University of Nevada, Reno

An Examination of the Contribution of Self-Stimulation on the Recall of Elementary Verbal Operants

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Psychology

by

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Abstract

Skinner's (1957) *Verbal Behavior* has made an impactful contribution to the analysis of verbal behavior in the field of behavior analysis. One noteworthy contribution has been the functional analysis of elementary verbal operants, which include copying text, echoic, taking dictation, textual, and intraverbal operants. However, compared to mands and tacts, these elementary verbal operants are arguably understudied, especially in controlled laboratory settings. Given that verbal operants such as these are considered to be socially significant behaviors for effectively behaving in verbal communities, it may be beneficial to account for often overlooked participating factors related to complex verbal interactions. An empirical analysis of self-stimulation as defined by responding to one's own stimulus response products in the present study appears to be lacking in the current body of behavior analytic literature. The purpose of this study sought to address this gap by investigating the participation of self-stimulation among verbal operants exhibiting point-to-point correspondence and formal similarity. In the pilot experiment, undergraduate students completed a series of trials in which they (1) performed a response of one of the following verbal operants in which access to response products were unmasked and masked: copying text, echoic, textual, or taking dictation, (2) completed a distractor task, and (3) recalled the initial target response in an intraverbal test. The subsequent online thesis experiment followed a similar set of procedures while accounting for limitations in the pilot experiment, but focused solely on copying text and taking dictation verbal operants. Results of the present study not only suggest that intraverbal performances were not differentially related to accessing stimulus response products between copying text and taking dictation verbal operants but that self-stimulation is functionally related to intraverbal recall upon which reinforcement is contingent.

Keywords: elementary verbal operants, point-to-point correspondence, copying text, taking dictation

Dedication

To my loved ones.

"Hózhóogo naasháa doo. Shitsijí' hózhóogo naasháa doo. Shikéédéé hózhóogo naasháa doo. Shideigi hózhóogo naasháa doo. T'áá altso shinaagóó hózhóogo naasháa doo. Hózhó náhásdlíí'. Hózhó náhásdlíí'. Hózhó náhásdlíí'. Hózhó náhásdlí" – Walk in Beauty (Diné teaching)

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An Examination of the Contribution of Self-Stimulation on the Recall of Elementary Verbal Operants

Verbal behavior is generally recognized as a distinguishing feature of the human psychological experience. We engage in conversations with close friends and family about our hopes, fears, past experiences, and plans for the future and, in doing so, establish meaningful relationships throughout the span of our lifetimes. The verbal communities into which we are born shape and maintain our behaviors, including those by which we interact within various environments (Novak & Pelaez, 2004; Pelaez et al., 2011; Skinner, 1957, 1974). As verbal communities continue to change, the study of human behavior—and verbal behavior in particular—has continued to capture the interest of many scholars, as indicated by the study of semantics, linguistics, grammar, and speech pathology.

While these studies contribute to bodies of knowledge in their own right, they do not necessarily focus on a functional analysis of verbal behavior that is specific to scientific systems like behavior analysis. In his seminal book *Verbal Behavior,* B. F. Skinner (1957) sought to address the problems that arise when only the form of verbal behavior is examined rather than functional behavior-environment relations. In doing so, Skinner identified the unit of analysis as the verbal operant, which describes a functional relation between a specific class of behaviors and their controlling variables (Skinner, 1957). In other words, identifying functional relations between motivating variables, discriminative stimuli, and consequences is a critical scientific activity in the experimental analysis of verbal behavior.

Skinner (1957) identified five classes of elementary verbal operants founded on the principles of behavior analysis that are under the control of prior verbal stimulation. These classes include the following: copying text operants (writing words seen), taking dictation operants (writing words heard), echoic operants (repeating words heard), textual operants (stating aloud words seen), and intraverbal operants (saying or writing something related to a written or verbal stimulus). Each of these verbal operants can be further classified as having either: 1) point-to-point correspondence between the stimulus and response product (e.g., "the beginning, middle, and end of the verbal stimulus matches the beginning, middle, and end of the response,"; Cooper, et al., 2007, p. 531) without formal similarity (i.e., when both the controlling antecedent stimulus and the response product share the same sense mode and physically resemble each other; Cooper et al., 2007) or 2) formal similarity, which assures point-to-point correspondence. For example, echoic and copying text operants share formal similarity and, by virtue of this property, they also exhibit point-to-point correspondence. Taking dictation and textual operants, however, share point-to-point correspondence but not formal similarity (see Table 1).

The taxonomy that Skinner proposed has contributed to an understanding of how different modes of antecedent stimulation (visual or auditory) and the stimulus products of their respective responses (e.g., vocal or written) participate in verbal interactions (Blair & Farros, 2019; Michael, 1982). To be clear, a response product is the natural outcome with respect to engaging in a particular type of response. Research has suggested that prior verbal stimulation sets the occasion for the emission of related verbal operants. For instance, visual response products may involve self-textual behaviors (e.g., when I copy the letters W-A-T-E-R, I say to myself "water"). Auditory response products may involve self-echoic behaviors (e.g., when I read aloud an important phone number, I repeat the digits to myself; Parrott, 1986). The observation that taking dictation and copying text operants may also involve self-textual operants, while textual and echoic operants may involve self-echoic operants, indicate that verbal operants are neither simple nor functionally independent from one another (Fryling, 2017; Greer & Ross, 2008; Hyten & Chase, 1991; Michael et al., 2011).

This is a critical point for scientific workers studying verbal behavior to consider. The issue of determining whether one verbal operant is functionally independent of another is not new to behavior analysis (Gamba et al., 2015; Lamarre & Holland, 1985; Twyman, 1996). Skinner (1957) acknowledged this issue as he stated, "(1) the strength of a single response may be, and usually is, a function of more than one variable and (2) a single variable usually affects more than one response" (p. 227). The complexities of these verbal operants vary, thus making "pure" forms arguably difficult to examine experimentally (Michael et al., 2011).

Although this may be the case, it is important to remember that verbal operants are constructs and, specifically, descriptions of classes of functional behavior-environment relations. The distinction scientific workers make between descriptions of events and the events described influence not only how behavioral events are conceptualized, but also the methods used to study them (Fryling & Hayes, 2009; Smith, 2016). The naturalistic perspective that Skinner proposed in *Verbal Behavior* was a much-needed alternative to mentalistic interpretations of language. However, an early criticism of Skinner's theoretical interpretation was that it did not contribute extensively to the development of empirical research on verbal behavior. The first citation analysis of Skinner's *Verbal Behavior* found that out of a total of 836 articles, only 31 (3.7%) could be categorized as empirical research (McPherson et al., 1984). These 31 articles were further categorized as descriptive, applied, or basic research. The additional finding that only 19 articles, which constituted 2.3% of the total number of articles identified in the study, involved the experimental manipulation of variables was particularly alarming. Despite having identified a relatively high number of citations, only a small percentage of articles were experimental in nature, thus indicating a need for more rigorous methods and analyses of verbal behavior in the behavior analytic community.

Additional citation analyses of *Verbal Behavior* (1957) have since been conducted and have included systematic examinations of other variables (e.g., population, age, verbal operants examined). Sautter and LeBlanc (2006) conducted an empirical analysis on *Verbal Behavior* from the years 1989–2004. They found that although there was a growing body of research pertaining to verbal operants and applied applications, the focus had been relatively restricted. They reported the frequency of studies published in peer-reviewed journals (e.g., *Journal of Applied Behavior, The Analysis of Verbal Behavior, Research in Developmental Disabilities)* throughout their selected time periods and found that mands, tacts, intraverbals, echoics, and autoclitics were the subjects of most empirical studies. Empirical articles focusing on mands constituted 72% of the published studies, followed by tacts, intraverbals, echoics, and autoclitics. Results from the citation analysis also showed that most of the research conducted on verbal operants has continued to be focused on the mand and tact operants (Finn et al., 2012; Pennington et al., 2016). A decade after Sautter and LeBlanc's (2006) findings, DeSouza et al. (2017) also reported that mands and tacts were still the most verbal operants studied and cited the continued importance of expanding research interests for a more complete account of verbal behavior.

Although mands and tacts are not the focus of this discussion, these findings may not be surprising to those who study or teach verbal behavior. Mands and tacts are often the focus of intervention programs for individuals diagnosed with major verbal behavior deficits (e.g., individuals diagnosed with autism). Moreover, the capacity to engage in mands and tacts, along with echoic and intraverbal operants, is necessary for the engagement of more complex forms of verbal behavior (Lerman et al., 2005). Additional outcomes of developing a capacity to engage in mands and tacts have also been reported. For example, this repertoire has been shown by early intervention programs to contribute to decreases in self-injurious behavior (Cornelius Habarad, 2015) and other inappropriate responding (Karmali et al., 2005). Thus, social validity (Wolf, 1978) associated with the acquisition of verbal operants has played an important role in helping to develop verbal behavior programs in both clinical and educational settings as well as for a variety of individuals.

The impact of Skinner's conceptualization of verbal behavior has also been examined by Dixon et al. (2007). The authors reviewed 100 articles previously selected from Dymond et al. (2006) and found that most of the empirical research had been conducted with young, atypical populations (77.7%). Included in this category were participants with physical, genetic, psychological, or developmental disability characteristics. These features of the research inspired by Skinner's analysis of verbal behavior may explain the lack of research on more complex operants such as copying text, taking dictation, textual, and intraverbal operants. Operants such as these require either fine motor skills or other historical factors critical for not only basic living skills but also for succeeding in educational settings. It is interesting that a more recent analysis (Presti & Moderato, 2016) which examined the experimental verbal operant literature in *The Analysis of Verbal Behavior*, produced similar results. From the years 1982–2013, the authors found that a relatively small percentage of published research papers were dedicated to studying intraverbal (16%), echoic (14.5%), textual (4.5%), copying text (1%), and taking dictation (1%) operants with most of the published articles in *TAVB* focusing on tacts (28.5%) and mands (22%).

In the case of the intraverbal, publication trends have demonstrated that this operant is garnering much more attention than it has in the past (Aguirre et al., 2016). An important issue acknowledged in this line of research has been the definition of the intraverbal itself. Although Skinner defined intraverbal behavior as "…verbal responses [that] show no point-to-point correspondence with the verbal stimuli which evoke them" (p. 71) and is behavior maintained by generalized conditioned reinforcement, intraverbals have been interpreted differently by researchers (Palmer, 2016). It has been pointed out that a broad interpretation permits the classification of *any* verbal response not exhibiting point-to-point correspondence with the verbal stimulus as intraverbal. Said differently, some researchers classify verbal responses as intraverbals even when responding is not maintained by a history of generalized conditioned reinforcement, while others strictly adhere to Skinner's explicit interpretation. This issue of whether or not verbal responses not exhibiting point-to-point correspondence when the antecedent verbal stimulus does not sufficiently evoke the appropriate verbal response remains (e.g., saying 1+2 = 4). Despite inconsistencies in experimental analyses with respect to how intraverbal control is conceptualized, the intraverbal operant construct has facilitated research on intraverbal training (Carroll & Kodak, 2015; Cihon, 2007; Contreras & Betz, 2016; Valentino et al., 2015), emergence (DeSouza et al., 2019; Dickes & Kodak, 2015; Pérez-González et al., 2007; Petursdottier et al., 2008), and problem solving (Kisamore et al., 2011; Mellor et al., 2015; Sautter et al., 2011) as demonstrated by Aguirre and colleagues (2016).

