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## Auditory picture superiority unconfirmed in recognition memory

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AUDITORY PICTURE SUPERIORITY  
UNCONFIRMED IN  
RECOGNITION  
MEMORY

Thesis

Submitted to

The College of Arts and Sciences of the  
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The Degree

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by

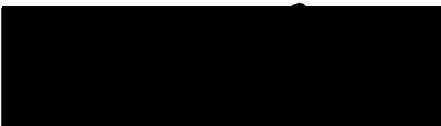
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Dayton, Ohio

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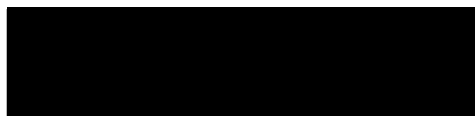
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## ABSTRACT

### AUDITORY PICTURE SUPERIORITY UNCONFIRMED IN RECOGNITION MEMORY

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An auditory analogue to the well-substantiated picture superiority effect (Kirkpatrick, 1894; Paivio & Csapo, 1969; Paivio & Csapo, 1973) was examined in a recognition memory paradigm. Recent research found a superior memory for sounds over spoken word labels in free recall (Crutcher & Beer, 2006; Crutcher & Taylor, 2008). This study examined memory for sounds and words in recognition. Participants listened to an auditory sequence of both readily identifiable sound effects and spoken word labels and were later asked to recognize from pairs of printed words ("forced-choice") each word that corresponded with an item from the encoding phase. Participants were not aware that they were going to be asked to remember the auditory items, so learning was incidental. No significant difference was observed between the number of spoken words and sound effects correctly identified by the participants. A number of methodological issues present in the study are addressed, including the need for a thorough examination of the stimuli along measures of familiarity, concreteness, imaginability, and labelability; the impact of using an incidental memory task versus an intentional memory task; and the

need for inclusion of a post-study questionnaire. Additionally, an interesting pattern of an auditory picture superiority effect for only categorically human sounds over their corresponding verbal labels emerged, suggestive of the need for further examination of the role of sound category as a mediating variable to an auditory picture superiority effect. Additionally, possible interpretations of the observed non-effect in recognition memory are explored, including the role of qualitative processing differences that underlie recognition memory and free recall.

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## CHAPTER I

### INTRODUCTION

For some time it has been known that pictures are better recalled than their corresponding nouns (Kirkpatrick, 1894; Madigan, 1983; Nelson, Reed, & Walling, 1976; Paivio, 1969; Paivio, 1979; Paivio & Csapo, 1969; Paivio & Csapo, 1973). The pictorial, or picture, superiority effect was the title conferred upon the surprising memory phenomenon in which individuals recall previously displayed pictures better than previously displayed words. The primary explanation for this observation is dual-coding theory (Paivio, 1979, 1983, 1990; Paivio & Csapo 1973). Dual-coding theory proposes that the reason for the observed improved recall of pictures over their word counterparts is that when an individual views a word, they encode this information verbally, whereas when a person views a picture, they encode this both visually *and* verbally (Paivio, 1975, 1990, 1991). This occurs because when viewing a picture of a recognizable object (e.g., a picture of a boat), a person is also highly likely to implicitly give a verbal label to the object (e.g., calling it “*boat*”). Logical extension of dual-coding theory suggests its translatability to additional sensory modalities, like audition. Recent research using free recall has demonstrated that auditory stimuli are remembered better than their verbal labels (Crutcher & Beer, 2006; Crutcher & Taylor, 2008). The purpose of this research is to expand on the finding that auditory images are remembered better than words by examining whether

individuals are better at recognizing printed words corresponding to sounds they have heard over their spoken word counterparts, thereby providing further support for the existence of an auditory analogue to the picture superiority effect, offering further exploration of the implications of dual-coding theory.

### *Support for the Picture Superiority Effect*

The picture superiority effect is a well-documented memory phenomenon. A great amount of research provides evidence for the effect (e.g. Blaxton, 1989; Kinjo & Snodgrass, 2000; Kirkpatrick, 1894; Madigan, 1983; Nelson, Reed, & Walling, 1976; Paivio, 1969; Paivio, 1979; Paivio & Csapo, 1969; Paivio & Csapo, 1973; Roediger & Blaxton, 1987; Snodgrass, 1980; Whitehouse, Mayberry, & Durkin, 2006). It has been shown that the effect persists regardless of memory processing being intentional, with participants being informed prior to encoding that their memory for the stimuli will be tested, or incidental, with participants performing another task during encoding designed to prevent them from anticipating a memory test (Paivio & Csapo, 1973). Recent research has found the effect with auditory stimuli as well, finding it persists under both intentional and incidental encoding conditions (Crutcher & Taylor, 2008). Additionally, the picture superiority effect appears to strengthen with age (Ally, Waring, Beth, McKeever, Milberg, & Budson, 2008; Whitehouse et al., 2006).

Although the effect has been consistently observed with designs utilizing cued recall (e.g. Nelson & Reed, 1976; Vidya & Gabrieli, 2000) and free recall (e.g. Paivio & Csapo, 1973; Ritchey, 1980), the phenomenon has not been found in all memory tasks. For example, the picture superiority effect has been examined in implicit

memory tasks with varying results, often divided between perceptual and conceptual tasks (Blaxton, 1989; Kinjo & Snodgrass, 2000; Roediger & Blaxton, 1987; Snodgrass, 1980). Perceptually implicit tasks, such as those using words to prime fragment completion, have shown a reversal of the picture superiority effect (Weldon & Roediger, 1987). Evidence has also suggested that implicit conceptual tasks, like the generation of categorical exemplars, result in no differences between using pictures and words as primers (Weldon & Coyote, 1996), a finding contrary to what would be predicted by theories suggesting pictures are advantaged by their deeper processing at encoding over words. Additionally, research using serial recall paradigms (e.g. Nelson, Reed, & McEvoy, 1977; Paivio & Csapo, 1969), in which order is to be recalled as well as the stimuli, has found mixed results, with manipulations of the stimulus presentation rate affecting the direction of superiority (Paivio & Csapo, 1969). Specifically, faster presentation rates of stimuli at encoding result in words being remembered better than pictures. This is possibly due to participants having inadequate time to verbally label the pictures. Furthermore, the picture superiority effect has been examined when response deadlines (or the maximum period of time that may elapse before a participant is required to respond) are manipulated. The effect has been found to be consistent with longer response deadlines (greater than or equal to 2000 ms), but is reversed when speed is encouraged over accuracy by using deadlines of less than 200 ms (Boldini, Russo, Punia, & Avons, 2007).

