Can touch-related adjectives be concrete or abstract in a memory task?
by Shannon Marie Kirby

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science . in Applied Psychology
Montana State University

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

The current study, comprised of five experiments, considered several issues from prior memory research (concreteness effects, imagery, and haptic processing). This study used adjectives previously rated on perceptual dimensions; the adjectives were considered extreme or central on the perceptual dimensions. Extreme words were hypothesized to be similar to concrete words and central words were hypothesized to be similar to abstract words. In Experiment 1, concreteness effects were found under recall. In Experiment 2, a visual imagery instruction condition, a touch imagery instruction condition, and an object condition were used, with dependent measures of immediate recall, a surprise final recall, and a recognition test. An effect of extreme vs. central was evident for the recall conditions. An effect of condition was present for the final recall; no significant results were seen in the recognition task. Results are consistent with the notion of concrete/abstract but more experimentation is necessary to be certain. Future avenues for research are discussed.

INTRODUCTION

Within cognitive psychology, the study of the psychology of language, or psycholinguistics, is robust. Research into how we process words and how we remember them has been studied for decades. More recently, research into word values or attributes that may affect information processing and memory, such as concreteness and imagery, has increased (Campos, 1989).

The specific aim of the present study is to examine whether touch-related adjectives are processed similarly to nouns in memory; thus the central focus of this study is on memory for adjectives. Previous research has tended to focus on verbs or nouns or words pairs, also known as word phrases.

Second, processing differences between concrete and abstract words will determine whether support for concreteness effects can be found when using single adjectives.

Third, as haptic processing has been demonstrated to impact memory and learning, this study also focused on whether haptic processing, i.e. active touch of objects associated with specific adjectives, will affect recognition and recall memory, as compared to visual and touch imagery.

In the present study, of interest were the word characteristics of concreteness and imagery. This literature will be discussed, followed by an examination of previous research using sense modalities (e.g. vision, touch), with particular attention on the touch modality.

Word Characteristics That Affect Memory

Concreteness

Extant literature reveals a great deal of empirical data regarding the contrast between concrete and abstract words and the differences in how they are processed and remembered. Concrete words refer to, and are frequently operationalized as, words that describe a substance or object or thing that is material, such as *tree* or *duck*, while abstract words tend to refer to something that clearly exists but is not material or an object or a person, such as *democracy* or *truth*. It has been demonstrated that concrete words, such as *desk* or *chair*, are easier to understand than abstract words, such as *liberty* or *freedom* (Schwanenflugel, Harnishfeger, & Stowe, 1988).

Research has shown that there is a distinct advantage in processing concrete words over abstract words, an advantage that is known as the concreteness effect. Previous research on word characteristics in this area has tended to focus on nouns, verbs, or noun-adjective pairs in paired associates learning studies.

For example, Begg (1972) did an experiment using adjectives (some concrete and some abstract) paired with nouns (some concrete and some abstract), which were selected from previous research (Paivio, Yuille, & Madigan, 1968); results indicated that more concrete adjectives were recalled and that more adjectives paired with concrete nouns were recalled than adjectives paired with abstract nouns. Klee and Legge (1976) used transitive verbs and found that concrete, imaginable words or sentences are learned and recalled better than abstract words or sentences. Further, Paivio (1971) demonstrated the superior performance of concrete nouns over abstract nouns on various forms of verbal learning. Yntema and Trask (1963) conducted research regarding effects of concreteness on temporal coding (i.e., when a participant is given a succession of items over some time frame, the coding of these items in memory may include information about the temporal occurrence of the item); their results showed that the quality of judgments of item order was significantly higher with concrete words than abstract words. Paivio and Csapo (1969) found that memory was positively affected by concreteness, although results were not always significant. Leung, Suzuki, and Foster (1983) found that the concreteness effect was quite robust; their results indicated that concrete nouns were better recalled than abstract nouns, even when other variables such as task difficulty were increased. In a study using transitive verbs, Klee and Legge (1976) found that abstract words or sentences are learned and recalled more poorly than concrete, imaginable words or sentences. Finally, Weiss and Rappelsberger (1996, as cited in Walker and Hume, 1999) "presented electroencephalographic evidence that suggests differences in the processing of concrete versus abstract words at a neurological level" (p. 1258).

The processing differences between concrete and abstract words or phrases are often measured in cognitive research by using explicit memory tests and/or implicit memory tests. Explicit memory testing, which is utilized in the present studies, refers to the fact that participants are asked, for example, to recall or recognize items from a prior situation.

Implicit memory refers instead to memory tests where no reference is made to a prior session.

As explicit memory tests, both free recall and recognition measures are used frequently to explore verbal processing and learning. Both recall and recognition require the participant to recall a particular event – the reading of the list, the presentation of the items, and so forth. In order for the participants to be successful at recalling specific words previously presented (recall) or to identify words that were on the previous list (recognition), they must be able to remember the episode during which the initial list was provided. Free recall tests assess learning by requiring participants to mentally refer back to a prior event or session and retrieve items from memory. Much in the same way a librarian must be able to locate a single volume in the library based on a numerical filing system, the retrieval in free recall relies heavily on the encoding process. Recognition tests also measure learning but by merely requiring the participant to recognize that they have seen the item in a previous session but not requiring them to retrieve it from memory. Despite whether the memory measure is free recall or recognition, concreteness effects have been found.

Begg (1972) used concrete and abstract noun-adjective phrases and found that concreteness of the words that comprise the phrases was positively related to recall, both for free recall (recall as much of what was presented as they could) and whole recall (given the same instructions as the free recall but the phrase "whether it be phrases or words" was added). Further research by Begg (1974) using concrete and abstract nouns found that more concrete words than abstract words were recalled, and that there was a positive relation between concreteness and free recall. Jackson and Michon (1984) found that twice as many concrete items than abstract items were freely recalled, under both remember-cued and forget-cued conditions (remember-cuing meaning that participants were given a three-second cue to remember the word; forget-cuing meaning participants were given a three-second cue to forget the item). Hamilton and Rajaram (2001) found concreteness effects with free recall as well; their results showed that there was a significant difference between the proportion of concrete studied items recalled and the proportion of abstract studied items recalled.

Although there are fewer studies of word or phrase concreteness that used recognition as the memory test, there is still evidence demonstrating concreteness effects when recognition measures are being used. Jackson and Michon (1984) used concrete and abstract nouns and remember-forget cues; they found that participants were more accurate in their recognition of concrete items than in their recognition of abstract items. Paivio and Csapo (1969) used three stimulus types (pictoral, concrete and abstract) and two presentation speeds (fast and slow, using an 8mm continuous filmstrip projector) and found that, at the slow rate, pictoral items were recognized significantly better than concrete words, which were recognized marginally better than abstract words. Jampolsky (1950, as cited in Gorman, et al., 1961) demonstrated that abstract words were more difficult to remember than concrete words when learning was measured using a recognition test.

In summary, there is no shortage of research that provides evidence for the robustness of concreteness effects under varying conditions and using various memory measures. A review of the literature indicates that there are several theories for concreteness effects; three of which will be discussed briefly below: context availability, depth of processing, and dual coding.

