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An auditory analog of the picture superiority effect in typically developing children

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## An auditory analog of the picture superiority effect in typically developing children

**Abstract**

It has been established that the memory for pictures is superior than the memory for words. This empirical phenomenon is referred to as picture superiority effect (PSE) (Paivio & Caspo, 1973; Mazard et al., 2002). The dual coded theory (DCT) proposed that visual information is coded in the memory twice unlike verbal information which is only coded once, therefore, pictures are more likely to be remembered (Paivio, 1969). Crutcher and Beer (2010) extended PSE to the auditory modality in the adult population, whilst finding that the recall of sounds is superior than the recall of words (spoken). Nevertheless, the long term of sounds and words has not been previously researched. The current study examined the memory for sounds and words (spoken) in an opportunity sample of 34 typically developing children, aged 6-12. During the experimental protocol children listened to 10 sounds and 10 words, which were later reported in a delayed free recall task. In line with the assumption of the DCT the study predicted that children would recall more sounds than words. A 2x2 mixed model ANOVA was conducted and a significant main effect of stimulus type was found, ( $F(1,32) = 33.80, p < 0.001; d = 1.47$ ), with more sounds being recalled than words. An exploratory hypothesis was also investigated to compare the recall of the auditory stimuli in male ( $n = 17$ ) children and female ( $n = 17$ ) children. No significant interaction between the variables of stimulus type and gender was found, ( $F(1,32) = 0.60, p = 0.44$ ).

<b>KEY WORDS:</b>	Picture superiority effect (PSE)	Dual coding theory (DCT)	Auditory modality	Typically developing children	Delayed free recall task
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## 1. Introduction

Paivio (1975) proposed an empirical phenomenon known as the dual-coding theory (DCT), which argues that human process and represent verbal and non-verbal information in two separate, but related cognitive systems. A large body of empirical literature suggests that in the memory tests, participants tend to have a better memory for non-verbal information rather than the verbal information (e.g. Crutcher & Beer, 2010; Huss & Weaver, 1996; Paivio 1975, 1991; Whitehouse, Mabrey & Durkin, 2006). This empirical finding has been reported for a wide range of sensory information. The effect was obtained within the visual modality i.e. pictures vs text (word), which showed that pictures are more likely to be recalled than the text. (O'Sullivan & Durso, 1983; Whitehouse, Mabrey & Durkin, 2006). The effect in the visual modality is referred to as the 'picture superiority effect' (Paivio & Caspo, 1973). The picture superiority effect (PSE) was most frequently found with free recall (Paivio & Caspo, 1973) however; other conditions were also used to demonstrate PSE such as cued recall (Nelson & Reed, 1976) and serial recall (Paivio & Caspo, 1969). Additionally, both intentional and incidental instructions have also been used to obtain the effect (Paivio & Caspo, 1973). Nevertheless, DCT does not only describe the verbal and visual codes. The non-verbal cues also include other sensory-based modalities such as olfactory. The recall of odours and their verbal labels was investigated in attempt to confirm the DCT (McDaniel & Lyman, 1990). Furthermore, the effect was established in the auditory modality (e.g. sounds vs spoken words), which was described as the auditory analog of the picture superiority effect (Crutcher & Beer, 2010).

Currently, most of the research investigating DCT focused on the visual modality to find PSE (e.g. Curran & Doyle, 2011; Whitehouse, Maybrey & Durkin, 2006). According to Paivio's (1975) DCT pictures are more likely to be remembered than words because they are dually coded, first in the sensory-based, visual code and then in the semantic, verbal code. On the other hand, words are found to be coded only once in the semantic, verbal code. Paivio (1975) argued that retrieval for pictures is superior because if one route is lost (either semantic or verbal) the other route is still likely to remain to allow recall. According to DCT, individuals tend to internally verbalise the label as well as focus the visual features (Paivio & Caspo, 1973). The picture information may enable admission to the semantic code and increase the intensity of encoding. Also, other research suggests that pictures are more distinctive, (Mintzer & Snodgrass, 1999) in both semantic and conceptual features (Welton and Roediger and Challis, 1989). Moreover, it has been suggested that pictures involve a deeper level of processing in comparison to words (McBride & Doshier, 2002).

Cattaneo, Rossen, Vecchi and Pelz (2008) investigated the PSE in spatial memory through monitoring eye movement. In the study, participants were required to memorise the location of words (text) and images (cartoons, icons and photographs), whilst their eye movement was recorded. Participants gazed at the images less often than at words but, when participants gazed at images, they did so for a longer duration of time than

when gazing at the words. The findings showed that the location of photographs and icons was also remembered better than the location of words, this supported the presence of PSE in the spatial memory.