### *The Picture Superiority Effect in Recognition Memory*

In addition to the previously discussed paradigms, recognition tasks have also been used and have found the picture superiority effect (Mintzer & Snodgrass, 1999; Pavio & Csapo, 1969; Paivio & Csapo, 1973; Shepard, 1967; Snodgrass & McLure, 1975; Standing, Conezio & Haber, 1970; Stenberg, 2006; Stenbert, Radeborg & Hedman, 1995). The effect is surprisingly strong, overriding effects of intramodal, transfer appropriate processing—items studied as pictures are better recognized than words, even when testing occurs in word format (Madigan, 1983). Interestingly, however, Stenberg, Radeborg, and Hedman (1995) found that although pictures were more often correctly recognized, even cross-modally, reaction times were faster for modality-consistent items between study and testing.

Recognition memory is notably more susceptible to an increase in correct responses (Pavio & Csapo, 1969), over and above what is typically expected of free recall paradigms (Paivio, Rodgers & Smythe, 1968; Shephard, 1967). Much of the debate around the difference between the processes involved in recall and recognition memory has traditionally centered on the issue of the involvement of retrieval. An earlier model, the trace-strength model, supported the idea that a single shared process underlies both memory types (Kintsch, 1966, 1970). The trace-strength model suggests that recognition and recall differ only in that the threshold of strength of familiarity necessary for recognition of an item is lower than the threshold needed for the recall of an item, but the single underlying process is fundamentally the same for both forms of memory (Kintsch, 1970). Proponents of this model have pointed to the number of common experimental manipulations that affect recognition and recall

similarly, such as manipulations of study time and retention intervals (Kintsch, 1966; Olson, 1969). On the other hand, many other experimental manipulations are found to impact recall and recognition memory differently, and this has raised doubts as to the likelihood that both types of memory rely on a single, common process. For example, it is well known that recall is better for familiar (common) words than for low-frequency (uncommon) words (Hall, 1954; Sumby, 1963), whereas the reverse is true of recognition (Gorman, 1961; Schulman, 1967; Schulman & Lovelace, 1970; Shepard, 1967).

Research demonstrating independence of the processes underlying recall and recognition memory has brought much support to two-process models (Atkinson & Juola, 1973, 1974; Mandler 1979, 1980, 1991; Tulving, 1985, 1982). For such models it has been proposed that in recall, a retrieval, or generative, stage in which candidate items are selected from long-term memory, is followed by a familiarity testing, or “recognizing,” stage in which the candidate item’s familiarity and contextual associations are evaluated to determine if the item had been presented during the encoding phase (Anderson & Bower, 1972, 1974; Kintsch, 1970, 1974). For recognition memory, on the other hand, some have argued that only the later stage—a familiarity check—of the previously described recall process is necessary, in that a retrieval, or a generative searching, stage is not essential because candidate items have already been “generated” by way of the test items (Anderson & Bower, 1972; Kintsch, 1970). Other models maintain, however, that retrieval is necessary for recall during testing in recognition (Tulving & Thompson, 1971, 1973). Snodgrass and McClure (1975) found that pictures and concrete nouns paired with instructions

to image those nouns are better recognized than words with no imaging instructions, and that performance is unchanged by using either pictures or words as the test items. Their findings suggest that the appearance of the picture superiority effect is due to subjects' use of a dual code at encoding. Additionally, item-by-item correlations revealed that participants were more consistent when the test items were in the same format as the items given during encoding (i.e., pictures during both encoding and testing, or words at both encoding and testing). Snodgrass and McClure concluded that this decrease in consistency—but not in efficiency—when forms are not matched could likely be attributed to the process of retrieval during recognition.

Although there are a multitude of competing two-process models of both memory types (e.g., Atkinson & Juola, 1973, 1974; Mandler 1979, 1980, 1991; Tulving, 1985, 1982; Yonelinas, 1994, 1997, 2001), current models tend generally to agree on the involvement of two-stages in the process of recognition memory (Bahrick, 1970; Gillund & Shiffrin, 1984; Juola, Fischler, Wood, and Atkinson, 1971; Mandler, 1972, 1980). Generally speaking, these two-stage models tend to agree upon the involvement of a familiarity evaluation stage, in which test items are judged for low or high familiarity, and a second, retrieval/recollection generative-based stage, in which items presented during encoding are retrieved from memory and compared to the test items. Current two-process models do differ on various issues, such as whether the two stages occur in parallel or sequentially, with familiarity testing being the faster of the two processes, and whether only items of moderate familiarity move to the generative stage (Gillund & Shiffrin, 1984). Although some computational models, such as the spreading activation model (SAM) (Ratcliff, Van

Zandt, & McKoon, 1995), maintain recognition memory can be accounted for by way of a single process (i.e., familiarity) alone, the majority of recent research has provided support for a distinction between stages of familiarity and recollection in recognition memory (Yonelinas, 2002). Empirical evidence includes observed processing speed differences for familiarity and recollection testing (Hintzman & Caulton, 1997; Gronlund, Edwards, & Ohrt, 1997), and distinct receiver operator characteristic curves for familiarity and recollection created in studies using response confidence (Kelley & Wixted, 2001; Glanzer, Kim, Hilford, & Adams, 1999). Additionally, neurophysiological support has been provided by evidence from brain lesioning resulting in dissociated impairment of the two processes (Aggleton et al., 2000), and from data collected based on ERP signals (Curran, 2000; Klimesch et al., 2001).

Exploration into the precise nature of the processes underlying recognition memory continues to be an extensive area of research and a topic of debate (for a thorough review, see Yonelinas, 2002). However, most current memory models and experimental evidence reliably points to clear differences existing between the memory processes involved in recognition and free recall. What is significant is that although free recall and recognition differ in the involved memory processes, the picture superiority effect is obtained for both types of memory.

#### *Explanations of the Picture Superiority Effect*

There are two prominent proposed explanations as to the cognitive basis of the picture superiority effect. These are the sensory-semantic model (Nelson, 1979; Nelson & Brooks, 1973; Nelson, Reed, & McEvoy, 1977; Nelson, Reed, & Walling,

1976; Stenberg, Radeborg, & Hedman, 1995) and Paivio's dual-coding theory (Paivo, 1979, 1983, 1990, 1991, 2007).

Nelson's sensory-semantic model maintains that pictures provide a superior sensory code when compared to words that predisposes them to be both more distinctive and a trigger for efficient and reliable semantic processing (Potter & Faulconer, 1975; Smith & McGee, 1980), which provides a mnemonic advantage (Craik & Lockhart, 1972). The sensory-semantic model presupposes two stores, one semantic and one sensory, into which information gleaned from pictures or words enters. The semantic store represents a common store for meanings of events, such that input modality is not important. For example, reading the word "horse" or seeing a picture of a horse result in identical semantic stores of information. Perceptual aspects of information are also stored, and this information is modality specific, such that the input format is retained. The perceptual qualities of an image, a word, or a sound are retained independently.