Context Availability Theory

Context availability theory (Schwanenflugel, Akin, & Luh, 1992) focuses on the ease with which a context, situation, or circumstance can be retrieved for a specific word. This theory argues that concreteness effects can be explained because it is easier to retrieve a context associated with a concrete word, such as *truck*, than it is to retrieve a context for an abstract word, such as *democracy*. According to context availability theory, comprehension is increased when contextual information involving the materials to be learned can be provided, whether it comes from the individual's past experience or from the environment (Schwanflugel et al., 1988). This contextual information is purported to aid the individual in making a connection between concepts necessary for comprehension; logically, this theory argues that provision of contextual information will result in more advanced comprehension whereas lack of this information will limit comprehension. In explaining concreteness effects, this theory makes the case that abstract materials are more difficult for people to find and access contextual information about, thus comprehension is poorer; concrete materials lend themselves much more easily to recalling context, which increases comprehension (Schwanflugel et al., 1988). For example, Garnham (1989) found that less information is necessary to recognize a word when the word occurs in context than when it does not.

Depth of Processing Theory

Another explanation for concreteness effects comes from the depth of processing hypothesis, which focuses more on the processes involved in learning and remembering, rather than on the structural aspects of the memory system (Craik & Lockhart, 1972; Craik & Tulving, 1975). Craik and Lockhart (1972) described memory as being distinguished by different information processing levels. This approach argues that memory performance is strongly affected by the depth of processing at encoding. This theory argues that earlier stages of perception are focused more on physical properties or sensory characteristics; for example, initially, we hear a piece of music in terms of such characteristics as tone, pitch, or rhythm but as time goes on, our processing of the music become deeper. We might begin to hear a pattern to the music or it may seem familiar and we try to think of where we have heard it before. For words, initially, the word is recognized and then, later, it might lead us to think of past experiences or images (Craik & Lockhart, 1972). Ultimately, explicit memory tests like recall are affected by the level of information processing at encoding; the deeper the processing at encoding, the more likely that recall will be successful (Craik & Tulving, 1975). Many studies have demonstrated that "an orienting task requiring semantic or affective judgments led to better memory performance than tasks involving structural or syntactic judgments" (p. 269, Craik & Tulving, 1975). In summary, the theory described above basically boils down to a simple statement: "memory performance depends on the elaborateness of the final encoding" (p. 291, Craik & Tulving, 1975).

Dual Coding Theory

A third explanation for concreteness effects, and perhaps one of the best known, is dual coding theory, originally put forth by Paivio (1971). Dual coding theory describes memory as having two representational systems that are independent of each other yet are interconnected and can potentially have an additive effect. This theory grew from the mnemonic technique of "one-bun, two-shoe" as such a technique relies on dual coding; to remember the words on a list, an image of the word to be remembered is integrated into the mnemonic and then, for recall, the image is converted back into a word. Paivio argues that images play a functional role in memory; the verbal system processes verbal information while the imaginal system processes non-verbal information. Both concrete and abstract words are represented in the verbal system but Paivio argued that concrete words are encoded into an imagery code while abstract words are encoded in a manner close to the verbal form in which the word was presented. The image that the concrete words are transformed into provides another way that those concrete words can be encoded and retrieved, thus rendering concrete words more likely to be recalled. Abstract words are only encoded verbally; they lack an imaginal representation in the imaginal system to act an as additional cue to aid in recall. Paivio (1971) showed that imagery is evoked by pictures and concrete words, but not by abstract words.

Later, Paivio (1978, as cited in Paivio, 1991) adopted new terminology; thus, the verbal representation became known as a *logogen*, or word generator, and the imaginal representation became known as an *imagen*, or image generator. Paivio (p. 259, 1991) argues that "activation is a probabilistic function of stimulus variables (e.g. word concreteness, meaningfulness, familiarity), contextual stimuli (e.g. task instructions), and individual differences (e.g. imagery or verbal ability)." In addition, Paivio's dual coding theory, in a manner similar to the depth of processing theory, takes into account the effects of processing information at different levels – representational, referential and associative. "*Representational processing* describes a relatively direct activation of logogens by linguistic stimuli and imagens by nonverbal stimuli; *referential processing* refers to the cross-system activation required in imaging to words and naming objects; and *associative processing* entails activation of representations within either system" (italics in original, p. 259, Paivio, 1991). In summary, this approach argues that memory performance is due primarily to the type of codes activated, verbal or non-verbal.

In the present study, all three theories lead to a similar hypothesis: as more cross-sensorial information is provided, memory performance should increase. However, these theories do not differentiate whether there should be a difference between visual and haptic imagery.

Imagery

A second variable in more meaning-based processing of information is imaging an item's reference versus simply reading words, which is known as the imagery effect (Hamilton & Rajaram, 2001). For example, the word *cat* can be read and learned but the probability of remembering it is likely to be higher if the word is read and an image of the word is formed. Earlier factor analytic results by Paivio (1968, as cited in Paivio, 1991) indicated that the best predictor of recall for words was the rated ease of imagery. Coney (2002) also argues that imagery plays a role in processing information and may affect memory and language. Perhaps the earliest research regarding effects of instructions to image is that of Kirkpatrick (1894, as cited in Paivio, 1971), who used 10-item lists of concrete nouns and instructions to form a mental picture of the objects being named. Free recall measures demonstrated that recall under imagery instructions is consistently slightly higher. Paivio (1971) argues that Kirkpatrick's research (1894, as cited in Paivio, 1971) supports the idea that "imagery can function as an alternative or supplementary memory code, which enhances the probability of correct recall of concrete words" (Paivio, 1971, p. 328). Using a memory test, Paivio (1969, as cited in Reeves, Hirsh-Pasek, & Golinkoff, 1998) demonstrated that high-imagery words were recalled better than low-imagery words.

In research by Coney (2002), noun stimuli were chosen carefully to avoid possible confounds; results showed that imagery was highly correlated with concreteness. To illustrate this point, close your eyes and visualize an image of the object or concept described by the following words: *cat, justice, watermelon, evil, star, honesty, ball, joy*. Which words did you find easier to mentally image, or create a mental picture of? It was probably much easier and faster to come up with an image for *cat, watermelon, star,* and *ball* than it was for *justice, evil, honesty* and *joy* because it is easier to generate an image for *cat, watermelon, star,* and *ball* because these words are more concrete and thus easier to image, or form a mental image of, while words like *justice, evil, honesty* and *joy*, being much more abstract, are more difficult to image.

Sense Modality and Memory

Another area that has come to the forefront in cognitive research is the effect of sense modality on memory (i.e. the effect of visual stimuli versus auditory stimuli versus tactile stimuli). Cognitive psychology has produced considerable research on the senses and their role in memory. For example, it has been demonstrated that visual dominance over the other senses occurs perceptually for such measures as length, size, curvature, spatial location and depth (Lederman & Abbott, 1981). Stadtlander and Murdoch (2000) had participants list adjectives that could be used to describe objects and indicate which sense the adjective made use of (vision, hearing, smell, touch or taste); results indicate that the visual system also dominated in memory; significantly more words related to vision than related to touch were listed by participants.

