EFFECTS OF VERBAL DISRUPTION ON DERIVED STIMULUS RELATIONS

by

Cullen J. Westerfield

Submitted in partial fulfillment of the

requirement for Departmental Honors in

the Department of Neuroscience

Texas Christian University

Fort Worth, Texas

May 3, 2021

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DERIVED STIMULUS RELATIONS

Project Approved:

Supervising Professor: Anna Ingeborg Petursdottir, Ph.D

Department of Psychology

Ellen Broom, Ph.D

Department of Psychology

Ronald Pitcock, Ph.D

John V. Roach Honors College

Abstract

We examined the effects of disrupting verbal mediation in a task that models the effects of visually presented information on conceptual behavior. The experiment was done asynchronously by sending participants a SuperLab 6.0 software experiment, requesting a screen recording using Zoom, and acquiring demographic, consent, and exit interview information using Qualtrics. Sixty participants were randomly assigned to four conditions. The tact-intraverbal (TI) groups first learned to match picture stimuli with textual labels, and then to associate pairs of textual labels. The intraverbal-tact (IT) groups received the opposite sequence. After training, all groups were tested for new relationships between the visual picture stimuli. One TI group and one IT group were given an additional verbal task during the test (TI-V and IT-V respectively), which was predicted to disrupt the performance more in the IT than the TI condition, due to IT participants being more reliant on solving the task verbally. No significant differences in accuracy or reaction time were noted between groups. However, only 41% of those in the IT-V group and 13% of those in the TI-V group actually performed the additional verbal task. The experiment should be repeated through real-time video calls or in person, so that participant instruction-following can be monitored and intervened on.

Effects of Verbal Disruption on Derived Stimulus Relations

From infanthood all the way through adolescence and into adulthood, humans learn about the world around them through the formation of concepts. Concepts are described as classes of stimuli (Keller & Schoenfeld, 1950). These stimuli can be grouped in one of three major ways: perceptual features, shared relations among stimuli, or learned associations. An example of grouping stimuli based on perceptual features would be seeing a cardinal and a falcon and recognizing both as "birds" through their similar features (e.g. beaks, feathers, wings), regardless of their noticeable differences (e.g. size and color). Relational concept formation is somewhat more abstract in nature. Although a large diamond ring and a fancy car may have nothing perceptually in common, one might classify both in the category of "expensive items", as they are more expensive than other types of rings and cars. Finally, many concepts are formed through learned associations. The stimuli are placed in this group simply because they are taught this way. This is especially important for correlating visual images with their associated verbal or written labels in language acquisition. The written or spoken word "DESK" has none of the same perceptual qualities as the physician object we refer to as a desk. We only associate the written word with the actual object because we were taught that these two objects belong to the same concept. These learned associative concepts are of significant interest in learning and teaching (Zentall et al., 2002). As much, they were the primary focus of this experiment.

When studying stimulus equivalence, or how stimuli all within the same concept relate to one another, three properties derived from mathematics apply: reflexivity, symmetry, and transitivity (Sidman & Tailby, 1982). A stimulus is reflexive if someone can recognize an item as itself. If a researcher presented a participant with an image of a chair, the participant would be able to recognize that same chair if asked to select it in an identity matching task. Second, a

relation is symmetric if the participant can form the inverse relationship from what has been taught. For example, if a researcher taught the participant that the word for an image of a chair is "chair", and the symmetric relation has emerged, then the participant will be able to select the image of a chair when the word is presented. Finally, a relation is transitive if an untrained relation between two previously unrelated stimuli emerges based on taught relations between other stimuli in the class. For example, if a researcher taught that the image of a chair was denoted by the written word "chair" and that the written word "chair" was pronounced as a vocalization "chair", a participant would be able to look at the image of chair and be able to vocalize the word "chair" through the connection of the written word, if the transitive relation emerged. These relations can often emerge without direct teaching.

These properties of stimulus equivalence are important in understanding how stimulus relations can emerge. One means to test emergent learned associations is known as the "intraverbal naming task", a procedure created by Petursdottir et al. (2015) to test components of Horne and Lowe's (1996) naming hypothesis, which has been cited in many similar emergent stimulus relations experiments (Lowe et al., 2002). The intraverbal naming task involves teaching participants a verbal label associated with a visual image (tact training), and then teaching the participant which verbal labels are paired with one another (intraverbal training). After this, when presented with an image-matching test, participants are able to pair images together that have been related through verbal labels, without ever directly being taught the connection between the images themselves. Prior research has shown that some children and most adults can pass this image-matching test (Jennings & Miguel, 2017; Ma et al., 2016; Petursdottir et al., 2015; Santos et al., 2015).

