Curtin School of Allied Health

A comparison of procedures to teach auditory-to-visual matching-to-sample tasks to children with Autism Spectrum Disorder

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Declaration

To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number #HR75/2013.

Signature:

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Abstract

Conditional discriminations or matching-to-sample tasks are one of the most targeted skills in intervention programs for children with ASD. Auditory-to-visual matching-to-sample (MTS), often referred to as receptive identification or receptive language, is a set of procedures used to teach conditional discriminations. Children with Autism Spectrum Disorder (ASD) often have difficulty learning these discriminations. These discriminations are learned when the learner observes the sample stimulus, scans the comparison array, and selects the comparison that matches the sample stimulus. The use of a picture-prompt may facilitate scanning of the comparison array and hence ensure that learners attend to the pertinent features of the comparisons. Experiment 1 looked at comparing the effectiveness and efficiency of the use of a picture-prompt to the use of an arrow-prompt (which is analogous to a finger-prompt) when teaching auditory-to-visual MTS tasks. Results showed that the use of a picture-prompt resulted in more efficient learning of discriminative relations and proved effective when learners did not learn the relations with the use of an arrow-prompt. Specifically, learners required fewer sessions to criterion, made fewer errors and the transfer of stimulus control was also seen earlier in the picture-prompt conditions than in the arrow-prompt conditions. The use of a differential observing response (DOR), which consists of a unique response that the learner makes before or during learning, may increase the probability that the learner has attended to the sample. Experiment 2 looked at the inclusion of a DOR in the form of an echoic (i.e., a requirement for learners to vocally repeat the sample aloud) to a procedure that did not include the use of a DOR when teaching auditory-to-visual MTS tasks. Results provided support for the inclusion of a DOR when teaching auditory-to-visual MTS tasks. Four of the five learners required fewer sessions to criterion and

three of the five learners made fewer errors in the conditions that included a DOR compared to the conditions that did not include a DOR. Shorter and less varied response latencies suggest that the inclusion of a DOR resulted in more fluent and accurate responding after the transfer of stimulus control as compared to a procedure that did not include the use of a DOR. Strategies for effective and more efficient teaching of these discriminative learning meet an important practical need for children with ASD given their difficulty in learning these relations. Learning conditional discriminations are valuable skills as they extend the ways in which people can assist them, and are necessary to maintain safety, complete routine activities of daily living and learn in educational settings. Results from these studies provide support for teaching procedures that are effective and more efficient by addressing pre-requisite skills embedded within the MTS task, in this case, encouraging attentional focus to the discriminative features of the comparison stimuli and the sample stimulus.

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Chapter 1: Introduction

Autism Spectrum Disorder (ASD) is a developmental disorder characterised by deficits in social reciprocity (i.e., difficulty in initiating and maintaining conversations and responding to initiations for interactions from others), deficits in developing and maintaining relationships (i.e., difficulties in building friendships or the absence of interest in people), unusual restrictive and repetitive behaviours, and language and communicative deficits (American Psychiatric Association, 2013). The language characteristics of many of these children include echolalia, pronoun reversal, production of utterances with tenuous or no obvious relation to the conversational context, unresponsiveness to questions and the lack of intentional communication (Rapin & Dunn, 2003). Individuals with ASD often require intensive and specialised teaching to improve levels of adaptive functioning as well as their language (Caron et al., 2017). Conditional discriminations or matching-to-sample tasks are one of the most targeted skills in intervention programs for children with ASD (Green, 2001; Grow et al., 2011).

Matching-to-Sample Tasks

Many, if not all, adaptive or daily living skills involve differentiated responding to environmental stimuli such as words, colours, shapes, numbers, and people. Conditional discriminations operate on a four-term contingency, which accounts for the context in which the differentiated responding occurs and includes a conditional stimulus, an antecedent, a response and a consequence. For example, when driving towards a traffic light (conditional/contextual stimulus), the light turns red (antecedent), you push on the brake gently (response) and you avoid getting caught on the red-light camera or avoid the risk of an accident (consequence). In completing this behavioural task, we are differentially responding to the colour of the traffic lights.