For many years, attention has also been focused on haptic perception or haptic processing. Haptics may be defined as "a perceptual system that incorporates inputs from cutaneous receptors and also from kinesthetic receptors embedded in muscles, joints, and tendons" (Loomis & Lederman, 1986, as cited on p. 356 of Klatzky, Lederman, & Reed, 1987). In other words, haptics refers to the touching or feeling of objects to collect information such as shape, weight, size, texture. It is a sense that most of us use frequently to extract information about objects, such as if our bath water is safe to step into or simply enjoying the sensual sleekness of a cat's fur. Haptic processing is clearly a perceptual process, one in which the goal is to collect sensory information.

Early pioneers in this area demonstrated the significance of active, versus passive, haptic exploration (Gibson, 1962; Katz, 1989). Lederman and Klatzky (1987) demonstrated the importance of active and systematic movements during haptic exploration; certain hand and finger movements, such as enclosure, are used to collect specific sensory information about the object on a perceptual level. Research by Lederman and Klatzky (1990) suggested that the most diagnostic property for haptic objects is shape, followed by size. This was further supported when Lederman and Klatsky (1990) found that shape, followed by size and texture, was especially important to haptic representations of common objects. Lederman, Summers and Klatsky (1996) found that material characteristics such as weight and temperature were more heavily emphasized in haptic only conditions but that geometric properties, particularly shape, were more heavily emphasized in vision conditions, whether a real object or imagery was used.

Based on research into use of different sense modalities and stimuli processing, both similarities and differences have been observed in the cognitive processing of three-dimensional objects, as well as for the recognition of them, with the senses of vision and touch. For example, objects in the world are perceived using both modalities, both vision and touch, and both the eyes and the hands explore the object in succession. However, there are some differences between the two modalities; for example, the eyes can examine a very large object very quickly while the hands are more suited to exploring a much smaller object.

Some research has attempted to determine a sensory modality order. Lederman and Abbott (1981) found that, when both haptic and auditory stimuli were presented, and the stimuli were manipulated to be in sensory conflict (i.e. the haptic stimuli are providing sensory information that conflicts with what is being heard), the participants relied on the haptic information to make the decision. Thus, while some research has shown vision to be the dominant sense, research also shows the value of the haptic information humans receive. Klatzky, Lederman, and Metzger (1985) conducted research using a wide variety of real objects and found that identification of these objects using haptics was both fast and very accurate, with 96% of the naming responses being correct.

The directed-attention hypothesis argues that "visual inputs are typically more salient than proprioceptive-kinesthetic inputs, or at least more closely attended," an argument that might be used to explain the dominance of vision shown in the extant literature (p.126, Lederman & Abbott, 1981). Lederman (1979) went one step beyond the directed-attention hypothesis and proposed the ecological validity hypothesis, which argues that, based on the situation or environment, some senses will be more appropriate than others so these are the senses that are most likely to be used to gather sensory information. Lederman (1979) argued that in many situations, more than one sense may be available and appropriate to gather sensory information in a given situation. Subsequently, Lederman and Abbott (1981) argued that the type of task was critical in determining which senses were used; they felt it was inappropriate to argue for an overall ordering of the senses. Klatzky, Lederman, and Matula (1993) found that vision and touch are used to learn about different characteristics or properties of objects; touch was used more often to gather sensory information about such characteristics as temperature, roughness, hardness and weight whereas vision was used to judge such properties as shape and size.

In short, it is important to reiterate that haptic processing, like vision or any other sense, refers to a perceptual data gathering process. Much of the research mentioned above describes studies into perceptually-based gathering of sensory information. There is very little research on what is encoded into memory and whether or not it is available for recall.

Research into haptic processing and memory has found that, as in verbal memory, there are differences between implicit and explicit memory; one study found that "the implicit test seems to rely on structural, shape-based representations of objects while explicit recognition appears to tap low-level, cutaneous sensory information" (p. 797, Ballesteros, Reales, & Manga, 1999).

Haptic processing has been shown to aid memory in both young and older participants, particularly when combined with visual perception (Stadtlander, Murdoch, & Heiser, 1998). Stadtlander et al. (1998) conducted a study using real objects in which participants were asked to look at the objects, look at and haptically explore the objects, or haptically explore the objects while blindfolded. Results indicate that real objects were recalled better than concrete, high-imagery nouns, by all participants, regardless of age. Additionally, there was an indication that visual imaging may play a role in memory for nouns associated with objects.

To summarize, there is a long history of research providing evidence for concreteness effects and more than one theory to explain their existence. Additionally, there are multiple variables that may affect how information is processed. And of course, the sense modality with which the information is processed may impact how the information is processed.

The Present Study

Based on the above research, several issues were considered in the current study. First, that the haptic qualities of a touch-related adjective (i.e. the intensity of the sense qualities of each of the adjectives), if high, will aid memory by making it to form an image at encoding. Words that were rated high (±4) on dimensional scales in the research by Stadtlander and Murdoch (2000) were considered extreme words, referring to the fact that they are being rated as strong or high in that dimension (such as hardness or roughness) while words that were rated low (±2) were considered central words, indicating that they are weaker or lower in that dimension. The concept of central and extreme words should be closely related to the concept of concreteness and the concreteness effect, where concrete items are remembered better than abstract items (Paivio, 1971).

Second, since imagery has been shown to be correlated with concreteness (Paivio, et al., 1968), it is anticipated that extreme words will be more like concrete words in that they are more likely to be imageable; central words are expected to be more like abstract words and less likely to be imageable. Together, the concepts of concreteness and imagery combine to suggest that the extreme words will be more like concrete words: they will be easier to image and that will facilitate remembering. In contrast, central words may be more like abstract words: they will be more difficult to image and this will result in poorer memory.

Third, choice of objects in this research was also important. There is evidence that people can become more efficient at certain cognitive tasks, such as scanning, if the items or images being used are distinct physically or conceptually (Madden, 1982, as cited in Craik & Jennings, 1992). For example, scanning would be more efficient using items such as a ball, a pen, and a banana than if items such as a pen, a crayon, and a pencil were used since the first three are clearly distinct from each other and the latter three are less so. Using three-dimensional objects nets the same effect (Puglisi, 1986, as cited in Craik & Jennings, 1992). Thus, objects in these studies were selected to be distinct from one another, such as a mitten, sandpaper, a telephone cord, and barbed wire. In addition, these objects needed to be small enough to fit in the hand so as to be haptically explorable. None of the objects used made noises or emitted strong odors. Most importantly, the objects used had to be empirically demonstrated to be related to specific adjectives.

Research Design and Objectives

In the current experiments and pilot studies, memory was tested explicitly using both free recall and recognition methods. The recall tests used in the present research required the participants to recall the specific words from a list previously provided to them. The recognition tests required the participants to determine which words had been presented during the research.

All studies conducted were approved by the Montana State University Human Subjects Committee.

Experiment 1 was intended to determine if previously rated touch related adjectives are recalled similarly to prior findings using concrete and abstract nouns, which shows that concrete words are better recalled than abstract words (Hamilton & Rajaram, 2001; Jackson & Michon, 1984).