The superiority of pictures over words in memory may be due to advantages achieved during the encoding of either the semantic or sensory information. For the most part, the sensory-semantic model maintains that the advantage of pictures over words is a sensory advantage, due to their greater perceptual distinctiveness. For example, the physical variation from typed word to typed word is greatly limited when comparing the rich differences in perceptual information provided between pictures. This distinctiveness advantage of pictures is supported by an observed reversal of the picture superiority effect when pictures of high visual similarity are used at encoding (Nelson, Reed, & Walling, 1976). Additionally, the sensory-

semantic model predicts that pictures will lose their advantage of distinctiveness over words when testing is not conducted in the same form as used during encoding.

Mintzer and Snodgrass (1999) tested this prediction, finding that pictures presented at encoding were recognized more often when pictures were also used at testing than when words were used at testing. On the other hand, words presented at encoding were recognized equally as often whether test items were pictures or words.

Although explanations of the picture superiority effect using the sensory-semantic model tend to identify perceptual distinctiveness as the main cause, Nelson (1979) suggests that pictures may enjoy a *semantic* advantage over words as well. In the semantic store, it is suggested that pictures may be encoded more efficiently than words (Roediger & Blaxton, 1987; Roediger, Weldon, & Challis, 1989; Weldon & Roediger, 1987).

Alternatively, Paivio's dual-coding theory maintains that pictures are more likely to be remembered than words due to pictures being more likely to be stored as two codes, whereas words are likely to be stored as only one (1979, 1983, 1990, 1991, 2007). When a word is seen, it is encoded primarily in the verbal modality, whereas pictures are encoded as a visual image as well as having a high probability of being implicitly encoded as a verbal label for the picture. When an individual is presented with a concrete visual stimulus they are likely to implicitly name that image. Additionally, these pictorial and verbal representations are believed to be stored in interlinked, but independent systems (Paivio, 1971, 1990). Dual-coding theory suggests that by increasing the likelihood of activation, this dual visual and verbal code advantages the recall of pictures over words and their single verbal code

during memory tests. Empirical evidence for the process of dual encoding is seen in that subjects are more likely to impulsively name pictures than they are to image concrete nouns (Snodgrass, Wasser, Finkelstein, & Goldberg, 1974). Additionally, when participants are explicitly instructed to image to words during encoding (i.e., to imagine the object referred to by the word), the picture superiority effect is negated (Paivio & Csapo, 1973). Paivio also suggests that the image code is inherently more memorable than the verbal code, so even if only a single code is stored, pictures will still be recalled more often than words (1990).

#### *Implications of Dual-coding Theory*

Although there is support for both dual-coding theory and the sensory-semantic model in explaining the picture superiority effect, the empirical support for Paivio's model has led to some interesting logical extensions and resultant experimentation. The heavy historical emphasis placed on the visual modality has tended to overshadow a possible modal hierarchy involving senses other than just vision (Paivio, 1991). For example, if the addition of a verbal label to a visual code facilitates memory, then it seems also likely that verbal labels applied to olfactory, gustatory, tactile, and auditory codes would lead to superior memory performance.

The amount of research exploring other sensory modalities for respective superiority effects has been fairly small. Tactile and olfactory memories have seen limited assessment, and a gustatory picture superiority analogue has yet to be examined. Much of the research examining odor memory has suggested that although retention for memories of odors in the long run is generally found to be good, it does not seem to be facilitated by the addition of verbal labels (Ayabe-

Kanamura, Kikuchi, & Saito, 1997; Engen & Ross, 1973; Lawless & Cain, 1975; Lawless & Engen, 1977). This may be due to an exceedingly narrow vocabulary for describing and naming scents when compared to visual stimuli. However, this lack of an effect is not universally supported. Empirical findings consistent with Paivio's dual-coding theory have also revealed memory for odors can be improved by the pairing of verbal labels with odor stimuli at encoding (Rabin & Cain, 1984). Elaboration in an additional modality (verbal or visual) has been found to improve odor retention, and memory for odors has displayed superiority to words (Lyman & McDaniel, 1990). The research exploring additional modality analogues to the picture superiority effect is even more limited when it comes to tactile examinations. Mahrer and Miles examined the ability of participants to recognize tactile sequences, finding that articulatory suppression hindered accuracy (2002). They reasoned that individuals were spontaneously employing verbal labels and visualization to assist memory for the tactile patterns and sequences, a conclusion consistent with dual-coding theory.

#### *An Auditory Picture Superiority Effect in Free Recall*

Although still relatively limited, slightly more experimentation has been devoted to the auditory domain, exploring memory for sounds compared with verbal labels. Examination of sounds utilizing free recall paradigms have produced mixed findings. Early research testing memory for sounds versus verbal labels in serial recall paradigms found that words were better retained, a finding consistent with studies using visual stimuli. However, when free recall was used, the difference disappeared, with recall of sounds and words being equal (Philipchalk & Rowe 1971).

Expanding upon this, Paivio, Philipchalk, and Rowe continued to show a superiority of verbal labels in serial recall, but obtained evidence that individuals tended to show a combined better free recall performance for nonverbal stimuli in the form of sounds and pictures than verbal stimuli (1975). However, in the free recall paradigm, when auditory stimuli and their corresponding verbal labels were compared independently, no advantage was seen for the sounds. Crutcher and Beer (2006), in examining the findings of Paivio et al. (1975), recognized that there appeared to be a small, but statistically non-significant advantage for sounds over verbal labels in free recall, believing that significance may have been lost to insufficient statistical power.

More recent examinations of an auditory picture superiority effect have provided support for the phenomenon in free recall paradigms (Crutcher & Beer, 2006; Crutcher & Taylor, 2008; Huss & Weaver, 1996). Huss and Weaver, utilizing a between-subjects design, found a significant increase in recall amongst individuals for sound stimuli over verbal stimuli (1996). Operating under the assumption that the advantage of the recall of sounds over words was relatively small and dependent upon sufficient statistical power for detection, Crutcher and Beer (2006) utilized a within-subjects design (experiments 1 and 3) and increased the number of stimuli (experiment 2) over what had been previously used by Paivio, et al (1975) and Huss and Weaver (1996) in between-subjects paradigms. The experiments found that sounds were more readily recalled than verbal labels in both within- and between-subjects designs. Furthermore, Crutcher and Beer (2006) found that the effect could be eliminated by asking participants to image sounds to the spoken word labels,

providing evidence of an auditory picture superiority effect and further support for dual-coding theory.