One explanation for the emergence of this transitive relation comes from Horne and Lowe's (1996) naming hypothesis. Coined the verbal mediation hypothesis (Horne & Lowe, 1996), this hypothesis states that participants use verbal behavior to solve problems like those presented in the image-matching test. Participants talk themselves through the task from the sample image to the comparison image in the following way: "This image A is called word A, and I know word A goes with word B and word B goes with image B. Therefore, image A must go with image B." However, this hypothesis relies heavily on the emergence of the reverse intraverbal relationship between word A and word B. Otherwise, participants would be able to complete the image-matching test with certain sample stimuli (using the intraverbal association they learned from word A to word B) and not with other sample stimuli (requiring the untaught backward intraverbal association from word B to word A).

When working with preschool children, Petursdottir et al. (2015) found that the children were able to perform well on the image-matching test as described in the intraverbal naming task, but they were unable to accurately complete a reverse intraverbal posttest. Seemingly, their correct responses on the intraverbal test were not products of the process described by Horne and Lowe's (1996) hypothesis. Previous literature offered the explanation of the joint control account of symbolic stimulus relations where participants could reverse engineer the solution by starting with the comparison stimuli and utilize the intraverbal relationship they had been taught (Lowenkron, 1988). However, reaction times found by Petursdottir et al. (2015) were not consistent with the extensive time that would be required to reverse engineer the solution using the comparison stimuli for every trial (Petursdottir et al., 2015).

Instead, Petursdottir et al. (2015) speculated that the participants might be visualizing the pictures during intraverbal training which could have facilitated performance on the image-

matching test. This led to the visual mediation hypothesis. This hypothesis suggests that visualizing the picture stimuli during intraverbal training would allow for another source of stimulus control to control correct responding during the image-matching test. Through this, participants have developed a covert association between the visual images. Now, during the image-matching test, the visual-visual stimulus association is already present without the need to "talk through" the problem using verbal mediation.

Visual imagining has already been proven to be a useful learning strategy (Engelkamp et al., 1989; Doherty-Sneddon & Phelps, 2005). For example, it has been shown to facilitate paired associations (Engelkamp et al., 1989). It has also been suggested that visual imagining is often used in problem-solving and recall, as noted by participants closing their eyes or averting their gaze while thinking. This type of learning strategy increases with age (Doherty-Sneddon & Phelps, 2005). As it relates to the intraverbal naming task, anecdotal evidence for the visual mediation hypothesis derives from Petursdottir and colleagues (2015) noting that participants closed their eyes at times during intraverbal training, suggesting that they might be trying to visualize the pictures. Along with this, other researchers have had participants reveal during the exit interview that they did indeed utilize visual imagining in the experiment (Jennings & Miguel, 2017).

More recent studies have directly tested predictions derived from the visual mediation hypothesis. Petursdottir et al. (2019) separated participants into tact-intraverbal (TI) and intraverbal-tact (IT) groups with the TI group receiving tact training before intraverbal training and the IT group receiving intraverbal training before tact training. The researchers predicted that participants in the TI group would perform more quickly on the image-matching test than participants in the IT group due to the TI group's ability to visualize the images during

intraverbal training. Visualizing the images during intraverbal training was not possible in the IT group because they had not yet learned to associate the images with their verbal labels. They found that the average reaction time in the TI group was significantly faster than in the IT group (Petursdottir et al., 2019).

Two subsequent studies were performed by Cox and Petursdottir (under review). Since the baseline retention of the 2019 study was quite low, the first experiment involved increasing the mastery criteria during the tact and intraverbal training phases. The second experiment began using textual verbal labels instead of vocalized verbal labels. Associations with these labels were taught using the same match-to-sample (MTS) technique utilized during previous image-matching tests. The results involved the TI groups being more accurate in both experiments. In the second experiment, the TI group was also significantly faster than the IT group. In both experiments, the reverse intraverbal posttest accuracy was correlated to the image-matching test accuracy for the IT group but not the TI group. Finally, in an exit interview for the second experiment, half of the TI group reported using visual imagining during intraverbal training, and these participants performed significantly better than participants in the same group who reported not using visual imagining during intraverbal training (Cox & Petursdottir, under review).

With increasing evidence in support of the visual mediation hypothesis, there has been an effort to further accentuate its effects. Cox et al. (in preparation) performed another study where a third experimental group was added alongside the TI and IT groups. This new group was a TI group that was also given explicit instructions to use visual imagining during intraverbal training. This new experimental group indeed performed significantly better than the other two experimental groups. However, it has yet to be determined if this increased performance is due to

visual imagining specifically or perhaps any kind of instruction directly providing a learning strategy to the participants (Cox et al., in preparation).