Mazard et al. (2002) also supported the existence of DCT and found that participants' recall of concrete words (text) was greater than that of abstract words (text); suggesting that words related to images are more likely to be retained and recalled. Also, a positron emission tomography (PET) scan analysis revealed activation in the visual regions only when participants proceed the concrete words. The findings suggest that participants engaged in visual imagery when thinking about the concrete words. Furthermore, when participants were exposed to the concrete words both the visual regions and verbal regions were stimulated. The findings from the study support DCT and provide further evidence of PSE, through demonstrating the activation of visual region and verbal regions when retaining visual stimuli. Nonetheless previous research has found that the picture superiority effect can be reversed or abolished, particularly when the presentation rates are fast or limited time is provided for the response (Boldini, Russo & Punia, 2007).

The understanding of picture superiority effect is well established in the adult population; but it has not yet been adequately researched in children. Some research has suggested that children learn better when the pictures and texts are presented simultaneously (Mayer, 2009), whilst other research suggest that they learn just as well when pictures and texts are presented sequentially (McCrudden et al., 2009). Whitehouse, Maybery and Durkin (2006) aimed to examine whether there is a change in the picture superiority effect between childhood and adolescence in a free recall task. In the study there were 80 participants aged 7-17. The children were divided into four groups based on their year group. The findings showed that all groups presented better recall of the picture stimuli than text (word) stimuli; therefore, demonstrating the picture superiority effect in children as young as aged 7. Additionally, it was found that the PSE increases with age. The increase with age in the PSE may be due to the greater availability of inner speech, which is found to increase with age, as this may affect the encoding of the pictorial stimuli via the double route (Paivio, 1971). One of the limitations of the study was that it was conducted exclusively with male participants; therefore, the developmental trajectory of the PSE in female child participants remains to be investigated.

According to Crutcher and Beer (2010) the multiple sensorimotor side of the DCT has been overlooked and instead was overly focused on the visual modality. Nevertheless, the non-verbal information can also account for other modalities such as olfactory. McDaniel and Lyman (1990) suggested that DCT might account for olfactory modality, as olfactory stimuli are coded in an olfactory component of the non-verbal imaginal system. In the study, participants were asked to name the odours, whilst participants in the controlled had to simply smell the odours. After a week the participants returned and were asked to recall the odours in a free recall task. The findings from the study showed that the recognition and recall of the odours was greatest with the participants who were asked to name the odours. The findings were interpreted in accordance to the working

memory, suggesting that the task was given to the participants while their use of hypothetical component might have been suppressed.

Historically cognitive science focused more on visual than auditory information (Holt & Lotto, 2011). There is currently little research on retention and recall of auditory information. Miller and Tanis (1971) focused on the auditory modality and separately measured the recognition memory for printed words, spoken words and sounds that were common. A forced recognition test was used to test each type of stimuli. The results showed that the recall for common sounds was the lowest with the mean score of 69% in comparison to spoken words with the mean score of 75%. The recall for printed words was superior with the mean score of 85%. The study concluded that there is a difference between the recognition memory for spoken words, printed words and common sounds. In contrast, a researched conducted by Huss and Weaver (1996) found that the recall for sounds is greater than for the verbal label of those sounds, supporting DCT.

Crutcher and Beer (2010) aimed to investigate a set of assumptions of the dual-coding theory in relation to the auditory modality on undergraduate students. The study examined the possibility of an auditory analog of the picture superiority effect. The authors reported four experiments that compared recall of environmental sounds and the spoken label of the sounds. Experiment 1 and 2 has found that the sounds were recalled better than their verbal labels. However, the authors found that in the second experiment, the verbal labels of the sounds were recalled as well as the sounds, when the participants were asked to imagine the sounds that they were exposed to. This supported the DCT in the assumption that when participants visualise the word, in effect, the word gets coded visually and verbally. Experiment 3 and 4 has extended the findings further by introducing incidental processing tasks. The results showed that the memory for sounds was enhanced over the words when participants were encouraged to label the sounds during encoding. The study found that in both incidental and intentional processing tasks twice as many sounds were remembered in comparison to words.