Matching-to-sample (MTS), often referred to as receptive identification or receptive language, is a set of procedures used to teach conditional discriminations. MTS usually involves but is not limited to (a) identity MTS (i.e., matching identical stimuli such as objects, pictures, etc.), (b) visual-to-visual MTS (i.e., matching picture to objects, matching a written word to a picture, matching a digit to written text and (c) auditory-to-visual MTS (i.e., selecting “spoon” from an array when asked to “pass me the spoon”). In the context of auditory-to-visual MTS procedures, the spoken words are referred to as *samples* and the array of items or pictures are referred to as *comparisons*. In other words, an auditory-to-visual MTS task requires a child to select the correct item or picture of the item from the *comparison stimuli* (an array of items or pictures) that corresponds to each *sample stimulus*, such as a spoken word. The procedure involves differentially reinforcing correct (described below) discriminative responding (Green, 2001), such as selecting the picture of the spoon and not the fork or knife from an array of pictures (e.g., picture of a spoon, fork and knife) when given the instruction, “point to the spoon”.

Green (2001) recommends that in order to establish conditional discriminations, (a) the samples should be presented an equal number of times in a random order in a block of MTS trials, (b) the same set of comparisons should be used in a block of MTS trials, (c) each sample should be associated with only one comparison, (d) it is preferable to have at least three comparisons, (e) each of the comparisons should be presented equal number of times in each possible position (e.g., on the left, middle and right) across a block of MTS trials, and (f) the positions of the comparisons should be presented in a random order.

Children with ASD often have difficulty learning these auditory-to-visual discriminations (McIlvane et al., 1990; Perez-Gonzalez & Williams, 2002; Saunders & Spradlin, 1989), possibly because learners are required to respond to certain objects or events in the environment with verbal labels (e.g., object names, action words) that bear little or no physical resemblance to those objects or events (Green, 2001). In addition, the child must discriminate the spoken sample from the other samples that are presented across successive trials (e.g., the spoken word "spoon" must be distinguished from the spoken words "fork" and "knife"). The child must also discriminate each comparison from the comparisons being presented (i.e., attend to the defining features of a fork, knife, and spoon) and the relations between each sample and its corresponding comparison (i.e., the spoken word to a particular comparison). Lastly, one factor that might also influence the learning of these discriminations is that an auditory sample is fleeting and hence the child does not have an opportunity to refer to the sample when making a selection. Therefore, strategies for effective teaching of discriminative learning meet an important practical need for children with ASD.

Teaching Procedures

Types of Prompts

A variety of approaches to teaching MTS tasks have been investigated with evidence that some approaches are more effective and efficient than others. Teaching techniques that have been used to teach MTS include (a) response prompts such as gestural prompting, modelling, and physical guidance; and (b) stimulus prompts such as positional prompting, stimulus fading, and stimulus shaping. Response prompts work directly on the response. For example, in gestural prompting or modelling, the teacher will model the desired behaviour such as pointing to the correct comparison, or when using physical guidance, the teacher physically guides the student by the hand to perform the entire movement of the response. Stimulus prompts, on the other hand, work directly on the (comparison) stimulus to cue a correct response. In other words, a teacher could use a position cue and place the correct comparison closer to the student or increase the intensity or dimensions of the correct comparison. The use of prompts is to help develop stimulus control. Stimulus control, a phenomenon that arises when a response occurs in the presence of a given stimulus and a different response in its absence (Green, 2001). Transfer of stimulus control occurs when behaviour initially evoked by a stimulus (i.e., a prompt) comes under the control of a different stimulus (i.e., the sample). Prompt fading procedures are used to transfer stimulus control from the prompt to the instruction which involves the sample stimulus when training auditory-to-visual MTS. That is, the prompts are faded out until the student responds correctly to the sample stimulus in the absence of the prompt.

Differential Reinforcement

Differential reinforcement is used to enhance the student's understanding that different selections lead to different consequences. Specifically, it is a procedure used to increase desirable selections while decreasing undesirable selections (Vladescu & Kodak, 2010). The use of differential reinforcement is recommended in procedures used when teaching children with ASD as they do not often acquire skills in the absence of motivational procedures (Leaf & McEachin, 1999; Vladescu & Kodak, 2010). Prompting procedures are often used initially and faded out using differential reinforcement to promote independent responding. For example, during an auditory-to-visual MTS task, making a correct response may lead to the delivery of a reward and praise but an incorrect response leads to the removal of teaching materials and attention from the teacher.

Least-to-Most Teaching Procedures

A common method used in training MTS employs a “least-to-most” teaching procedure (Saunders & Spradlin, 1990). This procedure provides opportunities for “error” selection and the learner experiences which selections lead to which consequences. It is termed least-to-most because initially the least amount of a prompt (i.e., no prompt is paired with instruction delivery) is provided and increasing levels of prompt are provided on subsequent trials where the learner continues to make errors. For example, the student is required to engage in a correct response within a given duration of time (e.g., 3 s) from the presentation of the instruction. If the student does not make a correct response after the specified duration of time, the teacher pairs the instruction with a prompt, such as a gesture prompt. Subsequently, if the student makes an error again, the student receives partial or full physical guidance to engage in the correct response.