This experiment is one of four follow-up experiments to the previously mentioned experiments with the continued goal of isolating and amplifying the effect of visual mediation. Two of the four experiments involve using other directed learning strategies as opposed to visual imagining to ensure the increased performance is due to visual imagining (mnemonics and visualizing the text labels specifically). One study involves an attempt to remove visual imagining altogether by providing certain conditions to eliminate visual mediation.

The goal of the following experiment was to examine the effects of disrupting verbal mediation during the image-matching test. In one of two TI groups and one of two IT groups, participants were given a separate verbal task to disrupt verbal mediation. The verbal task was predicted to disrupt performance more in the IT group than in the TI group because the TI group had an alternative visual route available to solve the task while the IT group was only able to use verbal mediation. Additionally, I assessed the relationship between participants' vividness of visual imagery and image-matching test performance, predicting that for TI group participants, but not IT group participants, more vivid visual imagery would be related to higher test scores and lower reaction times.

Methods

Participants

Participants included 60 undergraduate students from Texas Christian University, recruited from the human subjects pool (SONA) within the psychology department. These included 36 students who identified as female and 16 students who identified as male (with the remainder preferring to not disclose their gender or complete their demographic questionnaire),

ranging in age from 18 to 29 with a mean age of 20.1. All participants received credits that they could apply towards extra credit in psychology courses for participating in the study.

A total of 22 additional participants began the study but did not return data files to the experimenter or their data could not be included due to software problems (see discussion section).

Stimuli and Apparatus

The experiment was programmed using SuperLab 6.0 (Cedrus Corporation, San Pedro, CA) and presented to participants via a shared online cloud storage system available to all Texas Christian University students: TCU Box. Participants first answered three prescreening questions, a consent form, and a demographic questionnaire. Participants then downloaded the SuperLab Remote experiment software and maintained a constant screen recording through the application Zoom (Zoom Video Communications, San Jose, CA) during the SuperLab experiment. After the experiment, participants returned data files and video recordings to the experimenter via email. Lastly, participants completed an exit survey that included the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973). Surveys and other forms were distributed using links to the software Qualtrics (Qualtrics LLC, Provo, UT).

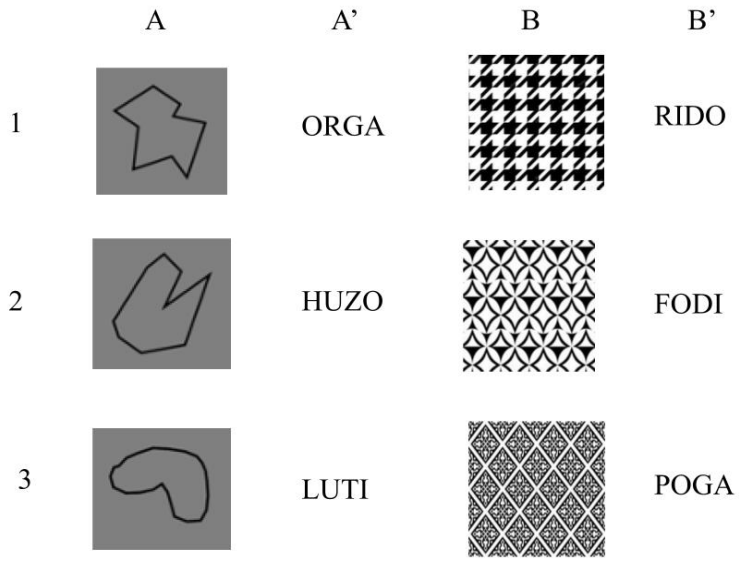
The picture stimuli consisted of six total images with three simple shapes being paired to three pattern designs (see Figure 1). All images were in black and white. These six images were designated A1, A2, A3, B1, B2, and B3 (for the purposes of the researcher only, as this information was not disclosed to the participants). All A stimuli were unnamable shapes, and all B stimuli were black and white vector patterns. The numbers indicate the pairs (e.g. A1 and B1 were paired together during training), which were chosen based on the results of a stimulus similarity survey that confirmed that there weren't any perceptual features that predisposed

participants to make a particular pairing. The decision to use simple images paired with patterns, as opposed to six simple images or six patterns was due to the results from a pilot study that found a greater difference between TI and IT groups when three shapes and three patterns were used as the stimuli.