Intraverbal responding is necessary to engage in an array of complex behaviors, particularly remembering. Skinner (1974) vehemently denounced cognitivist interpretations of thinking and remembering, and in doing so, he attributed the establishment of such behavior to contingencies of reinforcement. Answering questions correctly about past events and recalling information (e.g., dates, addresses, phone numbers, names) are socially significant behaviors which promote effective responding within the verbal community. Moreover, it is the verbal community that establishes and maintains reinforcing contingencies. For example, emitting "A-B-C…" in response to the prior vocal verbal stimulus "say the alphabet" when first learning to recite the alphabet, is reinforced with statements such as "good job!" As intraverbal relations increase, more elaborate responding is made possible. Just as how one may engage in self-echoic or self-textual behavior while emitting operants of other sorts, intraverbal responding may occur with respect to stimuli that are self-generated. To be clear, this is not to say that knowledge or memories are stored somewhere inside an organism ready to be retrieved. Rather, different sorts of memorial events (e.g., remembering, reminiscing, memorization) involve responding with respect to current stimulation inherent in present objects (Hayes, 1998; Kantor, 1977). For example, when one needs to remember to go to the doctor next week, a note written in a planner may function as a substitute stimulus to act accordingly. However, one needs to be able to read and write to act in such a way under such circumstances. Given the extensive work conducted in applied settings to teach complex forms of verbal behavior such as mands and tacts, it seems to be a worthy pursuit to better understand conditions under which other sorts of complex responding are made possible. A general theme from the literature reviews discussed above is that empirical work aimed at understanding the conditions under which copying text, taking dictation, textual, echoic, and intraverbal operants occur and how they may be related to recall events is lacking. Relatedly, while Skinner's (1957) taxonomy of these elementary verbal operants accounts for prior verbal stimulation with respect to stimulus response products, the self-stimulation that also participates during complex verbal interactions appears to be currently empirically overlooked and understudied in this regard.

In short, there is a need for more empirical research on verbal behaviors other than mands and tacts. It is essential to study more complex forms of verbal behavior, particularly the intraverbal, copying text, taking dictation, echoic, and textual operants as there appears to be a gap of knowledge with respect to empirical basic studies in the current literature. As already indicated by applied studies, Skinner's conceptualization of verbal behavior has much to offer in the design of systematic procedures for teaching a range of verbal behavior skills that vary in complexity (Sundberg & Sundberg, 2011). However, a better understanding of how self-stimulation participates in verbal interactions in a basic setting may help to guide curricula for teaching individuals how to effectively participate in a verbal community across a variety of educational and community settings.

Purpose of Study

The purpose of the present study was to investigate the extent to which self-stimulation, as defined by responding to one's own response products, participate in recall events across different verbal operants. To this end, a pilot experiment was first conducted that examined differences between copying text, taking dictation, textual, and echoic operants as related to performance in a novel intraverbal task with a typical undergraduate adult population. The pilot experiment sought to accomplish this purpose by examining conditions under which participants engaged in accurate spoken and typed responses of 7-digit sequences following a delay. This included conditions when participants were able to see or hear their own response products with respect to antecedent visual or auditory stimuli in comparison to conditions when they were not able to see or hear their own responses to address the extent to which self-stimulation participates in these circumstances. Results of this experiment may have implications for better understanding how overlooked factors such as self-stimulation may participate in recall and remembering events and thus serve to inform teaching practices to enhance intraverbal performance. Limitations of this experiment were addressed by the subsequent thesis experiment, to be described after detailing the methods and findings of the pilot experiment.

Pilot Experiment

Method

Participants

A total of 79 undergraduate students from the University of Nevada, Reno participated in this pilot experiment and were recruited using the university's online research management system (SONA). The pilot experiment was approved by the Institutional Review Board (IRB). Participants were required to be undergraduate students enrolled at the University of Nevada, Reno, be at least 18 years of age, proficient in English, and have no serious visual or auditory deficits.

Setting and Apparatus

The pilot experiment was conducted in a small room outfitted specifically for the purpose of running experimental sessions. The room consisted of three computer stations separated by partitions on top of a table. Each computer station was equipped with a chair, desktop computer, microphone, mouse, standard QWERTY keyboard, and headphones. The volume of auditory stimuli was set at 50% of the computer's output capacity that participants could hear through the headphones. Participants were instructed to set aside all personal items in a designated area of the experimental room prior to starting the session. Participants completed all experimental tasks on the computer at their station. All experimental tasks were programmed in JavaScript and Electron software.

Procedures

Informed consent was obtained from all participants prior to each experimental session. An inclusion form (see Figure 1) was also provided following obtaining consent but prior to beginning the experimental session to ensure that all participants met eligibility requirements. Participants were randomly assigned to one of four groups prior to experimentation: Copying

Text, Echoic, Textual, and Taking Dictation (see Table 2). Participants were provided instructions based on group assignment as shown in Table 4. An exit-questionnaire (see Figure 2) immediately followed the completion of the study. Participants were immediately debriefed (see Figure 3) and compensated for their participation by receiving one SONA credit upon completion of the study.

Experimental task. The experimental task consisted of a series of 20 trials comprising three parts in the following order: a training test, a distractor task, and an intraverbal test (see Figure 4). There were no programmed consequences other than proceeding to the next part of the experimental task.

Training test. Each trial began with a training test in which participants were presented with a 7-digit series (e.g., 1043783). How 7-digit series were presented during training tests, how much time participants had to respond after presentation of the 7-digit series during training tests, and how participants could produce digit series during training tests varied across groups, as detailed below. After the presentation of digits, participants had 3.5 or 7-s to reproduce the 7-digit series. A different, randomized 7-digit series was shown on each trial so that all participants contacted the same twenty 7-digit series but in different randomized orders.

Masking. For each participant, half of the training tests were masked and half were unmasked, presented in a randomized fashion. During masked training tests, restrictions were placed on stimulation produced by responding during the training test. If the participant was in the Copying Text or Taking Dictation group, all typed digits produced the character "•" rather than the typed digit (e.g., •••••••). If the participant was in the Echoic or Textual group, white noise was played through headphones. During unmasked training tests, all typed digits could be seen on the computer screen in the Copying Text and Taking Dictation groups and no white noise was played through headphones in the Echoic and Textual groups (see Table 3). Groups differed in the following ways during training tests:

Taking Dictation. 7-digit series were presented auditorily through headphones. After the presentation of 7-digit series during training tests, participants had 3.5-s to produce the series by typing on a keyboard. During unmasked training tests, participants could see the digits they typed. During masked training tests, a typed digit produced the character "•".

Echoic. 7-digit series were presented auditorily through headphones. Participants were instructed to say the digit series aloud. After the presentation of a 7-digit series during training tests, participants had 3.5-s to produce the series. During unmasked training tests, white noise did not play as participants spoke the digits aloud. During masked training tests, white noise played when participants could speak the digits aloud.

Copying Text. 7-digit series were presented visually on the computer screen. After the presentation of a 7-digit series during training tests, participants had 7-s to produce the series by typing on a keyboard. During unmasked training tests, participants could see the see digits they typed. During masked training tests, a typed digit produced the character "•".

Textual. 7-digit series were presented visually on the computer screen. Participants were to say the digit series aloud. After the presentation of a 7-digit series during training tests, participants had 7-s to produce the series. During unmasked training tests, white noise did not play as participants spoke the digits aloud. During masked training tests, white noise played when participants could speak the digits aloud.

Distractor task. The distractor task consisted of a modified ten second Stroop test in which four randomized color names were presented one at a time for two seconds in different colors in the middle of the computer screen. The participants were provided instructions on the computer to immediately identify the color that the words were presented in rather than what the word read. For example, if the word "RED" was presented in green, then participants needed to select the color "green".

Intraverbal test. Intraverbal tests only differed from training tests in that no 7-digit series were presented to participants. After reading instructions asking participants to recall the 7-digit series they had previously produced, participants had 7-s to reproduce the 7-digit series presented during the training test. Masking of response products was not programmed to occur during intraverbal tests. The following instructions were presented for the Copying Text and Taking Dictation groups during intraverbal tests:

> Type the entire sequence of digits in the white box again. You will not be able to delete any characters. Press "Enter" to begin and "Enter" when immediately finished.

The following instructions were presented for the Echoic and Textual groups during intraverbal tests:

> Repeat the entire series of digits aloud again. Press "Enter" to begin and "Enter" when immediately finished.

Dependent and Independent Measures

The independent variables included the stimulus modality of the presentation of digits (i.e., either visual in the Copying Text and Textual groups or auditory in the Taking Dictation and Echoic groups), response product of digits (i.e., either spoken auditory stimuli in the Textual and Echoic groups or typed visual stimuli in the Copying Text and Taking Dictation groups), and manipulating access to response products so that they were either unmasked (i.e., when participants either could see their response products in the Copying Text and Taking Dictation groups or could hear themselves speak without white noise in the Echoic and Textual groups) or masked (i.e., when participants saw indiscriminate symbols instead of discriminable digits in the Copying Text and Taking Dictation groups or heard white noise in the Echoic and Textual groups). The primary dependent variable was correct digits recalled during intraverbal tests. In the Copying Text and Taking Dictation groups, responses were typed, and, in the Echoic and Textual groups, responses were spoken. Responses across all groups were counted as correct during intraverbal tests for each response product that matched the correct place value within the corresponding stimulus during training tests. For example, if the presented stimulus was "8516734" during a training test in the Copying Text group and the participant's typed response product was "**85**3**67**43", then the total correct digits for this trial would be calculated as $\frac{4}{7}$.

Data Analyses

Data analyses were performed using SPSS computerized statistical software. The alpha for all tests was set at 0.05. Participant data was excluded if either of the following occurred: participants did not complete any of the intraverbal tests or if participants responded for less than 80% of the total trials. The sample size of each group after exclusions for echoic was 8 (with 9 exclusions), 14 for taking dictation (with 5 exclusions), 10 for copying text (with 2 exclusions) and 13 for textual (with 6 exclusions). Additionally, data for 12 participants are not included due to program errors in data recording.