Most-to-Least Teaching Procedures

“Most-to-least” teaching procedures, in contrast, minimises errors and increases the probability that a correct response will occur and lead to reinforcement (Fisher et al., 2007). It is termed most-to-least because initially the most amount of a prompt (i.e., a prompt is delivered simultaneously with instruction delivery) is provided and decreasing levels of a prompt are provided on subsequent trials. One such procedure is called *delayed prompting* (Touchette, 1971). In this procedure, the prompt (e.g., a gestural prompt such as a finger-point or physical guidance to the correct comparison on the current trial) is initially delivered immediately after the auditory sample and on subsequent trials the time interval between the delivery of the sample and the prompt increases. This delayed prompting procedure is the only prompting procedure that allows the point of transfer of stimulus control from the prompt to the auditory sample to be measured.

Effects of Least-to-Most and Most-to-Least Teaching Procedures

Godby et al. (1987) compared the effectiveness of a delayed prompting procedure with the least-to-most procedure to teach identification of objects. Three students with disabilities, one was diagnosed with ASD, a second had severe mental retardation, scoliosis, and a metabolic disorder, and a third with cerebral palsy and severe mental retardation, were recruited. Each instructional session included 10 trials, five for each object in a pair and they were presented in random order. In the delayed prompting procedure, a finger-point-prompt was delivered immediately after the instruction, “Point to [target]” was spoken. The finger-point-prompt was faded using a progressive time delay. In particular, after a correct response the finger-point-prompt was delayed by 1 s after the instruction has been spoken and this interval was increased by 1 s in each subsequent session. A maximum of a 7 s delayed was used. The delay remained at 7 s until the mastery criterion (100% independent correct responding across three consecutive sessions) was reached. In comparison, in the least-to-most prompt procedure, a hierarchy of four prompt levels was used. Initially, no prompts were delivered after the instruction was spoken. The students were given 5 s to respond. When they did not respond or responded incorrectly, the prompt hierarchy involved the instruction paired with a gestural cue related to the use of the object (Level 1), the instruction paired with the experimenter pointing to the item (Level 2), the instruction paired with a partial physical prompt (Level 3), and the instruction paired with a full physical prompt (Level 4). An alternating treatments design was used to compare the two procedures. Although the researchers found that both procedures were effective in teaching the relations to mastery for all three children, the delayed prompting procedure required fewer sessions to criterion (15% fewer sessions), fewer errors (75% fewer errors), and fewer minutes of direct instruction time (27% shorter in duration) before criterion was met than in the least-to-most procedure.

Gast et al. (1988) also compared the use of a delayed prompting procedure with a least-to-most prompting procedure when teaching sight word reading (naming the written word) to students with moderate retardation. Four female students were recruited to participate in this study. Each instructional session included 20 trials, 10 for each word in a pair and they were presented in a random order. For a response to be scored as correct, the students were required to say the word with the correct pronunciation or sign the word. In the delayed prompting procedure, the model (i.e., a spoken word or a sign) was presented immediately after the presentation of a card with a written word and a spoken instruction, “What word?”. This delay was used for each trial in the initial session (i.e., session one). In subsequent sessions, a constant time delay of 4 s was used. That is, there was a 4 s delay between the presentation of the card with a written word (food items) and a spoken instruction and the model prompt for all subsequent sessions. In the least-to-most procedure, a hierarchy of four prompt levels was used: (a) instruction alone, (b) instruction and description of the item, (c) instruction and photograph of each food item, and (d) instruction and model (i.e., a spoken word or a sign) of the word. Both procedures were found to be effective in teaching sight word reading to all four students. However, consistent with the findings of Godby et al. (1987), fewer sessions were required (18% fewer sessions), fewer minutes of instruction (30% shorter in duration) and approximately half the number of errors were made in the constant time delay procedure than in the least-to-most prompting procedure.

Other benefits have been noted for the most-to-least method compared to the least-to-most. Research that compared the effects of a delayed prompting procedure and a least-to-most teaching procedure have found that the selection of errors with some learners can have several detrimental effects such as being associated with maladaptive behaviours (Heckaman et al., 1998) and selection of errors can interfere with acquisition, which can be difficult to correct, and can inhibit skill generalization (MacDuff, 2001).