Each stimulus was given a two-syllable, arbitrary verbal label. These labels are denoted A'1, B'1, etc.

Figure 1

Picture and Text Stimuli Pairs



Measurements

The primary dependent variables included the percentage of correct responses during the image-matching test along with the speed of the responses during the image-matching tests, both of which were measured by the SuperLab software. A response was considered correct if the participant used the mouse to click and select the correct stimulus within five seconds (5000 ms). The correct comparison stimulus was the one that went with the sample stimulus based on the

taught tact and intraverbal relations. An incorrect response included either clicking on an incorrect stimulus within the five second time frame or not clicking on any stimulus at all within the aforementioned time frame. Reaction time was measured from the onset of the comparison stimuli presentation until the moment the participant clicked on a correct or incorrect stimulus, ranging from 0-5000 ms. Reaction time was not included for trials during which the participant did not make a selection within the five second interval. Other secondary dependent measures included the percent of correct responses during the post image-matching test retention tests, reverse intraverbal tests, and listener responding tests.

Procedure

Design and Overview

Participants were each randomly assigned to one of four groups: Tact-Intraverbal (TI; n = 17), Intraverbal-Tact (IT; n = 14), Tact-Intraverbal with disrupted verbal mediation (TI-V; n = 16), and Intraverbal-Tact with disrupted verbal mediation (IT-V; n = 13). The unequal sample sizes resulted from attrition related to failure to return data files and software failures.

Participants in the TI group received tact training prior to intraverbal training. Participants in the IT group received intraverbal training prior to tact training. Participants in the TI-V group received the same training order as the TI group, but they were also instructed to perform a secondary verbal task (repeatedly saying the English alphabet order aloud) during the image-matching test. Participants in the IT-V group received the same training order as the IT group and the same additional verbal task as the TI-V group. The mean ages were 20.08, 20.60, 19.93, and 19.56 for groups TI, IT, TI-V, and IT-V respectively. Of the participants who reported gender, there were 10 females and 5 males in the TI group, 10 females and 4 males in the IT group, 8 females and 5 males in the TI-V group, and 8 females and 2 males in the IT-V group.

After finishing the consent form and the initial demographic survey, participants downloaded the SuperLab software and began the experiment. The experiment began with tact and intraverbal training in the order indicated by their group. After reaching mastery in both conditions, participants were given a 30-trial image-matching test. After the image-matching test, participants were given the reverse intraverbal test (B'A'), the intraverbal retention test (A'B'), the tact retention test (AA'/BB'), and listener responding test (A'A/B'B). The participants were instructed to read every set of instructions aloud in the following welcome message on SuperLab:

> "*Thank you for participating in this study. Be sure to ready EVERY set of instructions out loud! Press the space bar when you are ready to begin."*

Tact training (AA'/BB')

During tact training, participants were taught the verbal labels A'1 through B'3 when presented with their respective A1 through B3 images. Trials were presented in blocks of six, with one presentation of each stimulus per trial block in a randomized fashion. The following instructions appeared on the SuperLab screen before tact training began:

> "*You will see 6 pictures paired with words, please try to remember what you see. Press the SPACE bar to continue."*

Immediately after the instructions page, the participants were given a single block of exposure trials before the MTS tact training started. For each exposure trial the visual stimulus appeared with its label directly below the picture for two seconds, followed by the message "Press the Space Bar to Continue". Pressing the space bar would begin the next exposure trial. No response was required or recorded by the participants in this initial exposure block other than

pressing the space bar to move to the next trial. At the conclusion of the single exposure block, the following instructions appeared for the participants:

> "*You will now see one of the 6 pictures. When you click on the picture, 3 words will appear. Choose the word that goes with each picture. If you are correct, you will proceed to the next trial. If you are incorrect, you will be shown the correct response before proceeding to the next trial. When you are ready to start, press the SPACE bar.*"

Training trials then began with the presentation of one of the picture stimuli (A1-B3). Once the participant used their mouse to click the sample stimulus, it disappeared and three comparison stimuli appeared at the corners of the screen. The participant had three seconds to click on a comparison stimulus. If the participant clicked on the correct comparison stimulus within the 3-s timeframe, the participant moved on the next trial. If the participant clicked on an incorrect stimulus or did not respond within three seconds, the sample stimulus was presented with the correct comparison stimulus below it for two seconds on the screen before moving on to the next trial. After each trial, participants were given the message on the screen "Press the Space Bar to Continue", allowing participants to advance to the next trial after pressing the space bar. Training continued in this manner until the participant responded with 100% accuracy across 30 trials.