There are currently no studies that compare the long-term memory for sounds and words in children. It is crucial to recognise children's cognitive development in order to understand how children retain information and how their information is transformed to their long term-memory. A multi-store model is a widely influential model of memory (Atkinson & Shiffrin, 1968; Blakemore, 1988; Capitani, Della Sala, Logie & Spinnler, 1992; Schmolck et al., 2002). The theory proposed that the memory consists of three components: sensory register, short-term memory (STM) and long-term memory (LTM) (Atkinson & Shiffrin, 1968). As the information is acknowledged by the sensory registers (one of the five senses) the information briefly enters the sensory memory (which lasts for less than a second). Only if the information is attended to, it travels to the STM. Cowan (2001) agreed that attention must be allocated to the stimulus/information to allow storage into the short term memory. Bunting, Cowan and Colflesh (2008) investigated the deployment of attention in short-term memory and found that a visual distraction during the retention was enough to interfere with the

recall. The multi-store model suggests that the information in the STM must be rehearsed (consciously or unconsciously) to travel to the LTM. Unrehearsed information is quickly lost.

Currently, there is no data regarding the 'auditory picture superiority effect' in typically developing children. Therefore, the developmental trajectory of memory for auditory information is still unknown. The current research will address this gap in literature. The current research will also explore the differences in recall for sounds and words as a function of gender in typically developing children. The findings will inform research about how the memory develops in childhood. The knowledge may inform and affect practice within the educational settings. At the present moment there is already some incorporation of sounds into teaching, but it is limited. Children's phonics in which they dramatise animal sounds (moo like a cow) or vocalising sounds such as, 'b' 'b' 'b' as they bounce a ball is found to be an effective way of learning letters in early years (Freun, 2007). Further investigating the memory of sounds and words may increase the use of sounds to support memory whilst teaching novel information at schools. The research may also support a development of an intervention program for children with intellectual disabilities. Understanding the memory of sounds can support the teaching of language, particularly for those with language difficulties.

The current study aims to test the following hypothesis:

H1: In line with the assumption of the DCT it is predicted that typically developing children will recall more sounds than words.

Moreover, the following exploratory hypothesis will be tested:

H2: It is predicted that there will be a difference between the recalled auditory stimuli in male children and female children.

## 2. Method

### 2.1. Design

A quasi-experimental design was used. The research was based on a 2x2 mixed model design. The within subject design factor was the 'stimulus type', which consisted of two levels: sounds and words. The between subject factor was 'gender' which also consisted of two levels: males and females. The dependent variable was the number of items correctly recalled in a delayed free recall test.

### 2.2. Participants

Prior to recruiting participants, the power analysis was conducted using G\*Power 3 to estimate a sufficient sample size. Power ( $1-\beta$ ) was set at 0.80 and  $\alpha=0.05$ , it showed that the required sample size was  $n=34$ . The current study was conducted with an opportunity sample of 35 typically developing children aged 6-12. The children have been recruited through the researcher's acquaintances. The sample consisted of 18 boys and 17 girls. However, one male was excluded from the study due to not paying attention to the experimental protocol. This was interpreted as a withdrawal of the consent. The mean age for boys was 7.65 (1.50) whilst the mean age for girls was 7.82 (1.91). The two groups were not significantly different in terms of their age, the change was accepted ( $t(32) = -0.30$ ,  $p=0.77$ ). The mean score in children's digit span test, Visual Aural Digit Span (VADS) (Koppitz, 1977) was 4.88 (.77). An independent-samples t-test was conducted to compare the VADS score in males and females. There was no significant difference in the VADS score between male ( $\bar{x}=4.88$ ,  $SD=.78$ ) and female ( $\bar{x}=4.88$ ,  $SD=.78$ ) children, ( $t(32)=.00$ ,  $p=1.0$ ).

### 2.3. Materials

The experimental stimuli in the study consisted of 20 items: 10 sounds and 10 words. The following sounds were used: fireworks, toilet flush, screaming, yawning, thunder, bubbles, guitar, hiccups and church bells. The following words were used: alarm clock, tiger, ambulance, drill, camera, clapping, hoover, microwave, scissors, whistling. Most sounds have been piloted with both children and adults (Unpublished PHD research). Whereas 2 sounds have been obtained from a website under the creative common license (Creative Commons, n.d.) on the following link: <https://www.freesound.org>. For the purpose of the study the recorded words were of a male, middle-aged, British English Received Pronunciation (RP) speaker. The sounds and words were matched on the frequency of occurrence using the British National Corpus (BNC) and the number of syllables. All the stimuli were edited and normalized using Logic Pro X and WavePad Sound Editor. The stimuli were edited and matched on the volume intensity. To ensure the stimuli in both conditions of stimulus type (sounds and words) were presented at the same rate a silence was added to the spoken verbal labels, after each word to make each word stimulus 5000ms. The experimental protocol was designed and delivered using SuperLab 5.0 on a HP laptop (model 15-bw069sa), to conduct the study with the children. Headphones (SONY MDR-ZX110W) were attached to the laptop during the

study to allow children to listen to the stimuli (sounds and words). A stopwatch (Ravencourt Z382) was used to measure the time during the distracter task.