The purpose of Experiment 1A was to isolate the locus of effects found in Experiment 1 and to empirically examine the anecdotal reports of participants. The ultimate goal was to determine which adjectives were associated most strongly with each of four sense modalities (visual, touch/haptic, auditory, olfactory).

Experiment 2, Pilot 1 was designed to identify objects that were considered intrinsically possessing characteristics for each of the adjectives; i.e. to connect the most salient adjective to an associated object. The goal was to find 39 adjectives joined consistently to 39 objects.

The purpose of Experiment 2, Pilot 2, was to circumvent the inconsistent results of Experiment 2, Pilot 1 and the goal remained to identify the most salient 39 adjectives and their related 39 objects. It was determined that adding additional adjectives and modifying the experimental procedure would further the chances of getting 39 adjectives with consistently high ratings.

Experiment 2 was intended to study central vs. extreme adjectives under tightly controlled conditions and to examine the influence of visual and touch imagery in memory, using measures of recall and recognition.

The hypotheses for each experiment and pilot study will be presented and discussed at the start of the methods section for that experiment.

METHOD

Experiment 1

As discussed previously, the concreteness effect refers to the memory advantage concrete words typically have over abstract words (Begg, 1972; Paivio & Csapo, 1969). Concrete words are generally remembered better and may be more similar to the extreme words in the present study while abstract words are generally remembered less well and may be more similar to central words in the present study. Much of the research to date has focused on nouns or verbs (Leung, Suzuki, & Foster, 1983; Paivio, 1971); of primary interest to the current research was how adjectives are processed.

Experiment 1 was designed to answer the following question: Are touch related adjectives that have been previously rated on perceptual dimensions (Stadtlander & Murdoch, 2000, e.g. scales indicating characteristics such as hardness/softness or roughness/smoothness) recalled similarly to previous research using concrete and abstract nouns that has demonstrated that concrete words are recalled better than abstract words (Hamilton & Rajaram, 2001; Jackson & Michon, 1984)? The experimental design was within-subjects using word type (central or extreme) as the independent variable and recall and recognition measures as separate dependent variables. This study was approved by the Montana State University Human Subjects Committee.

Hypothesis 1: More extreme words than central words will be recalled. The present experiment was conducted using adjectives previously rated on perceptual dimensions; extreme adjectives were those rated beyond ±4 on a scale of ±7; central adjectives were those rated between ±2 on the same scale (Stadtlander & Murdoch, 2000). It is expected that extreme words will be more similar to concrete words in previous research and will be recalled more readily than central words. It seems logical that there may be a parallel between concrete words and extreme words and between central words and abstract words. Concrete words are remembered better than abstract words, potentially for many reasons which include imagery, how they are encoded, and so forth (Coney, 2002; Hamilton & Rajaram, 2001; Paivio, 1971; Schwanenflugel, et al., 1992). All theories discussed above lead to the conclusion that extreme words, if indeed they are similar to concrete words, should be remembered better. From a theoretical perspective, the context availability theory (Schwanenflugel, et al., 1992) argues that abstract information is simply more difficult for people to link to a context than concrete information, which subsequently leads to better comprehension and remembering of concrete information. The depth of processing theory (Craik & Lockhart, 1972; Craik & Tulving, 1975) argues that memory performance is dependent upon how deeply or elaborately the information to be remembered is encoded – the more deeply it is processed, the easier the information should be to remember. Dual coding theory (Paivio, 1971) puts forth the argument that concrete words are encoded into the verbal system and into an imagery code while abstract words are encoded into the verbal system in a fashion similar to how the word was presented. Memory performance is subsequently better for concrete words for there are two means of retrieving the concrete information – verbally and imaginally.

Based on the three theories above, which all can be used to explain concreteness effects, it is expected that extreme words will perform similarly to concrete words in previous research and that central words will perform similarly to abstract words in previous research. Thus, extreme words may possess characteristics that make them more memorable, intense, or salient, – perhaps they are easier to image, perhaps they make it easier to find a context, and so forth - and so it is expected that these characteristics will result in more extreme words being recalled, compared to central words.

Hypothesis 2: More extreme words than central words will be recognized. Again, based on the research and reasoning above, it is expected that extreme words will be similar to concrete words in previous research and be recognized at a greater rate than central words.

Method

Participants. Participants were 29 upper division psychology students at Montana State University – Bozeman (21 females, 8 males) who were given extra credit in their class for their participation. One student failed to provide her age; the mean age of the remaining 20 females and 8 males was 25.82 years. Each participant completed two Volunteer Consent Forms, one of which was signed and given to the participant, the other of which was signed and retained by the experimenter.

Materials. A list of 44 adjectives was compiled based on previous research by Stadtlander and Murdoch (2000). All adjectives were low frequency, meaning that they occurred less than 20 times per million in English (Kučera & Francis, 1967) and contained between five and seven letters. In addition, all adjectives had a touch frequency of less than 20, which refers to the frequency of participants listing the word (Stadtlander & Murdoch, 2000). For example, in the Stadtlander and Murdoch (2000) study, participants used the word *fluffy* 19 times versus using the word *crisp* only twice when listing touch-related adjectives; thus, *fluffy* would have a touch frequency of 19 while *crisp* would have a touch frequency of two.

Half of the adjectives in this study were from the extreme ends of the rating scales used by Stadtlander and Murdoch (2000), such as hardness, part motion, roughness, shape, size. Thus, on a scale of ±7, the adjectives were rated as beyond ±4 and are subsequently referred to as extreme adjectives, which were expected to elicit memory performance that was similar to that in previous research on concrete words. Half of the adjectives were from the central regions of the rating scales, occurring between ±2, and are subsequently referred to as central adjectives, which were expected to elicit memory performance that was similar to that previous studies on abstract words. Two counterbalanced lists (List A, List B) were developed consisting of 22 words per list; 11 adjectives of each list were central words and the remaining 11 adjectives were extreme words (see Appendixes A and B for complete listings of stimuli).

Procedure. The experiment was conducted in two groups. Half of the participants received List A and the remaining half received List B. The experimenter read participants a list of 22 adjectives, either List A or List B, and told participants to remember them. Participants then engaged in a 30 sec distractor task in which the experimenter asked them to count backwards aloud by 7s from 100. Participants were then asked to recall the words, by writing them on a sheet of paper, from the list the experimenter had previously read. A recognition task was then given consisting of the 22 test words and 22 distractor words. The participant was instructed to circle those items that were previously read to them. All participants were debriefed at the conclusion of the experiment and participated in a discussion of memory strategies that were used in performing the task.

Results

In order to explore the difference between extreme words and central words for the conditions recall and recognition, two *t*-tests were conducted.

A significant difference was found between extreme and central words for the recall condition, $t(28) = 4.7$, $p <.001$ (extreme: $M = 4.07$, central: $M = 2.21$ words recalled); in the recall condition, more extreme words than central words were recalled. These results support Hypothesis 1. Additionally, the low number of words recalled indicates how difficult the task was for participants and why, in subsequent experiments, the number of words on the list was not as large.