### *An Auditory Picture Superiority Effect and Recognition Memory*

These recent findings have lent support to both the reality of an auditory picture superiority effect as well as to Paivio's dual-coding theory by showing that individuals exhibit a greater ability to recall sounds over verbal labels. Although evidence has strengthened the finding in free recall paradigms, the status of the auditory picture superiority effect in recognition is untested. The only previous investigation clearly analyzing the ability of participants to recognize sounds compared to verbal labels was performed by Miller and Tanis (1971). In the study, participants were presented with sounds, printed words, and spoken words. At test, participants were presented with items in matched format (i.e., sounds used at encoding were presented as sounds at test, etc.) and were asked to recognize the items to which they had previously been exposed. The study found that participants recognized sounds less frequently than both printed and spoken words in a forced-choice recognition test. Subjects' relatively low recognition ratio for sounds (less than 70% correct) in Miller and Tanis' study is in stark contrast to what has been seen for recognition of pictures (greater than 90% correct) (Standing, Conezio, Haber, 1970). Additionally, it has been shown that recognition memory for concrete sounds is also very good (Lawrence & Banks, 1973; Leung, 1997), calling into question the basis for Miller and Tanis' findings.

The purpose of this study was to examine the auditory picture superiority effect in a recognition paradigm, and to further test the implications of dual-coding

theory. With the additional empirical evidence of the effect observed in free recall paradigms (Crutcher & Beer, 2006; Crutcher & Taylor, 2008), examination of the effect in recognition memory was a logical next step. The experiment employed a within-subjects design, for increased statistical sensitivity. Additionally, recognition testing was conducted entirely in printed word form, regardless of modality at presentation. This is in contrast to the methodology employed in Miller and Tanis' experiments, where modality was matched between testing and encoding. This approach was taken to be consistent with prior research examining an auditory picture superiority effect in free recall (Crutcher & Beer, 2006; Crutcher & Taylor, 2008) and picture superiority in recognition (Boldini et al., 2007). It was predicted that more words would be recognized that corresponded to stimuli that had been presented as sounds during encoding than as verbal labels of sounds.

## CHAPTER II

### METHOD

#### *Participants*

The participants were 67 undergraduate students, between 18 and 22 years of age, from the University of Dayton enrolled in an introductory Psychology course. Participants were recruited via Sona System, a web-based participant recruitment tool, and were granted course credit for their participation in the study. The research was conducted in accordance with the Research and Review and Ethics Committee of the University of Dayton Psychology Department and the rules and standards established by the American Psychological Association. Participation was confidential—names and all identifying information were held separately from the experimental data collected. The study was conducted in a laboratory room approximately 5' x 7' in the St. Joseph building on the University of Dayton campus. The data of 3 participants were excluded from the analysis, for failure to complete the experiment. Two of these participants did not properly operate the computer program, causing the computer to freeze, and for the third participant, a fire alarm went off during testing. Therefore, the data for 64 participants were included in the analysis. Participants were tested in a one-way within-subjects design, with the independent variable being the stimulus type with 2 levels (sounds or spoken words)

and the dependent variable being the number of items correctly recognized at test.

### *Apparatus and Stimuli*

Seventy-six recorded sounds and 76 corresponding spoken word labels were used in the study. Sounds were selected from a CD of sound effects (Crutcher & Beer, 2006; Crutcher & Taylor, 2008) and from a website of free sound effects (<http://www.findsounds.com>). Spoken verbal labels were recordings made by the experimenter, and were therefore a male voice. All sounds and spoken word recordings were normalized and edited to be less than or equal to 2 seconds in length and at equal average playback volumes using GarageBand 4 sound editing software. Sound files were converted from uncompressed Audio Interchange File Format (.aif) or the Waveform Audio Format (.wav) to the 192 kbs MPEG-1 Audio Layer 3 (.mp3) format.

A software program written in Runtime Revolution was used to present the stimuli and was run on a Macintosh computer using the Mac OS X operating system. Sound stimuli were played through speakers attached to the computer. Two unique computer printed response forms were created for recording the participants' answers (see Appendix A), each consisting of 38 items. Each participant received only one of the two response forms, corresponding to the presentation order condition that that participant had been randomly assigned. Each item on a response form consisted of two typed words, one word corresponding to one of the stimuli that had been presented during the presentation phase, and a second that served as a foil. The order that the items appeared in on the answer forms, the pairings of correct items and foils, as well as whether the correct item or the foil appeared in the left or right hand

column, were randomized and did not correspond with the order that the stimuli had been presented during the presentation phase.

Additionally, a series of basic math problems (all one and two digit addition and subtraction) served as a distracter task during the retention phase, between the listening phase and the recognition phase (see Appendix B).

### *Stimuli Blocking*

The 76 sound effects were randomly divided into 4 unique blocks containing 19 different sounds in each. The spoken words corresponding to these sound effects were divided into 4 blocks corresponding to the 4 blocks of sound effects (e.g., if a block of sounds contained the sound of a dog barking, followed by an airplane passing, followed by a sneeze, then the corresponding spoken word block contained the spoken word “dog,” followed by “airplane,” and then “sneeze.”) Sixteen different presentation orders were then created by pairing one block of 19 sound effects with one block of 19 *non-corresponding* spoken words, creating a presentation list of 38 total items. No presentation list contained both the sound effect and the spoken word *referring to the same item* (e.g., no list contained both the sound of a dog barking and the spoken word “dog”). Each participant listened to only *one* presentation order consisting of 19 sound effects and 19 spoken words, for a total of 38 different stimuli. Each of the sound effects blocks occurred with each of the non-corresponding spoken word blocks. Each of the blocks occurred in both the beginning and end positions an even number of times across all participants (i.e., an equal number of participants heard a block of 19 spoken words before a block of 19 sound effects as heard a block of 19 sound effects before a block of 19 spoken words). Those items that were *not*

used in a given presentation served as foils on the answer form during recognition testing. All of the stimuli were presented an equal number of times across all participants.

### *Procedure*

Participants were randomly assigned to one of the 16 presentation orders of the auditory stimuli. These 16 orders were used for the purpose of counterbalancing. Each order was presented to a total of four participants.