#### **2.4. Procedure**

Firstly, ethical approval for the project was obtained from the University of West London ethics. The experimenter had a clear, valid Disclosure and Barring Service (DBS) check. This was important as the participants in the study belonged to the vulnerable population. During the recruitment stage, parents/ legal guardians of the prospective participants were approached and handed an information sheet inviting their children to take part in the study. The information sheet explained the purpose of the study and outlined the procedure. Those parents/ legal guardians who agreed for their child to participate in the study have been asked to sign a consent form. The parents/ legal guardians were asked to complete a short background information questionnaire on participant's age, gender and ethnicity. The parents/ legal guardians were reminded that the participation was voluntary and that they or their children could withdraw from the study at any point without giving a reason. Anonymity of the participants was protected, as instead of using children's names, a number was given to every child for identification purpose during the study. For the children and parents/legal guardians convenience the data was conducted in the participant's home. All visits were prearranged with the parents/legal guardians.

Children were tested individually in their own home, in a quiet room. Each child was sat at a desk in front of the laptop. The parents/legal guardians were asked to stay in the vicinity for the duration of the study. The experimenter explained the task to each child. Children were informed that in a moment they would see a cross in the middle of the screen. Then, through a set of headphones provided they would hear a selection of sounds and words. The children were asked to focus on the fixation cross throughout the entire presentation and listen carefully, while the stimuli were being presented one at a time. The children were not informed that their memory for the experimental stimuli was going to be tested. This was to prevent children from adopting mnemonics to intentionally learn the items, as this is likely to affect recall (English & Visser, 2014). Following the instructions, the experimenter answered any questions that the children had. A verbal consent was required from the children before starting the experiment. The experimenter asked, "Do you want to take part in the experiment?" Children were also reminded that they could withdraw from the study at any point, without providing a reason. A sign of disinterest or appearing otherwise unsettled during the experimental protocol led to its termination.

The experimental protocol of the current study was based on Crutcher and Beer (2010). The experimental protocol commenced with the written instruction (font size 29) appearing on the computer screen, followed by audio instructions read out by the same person whose voice was used to record the experimental stimuli. The presented instructions were also heard "You are going to hear a set of sounds and words. Please listen carefully." The audio instructions lasted 9000ms whilst the written instructions remained on the screen for 15000ms. Afterwards, the following message appeared:

“Ready? Press any key to start.” As the participant pressed any keyboard button the experimental protocol was activated. During the experiment a black fixation cross (+) appeared for 500ms before and after each trial. A total of 20 trials were included. In each trial an auditory stimulus (sound or word) was presented individually for the duration of 5000ms. The fixation cross remained in the centre of the screen during each trial as the stimulus was presented. The fixation cross was intended to ensure that participants remained focus on the screen and paid attention to each stimulus. The trials were separated with inter-trial interval (ITI) lasting for 1000ms. The sounds and words were presented in a random order during each experimental protocol. Once all the 20 stimuli had been presented a “thank you” sign was displayed in the centre of the screen for another 5000ms. Following the message, the children were asked to remove their headphones.

After the removal of the headphones, the participants were asked to do a distracter task, known as the Brown-Peterson Task (Peterson and Peterson, 1959). This consisted of counting backwards from 100 or 200 by the increments of two or three, (depending on the developmental stage) for the duration of one minute. The distracter task was auditory modality congruent with the experimental stimuli. This is because as participants were using their language to count out loud they were unable to rehearsal the items from the previous task. Immediately following the distracter task, participants were given 2 minutes to recall the auditory stimuli (both sounds and words) that they had heard during the experimental protocol. The responses were recalled using a response sheet To verify that the participants could reliably recognise the sound stimuli that appeared in the study, following recall they were asked to listen to all the 10 sounds again and name them. This ensured that during the analysis the researcher was able to realise if find if any sounds were wrongly interpreted rather than invented.

The final element of the study was the VADS test (Koppitz, 1977). During the digit span test participants repeated a sequence of digits after the researcher. These were presented at the rate of 1 digit per second. On the Aural-oral subtest the participants below 7 years old started with three digits whilst participants from 8 or above started with four-digit sets. The correctly reproduced digit sequences have been marked. The participants have been given two trials to correctly recall the sequence. If the participant in Trial 1 correctly recalled the sequence after the researcher, then the researcher went onto the next higher digit sets. However, if Trial 1 was incorrect the Trial 2 was given. The children that recalled Trial 2 correctly went onto the higher sets, but for children that incorrectly recalled both Trials the test was discontinued.