Heckaman et al. (1998) compared the effects of delayed prompting procedure and least-to-most prompting procedure on maladaptive behaviours of students diagnosed with ASD when engaged in tasks that were difficult. Specifically, they were interested in the effects of teaching procedures that minimises errors on maladaptive behaviours. In phase I of the study, the researchers compared the rate of maladaptive behaviours when the students are engaged in difficult versus easy tasks. Tasks were deemed to be difficult when the students performed at an accuracy level of no higher than 30% correct when they were unassisted across three consecutive days. Tasks were deemed to be easy when the students performed at an accuracy level of above 70% correct when they were unassisted across three consecutive days. Four boys with ASD who displayed some forms of maladaptive behaviours such as disruptive behaviours (e.g., yelling, absconding and screaming), aggression (e.g., hitting others) and self-injurious behaviours (e.g., hitting head with hands, hitting head against surfaces and pulling hair) were selected to participate in this study. Two of the four students engaged in higher rates of maladaptive behaviours with the difficult tasks relative to the easy tasks. One student demonstrated maladaptive behaviours more frequently with the easy tasks and the rate of maladaptive behaviours for the fourth participant was similar across both the easy and difficult tasks. The researchers then compared the rates of maladaptive behaviours when the students were engaged in a difficult task using a delayed prompting procedure and a least-to-most prompting procedure. Each of the four participants were taught different tasks: (1) sight word reading, (2) matching written words to pictures, (3) identification of food items (selection of the named item from an array) and (4) identification of sight words (selection of the named word from an array). In the delayed prompting procedure, the prompt chosen for each participant and task was delivered immediately with the instruction. A progressive time delay was used, that is, after meeting a criterion which varied across students, the delay was increased to 0.5 s then 1 s and increased in 1 s increments, up to 5 s. The delay was initiated and increased after a given number of correct consecutive (prompted and unprompted) responses and this ranged between three and nine correct consecutive responses across the four students. In the least-to-most prompting procedure, the instructor began each trial by delivering the instruction for that trial. The students were then given 5 s to respond. The instructor followed a hierarchy of prompts when the student did not respond or did not respond correctly. The prompt hierarchy again varied across the four students and mostly included response prompts (e.g., verbal, partial verbal, gestural and physical prompts). For all four students, the delayed prompting procedure was correlated with fewer errors than the least-to-most prompting procedure. The researchers also reported that maladaptive behaviours occurred infrequently with all students under both teaching procedures when prompts that resulted in correct responding were used. In general, they found that there were lower rates of maladaptive behaviours, fewer errors and trials where the students did not respond within 5 s, and shorter instructional time during the delayed prompting procedure than the least-to-most prompting procedure for all four students. In addition, sessions involving least-to-most procedure were two to three times longer than the sessions involving delayed prompting.

In summary, both least-to-most and delayed prompting teaching procedures have been found to be effective in teaching MTS to children with ASD, although delayed prompting has often been found to be more efficient (Godby et al., 1987; Gast et al., 1988) and associated with fewer errors and, hence, maladaptive behaviours (Heckaman et al., 1998). However, despite the advantages of applying a most-to-least prompting procedure, such as the delayed prompting procedure, some limitations of the procedure have been identified. For example, the response and stimulus prompts typically used to teach MTS used in such procedures does not require the learner to scan the comparison array (Fisher et al., 2007; Carp et al., 2012) nor actively observe (i.e., attend to) the sample stimulus (Carp et al., 2015; Vedora et al., 2017), and both are critical aspects of learning relations especially within auditory-to-visual MTS tasks (i.e., selection of an item from an array when the item is named). As reviewed in the following sections, some research has begun to address these pre-requisite skills, but few have examined the effectiveness of these procedures in auditory-to-visual MTS tasks and in children with ASD.