Results

Average correct digits recalled during intraverbal tests were analyzed using a 2 x 2 x 2 ANOVA with between-subjects factors of Stimulus Modality (Audio/Visual) Response Product (Spoken/Typed), and within-subjects factor of Masking (Masked/Unmasked). The analysis revealed that there were no significant main effects for Response ($f(1,41) = .056$, $p = .814$, partial $\eta^2 = .001$), Stimulus Modality ($f(1,41) = 1.026$, $p = .317$, partial $\eta^2 = .024$) or Masking ($f(1,41) = 3.02$, $p = .90$, partial $\eta^2 = .069$). There were also no higher order interactions between the factors of Stimulus Modality and Response Product (all p's > .05). However, the analysis showed a significant interaction effect between Stimulus Modality and Response Product ($f(1,42) = 4.69$, p $= .036$, partial $\eta^2 = .103$). Figure 5 illustrates these differences in average number of correct digits during intraverbal tests between groups. The combined average correct responses for spoken responses (Echoic and Textual groups: $M = 3.24$, $SE = .309$) were about the same as typed responses (Copying Text and Taking Dictation: $M = 3.14$, $SE = .285$). The combined average correct responses for when the stimulus modality was auditory (Echoic and Taking Dictation: *M* = 3.40, *SE* = .305) was higher than when the modality was visual (Copying Text and Textual: *M* = 2.98, *SE* = .289). Table 5 provides a summary of average correct digits recalled during intraverbal tests in all trials, masked trials, unmasked trials, trials 1-5, trials 6-10, trials 11-15, and trials 16-20 across all groups. The average correct digits in intraverbal tests categorized by preceding unmasked training tests (Copying Text: *M* = 2.61, *SD* = 1.30; Taking Dictation: *M* = 4.06, *SD* = 1.54; Echoic: *M* = 2.98, *SD* = .78; Textual: *M* = 3.78, *SD* = 1.57) was greater than the average correct digits in intraverbal tests categorized by preceding masked training tests (Copying Text: *M* = 2.34, *SD* = 1.27; Taking Dictation: *M* = 3.56, *SD* = 1.69; Echoic: *M* = 3.03, *SD* = 1.61; Textual: *M* = 3.19, *SD* = 1.74; see Figure 6).

Figure 7 shows average correct digits across the first five and last five intraverbal tests of masked and unmasked trials for participants across each group. With the exception of the unmasked trials for the Echoic group, average correct digits for intraverbal tests for both unmasked and masked trials were generally lower in the first five intraverbal tests than in the last five intraverbal tests. These data were analyzed using repeated measures 2 x 2 ANOVA with the within-subjects factors of Trial Block (First Five Trials/Last Five Trials) and Masking (Masked/Unmasked) for each group. For the Textual group, a significant main effect for Trial Block was detected ($f(1,12) = 14.60$, $p = 0.0024$, partial η^2 =0.622) but not for Masking ($f(1,12)$ = 3.210, $p = 0.098$, partial $\eta^2 = 0.469$). Post-hoc Sidak's multiple comparisons tests found a significant difference in the average correct digits between the first and last five unmasked trials (Trials 1-5: *M* = 3.231; Trials 6-10: *M* = 4.338; *p* = 0 .002) but not masked trials (Trials 1-5: *M* = 2.938; Trials 6-10: *M* = 3.446; *p* = 0 .139). For the Echoic group, neither a significant main effect for Trial Block ($f(1,7) = 1.037$, $p = 0.343$, partial η^2 =0.079) nor Masking ($f(1,7) = 0.018$, p = 0.897, partial $\eta^2 = 0.004$) was detected. For the Taking Dictation group, a significant main effect for Trial Block ($f(1,13) = 8.113$, $p = 0.014$, partial η^2 =0.399) but not for Masking ($f(1,13)$ =

1.468, $p = 0.247$, partial $\eta^2 = 0.294$) was detected. Post-hoc Sidak's multiple comparisons tests did not find a significant difference in the average correct digits between the first and last five unmasked trials (Trials 1-5: $M = 3.700$; Trials 6-10: $M = 4.414$; $p = 0 .065$) or masked trials (Trials 1-5: $M = 3.300$; Trials 6-10: $M = 3.829$; $p = 0 .191$). No significant interaction effects between Trial Block and Masking were found for any group (all p's > 0.050).

Because unmasked and masked trials were completely randomized and, thus, could have resulted in participants completing all unmasked trials before masked trials or vice versa, additional analyses were performed to determine changes in average correct digits across all trials irrespective of masking. Figure 8 shows average correct digits across four trial blocks of five trials for each group. While a slight increase in average correct digits is visually apparent for each group from the first five trials to the second five trials, subsequent continuous increases in average correct digits across trial blocks was only observed in the Textual group. Notably, in the Echoic group, average correct digits actually appears to decrease across later trial blocks.

Discussion

Although there was not a statistically significant main effect reported for masked and unmasked training tests with respect to accurate responding during intraverbal tests for all groups, visual analyses showed slightly higher accurate average responses when training tests were unmasked for three of the four groups. In other words, participants were generally able to accurately recall more digits during the intraverbal tests when access to stimulus response products was available. More specifically, this was demonstrated for the Taking Dictation, Textual, and Copying Text groups as indicated by higher average correct digits. While these findings suggest that access to products of one's own responding is not functionally related to intraverbal recall in this task, small and unequal group sizes may have thwarted observation of this relation, especially if it is subtle.

Interestingly, average intraverbal performance was the most accurate in the Taking Dictation group whereby participants engaged in typed responses to auditory stimuli. Previous findings indicate that higher rates of accuracy of various learning outcomes (e.g., reading) are observed when individuals hear target stimuli and then say the target response in comparison to hearing target auditory stimuli and writing the target response (Thompson, 1985). It is important to note that although participants were instructed to wait to respond until the entire sequence of digits were presented during training trials, it is possible that some participants immediately responded as each digit was presented in the Echoic and Taking Dictation groups, thus allowing for variability of the time participants had access to their permanent response products prior to intraverbal tests (e.g., 3.5-s if participants followed instructions to 7-s if instructions were not followed). A related issue was the delay to responding, as it was possible for participants to wait before pressing the Enter key following the distractor task before beginning intraverbal tests to engage in self-echoics. This was a possible confound across all groups. Additionally, typed responding under typical circumstances as experienced in unmasked training tests produces a permanent response product whereby responding may be made in response to the previous typed stimulus, establishing conditions necessary for self-textual operants. These variables may help to account for higher average correct digits during intraverbal tests that were preceded by unmasked trainings observed in the Taking Dictation group.

The second most accurate average intraverbal performance occurred in the Textual group in which participants vocally responded to visual stimuli. The difference between average correct digits recalled during intraverbal tests between masked and unmasked training trials was not statistically significant, raising the question of whether the preparations in the masking trials were sufficient to functionally diminish auditory stimulation that corresponded to vocal responding. It is plausible that the volume of the white noise did not adequately mask auditory stimulation for all participants.

The third most accurate average intraverbal performance was observed in the Echoic group in which participants vocally responded to auditory stimuli. Although it might have been expected that intraverbal performance would have been highest when both the stimulus modality and response mode were the same, this was not found to be case. It is also noteworthy that this was the only group that resulted in slightly higher average correct digits during intraverbal tests when the preceding training tests were masked compared to when they were unmasked. As stated above with respect to responding in the Textual operant group, more accurate responding during masked than unmasked trials may be attributable to poor masking of response products. Additional visual and tactile stimulation may have also contributed to this finding. For example, it was reported in the post-questionnaire by some participants that they would look at and lightly touch the digits on the keyboard while listening to the auditory stimuli and responding vocally during both masked and unmasked training trials. The stimulus-response relations in this group are not clear considering the report of using unanticipated visual aids from participants.

Lastly, the poorest performance during intraverbal tests on average was observed in the Copying Text group in which participants engaged in a typed response to visual stimuli. Although slightly higher accurate average correct digits were reported during intraverbal tests when training tests were unmasked, the results were not statistically significant. This however may be accounted for by the involvement of additional stimulation similar to the Echoic group. For instance, participants reported they were engaging in self-echoics during both masked and unmasked training trials as well as during the distractor task. Although the program was designed to mask typed responses, participants also reportedly looked at digits on the keyboard as a visual aid when typing rather than the computer screen. However, this may have also served as a disadvantage due to the limited time allotted to type seven digits within the seven seconds. Compared to the taking dictation, textual, and echoic groups, it is also to be mentioned that this is the only group that required interacting between two sorts of visual stimuli (visual stimuli on the computer screen and visual stimuli on the keyboard) within this limited time frame.

In sum, there was no observed difference in intraverbal recall produced by masking of stimulus response products among target verbal operants. However, visual analyses and descriptive statistics showed slightly better performance during intraverbal tests when training tests were unmasked among the Taking Dictation, Textual, and Copying Text groups while the opposite was found for the Echoic group. Additionally, average correct digits recalled in intraverbal tests were significantly higher for those in the Taking Dictation group than for those in the Copying Text group. Confidence in these findings is limited however by the possibility of insufficient masking of stimulus response products, unanticipated visual aids, and lack of stringent programmed contingencies for completing all parts of a trial and controlling for rate of reinforcement, as well as the small number of participants in each group. Addressing these limitations may help to provide a better account of the extent to which self-stimulation participates among these verbal operants.

Thesis

To reiterate, the purpose of the pilot experiment was to investigate the extent to which self-stimulation, as defined by responding to one's own response products, participant in recall events across Copying Text, Taking Dictation, Textual, and Echoic operants by measuring recall performance in a novel intraverbal task with a typical undergraduate adult population. The following thesis experiment sought to address the specific issues observed in the pilot experiment as discussed above to better address this purpose. Given the current COVID-19 pandemic, the format of the study was conducted online. Additionally, due to finding a significant difference in average correct digits recalled during intraverbal tests between the Copying Text and Taking Dictation groups and the infeasibility of programming rewards to be contingent on spoken responses using an online program, the thesis experiment only examined Copying Text and Taking Dictation operants.

Method

Participants

76 undergraduate students from the University of Nevada, Reno were recruited using the university's online research management system (SONA) and IRB approved flyers and in-person

recruitment scripts. Requirements for participation were the same as specified in the pilot study such that participants were undergraduate students enrolled at the University of Nevada, Reno, at least 18 years of age, proficient in English, and have no serious visual or auditory deficits. Participants were compensated with 1 SONA credit for completing one 30-minute session.

Setting and Apparatus

The study was conducted online such that participants could complete the experiment on a personal computer in a location with minimal distractions. All experimental software were programmed with Javascript and HTML and the study was hosted on a secure Microsoft Azure SQL server.

Procedures

Emails with Zoom invitations were sent to participants upon signing up for a session using the university's SONA system. They were informed to attend their scheduled session in a room with minimal distractions and to use a computer that was plugged in to an outlet source with a strong internet connection. They were also notified that they would be asked to enable their camera and to share their desktop to help them set up the study during the session. Participants were informed that the study could not be conducted on a phone or iPad.

Participants were pseudo-randomly assigned to either the Taking Dictation or Copying Text group such that a group was not assigned again until sessions for both groups were conducted. Upon attending their session, participants were asked to confirm their name and to ensure the volume on their computer was turned up to a comfortable level. They were instructed to turn on their webcam and to keep it on for the duration of the session. This allowed for the session to be appropriately monitored to confirm participants were not working on any other computer applications, ensure that the program was running smoothly, and to record abnormalities that occurred during sessions (e.g., internet connectivity issues, leaving to go to the bathroom, unexpected disruptions, etc.). If a participant logged in to their session on a phone or iPad, they were immediately asked to log back in on a computer or to reschedule their session.

Sessions were also rescheduled if internet connection issues were identified by observing "frozen" computer screens, delayed or lost audio, or "dropped" Zoom calls during the initial set up but before starting the experimental program. Sessions were terminated early where poor internet connection occurred and impacted the proper running of the program or when the experimental software suffered a compatibility issue with the participant's computer or internet browser.