A significant difference was found between extreme and central words for the recognition condition, $t(28) = 3.29$, $p < .01$ (extreme: $M = 7.76$, central: $M = 6.38$ words); in the recognition condition, more extreme words than central words were recognized. These results support Hypothesis 2.

Results regarding extreme versus central words, in both recall and recognition, parallel results in previous research regarding concrete and abstract words and support the prediction: extreme adjectives in the current study would elicit similar memory performance as concrete words from previous research and that central adjectives in the current study would elicit similar memory performance as abstract words from previous research.

Anecdotal post-experiment interview evidence was collected from participants and suggested that 1) participants appeared to be relying strongly/primarily on visual imagery, and 2) participants were not necessarily thinking about the words in terms of touch (e.g., a *dense* individual as opposed to an object that felt *dense*). The anecdotal information was collected after the experiment by asking participants to explain how they were recalling the objects, i.e., what processes or methods they were using to remember the adjectives.

Discussion

In summary, the predictions were supported: more extreme words than central words were recalled and more extreme words than central words were recognized. These results suggest that extreme adjectives are similar to concrete words, and central adjectives are similar to abstract words, when learning is measured using free recall and recognition.

Anecdotal evidence suggested that participants were using visual imagery to aid them and that they were not necessarily thinking about the adjectives in terms of touch. Subsequently, a follow-up study was conducted to clarify these findings in Experiment 1. Of concern was that participants' self-reports indicated that they used visual imagery to remember the words. A subsequent question was whether the stimuli varied systematically in their ability to generate visual and touch imagery. Since the original study by Stadtlander and Murdoch (2000) had participants generate touch-related adjectives, it was presumed in the current study that touch imagery would be high. A further question was whether there might be a greater overall sensory intensity for some words. Thus, participants in Experiment 1A were asked to rate each adjective for visual, touch, auditory, and olfactory intensity.

Experiment 1A

This study was designed to follow up Experiment 1 and isolate the cause of the concreteness effects as well as to empirically examine the anecdotal reports of Experiment 1 and determine if the words were considered primarily linked to the visual system as opposed to the presumed haptic system. The purpose of this study was to identify which of the 44 adjectives were associated most strongly with each of four sense modalities (visual, touch/haptic, auditory, olfactory). As these words had previously been selected based on their touch characteristics, it was hypothesized that touch would have the highest ratings. Furthermore, based on previous research (Lederman & Abbott, 1981; Stadtlander &

Murdoch, 2000), vision was expected to also have a high mean. This study was approved by the Montana State University Human Subjects Committee.

Hypothesis 1: touch will be the dominant sense (i.e. will have the highest mean rating), followed by vision. Touch is expected to have the highest mean rating in that these are all touch-related adjectives, selected from previous research (Stadtlander & Murdoch, 2000). Vision should have the second highest mean in that vision is a sense humans use often to collect information about their environment and objects in it and because visual imagery so often plays a role in memory. For example, Paivio (1971) put forth the dual coding theory that argued that imagery plays a functional role in memory and that concrete words have a memory advantage over abstract words because they are encoded verbally as well as imaginally whereas abstract words are more often encoded only verbally.

Hypothesis 2: it was expected that the overall ratings (all four sense modalities [vision, touch, auditory, olfactory] added together) for each word would correlate with performance on memory measures of recall and recognition obtained in Experiment 1. In other words, that the more "intense" the word was in terms of affecting a person's senses, the more likely it would be that the words would be remembered.

Method

Participants. The 11 participants included one Montana State University - Bozeman Psychology graduate student and 10 community volunteers. All 21 potential participants were emailed a memo briefly explaining the process and asking if they would like to participate and if so, to please return the rating form (which was attached) by a certain date. Consent was implied by the participants' completion and return of the form. Ten participants chose not to complete and return the form. One of the community volunteers failed to list age or years of education. Of the remaining nine volunteers and one graduate student, mean age was 38.80 years and mean education was 14.20 years.

Materials. A document listing 54 adjectives (all 44 adjectives from Experiment 1, plus an additional 10 words) vertically along the left side of the page was used. The 10 additional adjectives used were: *barbed, creamy, curly, floppy, glassy, plush, prickly, rocky, shiny, sleek.* These 10 words were also taken from the previous research by Stadtlander and Murdoch (2000); all adjectives were low frequency, meaning that they occurred less than 20 times per million in English and contained between five and seven letters. In addition, all adjectives had a touch frequency of less than 20, except for *prickly*, which had a touch frequency of 36. The document also contained four columns (one for each sense modality) and each word intersected horizontally with each of the four sense modalities (see Appendix C).

Procedure. Participants were solicited via email, asked to participate if they so chose, and given a deadline to return the completed document by if they wished to be involved; the rating document was attached. Participants were asked to rate the intensity of each of the adjectives on each of four sense modalities (visual, touch/haptic, auditory, olfactory) on a scale of 0 (no impression of the sense) to 7 (strong impression of the sense). Instructions were:

> "For each word, please rate the intensity of the word for each of the four senses listed. Use a scale of 0 = this word evokes no impressions of this sense to 7 = this word evokes a strong impression of this sense...Please rate all of the words on vision, then do all of the words on tactile, etc."

Results

For the list of 54 adjectives, rated on a scale of 0 to 7, the mean ratings for each sense modality are as follows: visual: $M = 5.12$, touch: $M = 4.77$, auditory: $M = 0.98$ and olfactory: $M = 0.84$. When these sense modality means were recalculated using only the original 44 adjectives from Experiment 1, on a scale of 0 to 7, the means for each sense are as follows: visual: $M = 5.06$, touch: $M = 4.72$, auditory: $M = 1.02$, and olfactory: $M = 0.93$.

In both cases, vision was the most highly rated sense, based on the means. These results do not fully support Hypothesis 1 since it was predicted that touch would be rated higher than vision as the adjectives being rated were all touch-related.

In order to explore whether differences between means for each sense modality were significantly different from one another, a repeated-measures ANOVA with ratings for the four sense modalities as dependent variables was conducted. Results indicate that there was a significant difference in the ratings of the words by sense modality, $F(1,3) = 152.78$, $p < .001$. In order to determine the locus of the effect, paired-sample t-tests, 6 overall, were conducted on all sense modality pairings. Alpha levels were adjusted by the following method: the overall alpha of .05 was divided by 6, resulting in a new alpha of .008. The alpha .008 was used in the post hoc tests to determine significance.

Results were statistically significant for the vision-auditory pairing, $t(43) = 14.71$, $p < .008$; for the vision-olfactory pairing, $t(43) = 17.29$, $p < .008$; for the touch-auditory pairing, $t(43) = 11.29$, $p < .008$; and for the touch-olfactory pairing, $t(43) = 18.50$, $p < .008$ (vision: $M = 5.06$; touch: $M = 4.72$; auditory: $M = 1.02$; olfactory: $M = 0.93$). No other comparisons were significant.

Results indicated that vision and touch were the senses most people associated with the adjectives most frequently. This partially supports the prediction of Hypothesis 1 in that vision and touch were the two most highly rated senses and the difference between the two was not significant; however, it does not fully support Hypothesis 1 in that vision was highest, followed by touch.