At the end of the experimental protocol the children were provided with the following verbal debrief: “Great work! You did very well on this task. How did you like it? In this task you have listened to different words and sounds, and you had try to tell me what they were. Adults, like me are more likely to remember sounds than words. I wanted to find out if children, like you also can remember more sounds than words. You did very well and helped me a lot. Thank you for taking part in this task.” The data were collated and entered SPSS.

### 3.Results

#### 3.1. The scoring of the responses from the experiment

The scoring of the responses followed a similar procedure to the one previously used in a memory task by Crutcher and Beer (2010). Responses that included the root word of the verbal label were accepted as correct responses, even if they were in a different form than the original verbal label. For instance, if the sound was 'scream' both 'screaming' and 'screamed' were accepted. Also, similarly as with Philipchalk and Rowe (1971) synonyms and words that referred to the sound labels, were accepted as correct responses i.e. 'storm' instead of 'thunder'.

#### 3.2. Data screening and statistical assumptions

The data was collated and then screened for any outliers and missing cases. The number of correctly recalled stimuli (sounds and words) was calculated for each gender separately. The histograms were visually inspected and indicated a degree of positive skew in each condition (words and sounds) for both participant groups (male and female). The Shapiro-Wilk test was conducted to assess the degree of positive skew. All p values were found to be highly statistically significant. Log and square root transformations were conducted to correct the distribution shape to normal, however this was not successful. Therefore, all the analysis was conducted on the untransformed data.

#### 3.3. Recall for sounds and words in males and females

The SPSS was used to calculate the mean number of correctly recalled items and standard deviation for both stimuli type (sounds and words) in males and females.

**Table 1: The mean number of the correctly recalled stimuli type (sounds and words) in males and females.**

	Sounds		Words	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
<b>Boys</b>	3.59	1.18	1.59	1.33
<b>Girls</b>	3.24	1.35	1.71	0.85

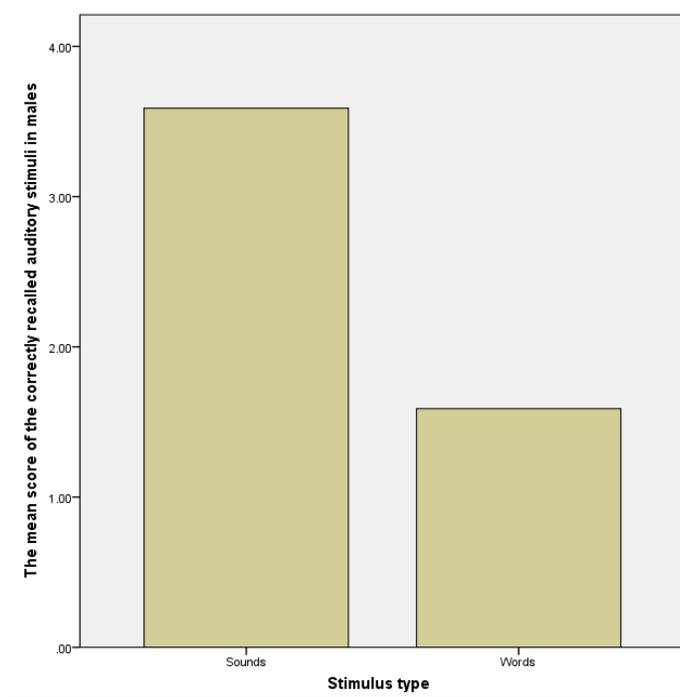
#### 3.4. Primary analysis

A 2x2 mixed model ANOVA was conducted to investigate the long-term memory for sounds and words in male and female children. There was a significant main effect of stimulus type, ( $F(1,32) = 33.80, p < 0.001; d = 1.47$ ), with the sounds ( $\bar{x} = 3.41, SD = 1.26$ ) being overall more recalled than words ( $\bar{x} = 1.65, SD = 1.10$ ). Following Hopkins (2004), the effect size was calculated to assess the magnitude with which the means have changed. The effect size for this analysis ( $d = 1.47$ ) was found to exceed Cohen's (1988) convention for a large effect size ( $d = 0.80$ ).