Participants in the study were tested individually. After arriving, participants were seated at a computer desk and presented with an informed consent form. After reading and signing the form, the experimenter read a set of instructions to the participant (see Appendix C) and demonstrated to the participant how to operate and advance the computer program. In the instructions, the experimenter explained to the participant that they would be listening to a series of auditory stimuli and then judging the duration of those stimuli by saying either “short,” “medium,” or “long” aloud to the experimenter immediately following the playing of each. This was done so that encoding of the stimuli would be incidental, with the participant not knowing that they would be tested on their memory for the stimuli. The experimenter then played four example auditory stimuli (2 sounds and 2 spoken words) not included in the actual experiment and asked the participant to judge the duration of each to ensure their understanding of the task. The participant was permitted to ask questions at this point for further clarification of the task and procedure. The stimuli advanced automatically following the initiation of the program by the participant. The

participants were not told that they would later be asked to remember these stimuli in any manner.

### *1. Listening Phase*

After initiating the program, the participant listened to and judged the duration of 19 spoken words and 19 sound effects via speakers attached to the computer. While listening to the stimuli, the subject was asked to focus on an unchanging black cross in the center of a white screen. This was for the purpose of preventing the participant from gazing freely around the room and not attending to the task and stimuli. The experimenter was seated a few feet away and facing the participant throughout the experiment, verifying that the participants gaze remained on the screen. The total time that elapsed between the onset of one stimulus and the onset of the next was 6 seconds, including the duration of both the auditory stimulus and silence. Following the playing of each stimulus, the participant judged its length by saying either "short," "medium," or "long" to the experimenter, who remained seated next to and facing the participant throughout the experiment. Depending on the condition the participant was in, they either heard a block of 19 sound effect stimuli before a block of 19 spoken word stimuli, or the reverse. The participant was not told that the stimuli would be presented in blocks or how many stimuli they would be judging. They also were not told which stimuli block they would be hearing first (sound effects or spoken words), nor were they warned before the stimulus block changed during the presentation. After the 38 stimuli had been presented, a screen appeared indicating that it was time to begin "Phase 2."

## *2. Retention Phase*

At this point, the experimenter indicated to the participant that they would now be asked to solve one and two digit math problems. The participant then solved the problems out loud without the use of pen, pencil, paper, or calculator, and was told to verbally think aloud while solving the problems, which was done to ensure that the participant was mentally engaged in the task. The experimenter read from a list of predetermined math problems until 3 minutes had passed.

The purpose of this task was to ensure the testing of long-term memory during the test phase and to prevent a ceiling effect. The math task was chosen to minimize interference with the test stimuli.

The total period of retention time was 5 minutes, with 1 minute for math task instructions, 3 minutes for the math task, and 1 minute for recognition test instructions.

## *3. Recognition Phase*

Participants were next provided an answer form consisting of 38 two-word item pairs. In each of the two-word item pairs, one word corresponded to an item (either a sound effect or a spoken word) presented during the listening phase, and the other had not. The participant was instructed to circle one word in each of the 38-item word pairs corresponding to the stimulus that he or she remembered hearing during the presentation (two-alternative forced-choice recognition test). After they had completed the answer form, they were debriefed by the experimenter and permitted to leave.

## CHAPTER III

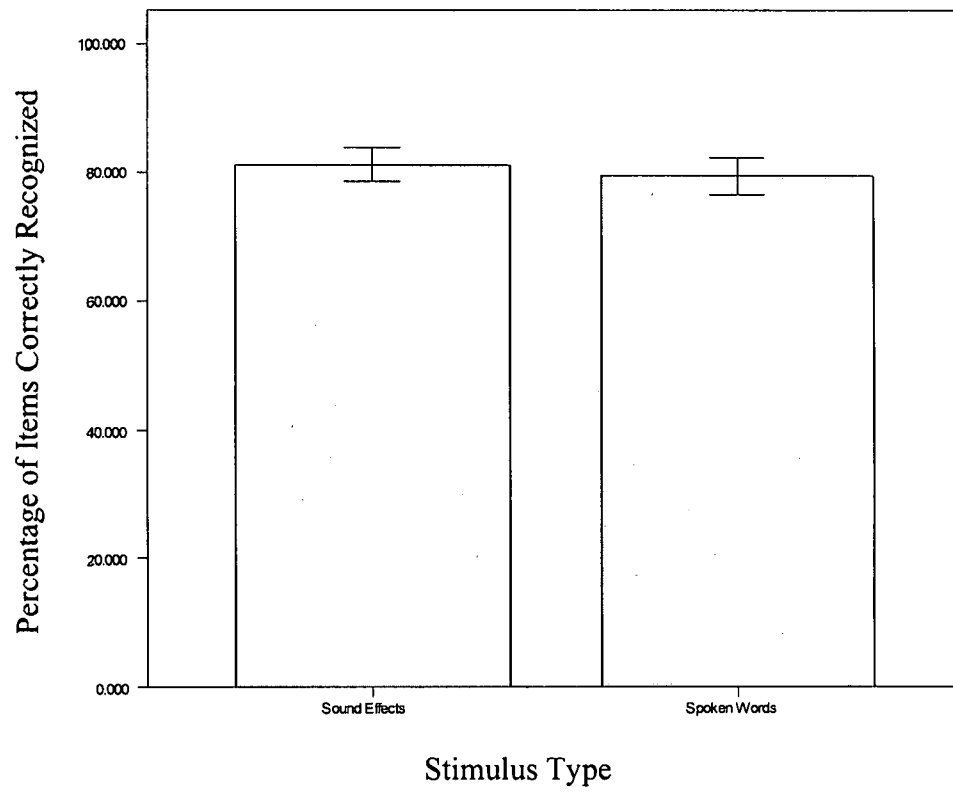
### RESULTS

A one-way repeated-measures Analysis of Variance was conducted to investigate whether Stimulus Type (Sounds or Verbal Labels) had a significant effect on the number of items correctly recognized. Descriptive statistics are displayed in Table 1. Stimulus Type, a within-subjects variable, did not have a significant effect on the percentage of printed words correctly recognized that were presented as sounds ( $M = 81.168$ ,  $SE = 1.33$ ) and those presented as verbal labels ( $M = 79.359$ ,  $SE = 1.45$ ) using a critical alpha of .05 ( $F(1, 62) = 1.192$ ,  $MSE = 87.891$ ,  $p = .279$  (see Figure 1)). The lack of an effect was not attributable to a ceiling effect.

Table 1.

*Descriptive Statistics of the Percentage of Items Correctly Recognized by Stimulus Type*

<b>Stimulus type</b>	<b><i>M</i></b>	<b><i>SD</i></b>	<b>N</b>
<b>Sounds</b>	81.168	10.64	64
<b>Spoken Words</b>	79.359	11.57	64



*Figure 1.* Percentage of items correctly recognized by stimulus type (Error bars:  $\pm 2$  SE).

