy
bowl
bottle
book
arrow
apple

Experiment 3

Words		Animate Image	Inanimate image
book	toast	trying to get a tan	changing colors
bottle	toy	dancing to music	falling from above
candy	coin	standing guard	made of wood
car	nail	crying because she is lonely	covered in dirt
chair	piano	doing push ups	shiny and new
cigar	ship	flirtatiously batting her eyes	faded from the sun
diamond	arrow	plugging his nose	wrapped in green paper
dress	jelly	laughing hysterically	old and molding
flag	hammer	running in circles	glowing in the dark
fork	bowl	playing tennis	hot pink and fuzzy
gold	dollar	has the flu	rotten and decaying
pipe	coffee	sticking his tongue out	covered in dust
rock	star	humming a song	painted in blood
ticket	pencil	praying on his knees	melting in a puddle
wine	slipper	trying to escape	on fire

Experiment 4

Animate Word	Inanimate Word	Animate Image	Inanimate Image
baby	nickel	running in circles	carved out of wood
bee	stove	wants to eat dinner	framed oil painting
goat	violin	singing a song	made of silver
owl	doll	is in love	forged of metal
wolf	pearl	flirtatiously batting her eyes	limited edition playset
duck	pencil	is writing a novel	chiseled of stone
father	kite	trying to escape	made of chocolate
trout	drum	dancing to music	made of plastic
turtle	whistle	standing guard	folded out of paper
minister	rake	crawling towards me	sketched in pencil
python	hat	wants to go outside	a keychain
engineer	tent	shaking because he is cold	a sculpture
judge	slipper	has a goofy grin	made of cheese
spider	journal	crying because she is lonely	a toy

Appendix D

Instructions used in the experiments

Experiment 1

In this task you will learn how to memorize a list of 30 words. To do this, you will imagine walking through a house – perhaps your childhood home – and placing each item in a different location. You'll place the items along a familiar path so that later you will be able to mentally retrace your steps and "pick up" the items you originally placed there. Some locations could be your driveway, front door, a chair in the living room, and so on. You may place a few items in the same room, but try your best to create a path.

Try to create a rich image of each word. For example, you might see the word PEACH. You would imagine placing the PEACH on the driveway of your house. To create a rich image of the PEACH, you might imagine that the PEACH is so large that it is blocking you from the driveway.

Next you might see the word BALL. You would want to imagine placing the BALL in the next location along the path through your house such as the hallway. You might then imagine that the BALL is painted in blood. Imagine that the blood is dripping from the BALL and onto the hallway floor.

You will see the word in capital letters and two boxes. Your job is to type the location in the box labeled "location" and briefly describe the image in the box labeled "image". For example, if you saw "PEACH", you would type:

Location: front door step
Image: blocking the front door

Experiment 2

Instructions in Experiment 2 were the same as Experiment 1 with the exception that the examples included animate examples for the animate conditions. The italics are added to show the differences in the animate compared to the inanimate examples. Subjects did not see italics.

Animate condition:

To create a rich image of the PEACH, you might imagine that the PEACH is *angrily trying to block* you from the driveway. *When imagining the objects, imagine that they are alive.*

Next you might see the word BALL. You would want to imagine placing the BALL in the next location along the path through your house such as the front door. You might then imagine that the BALL is *painting himself with* blood. Imagine that the blood is dripping from the BALL and on the front door.

Experiment 3 & 4

In this task you will learn how to memorize a list of 30 words. To do this, you will create an image of each word you see. Next you will imagine walking through a house – perhaps your childhood home – and placing each word in a different location along a path through the house. You'll place the images of the words along a familiar path so that later you will be able to mentally retrace your steps and "pick up" the items you originally placed there. You will be asked to type each location you choose. Don't worry if the items do not naturally belong in the location on your path. The goal is to place the items along a path and NOT to put items where you might typically find them. Next you will see an example of locations along a path.

For example, the path through your house might start on the driveway. The first word would go on the driveway. After your driveway, you might imagine walking up to your front door. The second item would go by the front door. From there you might walk through the front door to a chair in the living room. Therefore, your first three locations would be (1) your driveway, (2) front door, (3) a chair in the living room, and so on. To really remember the words, you will want to create a mental picture of the item interacting with the location. (You will see an example soon.) You may place a few items in the same room (for example, the kitchen table, the kitchen sink or the fridge), but try your best to create a path.

In addition to seeing a word, you will see a description of the word and a box to type the location. For example, you might see the word PEACH. The PEACH is described as being very large. Your job is to imagine the large PEACH at your first location of your path, such as the driveway.

When you write your location, describe the location and how your image is interacting with your location. For this example you would want to type:

> **Location**: The peach is so large that it is blocking me from entering my DRIVEWAY.

Recall Instructions (all Experiments)

Now we would like to see if you remember the words you saw. To remember the words, imagine yourself walking through the locations in your house and remembering the words you placed there.