A consent form (see Figure 9) was provided to all participants to view prior to beginning the experiment. Upon receiving consent, participants were instructed to share their desktop screen with only the internet browser opened and noted that it was important for them to not work on any other webpages or applications during the study. The URL link to the study website was then shared and the participant ID number and group assignment was then provided to begin the study. The instructions (see Figure 10) were read aloud to the participant in which they were told that the length of the study would depend on how many points they were able to generate at various parts during the study. In other words, if they failed to achieve an undisclosed number of points throughout the session, the session would be terminated before its maximum duration would allow them to accrue 1 SONA credit. However, no actual early session termination contingency was programmed with respect to earning a certain number of points at various parts of the study. This was to help increase the reinforcing value of points and to promote consistent responding throughout the study. Participants were allowed to read the instructions again to themselves as well as to ask questions before proceeding. A post-experiment questionnaire (see Figure 11) immediately followed the completion of the study. Participants were immediately debriefed (see Figure 12) and compensated for their participation.

Experimental task. Like in the pilot experiment, each trial consisted of a training test, distractor task, and intraverbal test with 20 trials per experimental session. The program recorded each typed key and each stimulus presentation to allow for precise descriptions of scheduled and behavioral events occurring during sessions. After participants finished reading the initial instructions, the experimental task was timed to control for rate of reinforcement. In other words, participants were not able to increase or decrease the speed at which the task was completed by responding slowly or quickly, respectively. Point contingencies were also imposed during the training tests, distractor task, and the intraverbal tests, as described below.

Training test. Each trial began with a training test in which participants were presented with instructions. After 2-s, 7-digit series (see Table 6) were presented. A different, randomized 7-digit series was shown on each trial so that all participants contacted the same twenty 7-digit series but in different randomized orders. Each digit in a series was presented for one second during training tests. Participants earned 5 points for each correct digit typed (based on value and placement within the typed sequence), delivered at the end of the trial aggregated with points earned in the intraverbal tests.

Masking. There were 10 masked and 10 unmasked training tests that were pseudo-randomized such that every two trials consisted of one masked and unmasked training test presented in random order. This was to help control for order effects so there weren't ever more than two types of the same training test presented consecutively. During masked trials the character "*" appeared rather than the typed digit (e.g., *******). During unmasked training tests, all typed digits could be seen on the computer screen in both groups. Groups differed in the following ways during training tests:

> ***Copying text.*** 7-digit series were presented visually on the computer screen. Each digit was presented for one second. During unmasked training tests, participants could see the see digits they typed (See Figure 13). During masked training tests, a typed digit produced the character "*" (see Figure 14)-.
>
> ***Taking dictation.*** 7-digit series were presented auditorily. Each digit was presented for one second. During unmasked training tests, typed digits appeared on the computer

screen (see Figure 15). During masked training tests, a typed digit produced the character "*" (see Figure 16).

Distractor task. The distractor task involved both auditory and visual discriminative stimuli. Participants were instructed to type characters shown and audibly spoken to them using a programmed computer synthesizer for 20-s. Characters involved randomized letters (e.g., 'f', 'l', 'c') and appeared in various spatial locations within a designated box for experimental stimuli to appear. Participants had 1-s to type each character and a 1-s break between characters. Participants avoided losing points by typing correct alphabetical characters within the 1-s window. For each incorrect response, 5 points were immediately deducted from the participant's total number of points as displayed at the top of the box where stimuli were presented.

Intraverbal test. Intraverbal tests were like those in the pilot study in that masking of stimulus response products was not programmed to occur during intraverbal tests (see Figure 17). The following instructions were presented for the Copying Text and Taking Dictation groups during intraverbal tests: "After the lines appear, retype the digits you typed before in the same order." The lines appeared 2-s after the presentation of instructions as in the training tests. Participants earned 10 points for each correct digit typed (based on value and placement within the typed sequence).

A 10 second inter-trial interval immediately followed intraverbal tests in which participants were told the trial was over, the number of points they earned, as well as to get ready for the next trial as the next trial would start soon.

Dependent and Independent Measures

Given that in the thesis experiment, participants contacted a discriminable contingency in which points were made contingent on each correct digit, average total correct digits and total correct intraverbal tests were examined as the primary dependent variables instead of average correct digits on a trial in order to assess if stimulus modality and masking were functionally related to the response upon specific point values were contingent (e.g., each digit) or reproducing a complete stimulus (e.g., to total sequence of digits). An intraverbal test was counted as correct when each response product matched the correct place value within the corresponding stimulus for all seven digits during training tests. If the presented stimulus was "8516734" during the first training test in the Copying Text group and the participant's typed response product was "**85**3**67**43", then the total correct intraverbal tests would be calculated as $\frac{0}{1}$. Correct digits were determined as they were in the pilot experiment. As the only two groups that were included were Copying Text and Taking Dictation, the only independent variables examined were stimulus modality of the presentation of digits and access to response products.

Data Analyses

The data analyses were performed using Prism 9 computerized statistical software. Alpha was set at 0.05 for all statistical tests. Participant data was not included for analyses for sessions terminated early. Participant data was also excluded if participants did not complete at least 85% of the intraverbal tests. Due to this exclusionary criterion there were 4 exclusions in the Copying text group and 2 exclusions in the Taking Dictation group. Additionally, data for 24 participants are not included due to internet connectivity issues disrupting the proper running of the program. The sample size of each group, after all exclusions, was 24 for the Copying Text group and 22 for the Taking Dictation group. One participant's data from the Copying Text group was not included in analysis concerning performance across trials because a poor internet connection prevented their data from being saved to the database.

Results

Figure 18 illustrates these differences in average total correct intraverbal tests between groups. The average total correct intraverbal tests were about the same for the Copying Text and Taking Dictation groups in both unmasked (Copying Text: $M = 2.333$, $SE = 0.457$; Taking Dictation: $M = 1.909$, $SE = 0.416$) and masked (Copying Text: $M = 2.000$, $SE = 0.571$; Taking Dictation: $M = 2.000$, $SE = 0.348$) conditions. The average total correct intraverbal tests was analyzed using a repeated measures 2 x 2 mixed ANOVA with the between-subjects factor of Stimulus Modality (Audio/Visual) and the within-subjects factor of Masking (Masked/Unmasked). The analysis revealed that there were no significant main effects for Stimulus Modality ($f(1,44) = 0.0127$, $p = 0.724$, partial $\eta^2 = .014$) or Masking ($f(1,44) = 0.205$, $p = 0.653$, partial $\eta^2 = 0.005$). There was also no interaction effect between Stimulus Modality and Masking ($f(1,44) = 0.626$, $p = 0.433$, partial $\eta^2 = 0.014$).

Figure 19 illustrates these differences in average total correct digits recalled during intraverbal tests between groups. The average total correct digits were about the same for the Copying Text and Taking Dictation groups in both unmasked (Copying Text: $M = 40.5$, $SE = 2.579$; Taking Dictation: $M = 39.364$, $SE = 2.770$) and masked (Copying Text: $M = 36.333$, $SE = 3.184$; Taking Dictation: $M = 36.136$, $SE = 2.558$) conditions. The average total correct digits was analyzed using a 2 x 2 mixed ANOVA with the between-subjects factor of Stimulus Modality (Audio/Visual) and the within-subjects factor of Masking (Masked/Unmasked). The analysis revealed that there was a significant main effect for Masking ($f(1,44) = 5.114$, $p = 0.029$, partial $\eta^2 = 0.104$) but not Stimulus Modality ($f(1,44) = 0.034$, $p = 0.854$, partial $\eta^2 = .004$). Post-hoc Sidak’s multiple comparisons tests did not find significant differences in the average correct digits between unmasked and masked trials in the Copying Text group ($p = .139$) or in the Taking Dictation group ($p = 0.326$). No interaction effect between Stimulus Modality and Response Product was observed ($f(1,44) = 0.083$, $p = 0.775$, partial $\eta^2 = 0.002$).

Figure 20 shows average correct digits across the first five and last five intraverbal tests of masked and unmasked trials for participants in the Copying Text group. Average correct digits were generally lower in the first five intraverbal tests (Unmasked: $M = 3.791$, $SE = 0.355$; Masked: $M = 3.582$, $SE = 0.358$) than in the last five intraverbal tests (Unmasked: $M = 4.336$, $SE = 0.299$; Masked: $M = 4.036$, $SE = 0.411$). These data were analyzed using repeated measures 2 x 2 ANOVA with the within-subjects factors of Trial Block (First Five Trials/Last Five Trials) and

Masking (Masked/Unmasked). The analysis revealed that there was a significant main effect for Trial Block (*f*(1,21) = 5.735, *p* = 0.026, partial η^2 =0.242) but not Masking (*f*(1,21) = 0.826, *p* = .374, partial η^2 = .077). Post-hoc Sidak's multiple comparisons tests did not find significant differences in the average correct digits between the first and last five unmasked trials (*p* = 0.114) or masked trials (*p* = 0.209). No interaction effect between Stimulus Modality and Response Product was observed (*f*(1,21) = 0.056, *p* = 0.816, partial η^2 = 0.003).

Figure 21 shows average correct digits across the first five and last five intraverbal tests of masked and unmasked trials for participants in the Taking Dictation group. Like for the Copying Text group, average correct digits were generally lower in the first five intraverbal tests (Unmasked: *M* = 3.500, *SE* = 0.340; Masked: *M* = 2.982, *SE* = 0.266) than in the last five intraverbal tests (Unmasked: *M* = 4.373, *SE* = 0.311; Masked: *M* = 4.245, *SE* = 0.305). These data were analyzed using repeated measures 2 x 2 ANOVA with the within-subjects factors of Trial Block (First Five Trials/Last Five Trials) and Masking (Masked/Unmasked). A significant main effect for Trial Block was detected (*f*(1,21) = 20.25, *p* = 0.0002, partial η^2 =0.603) but not for Masking (*f*(1,21) = 2.538, *p* = 0.126, partial η^2 = .122). Post-hoc Sidak's multiple comparisons tests did not find significant differences in the average correct digits between the first and last five unmasked trials (*p* = 0 .114) or masked trials (*p* = 0.209). No interaction effect between Trial Block and Masking was observed (*f*(1,21) = 1.068, *p* = 0.313, partial η^2 = 0.048).

Figure 22 shows the correlation between the total correct intraverbal tests on masked trials and total correct intraverbal tests on unmasked trials. Because neither total correct intraverbal tests on masked and unmasked trials passed Shapiro-Wilk normality tests, Spearman correlation coefficients were used to analyze their relation in each group. The analysis revealed a significant positive association between performance on intraverbal tests preceded on masked and unmasked trials for both the Copying Text (*r*(22) = .63, *p* = 0.001) and the Taking Dictation (*r*(20) = .71, *p* < 0.0001) groups.

Discussion

Findings from the thesis experiment suggest that intraverbal performances were not differentially related to copying text and taking dictation verbal operants. Statistical analyses did not find any significant differences in average correct intraverbal tests during either unmasked and masked trials between groups, although visual analyses showed that the average correct intraverbal tests was slightly below or above two for both the Copying Text and Taking Dictation groups. Additionally, statistical analyses did not find any significant differences in average total correct digits between groups. Compared to average total correct intraverbal tests, the average total correct digits show that participants were able to accurately recall a higher proportion of digits in both masked and unmasked trials of both Copying Text and Taking Dictation groups.