In addition to the analysis conducted for the main effect of the within-subjects variable of Stimulus Type, a 2 x 2 mixed design Analysis of Variance was also conducted to test for an interaction of the between-subjects control variable of Stimulus Blocking Order (Sounds first or Spoken Words first) and the within-subjects variable of Stimulus Type. The main effect of Stimulus Blocking Order was not significant ( $F(1, 62) = .048$ ,  $MSE = 161.165$ ,  $p = .827$ ). Furthermore, there was no significant interaction between Stimulus Type and Stimulus Blocking Order ( $F(1, 62) = 1.418$ ,  $MSE = 87.891$ ,  $p = .238$ ).

## CHAPTER IV

### DISCUSSION

The tendency for individuals to remember sounds over their corresponding spoken word labels has been found when individuals are asked to freely recall the stimuli by writing down corresponding words (Crutcher and Beer, 2006), whether learning is intentional or incidental (Crutcher and Taylor, 2008). This study was designed to examine if the effect would continue to be observed when participants are given the printed labels during testing and asked to recognize those items corresponding to the stimuli they had heard during the presentation phase. Recognition testing resulted in no significant difference between the number of printed words correctly selected that had been presented as sounds and those that had been presented as spoken verbal labels.

According to dual-coding theory, sounds ought to have been observed to be more frequently recognized than spoken words. The results may be interpretable in the framework of a sensory-semantic model, particularly when considering post hoc observations of a categorical stimulus effect, described in detail later. However, further analysis of the results and methodological limitations discussed below prevent a definitive conclusion of support for dual-coding theory or an alternative model, but instead point toward a few directions for future inquiry.

### *Methodological Concerns*

In order to verify the success of the incidental paradigm, a post-study questionnaire should have been administered. Although the participants all engaged in judging the length of the stimuli during the presentation, it is unclear as to whether this task was sufficient in preventing the participants from becoming aware of an impending memory test. Participants that had anticipated that they would be tested for their memory of the stimuli may have employed memory strategies that others did not.

Additionally, it is unknown if presenting the stimuli in blocks created significant confusion or distraction for the participants. The experimenter told the participants that they would be listening to both sounds and spoken words. Both sound and spoken word stimuli were also played for the participants as examples to ensure their understanding of the task. During the actual encoding phase, the stimuli were presented such that 19 of one stimulus type (sounds or spoken words) were presented before 19 of the other stimulus type. Because participants were anticipating hearing both sound and spoken word stimuli, this may have seemed confusing or strange, possibly distracting the participants and interfering with the processing of the stimuli in memory. Warning the participants that the presentation of the stimuli was going to occur in blocks may have averted this problem. Again, a post-study questionnaire would have provided some insight into any surprise or confusion the participants may have had associated with the blocking of the stimuli.

Furthermore, the method of testing used in the study may not have been ideal. At test, the participants were given an answer form containing 38 word pairs. The

participants then selected the one word from each pair that they believed corresponded to a sound or spoken word that they had heard during the presentation. Giving the test so that all of the test items were presented at once on the answer form may not have been best for ensuring that participants engaged in fully processing each of the test item pairs. Alternatively, the test could have been administered electronically and presented only one test pair at a time. This would have helped to ensure that each word pair was fully processed by the participants.

#### *The Impact of Incidental versus Intentional Learning in a Recognition Paradigm*

In congruence with Crutcher and Taylor (2008), an incidental learning paradigm was used in this study. Crutcher and Taylor (2008) revealed a trend, though non-significant, in the direction of incidental learning (compared to intentional learning) resulting in a greater difference between the number of sounds and words being successfully recalled.

Previous research on words has found that in recognition, participants learning under incidental instructions recall more words than those learning under intentional instructions (Eagle & Leiter, 1964). However, recent research examining recognition memory for environmental sounds under incidental and intentional learning conditions found that intentional instructions result in greater recognition accuracy than incidental instructions (Cycowicz & Friedman, 1999). This discrepancy between the effects of learning type on sounds and words may have contributed to the observed lack of a significant difference between the number of sounds and words recognized by participants in this study.

An examination should be conducted that includes a manipulation of the learning conditions to rule out the possibility that incidental instructions in fact eliminated the observation of an auditory picture superiority effect in recognition in this study.

### *Selection of Stimuli*

Readily identifiable and “labelable” sound stimuli were surprisingly difficult to find. The set of 76 sound stimuli used in this study was created by adding 36 stimuli to the 40 sound stimuli taken from the set used by Crutcher et al. (2006, 2008). Preventing a ceiling effect was a primary concern for this recognition study, driving the need to increase the number of stimuli over what had been used in recent studies by Crutcher, et al. in free recall (2006, 2008). A search of literature provided few additional sounds suitable for use in this study, so the 36 additional sound stimuli used in this study were arrived at primarily through the process of brainstorming by the experimenter. These additional sound stimuli were not pre-tested for consistency in labels used by participants, whereas the sound stimuli used by Crutcher, et al. had been tested.

Given that the “new” sound stimuli had not been pre-tested, an analysis of the overall effect of stimulus type (Sounds versus Spoken Words) on the number of test words correctly recognized was conducted by using only the “old” stimuli (the original stimuli used by Crutcher, et al., (2006, 2008)). Due to the fact that not all participants received the same number of “old” and “new” stimuli, participants’ scores for the “old” stimuli were converted to a proportion of the number correct (the number correctly recognized) out of the number possible (the number of “old” sound

effects or spoken words a particular participant had received). No significant effect of stimulus type was found for the difference between the proportion of words correctly recognized that were presented as sounds ( $M = .832$ ,  $SE = .015$ ) and the proportion of words correctly recognized that had been presented as spoken words ( $M = .811$ ,  $SE = .018$ ),  $F(1, 63) = .927$ ,  $MSE = .014$ ,  $p = .339$ . An examination of only the “new” stimuli also revealed no significant difference between the proportion of sounds correctly recognized ( $M = .787$ ,  $SE = .019$ ) and the proportion of spoken words correctly recognized ( $M = .777$ ,  $SE = .020$ ),  $F(1, 63) = .127$ ,  $MSE = .023$ ,  $p = .722$ . The lack of an overall effect of auditory picture superiority in this study could not be attributed performance differences between the “old” and “new” stimuli.