We would like you to recall only the names of the objects you saw. For example, if you imaged a PEACH blocking the front door step, you will ONLY write "peach". You will NOT write anything else for this word.

Please do not cheat or open other tabs or browsers during the experiment. We will not be able to use your data if you have cheated.

VITA

VITA

JANELL R. BLUNT

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EDUCATION

Purdue University West Lafayette, IN
B.A., with honors in Psychology 2010
Advisor: Jeffrey D. Karpicke

Purdue University
M.S., Cognitive Psychology 2013
Advisor: Jeffrey D. Karpicke

Purdue University
Ph.D., Cognitive Psychology Expected 2015
Advisor: Jeffrey D. Karpicke

HONORS AND AWARDS

Purdue University Graduate Student Excellence Award ($500) 2014
Purdue University Department Graduate Research Publication Award ($500) 2014
National Science Foundation Graduate Fellowship ($30,000/year) 2012
American Psychological Association Junior Scientist Fellowship ($1,000) 2011
Purdue University Department Award for Graduate Research Innovation ($1,500) 2011
Purdue University Mortar Board Fellowship ($2,500) 2010
Purdue University Dean's List 2007-2010
Purdue University College of Liberal Arts Honors 2007-2010

RESEARCH INTERESTS

Applying cognitive science to education
Human learning strategies, especially retrieval-based activities such as collaborative learning and concept mapping

PUBLICATIONS

Karpicke, J. D., & **Blunt, J. R.** (2011). Retrieval practice produces more learning than elaborative studying with concept mapping. *Science, 331,* 772-775.

Karpicke, J.D. & **Blunt, J.R.** (2011). Response to comment on "Retrieval practice produces more learning than elaborative studying with concept mapping". *Science, 334*, 453.

Nairne, J.S., VanArsdall, J. E., Pandeirada, J.N.S., **Blunt, J.R.** (2012). Adaptive memory: Enhanced location memory after survival processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38(2),* 495-501.

VanArsdall, J. E., Nairne, J. S., Pandeirada, J. N. S., & **Blunt, J. R**. (2012). Adaptive Memory: Animacy processing produces mnemonic advantages. *Experimental Psychology (formerly Zeitschrift für Experimentelle Psychologie)*, 1-7.

Blunt, J. R. & Karpicke, J. D. (2014). Learning with retrieval-based concept mapping. *Journal of Educational Psychology, 106,* 849-858*.*

Karpicke, J. D., **Blunt, J. R**., Smith, M. A., & Karpicke, S. S. (2014). Retrieval-based learning: The need for guided retrieval in elementary school children. *Journal of Applied Research in Memory and Cognition*, 3, 198-206.

Nairne, J. S., Pandeirada, J. N. S., VanArsdall, J. E., & **Blunt, J. R**. (2014). Source-constrained retrieval and survival processing. *Memory & Cognition*. Advance online publication

MANUSCRIPTS UNDER REVIEW

Blunt, J. R. & Karpicke, J. D. (under review). Retrieval-Based Learning: Positive Effects of Retrieval Practice in Elementary Children. *Memory and Cognition*

Smith, M. A., **Blunt, J. R**. & Karpicke, J. D. (under review). Providing Guides During Retrieval-Based Learning may Inhibit Students' Successful Recall. *Applied Cognitive Psychology.*

Blunt, J. R. & Karpicke, J. D. (under review). Concept mapping: Unanswered questions and unquestioned answers. An empirical review. *Educational Psychology Review.*

MANUSCRIPTS IN PREPARATION

Blunt, J. R. & Karpicke, J. D. (in prep.) Relational and item specific processing in retrieval practice.
Blunt, J.R., Rahman, A., & Karpicke, J.D. (in prep.) Individual and collaborative retrieval practice effects on long-term learning.
Blunt, J. R., Bauernschmidt, A., & Karpicke, J. D. (in prep). Does training on concept mapping improve learning?

COLLOQUIA AND INVITED TALKS

What makes supernatural concepts memorable? Purdue University Cognitive and Learning/Memory Colloquium, West Lafayette, IN (April, 2011).
Concept mapping as a retrieval practice activity. Purdue University Cognitive and Learning/Memory Colloquium, West Lafayette, IN (November, 2011).
How students (should) study. Invited talk, Purdue University Biochemistry Club, West Lafayette, IN (March, 2012)
Grant writing for graduate students. Invited talk, Purdue University Human Development and Family Services Colloquium, West Lafayette, IN (February, 2013).
Myths of student learning: A cognitive science perspective. Invited talk, Purdue University Physics Education Research Seminar, West Lafayette, IN (September, 2013).