Although statistical analyses did reveal a significant main effect of masking with respect to average total correct digits, there was no significant difference in the average correct intraverbal tests between unmasked or masked trials. These results suggest that functional relations between access to response products and intraverbal recall cannot be separated from the contingency with respect to which digits were recalled. Participants were not rewarded for reproducing complete sequences of digits; rather, points were made contingent on the typing of each correct digit, not an entire sequence. Additional studies could explore this further by examining whether self-stimulation is related to intraverbal recall when points are made contingent on recalling entire sequences of digits rather than each digit individually.

A positive correlation was also found between performance on intraverbal tests for unmasked and masked trials. In other words, a participant's performance was similar on intraverbal tests when preceded by either masked or unmasked training tests. Generally, if a participant had a low number of total correct intraverbal tests during unmasked trials, then they also had a low number of total correct intraverbal tests during masked trials and vice versa. This finding, combined with the slight difference in average correct digits across masked and unmasked trials, suggests that while masking may be functionally related to intraverbal recall, other individual factors participate in such events. Additional studies could examine such potential factors, which may pertain to verbal competency, and reinforcement histories for remembering.

The average correct digits recalled during intraverbal tests across the first five and last five intraverbal tests of masked and unmasked trials in the Copying Text and Taking Dictation group show a similar pattern of responding. In the Copying Text group, visual analyses show a slight increase of average correct digits between the first five and last five intraverbal tests between unmasked and masked trials. Slightly higher averages are observed for unmasked trials compared to masked trials. This pattern was also observed in the Taking Dictation group and may be indicative of practice effects over time. Accordingly, participant performance seems to improve across the task. This suggests that if intraverbal recall is differentially related to other verbal operants, it may only be so at certain points in this task.

There are notable limitations to the study that was conducted. The study was conducted in an online format rather than in a controlled lab setting. This made it difficult to control for the equipment participants used as they had different setups to participate in the experiment. For example, some participants needed to wear headphones while others used computer speakers as well as used different keyboards and computer settings. As such, it was difficult to ensure that volume settings remained the same across all participants during the distractor task when characters were being presented. The experimental program also required a strong internet connection to run smoothly across various internet browsers and presented a major barrier as participant data was excluded if the program was disrupted.

An additional limitation to consider is that the topography required in both the Copying Text and Taking Dictation groups were typed responses. Participants were instructed to type their responses during training and intraverbal tests in both groups. When Skinner (1954) discussed writing, he stated that writing could be understood as occurring in three stages that involved requiring external support from the environment, making differentiated marks, and transmitting the marks to the appropriate parties (pp.69-70). By these standards, typed responding was thought to be analogous to a hand-written response. However, typed and written responses have different topographies that involve different sorts of behaviors, such as scanning for correct characters in the case of typed responses and minimal unit repertories (e.g., the way in which letters are produced and how closely response products resemble antecedent visual stimuli). Michael (1985) discussed the distinctions between such topography-based and stimulus-selection-based verbal behavior, one of which is how topography-based verbal behavior exhibits point-to-point correspondence between the form of response and respective response product. Selection-based verbal behavior, however, does not share this characteristic as it involves conditional discriminations. In this study, typed responding may be considered a sort of selection-based behavior as related to possibly scanning for and selecting the correct key on a keyboard that matched the presented stimulus. Research examining these sorts of verbal behaviors with different populations (e.g., individuals diagnosed with intellectual disabilities and college students) suggests that topography-based and selection-based verbal behavior differ with respect to performance related to intraverbal relations and other verbal operants (Bloh, 2016). However, studies have yielded mixed results as they relate to which method is better for teaching various forms of complex verbal behavior. The results of this current study suggest that copying text and taking dictation verbal operants, as conceptualized as selection-based behavior, may be functionally equivalent for individuals who engage in other forms of complex verbal behavior.

Additionally, although measuring self-echoic behavior was not the focus of the current study, participation of self-echoic behavior is expected to have occurred based on recall strategies participants reported on the post-questionnaire. In the Copying Text group, some examples included the following: “I would find a rhythm in my head to say the pattern of numbers to. Then repeat it while I was typing the letters,” and, “[I] started saying the numbers in my head as they showed up, adding to it each time. [F]or example: 123 "123" 1234 "1234" and so on. [A]nd then when [I] did the letters [I] would type one then say the sequence in my head, type one say the sequence, over and over again." Similar responses were also observed in the Taking Dictation group and included responses referring to chunking numbers. Some example responses were the following: "Remembering the digits in pairs of 2 or 3," and "I tried to remember them in a group of 3, then 4." These responses in combination with the findings that intraverbal performances were not differentially related to masked and unmasked trials in the copying text and taking dictation verbal operants, suggest that self-echoic behavior may participate to a greater degree than access to one's own visual response products under these circumstances. These findings support the conceptualization and applied research that suggests verbal operants are not independent from one another, despite taxonomical descriptions.

The results obtained in this study have applied implications for scientist-practitioners and educators. Teaching individuals to emit appropriate intraverbal responses related not only to academic areas but other practical areas such as being able to accurately recall one's own name, home address, or phone number when asked, for example, are considered to be socially significant behaviors. In such cases, providing incorrect or partial responses to such questions may not produce desired outcomes. The finding that the majority of participants recalled few entire sequences of digits but still accurately recalled a proportion of correct digits in the sequences, suggests that the imposed contingencies also influenced intraverbal performance during masked and unmasked trials. If practitioners aiming to establish intraverbal recall do so by reinforcing the production of each correct part of an entire response rather than the entire response, they may reinforce ineffective performance. Relatedly, the significant main effect of masking with respect to average digits recalled in both the Copying Text and Taking Dictation groups indicates that access to stimulus response products participates in recall events. Arranging the environment to best serve clients and students should include the consideration of providing adequate resources and conditions. For example, appropriate lighting and noise levels during training and study sessions may need to be adjusted for individuals to adequately access stimulus response products while also providing an appropriate number of practice opportunities. Results from this study suggest that practice opportunities may also vary with respect to taking dictation and copying text operants, as they may be functionally equivalent with respect to their participation in recall under certain circumstances.

Future research could continue to focus on extensions to improve the current study in various ways. A within-subject ABAB reversal design could help to determine if there are any differences between copy text and taking dictation verbal operants, although an alternating treatments design may be better suited given evidence of practice effects observed across both the pilot and thesis experiments. The addition of a control condition whereby participants are presented with a series of digits but are not required to respond before the distractor task would also serve to examine the extent to which visual response products participate in intraverbal relations. It is also worth mentioning that intraverbal test performance may be related to the modality of antecedent verbal stimuli as they relate to one's history with respect to classes of elementary verbal operants. For example, auditory stimuli may be considered to be more transitory in nature than visual stimuli, whereby responding may occur in response to the previous typed or written stimulus that establishes conditions for self-textual operants. A further examination of these relations and how they contribute to the acquisition of intraverbal responding may be additional topics to explore.

Additionally, protocols could specifically attempt to account for measuring self-echoic behavior. Given the questionnaire responses, this seems to be a reasonable next step to account for the extent to which self-echoic verbal operants relate to remembering events with respect to other verbal operants. Moreover, participants could be required to write the target responses during training and intraverbal tests in both the Copying Text and Taking Dictation groups to further examine the participation of self-stimulation and functional relations. Manipulating the distractor task by having participants also say or not say the characters they see aloud may also serve to examine the effects of visual or auditory interference on intraverbal performance with respect to different verbal operants and additional participating factors. Empirical studies and suggested extensions, as discussed, may help to identify participating factors related to verbal operants and provide a more coherent account of understanding and teaching complex verbal behaviors.

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Table 1

Characteristics of Elementary Verbal Operants

Verbal Operant	S^D/ Response	Point-to Point Correspondence	Formal Similariy
Copying Text	Visual / Written	Yes	Yes
Taking Dictation	Audiotry / Written	Yes	No
Echoic	Audiotry / Spoken	Yes	Yes
Textual	Visual / Spoken	Yes	No
Intraverbal	Visual or Auditory / Written or Spoken	No	No

Table 2

Experimental Groups and Descriptions

Condition	Description
Group 1 – Taking Dictation	Seven digits were presented through the headphones and participants typed the digits they heard. In the unmasked conditions, participants were able to see the digits they typed. In the masked conditions they were not able see the typed digits.
Group 2 – Copying Text	Seven digits were presented on the computer screen and participants typed the digits they saw. In the unmasked conditions, participants were able to see the digits they typed. In the masked conditions they were not able to see the digits they typed.
Group 3 – Echoic	Seven digits were presented though the headphones and participants repated the digits aloud. In the unmasked conditions, participants were able to hear the digits they said aloud. In the masked conditions, white noise played through the headphones and they were not able to hear the digits they said aloud.
Group 4 – Textual	Seven digits were presented on the computer screen and participants repeated the digits aloud. In the unmasked conditions, participants were able to hear the digits they said aloud. In the masked conditions, white noise played through headphones and they were not be able to hear the digits they said aloud.

Table 3

Verbal Operants and Descriptions of Unmasked/Masked Tests

Verbal Operant	Unmasked Trials	Masked Trials	Intraverbal Test Response
Taking Dictation	Can see typed response	Cannot see typed response	Can see typed response
Copying Text	Can see typed response	Cannot see typed response	Can see typed response
Echoic	Can hear vocal response	Cannot hear vocal response	Can hear vocal response
Textual	Can hear vocal response	Cannot hear vocal response	Can hear vocal response

Table 4

Group Instructions

Group	Intructions
Group 1 – Taking Dictation	You will be asked to listen to a series of digits and to type them on the keyboard. Sometimes the digits you type will appear on the computer screen and sometimes the digits you type will not appear on the computer screen. Please do not repeat the digits aloud. Press "Enter" when you are ready to begin.
Group 2 – Copying Text	You will be asked to look at a series of digits and to immediately type them on the keyboard. Sometimes the digits you type will appear on the computer screen and sometimes the digits you type will not appear on the computer screen. Please do no repeat these digits aloud. Press "Enter" when you are read to begin.
Group 3 – Echoic	Please put on the headphones and to no remove them until instructed to take them off. You will be asked to listen to some digits and to repeat them aloud. Do not write or type any of the digits that you hear. Press "Enter" when you are ready to begin.
Group 4 – Textual	Please put on the headphones and do not remove them until instructed to take them off. You will be asked to look at some digits and to read them aloud. Do not write or type any of the digits that you hear. Press "Enter" when you are ready to begin.