Intraverbal Training (A'B')

In intraverbal training, participants were taught to pair the comparison stimulus of a label from the A series with a label from the B series of stimuli. A1' was paired to B1', A2' to B2', and A3' to B3'. Trials were presented in blocks of three trials with one presentation of each A' stimulus as the sample per block in a randomized order. Intraverbal training began with the following instructions:

"You will now see one word immediately followed by a second word. You will then be prompted to press the space bar to see another pair of words. Please try to remember the pairs that you see. Press the SPACE bar to continue."

Participants were then exposed to a single three-trial block to become exposed to the correct stimuli pairs. The A' stimulus was presented first, followed by the B' stimulus after two seconds. The message "Press the Space bar to Continue" appeared between the trials. At the conclusion of the single block of exposure trials, the following instructions were given:

"You will now see one of the words in each pair. When you click on the word, you will see 3 more words. Select the word that completes the pair. If you are correct, you will continue to the next trial. If you are incorrect, the correct response will appear in GREEN before moving to the next trial. Press the SPACE bar to continue."

Each trial began with the presentation of the A' textual stimulus. Similar to the tact training with the only difference being the stimuli, the participant would click on the sample stimulus and then have three seconds to select the appropriate comparison textual stimulus. Once the sample stimulus was clicked, it would disappear and three possible comparison stimuli would appear in the corners of the screen with one correct answer and two incorrect answers. Clicking on the correct answer within three seconds allowed the participant to proceed to the next trial. An incorrect response or no response after three seconds caused the participant to be presented with the correct pair of stimuli for two seconds before moving on to the next trial. The message "Press the Space Bar to Continue" appeared between trials. Training continued in this manner until 15 correct answers were provided continuously.

Image-Matching Test (AB/BA)

The image-matching test consisted of 30 trials organized into five blocks of six trials. At the beginning of this section, the following instructions were presented to the participants on the screen:

> *"You will see an image in the center of the screen. When you click on the image, three images will appear in the corners of the screen. Click on the image that goes with the image in the center. You will not be told if your responses are correct or incorrect, but please do your best to respond correctly. Press the SPACE bar to continue."*

Participants in the TI-V and IT-V groups also received this instruction about their additional task:

> "*After you read the following instructions, begin to say the ABC's out loud until you see the next set of instructions. Do not pause or stop saying the ABCs until the next instructions appear. Please be sure to say them loudly enough to be heard over your zoom video recording, so that we can verify that you followed these instructions."*

Each trial began with the presentation of one of the six image stimuli (A1-B3) as the sample stimulus at the center of the screen. Similar to the training stages, the participant has unlimited time to look at the sample stimulus. Once the participant clicked on the sample stimulus, it would disappear and three comparison stimuli would appear in the corners of the screen. The participant then had five seconds to select the correct comparison stimulus. A response was correct if the participant selected the correct comparison stimulus based on the previously taught intraverbal pairs within five seconds. Unlike the training trials, no feedback was given for correct or incorrect responses. The phrase "Press the Space Bar to Continue" appeared between trials.

Reverse Intraverbal Test (B'A')

The reverse intraverbal test was conducted prior to the baseline retention tests and assessed the emergence of the B'A' intraverbal relationship. To begin this stage, the participants were presented with the following instructions:

> *"You will now see one of the words again. When you click on it, 3 more words will appear in the corners of the screen. Click on the one that you think completes the word pair. Press the SPACE bar to continue."*

The reverse intraverbal test consisted of six B'A' trials where the B' stimulus serves as the sample twice. These trials were identical to the intraverbal training, except that each trial presented a stimulus from the B series as the comparison stimulus instead of the A series, and no feedback was provided for correct or incorrect answers.

Intraverbal Retention Test (A'B') and Tact Retention Test (AA'/BB')

The purpose of the intraverbal and tact retention tests was to assess the maintenance of the trained intraverbal and tact relationships throughout testing. These tests were given after the reverse intraverbal test to ensure that the intraverbal retention test would not interfere with the reverse intraverbal test. The intraverbal and tact retention tests each consisted of six trials (two groups of each three stimuli pairs for the intraverbal retention test and one trial for each tact pairing for the tact retention test. The intraverbal retention test was identical to the intraverbal training with the exception that no feedback was given to the participants. The instructions for the intraverbal retention test are stated below:

> *"You will now see one of the words from the word pairs. When you click on it, 3 other words will appear in the corners of the screen. Click on the one that completes the word*

pair. You will not be told if you are correct or incorrect but try your best to respond correctly. Press the SPACE bar to continue."