A by-item analysis was conducted by calculating the probability of each word being recalled and recognized in Experiment 1. Results indicated a correlation of $r(44) = .42$, $p<.01$ between the probability of recalling the word from Experiment 1 and its mean visual rating. A correlation of $r(44) = .35$, $p<.05$ was found between the probability of recognizing the word in Experiment 1 and its visual rating. These correlations indicate that there was a significant relationship between the adjective's visual rating and the probabilities of both recalling and recognizing a word. These results confirm the anecdotal reports from Experiment 1; the results may be based on the words' ability to invoke visual imagery, not on subject effect.

A correlation of $r(44) = .07, p > .05$ was found between the probability of recalling the word and its touch rating; for auditory, $r(44) = .05, p > .05$; for olfactory, $r(44) = .18, p > .05$. A correlation of $r(44) = .05, p > .05$ was found between the probability of recognizing the word and its touch rating; for auditory, $r(44) = .19, p > .05$; for olfactory, $r(44) = .23, p > .05$. These results indicate that there was not a significant relationship between the adjectives' rating for touch, auditory or olfactory and the probabilities of recalling or recognizing a word.

A correlation of $r(44) = .03, p > .05$ was found between recall and overall sense intensity rating for each adjective (i.e. summing the score in each of the four sense modalities for each word) and a correlation of $r(44) = -.07, p > .05$ was found between recognition and overall sense intensity rating for each adjective. Being that both of these correlations were non-significant, the results do not support Hypothesis 2.

Discussion

In summary, participants rated adjectives on four sense modalities and results indicated that these adjectives have both a strong visual and touch component while having virtually no auditory or olfactory component. As participants were not using objects associated with each adjective, there was no way of knowing what participants were thinking of when they rated an adjective. For example, in rating the word *wooly,* a person could be thinking of sheep, a wool mitten, the smell of wet wool, a special event or time in their life that the adjective brought to mind, and any number of other things. Experiment 1 and

Experiment 1A demonstrated a strong visual as well as touch component. Of interest was whether participants could utilize visual imagery instruction and touch imagery instruction to remember adjectives as well as whether the use of three-dimensional objects paired with adjectives would improve memory through the combination of visualization and haptic processing. Experiment 2 and the associated Pilot Studies sought to select objects that were clearly linked to the adjectives in the study, in an attempt to force participants to use objects and process in terms of touch, versus selecting something on their own.

As a result of Experiment 1 and 1A, it was determined that additional research would be needed. The intent of further research was to tighten the methodology being utilized and to experimentally manipulate visual imagery versus touch imagery instructions. In addition, in an attempt to lead participants to specifically use touch related information to remember the adjectives, in a third condition, objects were needed that were consistently associated with the adjectives.

Experiment 2, Pilot 1

This pilot study was designed to identify objects that were considered characteristic of each of the adjectives. It was intended to link the most salient adjectives to associated objects. The goal was to find 39 objects consistently linked to 39 available adjectives. Selection of objects was important. It has been demonstrated that people can improve at certain cognitive tasks (e.g. scanning) if the items of images being used are discriminable from one another physically or conceptually (Madden, 1982, as cited in Craik & Jennings,

1992) so the objects selected for Experiment 2 needed to be quite distinct. Objects also had to be small enough to fit in one or both hands so as to be haptically explorable, as in research by Lederman and Klatzky (1987). This study was approved by the Montana State University Human Subjects Committee.

Hypothesis 1: at least 39 objects will be consistently linked to 39 adjectives to be used in Experiment 2.

Method

Participants. Participants were two graduate psychology students and two undergraduates at Montana State University – Bozeman (1 male, 3 females). Mean age of participants was 22.5 years. Verbal consent was given by all of the participants.

Materials. Forty-two objects, small enough to fit in the hand, were selected based on the characteristics of each object that seemed most salient to the experimenters. Such items included a bottle opener (which was intended to elicit the adjective jagged), ping pong ball (which was intended to elicit the adjective hollow), burlap (which was intended to elicit the adjective woven) and sheep skin (which was intended to elicit the adjective wooly). It was hoped that each object had characteristics that would be sufficiently salient during haptic exploration to generate a list of adjectives associated specifically with the object.

Procedure. Participants were tested individually, with one experimenter and one participant per session. Blindfolded participants were handed, one at a time, a series of 42 objects that were small enough to be held in the hand. Participants were asked to thoroughly explore the object using both of their hands and to describe the object using only adjectives. Participants were allowed up to two minutes for each object to do this; the next object was not presented until the participant indicated that they had listed all the adjectives they felt described the object. The experimenters took notes on participant responses, which were recorded for all participants, for each object (see Appendix D for a list of objects used).

Results

Data from participants were examined for patterns in participant response, such as did the participants consistently use the same or similar adjectives to describe the object? Were any of the adjectives they used to describe the object the same adjective that was thought to be characterized by the object? Based on data collected from the four participants, there was very little consistency across participants in terms of what adjectives they used to describe each of the objects. There was wide variation in terms of the types of adjectives used to describe objects; for example, the object "can" was used in the hopes that it would elicit the adjective *hollow*. Data from the four participants shows that the following adjectives were used by participants and the frequency they were used: metal (1), thin (1), bends (2), flexible (1), polished (1), smooth (2), light (2), hollow (2), cylindrical (1), and crushable (2).

Discussion

In short, there was little consistency across participants in terms of responses and adjectives used to describe each of the objects varied tremendously. Rather than conduct a quantitative analysis on what were clearly inconsistent responses, these results determined that a more effective approach might be to revise the procedure and provide participants with a list of adjectives paired with objects and have them rate how well they feel the adjective is characteristic of the object, which was the basis for Experiment 2, Pilot 2.

Experiment 2, Pilot 2

The purpose of this pilot study was the same as for Experiment 2, Pilot 1: to identify the most salient adjectives and their related objects, circumventing the problem in Experiment 2, Pilot 1, of inconsistent results. For Experiment 2, Pilot 2, participants were given a list of adjectives paired with objects and asked to rate how well they felt the adjective was characteristic of the object. Due to the inconsistency of the responses in Experiment 2, Pilot 1, it was determined that adding additional adjectives, a total of 48, would further the chances of getting 39 adjectives with consistently high ratings. Selection of objects followed the same reasoning as described in Experiment 2, Pilot 1. This study was approved by the Montana State University Human Subjects Committee.

Hypothesis 1: at least 39 objects will be consistently linked to 39 adjectives to be used in Experiment 2.

Hypothesis 2: participants' rating of objects will not be related to whether the adjective paired with the object is central or extreme.

Method

Participants. Participants were eight lower division psychology students (5 female, 2 male, one did not provide gender) at Montana State University – Bozeman who were given class credit for their participation. Each participant completed two Volunteer Consent Forms, one of which was signed and given to the participant, the other of which was signed and retained by the experimenter.