A closer inspection of the stimuli revealed what could be noted as categorical boundaries of the stimuli. A number of the stimuli fell into the categories of “human sounds,” “animal sounds,” and “instrument sounds.” Analysis of the number of times each of the items grouped by these sound categories were correctly recognized (including a category of “other” for those items that did not fit into one of these three categories) revealed a pattern that indicated that the “human” category resulted in items being more frequently correctly recognized. “Human” sounds were operationally defined as any sound (and its corresponding word label) that is made or caused by a human voice or body directly, and not indirectly as through some additional medium or invention (e.g., the sound result of pressing keys on a piano was not considered a “human” sound). An analysis was conducted examining the overall effect of stimulus type (sound effect versus spoken word) on the number of test words correctly recognized by looking at only those items that fell into the “human”

category. For the same reasons as described for the analyses conducted on the “new” and “old” stimuli, participants’ scores for only the “human” stimuli were separated out and converted to a proportion of the number correct (the number correctly recognized) out of the number possible (the number of “human” sound effects or spoken words a particular participant had received). This analysis revealed a significant effect of stimulus type, such that the proportion of words correctly recognized that were presented as sounds ( $M = .921$ ,  $SE = .018$ ) was greater than the proportion of words correctly recognized that had been presented as spoken words ( $M = .811$ ,  $SE = .024$ ),  $F(1, 63) = 13.452$ ,  $MSE = .029$ ,  $p = .001$ . On the other hand, an examination of all other, “non-human,” items revealed no significance between the proportion of sounds correctly recognized ( $M = .773$ ,  $SE = .017$ ) and the proportion of spoken words ( $M = .794$ ,  $SE = .016$ ),  $F(1, 63) = 1.116$ ,  $MSE = .013$ ,  $p = .295$ .

It is interesting and suggestive that when looking only at those items that fall into this category of “human,” an auditory picture superiority effect becomes apparent. Speculation as to why this may be leads one to think there is possibly something unique in the way “human” sounds are treated in memory when compared to other sounds. This may be due to an increased familiarity of these sounds and/or an evolutionary psychological component. Explanations for this post hoc observation are pure conjecture, and will require further planned investigation. An examination using free recall at test, where the auditory picture superiority effect has already been found, while including sound category (“human” versus “non-human”) as a manipulation would assist in shedding light on this issue.

Furthermore, it has become apparent through the course of conducting research on memory for auditory stimuli, identifying an extensive number of sounds that can be easily given a verbal label (i.e., “labelability” of the sounds) for inclusion is quite challenging. The need to increase the number of stimuli substantially to 76 items—from the 40 items originally used by Crutcher, et al., (2006, 2008)—may have decreased the overall familiarity rating of the set. Anecdotally speaking, the earlier items were more easily identified as candidates for inclusion than the later items, so one can speculate that these sounds (and their corresponding verbal labels) may also be more familiar than those added for this current study on recognition. A lower overall level of familiarity (and “labelability”) of the current set of stimuli may have contributed to the lack of an effect of auditory picture superiority in the current study. Future studies should control for stimulus variation, particularly along measures of familiarity, as well as imagery ratings, concreteness, frequency of use, and “labelability.”

#### *Implicit Sound Labeling and Familiarity*

The discrepancy between the findings of the current study and previous research by Crutcher et al., (2006, 2008) that found support for an auditory picture superiority effect suggests the possibility of distinct qualitative differences underlying the processes of recall and recognition, as discussed in the review. To maintain consistency with previous research conducted by Crutcher et al., (2006, 2008) on auditory picture superiority and research conducted on the picture superiority effect, printed words were used as the test items, creating a cross-modal recognition test for the sound condition. As discussed in the introduction, according to both one- and

two-stage models of recognition, the first step in successfully responding to a test item is a familiarity test. For those items that had been presented as sounds, a successful familiarity check would depend upon the sound effect having been implicitly given a verbal label during encoding, as dual-coding would predict, and then on that label matching the test item. This may lead to problems for sounds that have greater ambiguity in the verbal labels that may be used to describe them. For example, the sound of a horse galloping may be implicitly (and correctly) labeled either “gallop,” “horse,” or “trotting” by the participant. The test item (in this case, the printed word “gallop”) may not match the label implicitly provided by the participant during encoding, possibly resulting in a failure of recognition due to the test item not eliciting a response strong enough to reach the threshold necessary to pass the familiarity check.

Free recall studies may be advantaged in this capacity over the recognition design used in this study in that a liberal scoring system can be used that is inherently less dependent on the participant providing implicit verbal labels that match the experimenters’ labels. For example, the sound of a horse galloping is said to have been successfully recalled if the participant writes down “horse,” “trotting,” etc. Clearly, such responses are indicative of a successful recall of the sound stimulus from the presentation, and it would be erroneous to mark these as incorrect responses simply because they are not an exact match to the label determined for the sound by the experimenter (e.g., “gallop”). However, in the present study on recognition memory, the labels provided during recognition testing inherently limit the participant

to the labels determined by the experimenter, possibly contributing to a reduction in the number of sounds being correctly recognized.

Future research could reduce the impact of such labeling variation by first conducting a sound labeling study to determine the best items for inclusion in the experiment, as was done by Crutcher & Beer (2006) prior to their study on free recall. Sounds for which there is a large variety of labels provided by participants could be eliminated entirely and the sounds that are labeled most consistently ought to be included.

#### *Limitations and Future Directions*

Summarizing and expanding on what has been expressed in the above analyses, it has become apparent that further study is necessary to better understand the auditory picture superiority effect and dual-coding theory. Extension of dual-coding theory predicts that sounds should be more frequently recognized than spoken words, even when testing is in printed word form. It is likely, however, that the processes involved in recognition memory are qualitatively distinct from free recall, and methodological limitations of the current study may have contributed to the observed non-effect. Further research has been suggested for additional studies in recognition memory of an auditory picture superiority effect, including controlling for non-matching implicit sound labels by first conducting a sound labeling study to determine the best items to be included in the experiment. Additionally, a study including a manipulation of learning condition could explore the possibility that incidental instructions eliminated the appearance of an auditory picture superiority effect in recognition memory.

Furthermore, an examination of the impact of sound stimuli category should be conducted to tease out the meaning of the post hoc finding that “human” sounds were better recognized than the spoken word labels for the “human” sounds, but “non-human” sounds were not better recognized than their spoken word counterparts. This study should be conducted using free recall at test, where the auditory picture superiority effect has been previously found, and should control for familiarity, concreteness, imagery ratings, frequency of use, and “labelability” of the stimuli.