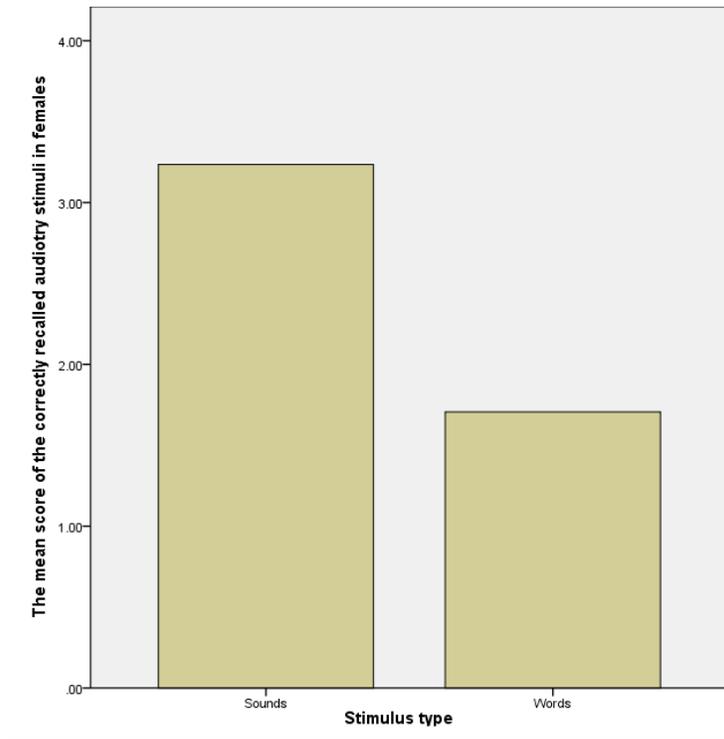
No significant main effect of gender was found ( $F(1,32) = 0.24, p = 0.67; d = 0.15$ ). These results indicate that in the study there was no significant difference between male and female participants in recall of the auditory stimuli. Additionally, there was also no significant interaction between the variables of stimulus type and gender, ( $F(1,32) = 0.60, p = 0.44$ ).

A paired sample t-test was conducted to assess if there is a significant effect of stimulus type (sounds and words) in males. A significant simple main effect of stimulus type was found in male children ( $t(16) = 4.26, p < .001$ ).

Similarly, a paired sample t-test was conducted to assess if there is a significant effect of stimulus type (sounds and words) in female children. A significant simple main effect of stimulus type was found in females ( $t(16) = 3.98, p < .001$ ).



**Figure 1: The mean score of the correctly recalled sounds and words in male children.**



**Figure 2: The mean score of the correctly recalled sounds and words in female children.**

Both bar charts indicated that on average the recall for the sounds is superior in comparison to the recall for words in both participant groups (male and female).

### 3.5. Exploratory analysis

A Pearson product-moment correlation coefficient was computed to assess the relationship between the participants VADS score and their recall for sounds. There was a positive correlation between the two variables ( $r(34) = 0.37$ ,  $p < 0.05$ ). Similarly, Pearson correlation coefficient was computed to assess the relationship between the VADS score and the recall of words. A positive correlation was also found between the two variables ( $r(34) = 0.34$ ,  $p < 0.05$ ).

An independent-samples t-test was conducted to compare the recall of sounds in bilingual and non-bilingual children. It was found that there was no significant difference in the recall of sounds in bilingual ( $\bar{x} = 3.36$ ,  $SD = 1.18$ ) and non-bilingual ( $\bar{x} = 3.50$ ,  $SD = 1.45$ ) children, ( $t(32) = -0.29$ ,  $p = 0.77$ ). Then, an independent-samples t-test was also conducted to compare the recall of words in bilingual and non-bilingual children. It was found that there was no significant difference in the recall of words for bilingual ( $\bar{x} = 1.68$ ,  $SD = 1.21$ ) and non-bilingual ( $\bar{x} = 1.58$ ,  $SD = 0.90$ ) children, ( $t(32) = 0.25$ ,  $p = 0.80$ ). These results suggest that being bilingual does not have a significant effect on the recall of sounds and words in children.

## 4. Discussion

### 4.1. What the study found and the assimilation of current findings to previous research.

The study aimed to test for the auditory analog of the picture superiority effect in typically developing children. As predicted with the assumption of DCT, it was found that children's recall of sounds was superior to their recall of words; therefore the primary hypothesis was accepted. On the other hand, the exploratory hypothesis was rejected, as there was no significant difference in the recall of the auditory stimuli between males and females.

Whitehouse, Maybrey and Durkin (2006) found that children from age 7 recall more pictures than text (words), hence demonstrating PSE. The current research extends the findings from the visual modality to the auditory modality in typically developing children. The study found that children do not only have a better memory for pictures (as previously discovered), but also sounds in comparison to words (both text and spoken). The present study has also found that the phenomenon occurs even earlier than previously reported, as the study found that children from age 6 already recalled more sounds than words. Freun (2007) found that children in early years education might often learn to vocalise sounds, particularly when learning phonics. This may increase the superior recall for sounds. Whitehouse, Maybrey and Durkin (2006) only investigated the existence of PSE in male children. In comparison, this study compared both male children and female children recall of the auditory stimuli. The empirical findings showed that both male and female recalled more sounds than words, demonstrating an auditory analog of the picture superiority effect in both participant groups (males and females).