Materials. Forty-eight adjectives were used in this pilot study. Of the 44 original words from Experiment 1, six (*frosty, immense, oblong, pulsing, frigid, petite*) were excluded from this pilot as they seemed to pose an operationalization issue: the experimenters found that it was very difficult to find objects that matched these particular adjectives. Ten new adjectives were used: *barbed, creamy, curly, floppy, glassy, plush, prickly, rocky, shiny, sleek.* These were also taken from earlier research by Stadtlander and Murdoch (2000). All adjectives were low frequency, meaning that they occurred less than 20 times per million in English and contained between five and seven letters. In addition, all adjectives had a touch frequency of less than 20, except for *prickly,* which had a touch frequency of 36.

There were 84 objects used in this pilot study; each adjective had one or more objects paired with it. Some adjectives had as many as three different objects paired with it for participants to rate in terms of how well the adjective characterized the object. Multiple objects were paired with adjectives in order to find the best possible match between the object and the adjective. For example, there were three different objects (a metal padlock, a heavy plastic figure, and a cork) associated with the adjective *dense*. The goal, in preparation for Experiment 2, was to find a minimum of 39 object-adjective pairs (13 for each of three conditions).

Procedure. Experimenters instructed participants:

> "I am going to show you a series of objects. For each object I am going to give you an adjective that may be related to this object. I would like you to rate the object on a scale of 1-5 as to how well you think it captures the adjective. So if you felt that the adjective had no relationship to the object you would rate it as a 1. If you felt that the object was a perfect example of the adjective you would rate it as a 5. For an example, if I gave you a penny and had you rate it for the adjective *hard* you would rate as a 5, but if I gave you the adjective *mushy* it would be a 1. Any questions?"

Participants were asked to rate each object of the given adjective on a scale of 1 (not characteristic of the adjective) to 5 (very characteristic of the adjective). See Appendix E for a list of the object-adjective pairs and the instructions given to each participant.

Results

A mean rating for each object was calculated. The goal of this pilot study was to find 39 object-adjective pairings. This goal was met and the 39 highest rated objects and adjectives were selected to be used in Experiment 2; all object-adjective pairings selected had mean ratings of 3.5 or higher. Thus, Hypothesis 1 was met. Descriptive statistics were run in order to verify that the level of interrater variance was minimal. To that end, means of all subject ratings (scale of 0 to 5) of each word were generated, as well as variance for each word. Presuming that the lowest level of possible variance between raters would be 0 and the highest possible was 8.82, a mid-level variance of 4.4 was used. The mean overall variance (0.85) for all words was compared to the mid-level variance (4.4), which means that the interrater variance was very low, which further suggests that interrater reliability was consistently high.

As expected, there was not a relationship between whether the word was extreme or central and rating of the objects, $r(38) = .27$, $p > .05$. In other words, ratings of the objects were not related to whether the adjective paired with the object was extreme or central, which was required to prevent possible stimulus confounds between word type and the rating of the object. Thus, Hypothesis 2 was supported.

Discussion

In summary, by creating pairings of adjectives with objects, the inconsistencies of Experiment 2, Pilot 1 were avoided and the goal of identifying 39 adjective-object pairs for use in Experiment 2 was achieved. Each pair selected had a rating of at least 3.5, on a scale of 0 to 5, indicating that the participants felt the objects consistently demonstrated the characteristics of the adjective.

Experiment 2

This experiment was designed to examine memory for central vs. extreme adjectives under tightly controlled conditions and to examine the influence of visual and touch imagery in memory. This was a 2 (word type: extreme or central) x 3 (condition: visual imagery instructions, touch/haptic imagery instructions, object) within-subjects design utilizing the memory measures of immediate recall, final recall and recognition as the dependent variables. This study was approved by the Montana State University Human Subjects Committee.

Based on previous research into concreteness effects and imagery, it is logical to presume that the concepts of central and extreme should be closely related to the concept of concreteness and the concreteness effect, where concrete items are remembered better than abstract items (Paivio, 1971). Additionally, since imagery has shown to be correlated with concreteness (Paivio et al., 1968), it is reasonable to expect that extreme words may be more like concrete words in that they are more likely to be imageable; central words may be more like abstract words and less likely to be imageable. Together, the concepts of concreteness and imagery combine to suggest that the extreme words may be more like concrete words in that they may be easier to image and that will facilitate remembering. In contrast, central words may be more like abstract words in that they may be more difficult to image and this will result in poorer memory. This logic is the basis for Hypotheses 1, 3, and 5, which follow below.

Furthermore, based on previous research, it is reasonable to suppose that the object condition will produce the highest levels of performance because it allows the participants to encode on two levels, following the logic of the dual coding theory (Paivio, 1971): one verbal where they hear the word and one non-verbal where they also touch the corresponding object, and perhaps generate a mental picture. It may also be that by providing both the spoken word as well as the associated object to hold would lead to easier generation of a context, such as is argued in the context availability theory (Schwanenflugel et al., 1992). Finally, as in the depth of processing theory (Craik & Lockhart, 1972; Craik & Tulving, 1975), processing both the spoken adjective and haptically exploring its associated object may lead to deeper processing which may, in turn, lead to enhanced memory performance. Additionally, research by Stadtlander et al., (1998) found that real objects were better recalled than concrete, high-imagery nouns. Logically, pairing the adjective with an associated object may improve memory performance.

The visual imagery instruction condition is expected to produce the second highest mean in that it is a sense humans use frequently and that is useful in gathering information and because visual imagery so often plays a role in memory. However, the visual imagery instruction condition will not be as efficient as the object condition as it is only a single sense (e.g. people are only being asked to visually imagine, or image, the adjective) and limited to only information that the eyes are useful for collecting, such as geometric properties of an object (Klatzky et al., 1993). Thus, mental images formed are likely to include information about size or shape rather than texture or weight.

The touch imagery instruction condition will show the lowest memory performance; it is a single sense and provides information in situations for which touch is the most useful modality, such as for gathering information about texture or an object's material (Klatzky et al., 1993). This logic leads to Hypotheses 2, 4, and 6, which follow below.

In essence, there are two hypotheses for each of the three dependent variables: immediate recall, final recall, and recognition.

Hypothesis 1: for immediate recall, more extreme words than central words will be recalled.

Hypothesis 2: for immediate recall, the object condition will result in the highest number of adjectives recalled, visual imagery instruction condition next, and touch/haptic imagery instruction condition the least.

Hypothesis 3: for final recall, more extreme words than central words will be recalled.

Hypothesis 4: for final recall, the object condition will result in the highest number of adjectives recalled, visual imagery instruction condition next, and touch/haptic imagery instruction condition the least.

Hypothesis 5: for recognition, more extreme words than central words will be recognized.

Hypothesis 6: for recognition, the object condition will result in the highest number of adjectives recalled, visual imagery instruction condition next, and touch/haptic imagery instruction condition the least.

Method

Participants. Participants were 30 students (15 male, 15 female, mean years of age 22.93; mean years of education 14.87; 28 Caucasians, one African American and one Native American) in a lower division psychology class at Montana State University – Bozeman who received extra credit for their participation. Each participant completed two Volunteer Consent Forms, one of which was signed and given to the participant, the other of which was signed and retained by the undergraduate experimenter. At the end of each experimental session, participants were debriefed.