The tact retention test was identical to the tact training with the exception that no feedback was given to the participants. The instructions for the tact retention test are stated below:

"You will now see the images again one at a time. When you click on the image, 3 words will appear in the corners of the screen. Choose the word that goes with each picture. You will not be told if you are correct or incorrect, but try your best to respond correctly. Press the SPACE bar to continue."

Listener Responding Test (A'A/B'B)

The purpose of the listener responding test was to ensure that the participants could select the appropriate visual stimuli (A1-B3) when presented with the verbal label for a stimulus. At the beginning of this stage, the following instructions were given:

"You will now see one of the words in the middle of the screen. When you click on the word, 3 pictures will appear in the corners of the screen. Choose the pictures that goes with the word. You will not be told whether you are right or wrong, but please try your best to respond correctly. Press the SPACE bar to continue."

The test consisted of a single six-trial block in which each label was presented as the sample stimulus one time. Three seconds were allotted as an answering period after the sample stimulus had been selected with the possible matching comparison stimuli appearing at the corners of the screen. A correct answer involved the participant clicking on the correct comparison stimulus that matched the given verbal label, while an incorrect answer involved either clicking on the incorrect stimulus or taking longer than the allotted three seconds. The

participant was not given any feedback during these trials. After each trial, the following message appeared: “Press the Space Bar to Continue”. After the completion of the listener responding test, participants were told that the experiment had been completed and were thanked for their participation.

Exit interview

Following the completion of the experiment using the SuperLab software, participants were instructed to complete an exit interview using Qualtrics. After the participants provided a code number received from the experiment, the following questions were asked:

1. In the last part of the study, you first saw an image and were then asked to click on the matching image. How did you know which one to click?

2. When you were memorizing which words went together, was there anything that helped you remember?

3. When you were memorizing which words went together, did you at any point try to visualize their images together?

Following this, the participant was given the VVIQ to test their ability to visualize images generally. The VVIQ involves a total of 32 questions, 16 done with the participant’s eyes open and 16 done with eyes closed, using four repeated scenarios (Marks, 1973). For each scenario (e.g. “imagine the face of a loved one not currently with you”, “imagine a sunrise”, etc.), participants are given four questions to assess the vividity in the details of the mental image that they were able to create. Participants were then able to choose the level of vividity on a scale of 1-5. For example, if asked to visualize a sunrise in the scenario and then imagine that the sunrise is suddenly blocked by storm clouds in the question, the participant would be able to select their level of vividity in visualizing this scenario using the options below:

1. Perfectly clear and as vivid as normal vision
2. Clear and reasonably vivid
3. Moderately clear and vivid
4. Vague and dim
5. No image at all; you only "know" that you are thinking of this object

Low ratings would suggest that the participant has strong visualization abilities, which could mean they are more capable of utilizing visual mediation compared to those who scored highly on the VVIQ.

Results

Retention of Baseline Relations

Baseline retention tests were given to the participants following the image-matching test. In a 2 x 2 (verbal task x training sequence) ANOVA, there were no main effects of either training sequence or the verbal task on tact retention, nor were there interaction effects between training sequence and verbal disruption (*ps* > .19). For intraverbal retention, there was a significant main effect of training sequence, $F(1,56) = 4.643$, $p < .05$, such that the TI groups performed with higher accuracy than the IT groups. There was no main effect of the verbal task nor did it interact with training sequence (*ps* > .45).

Image-Matching Test

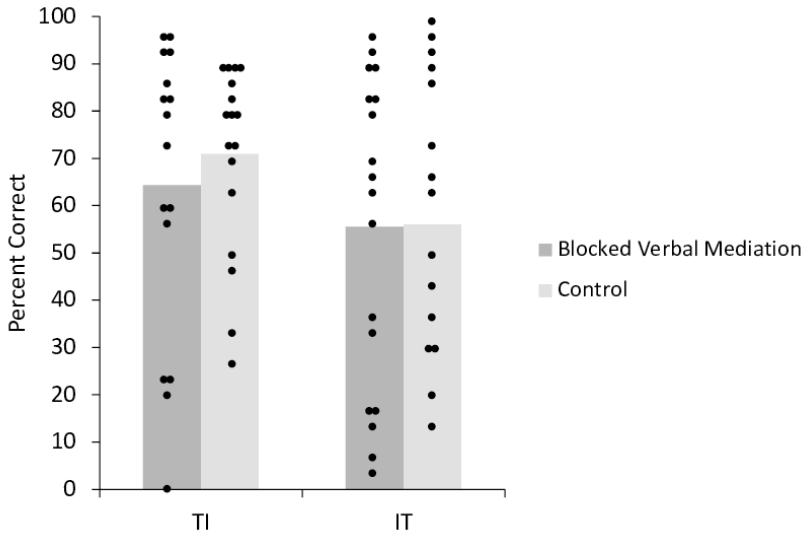
Selection Accuracy

Figure 1 shows the distribution of scores in the image-matching test across groups. Scores were highly variable in all groups with a slight negative skew in the TI groups but not in the IT groups. Percent correct on the image-matching test was significantly correlated with both tact retention ($r = .36$, $p < .01$) and intraverbal retention ($r = .69$, $p < .001$). The correlation with