The study has shown logical evidence for superior recall of sounds over words. This effect was previously obtained in the adult population, however PSE in the auditory domain is still limited (Huss & Weaver, 1996; Crutcher and Beer, 2010). Huss and Weaver (1996) measured the recognition memory for sounds and their spoken labels, discovering that participants showed a superior recall for sounds in comparison to words. In comparison to the current study, Huss and Weaver integrated the auditory stimuli between the encoding and testing presentation in a between group. For instance, a spoken label might have been encoded as label and tested as a label in one group, whilst in the other group the spoken label might have been encoded as a sound and also tested as one. The format of the study is not reliable enough to evidence DCT because integrating the auditory stimuli might have interfered with the results. In contrast, the current study accounts better for the DCT as all sound stimuli and word stimuli have been carefully selected and every child was exposed to all the same sounds and words to obtain the effect. The researcher also ensured that the chosen sounds and words do not interact and the sounds and words were varied (both social and environmental sounds were included).

The current's study protocol was based on Crutcher and Beer (2010). Crutcher and Beer have used four different experiments to show evidence for the auditory analog of the picture superiority effect. Crutcher and Beer study was the first study to obtain the effect using a within-subject design. The current study replicated the findings, whilst also using a within-subject design in typically developing children. In experiment four of the study, Crutcher and Beer included three groups: incidental, intentional and the free strategy. The findings later revealed that all participants recalled more sounds than words, particularly in the incidental group. In the current study children were also not informed that the task will be testing their memory instead, they were asked to listen to a set of sounds and words. According to English and Visser (2014) adopting mnemonics to intentionally learn items can affect the recall. As the assumption of DCT was being measured the experimenter preferred not to interfere with the encoding and children were not encouraged to develop strategies to memories the items rather, reveal if children unintentionally memorise more sounds or words.

The findings from the current study are found to be consistent with the assumption of the DCT (Paivio, 1969). The findings are consistent with the DCT explanation, which suggests that sounds are coded auditory and verbally, whereas the words are only coded verbally. However, there are also other explanations that can account for the findings. McBride and Doshier (2002) attempted to explain PSE by explaining that pictures involve a deeper level of processing. It may be that sounds also involve a deeper level of processing. Nevertheless, the explanation has not been acquired towards sounds and this explanation must be elaborated and evidenced further.

Apart from evidencing the auditory analog of the picture superiority effect in typically developing children the study also introduced another novel finding. It was found that there is a correlation between both the recall of sounds and words and the VADS test. Previously, Smith and Simth (1988) found that the VADS score correlated with reading. However, no previous research found a correlation between the VADS score and either the words or sounds. Since reading involves visual perception of the printed symbols and the oral recall, it may be that the correlation between VADS score and words also exists, as individuals might visually perceive the words. Further research should investigate and attempt to explain the correlation between the VADS score and the recall of sounds and words.

#### **4.2. Strengths and weaknesses of the study**

One of the strengths of the study is that the recency effect has been eliminated. According to the multi-store model, it was found that when individuals are presented with a list of words, the recall tends to be greatest for the words in the beginning (primacy effect) and at the end (recency effect) rather than the words in the middle (Capitani, Della Sala, Logie & Spinnler, 1992). In the current study, after listening to all the auditory stimuli, children engaged in a Brown-Peterson Task (Peterson & Person, 1959), a distracter task that was modality congruent to the experimental stimuli. As the children were counting out loud they were unable to rehearse the experimental stimuli;

therefore the short-term memory was cleared (including the most recently heard items) and all stimuli recalled in a delayed test were accessed from the long term memory. Another strength of the study was the use of the fixation cross to ensure children pay attention the stimulus. According to the multi-store model, children must pay attention to the stimulus in order to transfer the item into the short-term memory (Cowan, 2001; Cowan & Colflesh, 2008). Without the fixation cross, children might have been easily distracted and not focused on the task. It was crucial for children to pay attention to the stimulus to transfer information from the sensory memory to the short-term memory, and then long term memory (if rehearsed). (Atkinson & Shrifin, 1968). As the current research was measuring the long-term memory it was important for children to pay attention during the protocol and the fixation cross was a useful tool to support that.