The results point generally to the elusiveness of the auditory picture superiority effect, particularly in recognition. Moreover, the observed results run contrary to what would have been anticipated from dual-coding theory. The sensory-semantic model would explain previous findings of an auditory picture superiority effect in free recall as being due to sounds more efficiently accessing semantic meaning while also being more distinctive than spoken words, and would predict observation of an auditory picture superiority effect in recognition memory as well. It could be suggested that the limitations mentioned in the current study led to a non-effect that may be explained in terms of the sensory-semantic model. For example, the advantage given by the distinctiveness of sounds over words may have been lost in the cost of changing modality from sound effects at encoding to printed words at test (i.e, in a recognition paradigm, the advantage given by the distinctiveness of auditory images is lost when testing in printed word labels). Additionally, the finding of an effect when conducting the analysis for only “human” stimuli may be due to “human” sounds accessing semantic meaning more efficiently than other sounds. The limitations of this study, however, prevent definitive conclusions from being drawn

about dual-coding theory, the sensory-semantic model, and an auditory picture superiority effect, but instead point in a number of distinct and encouraging directions for future investigation.

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## APPENDIX A

### ANSWER FORMS

Answer Form 1

**For each, circle the item that you remember hearing during the presentation:**

- |    |           |            |
|----|-----------|------------|
| 1  | flush     | knocking   |
| 2  | harmonica | harp       |
| 3  | monkey    | gunshots   |
| 4  | scream    | thunder    |
| 5  | waves     | drip       |
| 6  | slurp     | cow        |
| 7  | wind      | rain       |
| 8  | breathing | explosion  |
| 9  | rattle    | dolphin    |
| 10 | crickets  | squeak     |
| 11 | crying    | honking    |
| 12 | chewing   | heartbeat  |
| 13 | click     | owl        |
| 14 | shatter   | airplane   |
| 15 | gargle    | kiss       |
| 16 | whip      | footsteps  |
| 17 | gallop    | zipper     |
| 18 | sawing    | duck       |
| 19 | tear      | chicken    |
| 20 | violin    | coughing   |
| 21 | piano     | ticking    |
| 22 | whistle   | motorcycle |
| 23 | sneeze    | sheep      |
| 24 | drum      | doorbell   |
| 25 | cat       | gong       |
| 26 | scissors  | frog       |

- |    |           |            |
|----|-----------|------------|
| 27 | bug       | pig        |
| 28 | chainsaw  | belch      |
| 29 | lion      | clapping   |
| 30 | bells     | siren      |
| 31 | camera    | guitar     |
| 32 | spit      | snoring    |
| 33 | pop       | yawn       |
| 34 | train     | jackhammer |
| 35 | hiccup    | laughing   |
| 36 | telephone | register   |
| 37 | bowling   | typing     |
| 38 | dog       | splash     |

Answer Form 2

**For each, circle the item that you remember hearing during the presentation:**

- |    |            |            |    |           |          |
|----|------------|------------|----|-----------|----------|
| 1  | siren      | clapping   | 27 | bug       | scissors |
| 2  | gargle     | pig        | 28 | breathing | harp     |
| 3  | doorbell   | rattle     | 29 | honking   | whip     |
| 4  | bowling    | whistle    | 30 | camera    | thunder  |
| 5  | airplane   | telephone  | 31 | dog       | crickets |
| 6  | gong       | harmonica  | 32 | sawing    | kiss     |
| 7  | jackhammer | motorcycle | 33 | owl       | wind     |
| 8  | pop        | ticking    | 34 | guitar    | lion     |
| 9  | zipper     | crying     | 35 | click     | chicken  |
| 10 | knocking   | chewing    | 36 | explosion | drum     |
| 11 | rain       | register   | 37 | snoring   | monkey   |
| 12 | train      | waves      | 38 | cat       | laughing |
| 13 | scream     | piano      |    |           |          |
| 14 | hiccup     | frog       |    |           |          |
| 15 | splash     | spit       |    |           |          |
| 16 | violin     | chainsaw   |    |           |          |
| 17 | coughing   | sheep      |    |           |          |
| 18 | duck       | gunshots   |    |           |          |
| 19 | sneeze     | flush      |    |           |          |
| 20 | footsteps  | gallop     |    |           |          |
| 21 | slurp      | typing     |    |           |          |
| 22 | shatter    | cow        |    |           |          |
| 23 | tear       | heartbeat  |    |           |          |
| 24 | yawn       | dolphin    |    |           |          |
| 25 | squeak     | belch      |    |           |          |
| 26 | bells      | Drip       |    |           |          |

## APPENDIX B

### DISTRACTER TASK

Math Equations

Time: 3 min

$17+32$

$14+6$

$80-18$

$14+35$

$6+2$

$76-48$

$12+29$

$8-4$

$92+3$

$44+7$

$15-8$

$65-15$

$2+17$

$37+56$

$84-28$

$6+9$

$19-12$

$41+12$

$8+66$

$77-22$

$40+14$

$13+13$

$33-14$

$24+39$

$11-5$

$81+12$

$16+53$

$14-6$

$64+23$

## APPENDIX C

### INSTRUCTIONS

I am going to give you some brief instructions. You will see a screen like this <indicate to screen> that says, "Press the spacebar to begin." You will press the spacebar and a screen will appear with a target in the center. You will be hearing a sequence of sound effects and spoken words. While listening to the auditory stimuli, I would like you to remain focused on the target. I would like for you to judge the length of each of the auditory stimuli by saying either "short," "medium," or "long" immediately after each item finishes playing. I will now play for you some examples of what these stimuli will sound like. **<Click first button to play "elephant trumpeting" sound>** Now you would say to me either "short," "medium," or "long," whichever you feel. For example, that sound may have been "medium" in length **<Click second button to play spoken word "alarm.">** Again you would tell me "short," "medium," or "long." **<Click third button to play "helicopter" sound>** What would be your response for that item? **<Click fourth button to play spoken word "hammer". >** And that item? During the actual experiment, the stimuli will continue to play automatically and you will continue to tell me "short," "medium," or "long" following each one. There will be more than just four stimuli. Instead of these four "Example" buttons, you will see a single red button in the lower right portion of the screen. Click this button using the mouse one time to initiate the playing of the auditory stimuli, after which they will continue automatically. Any questions? You are all set to begin.

Ok. Now I would like for you to solve some math problems for me. These problems will be one and two digit addition and subtraction. While you are solving these problems, I would like for you to describe to me the process you are using in your head to arrive at an answer. For example, if I were to give you "18 plus 13," it may be the case that what you are doing is first adding the eight and the three to get eleven, and then carrying the one to get 31. Please just describe to me thinking aloud whatever strategy you happen to be using.

Now I would like for you to remember as many of the auditory stimuli from the presentation that you can. For each item, circle one of the two available choices. For example, one of the example stimuli that I played for you was the sound of a helicopter, so you would circle the word "helicopter." One of the spoken word examples that I played for you was "alarm," so you would circle the word "alarm." Please circle one answer for each of the 38 items.

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