intraverbal retention (but not tact retention) was significant in all four groups: TI, $r = .728$, $p = .001$; IT, $r = .679$, $p = .008$; TI-V, $r = .522$, $p = .038$; and IT-V, $r = .910$, $p = .000$. Tact and intraverbal retention were used as covariates in the 2 x 2 (verbal task x training sequence) analysis of covariances for accuracy in the image-matching test. When controlling for tact and intraverbal retention, there was not a significant main effect of either the verbal task, $F(1,54) = 3.167$, $p = .08$, or training sequence, $F(1,54) = 2.780$, $p = .10$, and no interaction between training sequence and verbal task, $F(1,54) = .141$, $p = .71$.

Figure 2

Image-Matching Test Accuracy



Note. Accuracy during the image-matching test where each black dot represents a participant and the bars represent the average percent correct in each condition.

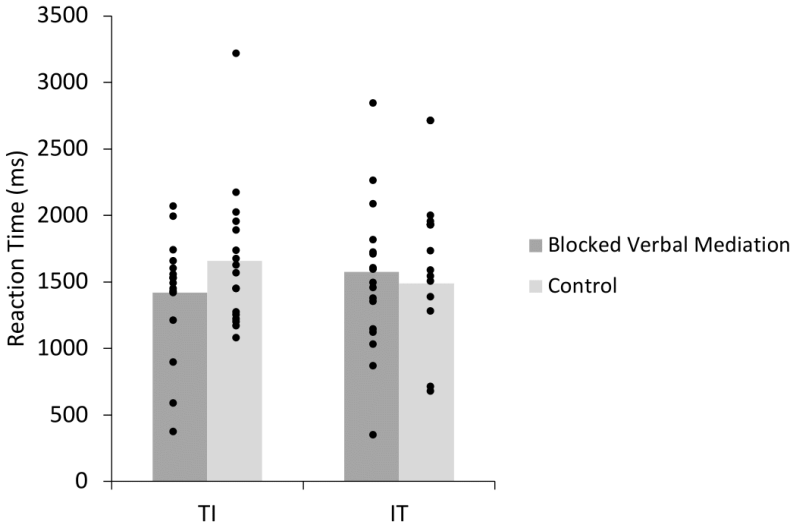
Reaction Times

Figure 2 shows the distribution of median reaction times for participants in each group during the image-matching test. Because the distribution of individual reaction times is positively skewed, each participant's median reaction time was used instead of the mean reaction

time. Median reaction times were not significantly correlated with either tact (r = .05, p = .72) or intraverbal (r = .15, p = .26) retention. On a 2 x 2 (verbal task x training sequence) ANOVA, there was no significant main effect of either the verbal task, $F(1,56) = 1.954$, p = .17, or training sequence, $F(1,56) = .604$, p = .44, nor was there an interaction between the two, $F(1,56) = .070$, p = .793.

Figure 3

Image-Matching Test Reaction Times



Note. Reaction times during the image-matching test where each black dot represents a participant and the bars represent the average percent correct in each condition.

Reverse Intraverbal and Listener Responding Tests

On the reverse intraverbal posttest, there was a significant main effect of the verbal task on reverse intraverbal performance when controlling for intraverbal retention, $F(1,55) = 10.584$, $p < .01$, such that groups assigned the verbal tasks performed with lower percentage accuracy (M = 70.7%, SD = 33.82) than groups not assigned the task (M = 84.9%, SD = 20.36). There was no main effect of training sequence and no interaction between verbal task and training sequence

(ps > .38) Reverse intraverbal scores were strongly positively correlated with image-matching test accuracy where TI, $r = .536$, $p = .027$; IT, $r = .578$, $p = .030$; TI-V, $r = .831$, $p = .000$; and IT-V, $r = .884$, $p = .000$. Accuracy on the listener responding test was not significantly affected by the experimental manipulation (*ps* > .18).