CONFERENCE PRESENTATIONS

Karpicke, J. D., & **Blunt, J. R**. (2010, August). *Retrieval practice produces more learning than elaborative studying with concept mapping*. Invited symposium talk at the 20th Annual Meeting of the Society for Text and Discourse, Chicago, IL.
Nairne, J.S., **Blunt, J.R.**, & VanArsdall, J.E. (2011, May). *What makes supernatural concepts memorable?* Talk delivered at the 83rd Annual Meeting of the Midwestern Psychological Association, Chicago, IL.
Nairne, J.S., VanArsdall, J.E., Pandeirada, J.N.S., **Blunt, J.R.** (2011, November). *Adaptive memory: Enhanced location memory after survival processing*, Poster at the 52nd Annual Meeting of the Psychonomics Society, Seattle, WA.
Blunt, J.R. & Karpicke, J.D. (2011, November). *Concept mapping as a retrieval practice activity.* Poster at the 52nd Annual Meeting of the Psychonomics Society, Seattle, WA.
Smith, M. A., **Blunt, J. R.,** & Karpicke, J. D. (2012, May). *Cuing students' retrieval practice results in greater conceptual understanding.* Poster at the 24th Annual Meeting of the Association for Psychological Science, Chicago, IL.

Bauernschmidt, A., **Blunt, J. R**., & Karpicke, J. D. (2012, May). *Does training on concept mapping improve learning?* Poster at the 24th Annual Meeting of the Association for Psychological Science, Chicago, IL

Blunt, J.R., Rahman, A., & Karpicke, J.D. (2012, November). *Individual and collaborative retrieval practice effects on long-term learning*. Poster at the 53rd Annual Meeting of the Psychonomics Society, Minneapolis, MN.

Smith, M. A., **Blunt, J. R.,** Karpicke, S., & Karpicke, J. D. (2013, May). *Generating Cues for Retrieval Practice Improves Learning in Elementary Students*. Talk at the 85th Annual Meeting of the Midwestern Psychological Association, Chicago, IL.

Blunt, J. R. & Karpicke, J. D. (2013, May). *Relational and item specific processing in retrieval practice*. Poster at the 25th Annual Meeting of the Association for Psychological Science, Washington, D.C.

Karpicke, J. D., Grimaldi, P. J., **Blunt, J. R.,** Smith, M. A., & Karpicke, S. (2013, May). *Retrieval-based learning: The need for guided retrieval practice*. Talk presented at the 25th Annual Meeting of the Association for Psychological Science, Washington, D.C.

Smith, M. A., **Blunt, J. R.,** Karpicke, S. & Karpicke, J. D. (2013, August). *Generating cues for retrieval practice improves learning in elementary students.* Poster presented at the 121st Annual Convention of the American Psychological Association, Honolulu, HI.

Karpicke, J. D., Grimaldi, P. J., **Blunt, J. R**., Smith, M. A., & Karpicke, S. (2013, August). *Retrieval-based learning: The need for guided retrieval practice*. Talk presented at the 121st Annual Convention of the American Psychological Association, Honolulu, HI.

Blunt, J.R. & Karpicke, J.D. (2013, November). *Individual differences in retrieval practice with children.* Poster at the 54nd Annual Meeting of the Psychonomics Society, Toronto, ON.

Blunt, J.R. , Nunes, L.D., Karpicke, S. S., & Karpicke, J.D. (2014, November). *Retrieval Practice with Children in the Classroom.* Poster at the 55th Annual Meeting of the Psychonomics Society, Long Beach, CA.

TEACHING EXPERIENCE

Supervising Undergraduate Research
Research Assistants (15 students, Spring, 2011 – present)
Honors Students (1 student, Fall, 2011 – Spring 2012)

Cognitive Psychology (PSY 200) — Fall 2010
Teaching Assistant
Instructor: Dr. Jeffery D. Karpicke

Cognitive Psychology (PSY 200) — Spring 2011
Teaching Assistant
Instructor: Dr. Gregory Francis

Elementary Psychology (PSY 120) Fall 2011
Teaching Assistant
Instructor: Dr. James S. Nairne

RESEARCH AFFILIATIONS

Social Lab, Purdue University Spring, 2008
Research Assistant
Principal Investigator: Dr. Stephanie A. Goodwin

Clinical Lab, Purdue University Fall, 2008 – Spring 2009

Research Assistant
Principal Investigator: Dr. Christopher I. Eckhardt

Cognition and Learning Lab, Purdue University Spring, 2009 - Spring, 2010
Honors Thesis Student
Advisor: Dr. Jeffrey D. Karpicke

Adaptive Memory Lab, Purdue University Summer, 2010 – Summer, 2011
Graduate Student
Principal Investigator: Dr. James S. Nairne

Cognition and Learning Lab, Purdue University Summer, 2011 – present
Graduate Student
Principal Investigator: Dr. Jeffrey D. Karpicke

AD HOC REVIEWER

Applied Cognitive Psychology
British Journal of Psychology
Educational Psychology: An International Journal of Experimental Educational Psychology
European Journal of Psychology of Education
Psychonomic Bulletin and Review

PROFESSIONAL AFFILIATIONS

Association for Psychological Science
American Educational Research Association
American Psychological Association
International Association for Metacognition
Midwestern Psychological Association