The study was conducted in one block, which was found to shorten the protocol of the study. Children are found to sometimes have a short attention span, thus presenting sounds and words in one block made the study shorter, but also simpler to conduct. Although, perhaps conducting it in two separate blocks (i.e. sounds and then words) would reveal different results.

One of the limitations of the study is that children heard some sound stimuli more than once (i.e. the hiccup sound was repeated three times to fill out the time gap of 5 secs). Whereas all the word stimuli were heard only once; and instead a silence was added to fill out the gap of 5secs. It is possible that hearing some of the sounds multiple times allowed children to unconsciously rehearse those items more, and therefore this increased their recall. Additionally, children were exposed to every sound stimuli for a total of 5 secs whilst the word stimuli lastly between 2-4 secs without the silence. Perhaps the longer exposure of sounds further influenced the recall. Nevertheless, the silence was added to the word stimuli to ensure that each auditory stimulus (sound and word) was presented for the same amount of time.

Another possible limitation of the study is that a degree of positive skew that was indicated during the visual inspection of the histogram. The degree of positive skew was observed in each condition (words and sounds) for both participant groups (male and female). Log and square root were not successful at changing the distribution shape to normal, so the untransformed data was used for the analysis. According to Erceg-Hurm and Mirosevich (2008) a violation of normality in parametric test may result in inaccurate estimation of the p values as well as the effect sizes, which can lead to errors during the interpretation of the findings. However, in the current research the distribution was only moderately skew. Bock (1975) argued that distributions that may noticeably depart from normality need sums of 50 or more observations to approximate the normality. However, for a moderately non-normal distribution, the approximation is good if there are 10 or more observations. The current research has used 17 participants in each participant group; therefore the approximation is seen as acceptable.

### 4.3. Implications of the study and future research

The empirical findings, suggesting the existence of auditory along of the picture superiority effect may be beneficial to imply in the real world, such as the educational setting. According to Freun (2007) vocalising sounds such as 'bbb' and exaggerating animal sounds during phonics is found to be an effective teaching method for children in early years. The incorporation of sounds in primary schools and secondary schools is rare. Perhaps incorporating sounds whilst children are learning a new language may support their achievement. For instance, as children learn the word 'baby' in another language, it might be helpful not only to hear the word, but also hear the sound of the baby to help memorise the word. Another possibility is to develop an early intervention program for children with intellectual disabilities or language impairment. The program should consist of incorporating sounds into teaching. For example, children may play a 'sound lotto' game in which they need to match taped sounds to pictures. This can help children to develop their vocabulary whilst discriminating the sounds and recalling what they heard.

Future research should compare the recall of sounds and words in children with intellectual disability and a controlled group (typically developing children) to see if the same effect can be obtained. No previous research compared the recall of sounds and words in children with intellectual disability i.e. Autism.

Currently, this is the first study to find the auditory analog of the picture superiority effect in typically developing children. It is unknown whether the recall of sounds would still be superior in other memory tasks such as serial recall or cued recall in children. Research investigating PSE was able to obtain the effect in free recall, serial recall and cued recall in the adult population (Nelson & Reed, 1976; Paivio & Caspo, 1969). It is important to investigate the effect with other memory tasks because one experiment (with free recall) cannot generalise the existence of PSE in the auditory domain for all memory tasks in children. It should also be further investigated whether DCT best accounts to explain the effect in the auditory domain or perhaps other theories provide a more significant explanation for the superior recall of sounds in comparison to words. Other research may also wish to examine if the PSE in the auditory domain can be reversed or abolished as previously found in the visual domain (Boldini, Russo & Punia, 2007).

Whitehouse, Maybrey and Durkin (2006) found that PSE increases with age. It is unknown whether the auditory analog of the picture superiority effect also increases with age. The current research included children between age 6-12, however there was no significant difference between the age groups to determine the increase between the chronological age and children's recall of the auditory stimuli. Further research should examine the development of the auditory analog of the picture superiority effect. This knowledge might guide educational settings on which age groups are most likely to benefit from incorporating sounds into learning.

#### 4.4 Conclusion.

In conclusion, the results in the study are consistent with the DCT. The well-established PSE has been extended from the visual modality to the auditory domain in typically developing children, from as young as age 6. An auditory analog of the picture superiority effect was observed in both male and female children, which is a robust empirical finding. Moreover, no significant difference was found in the recall of sounds and words between males and females. Further research needs to investigate this effect with other memory tasks (i.e. serial recall) and also compare the recall between typically developing children and children with intellectual disabilities. Additionally, further research should investigate whether the DCT provides the most suitable explanation for the auditory analog of the picture superiority effect in typically developing children.

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