Table 5

Descriptive Statistics of Average Digits Recalled Across Groups

	All Trials		Masked Trials		Unmasked Trials		Trials 1-5		Trials 6-10		Trials 11-15		Trials 16-20	
Group	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Textual	3.485	1.647	3.192	1.737	3.777	1.565	2.492	1.251	3.292	1.937	4.046	1.530	4.154	1.980
Echoic	3.000	1.223	3.025	1.610	2.975	0.783	2.550	1.150	3.575	1.908	3.200	1.414	2.675	1.031
Taking Dictation	3.811	1.604	3.564	1.686	4.057	1.540	2.914	1.704	4.214	1.462	4.043	1.842	4.071	1.730
Copying Text	2.475	1.259	2.340	1.274	2.610	1.298	2.180	1.318	2.500	0.958	2.780	1.762	2.440	1.543

Table 6

List of Stimuli

7-digit sequences
1. 7482561
2. 3962185
3. 2487136
4. 3815296
5. 1853962
6. 3496157
7. 8573249
8. 3847152
9. 6853792
10. 8749231
11. 6189257
12. 1485237
13. 2539146
14. 4236158
15. 6152438
16. 8516734
17. 5961843
18. 7639184
19. 4728563
20. 7259841

Participant Pre-Experiment Inclusion Form

Please Indicate the following:	Yes	No	N/A
Are you under the age of 18?			
Do you experience any difficulty seeing 16 to 30 inches from a computer screen (e.g., arm's length distance)?			
Do you experience any hearing impairments?			

**If you have answered anything "Yes" to any of the above listed questions then you are ineligible to participate in this study.

I attest that all of the above marked information is accurate.

____
Participant Name (Printed)

____ __________
Participant Signature Date

Figure 1. Participant Pre-Experiment Inclusion Form.

Post-experiment Questionnaire

Instructions: Please complete the following questions.

Participant Code: _____________

1. Did you use any strategies to remember the sequence of digits? If so, please describe.

2. How easy or difficult did you find remembering the sequence of digits?

Very easy	Easy	Neither easy nor hard	Difficult	Very difficult

3. Had you heard anything about this study before you participated? Please indicate:

   Yes
   No

4. Please select the following gender you most identify with:

   Androgynous/Nonbinary
   Female
   Male
   Other
   Prefer not to answer.

5. Please select the following age you most identify with:

   18 - 25
   25 - 35
   35 - 45
   45+
   Prefer not to answer.

6. Any other comments about the study?

Figure 2. Post Experiment Questionnaire.

Participation Debriefing Form

The aim of the present study is to see how five types of verbal behaviors are related. More specifically, by examining the conditions under which participants engage in accurate verbal and typed responses of seven digit sequences following a delay. This includes conditions when participants can see or hear their own responses with respect to visual or auditory stimuli in comparison to conditions when they cannot see or hear their own responses. Results of this study may have implications for teaching methods.

If you are interested in more information regarding this area of research, please see the following recommended resources:

- Fryling, M. J. (2017). The functional independence of Skinner's verbal operants: Conceptual and applied implications. *Behavioral Interventions*, *32*(1), 70-78.

- Skinner, B. F. (1957). *Verbal behavior.* New York, NY: Apppleton-Century-Crofts.

If you have any complaints, concerns, or questions about this study, please feel free to contact Dr. Linda Hayes at lhayes@unr.edu, Jamiika Thomas at jamiikathomas@gmail.com, or Melanie Stites at melstites@gmail.com.

Thank you for your participation!

Figure 3. Participation Debriefing Form.

Figure 4. A trial consisted of the following parts: a training test, distractor task, an intraverbal test, and a 3 s inter-trial interval (ITI).

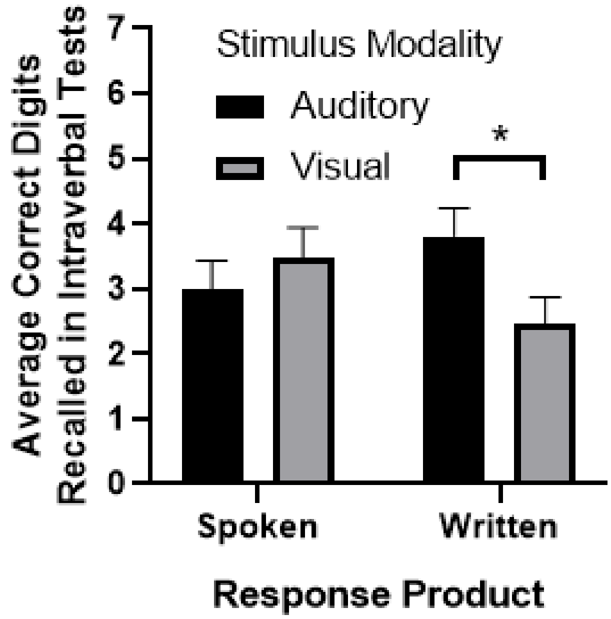


Figure 5. Average correct digits recalled during intraverbal tests between groups. Graph bars from far left to right correspond with the following groups: Echoic, Textual, Taking Dictation, and Copying Text. Error bars denote +/- 1 SE.

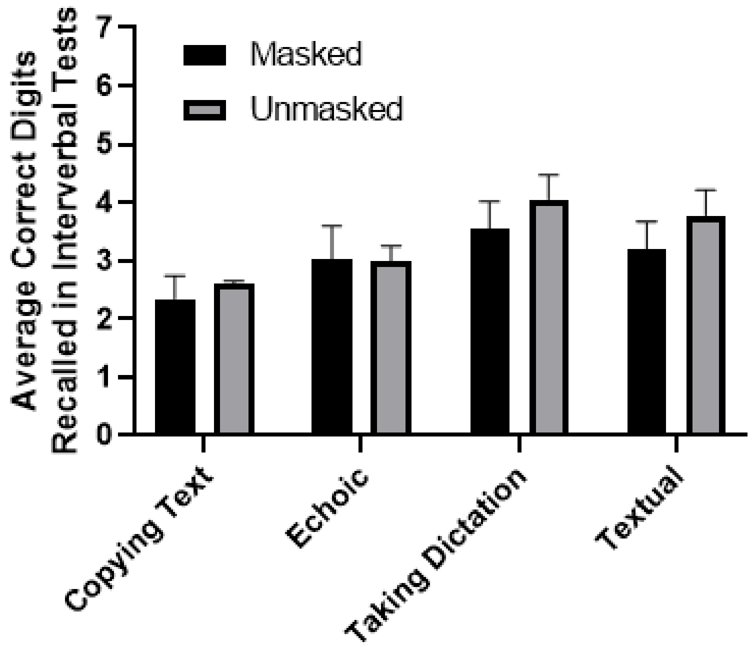


Figure 6. Average correct digits recalled in intraverbal tests between groups during unmasked and masked trials. Error bars denote +/- 1 SE.

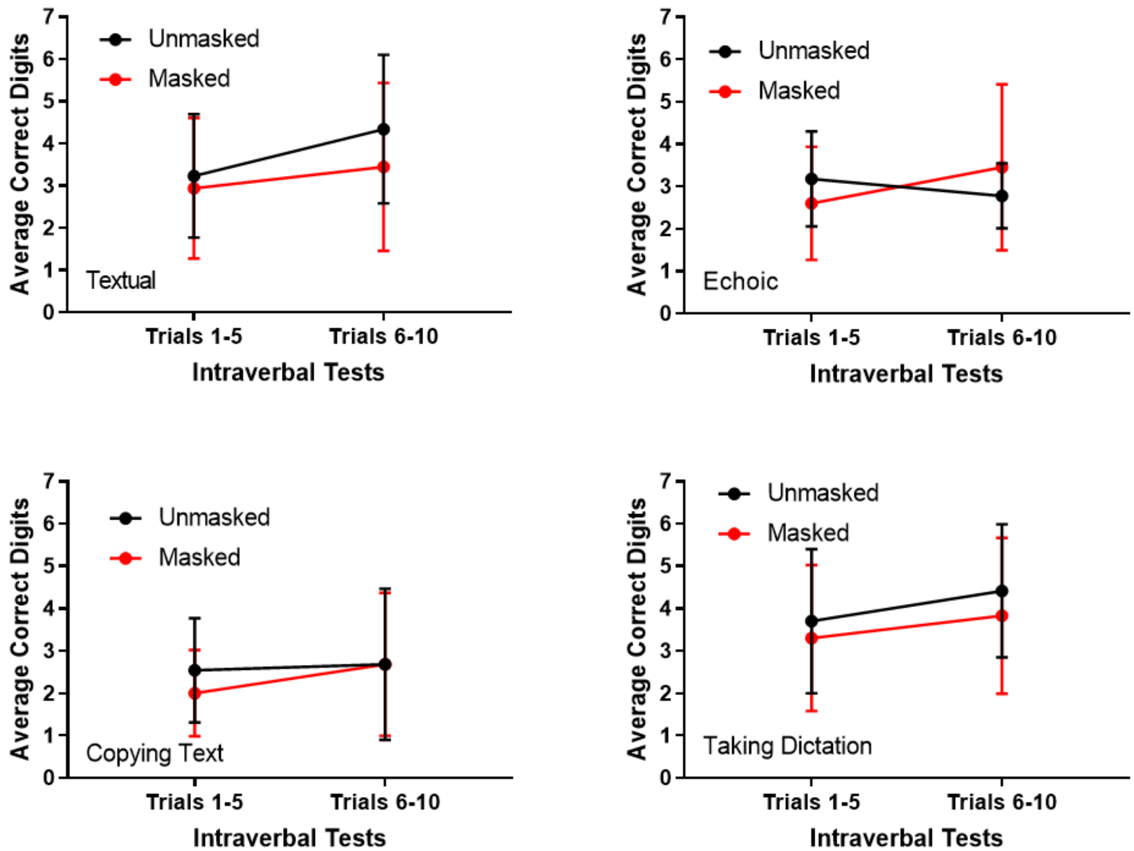


Figure 7. The average number of correct digits recalled during intraverbal tests in bins of the first and last five unmasked and masked trials across the Textual (*top left*), Echoic *(top right)*, Copying Text (*bottom left)*, and Taking Dictation groups (*bottom right)*.

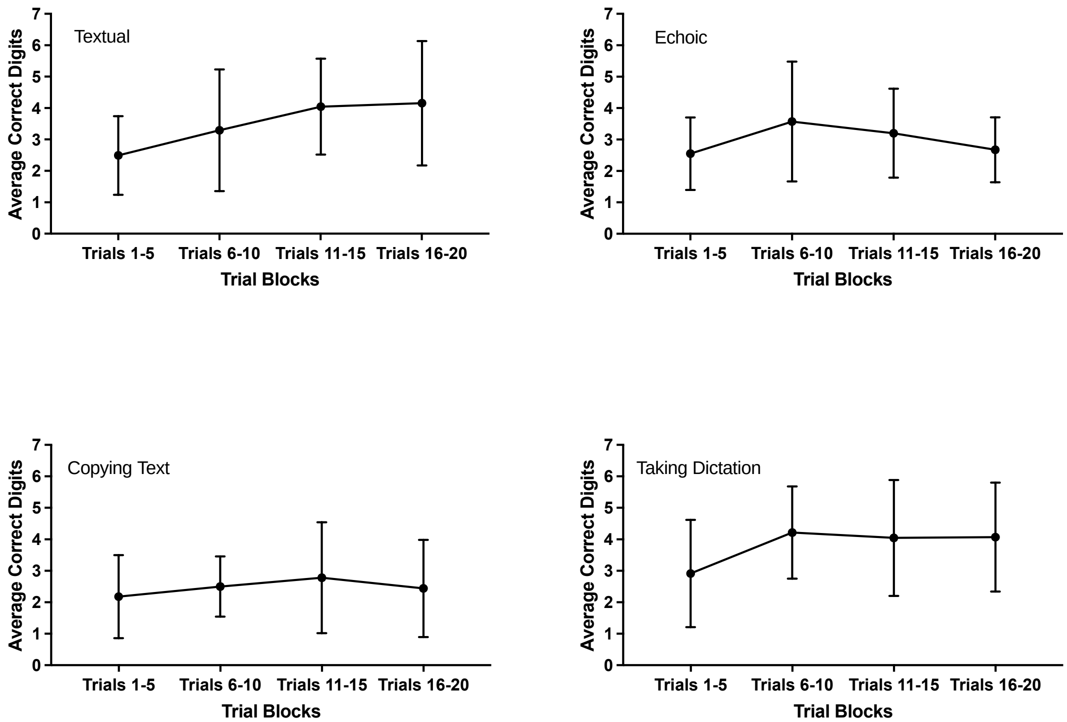


Figure 8. The average number of correct digits recalled across all intraverbal tests in bins of five trials across the Textual (*top left*), Echoic *(top right),* Copying Text (*bottom left),* and Taking Dictation groups (*bottom right)*.