Materials. The adjectives/objects derived in the Pilot Studies were randomly assigned to one of three lists (AA, AB, AC) these were counterbalanced between the participants. By doing this, it was insured that each participant had a different list and thus, list order effects were mitigated. Prior to the experimental session, each participant was given a study number with half of the participants given even numbers and the remaining half given odd numbers; even numbered participants were given the objects in reverse order. After every 12 participants, the adjectives/objects were re-randomized into three new lists (BA, BB, BC; & CA, CB, CC) and were again counterbalanced between the participants (see Appendix F for a complete listing of items and counterbalancing). This insured that every subject received the adjectives in a different order under the various conditions. Each list had either six central words and seven extreme words or 5 central words and 8 extreme words, for a total of 13 words per each of three lists.

Although objects were associated with the adjectives, the only condition that used the objects was the object condition (visual and touch conditions only used the adjectives).

Stimuli. In this study, there were three conditions (visual imagery instruction, touch/haptic imagery instruction, object), each being tested in terms of immediate recall, final recall, and recognition. In order to test memory, each list needed to be longer than short-term memory capacity, which is often described as 5-9 items (Miller, 1956; Reisberg, 2001). Consequently, 39 adjectives and the object most highly associated with each adjective (based on a mean rating of 3.5 or above from Experiment 2, Pilot 2) were used, with 13 adjectives for each condition list. Of the 39 words used, 22 were considered extreme and 17 were considered central.

Procedure. Each experimental session was conducted individually in a laboratory setting, with only the participant and the experimenter present. All three conditions were used with each participant. Thirteen words were to be used in each of 3 conditions for a total of 39 adjectives. The order in which each participant received the conditions varied by the participant's assigned counterbalancing (by even or odd number subject) prior to the experimental session. Participants were required to recall the items after each list (immediate recall) and a final recall test surprise (participants were not told to expect this memory test) was given of all words given in all conditions (final recall). Finally, a recognition task was given consisting of the 39 words from the original list with an additional 39 distractors, all in random order (please see Appendix G for the recognition test given to the participants. Embedded in this Appendix G is also the recognition key used by experimenters [the original adjectives used in the study are in bold], which included whether the 39 adjectives were extreme or central). The entire study took approximately one hour.

Briefly, the visual imagery condition was conducted and followed by a test of immediate recall for the adjectives in that condition. The touch imagery condition was conducted and followed by a test of immediate recall for the adjectives in that condition. The object condition conducted and followed by a test of immediate recall for the adjectives in that condition. A surprise test of recall of adjectives from all three conditions was then conducted, followed by a recognition task of adjectives from all three conditions. The order of the three conditions was counterbalanced between participants.

In the visual imagery condition, participants were instructed to visually imagine an object that was consistent with a given adjective. Experimenters provided the following instructions to participants:

> "In this part of the experiment I am going to read you a list of 13 adjectives. I want you to try to visualize an instance of each word to help you remember it. So for example, if the word was *brassy* you might visualize a brassy object to help you recall it later. I am going to give you 5 sec with each word so that you can visualize it. Do you have any questions?"

The experimenter read the list of 13 words at a rate of one word every five seconds. Participants then engaged in a distractor task for 30 seconds, in which they were asked to count backwards from 100 by 7's. The experimenter then asked the participant to write down as many of the words from the list that they could remember (immediate recall).

In the touch/haptic imagery condition, participants were asked to imagine touching an object consistent with the adjective. Experimenters provided the following instructions to participants:

> "In this part of the experiment I am going to read you a list of 13 adjectives. I want you to try to imagine what an object with this characteristic would feel like in order to help you remember it. So for example, if the word was *soft* you might imagine feeling a soft object to help you recall it later. I am going to give you 5 sec with each word so that you can visualize it. Do you have any questions?"

The experimenter read the list of 13 words at a rate of one word every five seconds. Participants then engaged in a distractor task for 30 seconds, in which they were asked to count backwards from 100 by 6's. The experimenter then asked the participant to write down as many of the words from the list that they could remember (immediate recall).

In the object condition, participants, while blindfolded (using a black night mask that thoroughly covered both eyes and fastened securely behind the head, were given and asked to hold a real object characteristic of the adjective and then asked to use the object to remember the word. Experimenters provided the following instructions to participants:

> "In this part of the experiment you are going to be blindfolded. I am going to read you a list of 13 adjectives and I am going to have you hold an object that characterizes the adjective. So for example, if the word was *hard* I might give you a small piece of metal to help you recall it later. I am going to give you 5 sec with each object so that you can remember it. Do you have any questions?"

The experimenter read the list of 13 words at a rate of one word every five seconds; the participant was expected to hold and haptically explore the object for those five seconds. Participants then engaged in a distractor task for 30 seconds, in which they were asked to count backwards from 100 by 8's. The experimenter then asked the participant to write down as many of the words from the list that they could remember (immediate recall).

For the final recall, which was a surprise task in that participants were not told to expect, experimenters instructed each participant to write down as many of the adjectives as they could that were in the study and to alert the experimenter when they had completed the task. Participants were given up to five minutes to complete the final recall task.

For the recognition task, participants were given a list of adjectives, which included the original 39 used in the study plus 39 distractor words which were not used in the study. The experimenter instructed participants to circle all of the words that were in the study.

Next, each participant verbally completed a questionnaire that included demographic information (such as gender, age, race and years of education) and were also asked specific questions regarding how they did the task in each condition ("How did you do the task with the visual imagery instructions?"). The questionnaire also contained questions about which task they found the easiest and why, asked participants to explain which sense they felt they relied on the most, and asked them to answer whether they considered themselves more visual, tactile or auditory. Being that there was very little consistency, no quantitative analysis was conducted.

Finally, each participant was debriefed by the experimenter.

Results

All data in the following statistical analyses were transformed to percentages. A 2 (word type: extreme or central) x 3 (condition: visual, touch/haptic, object) repeated-measures ANOVA was conducted for each dependent variable (immediate recall, final recall, and recognition) to see if there was a main effect for word type or condition or an interaction between the two independent variables. Paired samples post hoc t-tests were conducted where results were significant.

Immediate Recall. For immediate recall, there was a main effect of word type, $F(1,58) = 7.67$, $p < .05$, demonstrating that more extreme words ($M = 64.30\%$) than central words ($M = 57.23\%$) were recalled. This supports Hypothesis 1; not only were the concreteness effects from Experiment 1 not lost, Experiment 2 was able to successfully replicate the concreteness effects under more controlled experimental conditions.

The main effect of condition was not significant, $F(2,58) = 1.47$, $p > .05$ (Vision: $M = 61.30$; Touch: $M = 58.08$; Object: $M = 62.92$). This does not support Hypothesis 2.

There was a significant interaction between word type and condition, $F(2,58) = 5.98$, $p < .05$. In immediate recall, extreme words were remembered significantly better than central words in the visual imagery condition; in the touch imagery condition, extreme words were recalled marginally better than central words, and there was not a significant difference under the object condition (see Figure 1).