Exit Interviews/VVIQ

A total of 49 participants completed the exit interview and VVIQ questionnaires: 14 in the TI group, 12 in the IT group, 13 in the TI-V group, and 10 in the IT-V group. When asked how they knew which image to select on the image-matching test, two participants in the TI group but no participants in other groups made references to mental imagery or visual representations. When asked if they had done anything to help them memorize word pairs during intraverbal training, most participants reported strategies related to the words themselves such as memorizing the first letters of the words that went together; no participant mentioned visualizing the images. When directly asked if they had visualized the images during intraverbal training, nine participants in the TI and TI-V groups said yes (33.3%), but so did eight participants in the IT and IT-V groups (36%), even though they had not yet seen the images when they underwent intraverbal training. Accuracy and reaction times on the image-matching test did not differ significantly on independent-samples *t*-tests between participants who did and did not report visualizing in either TI or the IT groups (*ps* > .29).

In regard to the VVIQ, of a total possible score from 32-160, the mean total score was 68. VVIQ scores did not differ between groups: $F(3,45) = .960$, $p = .42$. VVIQ scores were not significantly correlated with either accuracy or reaction times in either the TI or the IT groups (*ps* > .220).

Discussion

Contrary to my hypothesis, the verbal disruption task did not impair the performance of the TI or the IT groups. In addition, there was no significant difference in either reaction time or accuracy between the TI and IT groups. This finding stands in contrast to previous research in which the TI sequence has produced more accurate or faster responses than the IT sequence.

A likely explanation why the verbal disruption task did not impair performance is that upon review of videos recorded by the participants, it was found that very few participants in the verbal disruption group actually followed the instructions to perform the verbal task out loud during the image-matching test. Specifically, only 13% of those in the TI-V condition and 41% of those in the IT-V correctly executed the additional verbal task. Some participants completely ignored the instructions, some quickly said their ABC's once before starting the image-matching test, and some said their ABC's continually but took long pauses while thinking about the trial. Therefore, the likely cause for noting no significant differences between the groups with the additional verbal task compared to those without is that most individuals in the TI-V and IT-V groups essentially treated the experiment like their control counterparts and did not let the verbal task interrupt them. If the experiment is replicated, the presence of an experiment may be necessary to encourage participants to follow instructions.

The effect of training sequence on image-matching test performance found in previous studies (Cox et al., under review; Petursdottir et al., 2019) was not replicated in the present study. Similar to the previous studies, mean accuracy was higher and mean reaction times were lower in the TI groups than in their IT counterparts. However, these differences were not statistically significant in the present study. One possible reason is that the experiment was statistically underpowered due to the small number of participants in each group and the highly

variable performance within groups. The planned sample size was 25 participants in each group. However, due to the COVID-19 pandemic, not as many participants were able to be scored as intended. Moving the experiment from in person at Texas Christian University's campus to an online format resulted in serious technical difficulties, varying from SuperLab not correctly scoring the participant trials, SuperLab skipping the tact training section for some of those in the IT and IT-V conditions, screens not being recorded correctly using Zoom, or individuals not sending their SuperLab data file or Zoom recording to the researcher. While the participants who experienced these issues were not included in the data, it did result in a significantly smaller pool of usable participant data.

Since not all members of the TI and TI-V conditions are guaranteed to use visual mediation as opposed to verbal mediation, a larger number of participants may be required to demonstrate the effect. In fact, only 33.3% of those in these TI and TI-V conditions reported utilizing visual imagining of the stimuli during the intraverbal training. Consistent with this finding, exit interviews and correlations between VVIQ scores and image-matching performance did not support a role of visual mediation in the TI groups. In addition, accuracy on the image-matching test was correlated with both intraverbal retention and reverse intraverbal test performance in all groups, suggesting all groups' performance may have been dependent on verbal strategies, and not just the performance of the IT groups. In other words, in spite of a visual mediation route being available to participants in the TI group, most participants may have solved the task verbally.

While the verbal task did not impair performance on the image-matching test, it did impair performance on the reverse intraverbal test, even when controlling for intraverbal retention. This finding was unexpected, but may reflect that the verbal task disrupted the

participants' verbalizations about the stimuli, even if not sufficiently to produce a significant effect on image-matching performance

Therefore, these findings do not invalidate the accuracy of previous literature, research, and the visual mediation hypothesis, but rather exemplify the flawed data from participant error using the current methodology. Moving forward, the recommendation is that this study be replicated with a more synchronous methodology. Many of the issues that were encountered, like technical difficulties and misunderstanding instructions, could easily be corrected by the presence of an experimenter. This study should either be done via a synchronous video call or preferably in person if it can be done safely.

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