University of Nevada, Reno
Institutional Review Board
Approved on: March 24, 2021

We are conducting a research study to learn more about the conditions under which individuals engage in accurate verbal responding.

If you volunteer to be in this study, you will be asked to follow instructions on the computer to either type digits you see and/or hear and to complete questionnaires pertaining to the study. You will be monitored via a webcam during the study.

We have described the general nature of what you will be asked to do but the full intent of the study will not be explained to you until after the completion of the study. At that time, we will give you more information about the study and give you an opportunity to ask questions.

Your participation should take about 30 minutes.

This study is considered to be minimal risk of harm. This means the risks of your participation in the research are similar in type or intensity to what you encounter during your daily activities.

Benefits of doing research are not definite; but we hope to learn more about the conditions under which accurate verbal and typed responding occurs. More specifically, we would like to learn more about the interrelationship that occurs between verbal responses of different sorts. There are no direct benefits to you in this study activity.

The researchers and the University of Nevada, Reno will treat your identity and the information collected about you with professional standards of confidentiality and protect it to the extent allowed by law. You will not be personally identified in any reports or publications that may result from this study. The US Department of Health and Human Services, the University of Nevada, Reno Research Integrity Office, and the Institutional Review Board may look at your study records.

Required Language

You may ask questions of the researcher at any time by calling Jamiika Thomas (775-250-2421) or by sending an email to Jamiika Thomas (jamiikat@unr.edu).

Your participation in this study is completely voluntary. You may stop at any time. Declining to participate or stopping your participation will not have any negative effects on your grade.

You may ask about your rights as a research participant. If you have questions, concerns, or complaints about this research, you may report them (anonymously if you so choose) by calling the University of Nevada, Reno Research Integrity Office at 775.327.2368.

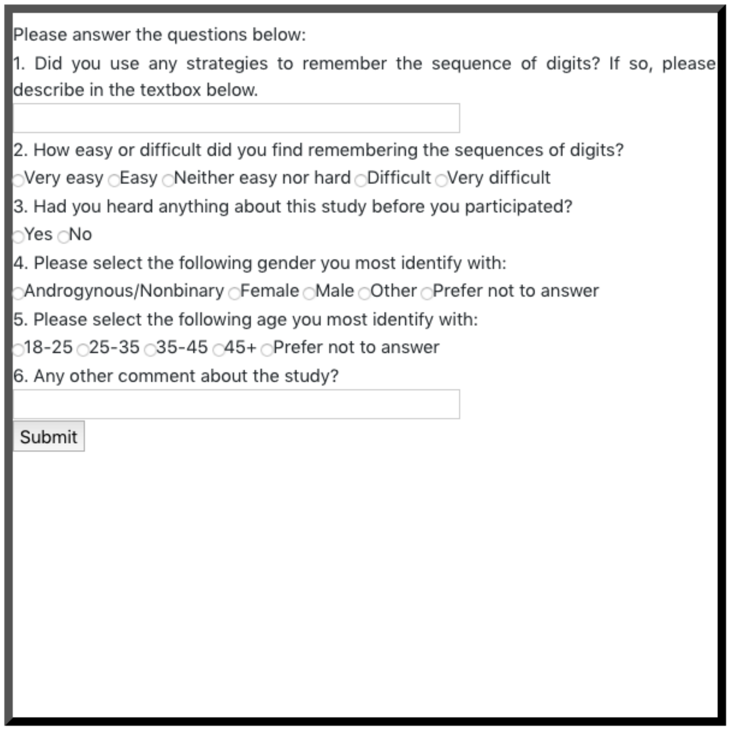
You may ask about your rights as a research participant. If you have questions, concerns, or complaints about this research, you may report them (anonymously if you so choose) by calling the VA Sierra Nevada Health Care System's Research Compliance Officer at 775-326-2783, or the University of Nevada, Reno Research Integrity Office at 775.327.2368.

Thank you for your participation in this study!

Figure 9. Participant consent form.

For this study, you will be participating in several trials. Each trial is comprised of three portions. For the first portion of each trial, you will either hear or see 7 digits. Type the digits as you hear or see them. Use numbers (e.g., "1") instead of letters (e.g., "one") to type the digits. You will not be able to type the next number until you hear or see it. You will receive points for typing correct digits in the order you hear or see them. You can use the Backspace key to delete digits. Please do not repeat the digits aloud. Sometimes the digits you type will appear on the computer screen after you type them, and sometimes they will not. On the second portion of each trial, you will complete a typing task. You will be asked to type letters you see on the screen before they disappear to avoid losing points. On the third and last portion of each trial, you will be asked to type out the series of digits you heard or saw at the beginning of the trial in the same order. Again, you will have seven seconds to type in the digits. You will be given points for typing correct digits in order. All points you receive on a trial will be given to you at the end of each trial. You will start the study with 100 points. Remember, the amount of SONA you receive is dependent on how long you spend completing the study. If you do not have enough points at various points in the study, the study will end prematurely. The more points you get, the longer the study will continue until its maximum duration so you receive 1 SONA credit. When you are ready to begin, press *Space*.

Figure 10. Instructions for Copying Text and Taking Dictation groups.



Please answer the questions below:

1. Did you use any strategies to remember the sequence of digits? If so, please describe in the textbox below.

2. How easy or difficult did you find remembering the sequences of digits?

○Very easy ○Easy ○Neither easy nor hard ○Difficult ○Very difficult

3. Had you heard anything about this study before you participated?

○Yes ○No

4. Please select the following gender you most identify with:

○Androgynous/Nonbinary ○Female ○Male ○Other ○Prefer not to answer

5. Please select the following age you most identify with:

○18-25 ○25-35 ○35-45 ○45+ ○Prefer not to answer

6. Any other comment about the study?

Submit

Figure 11. Post-experiment questionnaire.

University of Nevada, Reno
Institutional Review Board
Approved on: March 24, 2021

Participation Debriefing Form

Thank you for participating in the study. Incomplete disclosure/deception was used in this study as it pertained to the point contingency described in the instructions. You were informed that if you did not earn enough points throughout the study, then the session would terminate. This was necessary to increase the reinforcing value of points earned as well as to promote consistent responding throughout the study. However, the duration of the session was not determined by the number of points earned, but rather by the number of programmed trials. Please let me know if you have any questions about this aspect of the study. Please refrain from talking to others about the incomplete disclosure/deception to minimize the possibility of the results being skewed.

Additionally, the aim of the present study is to see how types of verbal behaviors are related. More specifically, by examining the conditions under which participants engage in accurate responses of seven digit sequences following a delay. This includes conditions when participants can see or hear their own responses with respect to visual or auditory stimuli in comparison to conditions when they cannot see or hear their own responses. Results of this study may have implications for teaching methods.

If you are interested in more information regarding this area of research, please see the following recommended resources:

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If you have any complaints, concerns, or questions about this study, please feel free to contact Dr. Linda Hayes at lhayes@unr.edu or Jamiika Thomas at jamiikathomas@gmail.com.

Thank you for your participation!

Figure 12. Participation debriefing form.

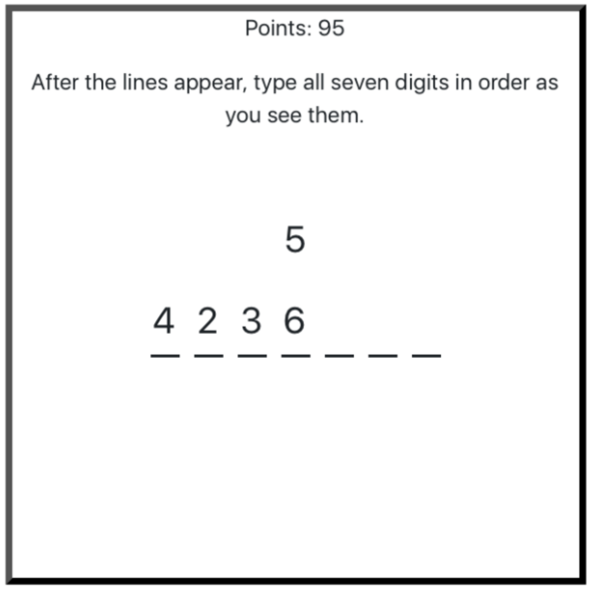

Figure 13. Example of an unmasked trial in the Copying Text group.

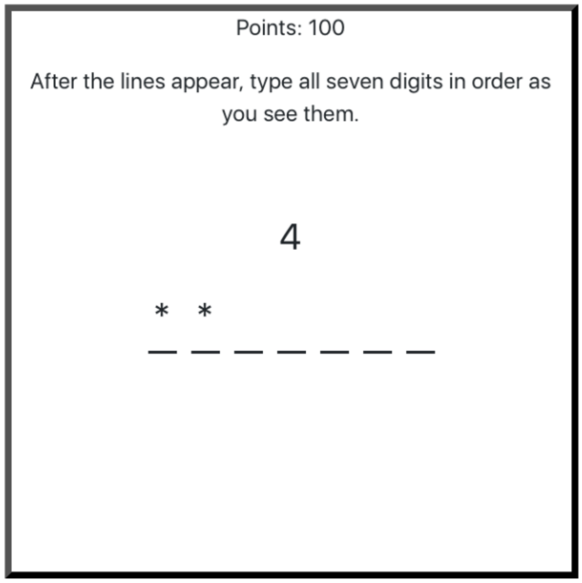

Figure 14. Example of a masked trial in the Copying Text group.

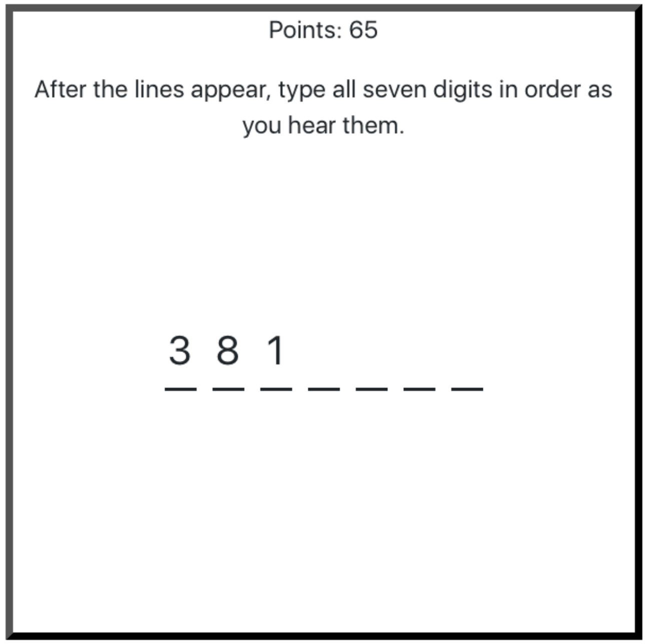

Figure 15. Example of an unmasked trial in the Taking Dictation group.

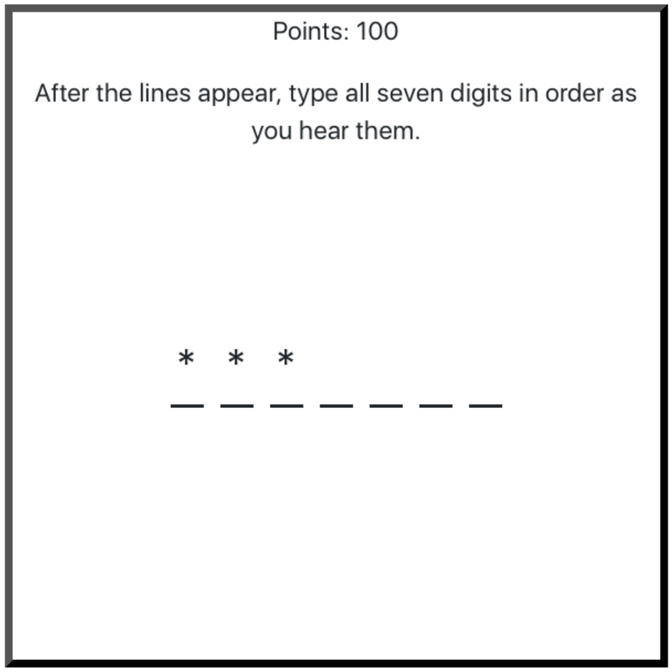

Figure 16. Example of a masked trial in the Taking Dictation group.

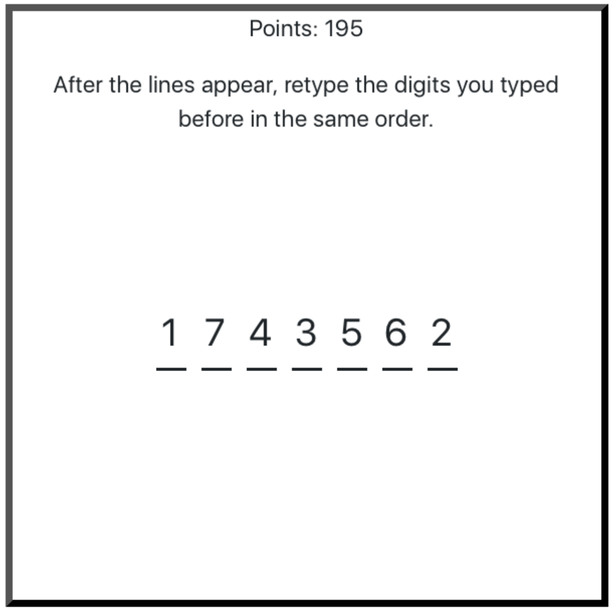

Figure 17. Example of an intraverbal test for both the Copying Text and Taking Dictation groups. *Note*. Response products are not masked during intraverbal tests.

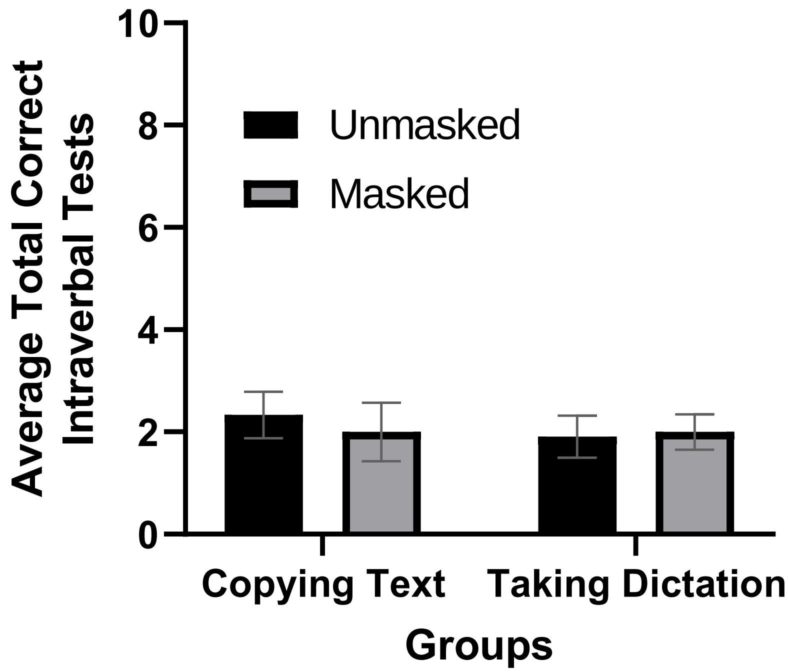

Figure 18. Average total correct intraverbal tests for all groups when training tests were either masked or unmasked.

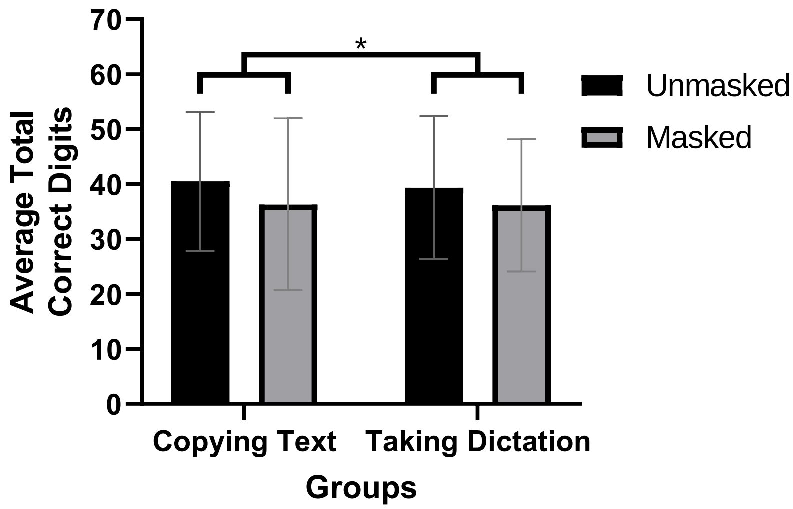

Figure 19. Average correct digits recalled in intraverbal tests for all groups when training tests were either masked or unmasked.

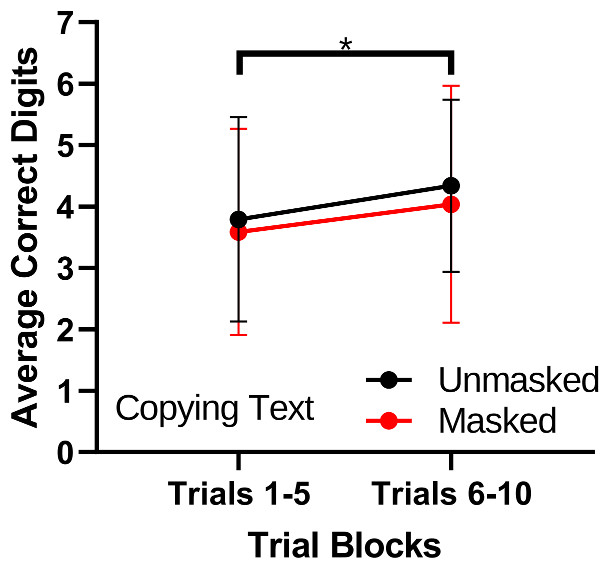

Figure 20. The average number of correct digits recalled during intraverbal tests in bins of the first and last five unmasked and masked trials for the Copying Text group.

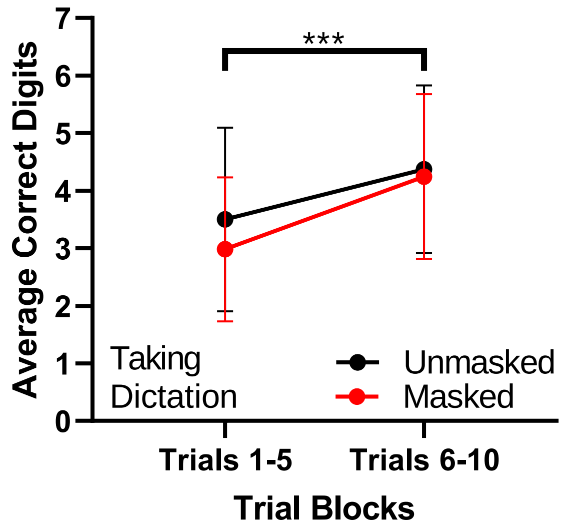

Figure 21. The average number of correct digits recalled during intraverbal tests in bins of the first and last five unmasked and masked trials for the Taking Dictation group.

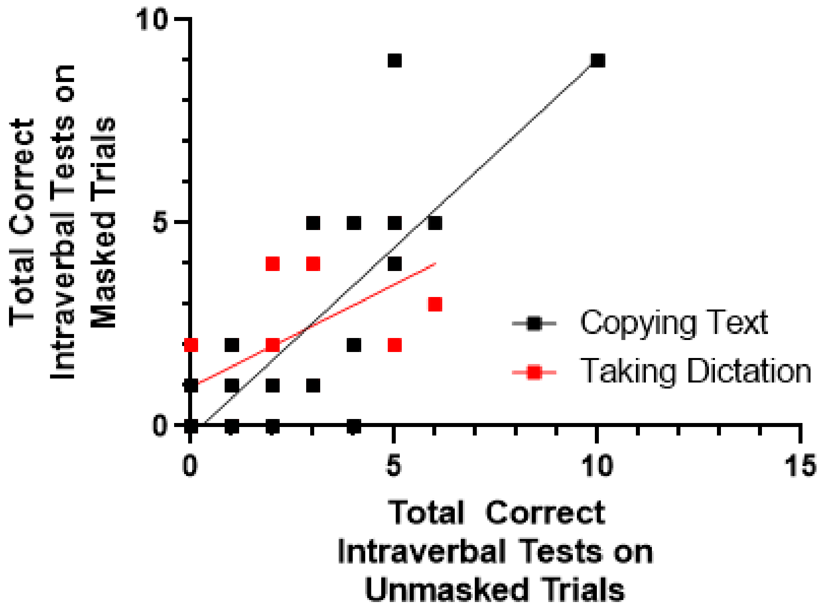

Figure 22. Relationship between total correct intraverbal tests on masked trials and total correct intraverbal tests on unmasked trials. Spearman r = .63 in the Copying Text group. Spearman r = .71 in the Taking Dictation group.