Pre-requisites Skills Associated with Auditory-to-Visual MTS Tasks

Scanning of the Comparison Array

MTS or stimulus relations are learned when the learner observes the sample stimulus, scans the comparison array, and selects the comparison that matches the sample stimulus on each trial. Fisher et al. (2007) compared the efficiency of three least-to-most teaching procedures in an auditory-to-visual MTS task. Each session consisted of 16 trials where a four-comparison array was used. The sessions were delivered by an instructor using flashcards while seated at a table with the participant. The flashcards were arranged out of sight of the participants before the instructor presented the array. In one procedure, the participants received no feedback for correct or incorrect comparison selection. In the second, a least-to-most teaching procedure was used where correct selections resulted in the presentation of a preferred toy or one small edible (e.g., one M&M®) and incorrect selections resulted in a finger-point-prompt (i.e., the instructor says, "point to ____ like this" while simultaneously pointing to the correct comparison). In the third procedure, a picture-prompt embedded within a least-to-most teaching procedure was used. Similar to the second procedure, correct responding also resulted in the presentation of a preferred item. However, when an error was made, a picture-prompt was introduced to encourage scanning of the comparison array. That is, in place of a finger-point to the correct comparison, the therapist held up a picture that was identical to the correct comparison and said, "this is ____" while pointing to the picture in hand and then said, "point to ____" while pointing to the correct comparison in the array. They found that for one participant, the percentage of independent correct responses was as close to 80% in the condition that involved the use of a picture-prompt as part of an error correction procedure compared to 50% in the condition that applied the least-to-most teaching procedure at the end of 40 sessions. The level of independent correct responding was low in all three conditions initially for the second participant. It remained low in the condition where no-feedback was provided and in the condition where a least-to-most procedure with a finger-point-prompt during the error correction was used. The level of correct responding increased substantially in the condition which involved the use of a picture-prompt as part of an error correction procedure from session 16. Therefore, the picture-prompt was effective when compared to the no-feedback and the finger-point-prompt procedures. A limitation of the study was that the researchers did not use a balanced design where each stimulus is presented as the correct and incorrect comparison equal number of trials per session. This was especially problematic as the comparisons that were correct in each condition were never presented as incorrect comparisons. Therefore, the participants may have learned to select the comparisons irrespective of the spoken sample and as a result the selection of these comparisons were correlated with the delivery of a reinforcer.

Carp et al. (2012) conducted a systematic replication of Fisher et al. (2007) where a balanced design was used to compare the effects of the use of a picture-prompt and a finger-point-prompt as part of an error correction procedure and a condition where no feedback was given for responding in a least-to-most prompting procedure when teaching auditory-to-visual MTS tasks to children with ASD. Each session consisted of 16 trials where a four stimuli comparison array was used. The position of the correct comparison was counterbalanced across the 16 trials. The sessions were delivered by an instructor using flash cards as in the Fisher et al. (2007) study. The procedures used in the three conditions in the Carp et al. (2012) study were identical to that of the Fisher et al. (2007) study. Unlike the Fisher et al. (2007) study where a mastery criterion was not set, the mastery criterion of the Carp et al. (2012) study was three out of five consecutive sessions where the participants made independent correct responses on at least 14 of the 16 trials (87.5%). One of the four participants met mastery criterion only in the picture-prompt condition and not in the finger-point-prompt or no-feedback conditions. A second participant also met mastery criterion in the picture-prompt condition and not in the finger-point-prompt or no-feedback conditions when a procedural modification was made starting with session 65 (the number of trials per session was reduced from 16 to eight). The third participant met mastery criterion in the picture-prompt and the finger-point-prompt conditions and scores in the no-feedback condition remained at chance level. However, fewer sessions were required to meet mastery criterion in the picture-prompt condition as compared to the finger-point-prompt condition. The fourth participant did not meet mastery criterion in any of the conditions but scores exceeded 80% by the ninth session in the picture-prompt condition. However, scores did not improve after prolonged training. Her performance in the finger-point-prompt condition was better than that in the no-feedback condition but lower than that in the picture-prompt condition. Performance remained at chance level in the no-feedback condition throughout the training. Therefore, the results supported the effects reported by Fisher et al. (2007) that the use of a picture-prompt was more effective than the finger-point-prompt procedure and when no feedback was provided for responding. The use of a picture-prompt in the error correction procedure encouraged the discrimination of relevant features of the comparison stimuli which is crucial when learning conditional discriminations as opposed to the finger-point-prompt which does not require discimination of the comparison stimuli.

However, the effects of the use of a picture-prompt on acquisition of auditory-to-visual MTS tasks, in both studies may, however, be undermined by the inclusion of a finger-point in the picture-prompt procedure as the inclusion of a finger-point does not necessitate the scanning of the comparison array. The inclusion of a finger-point in the picture-prompt condition does not require that learners discriminate the relevant features in order to make a prompted correct selection. The prompted correct selection may be occasioned by the finger-point-prompt rather than the picture-prompt. Also, on each error correction trial in the picture-prompt condition, the sample was presented twice as opposed to only once in the finger-point-prompt condition. Participants may have learned the MTS tasks quicker due to the sample being repeated once more in the picture-prompt conditions than the finger-prompt and no-feedback conditions.

Vedora and Barry (2016) attempted to address these issues by evaluating the effectiveness of picture prompts used in a most-to-least delayed prompting procedure in an auditory-to-visual MTS task. Each session consisted of 18 trials where a set of three stimuli were presented in a pseudorandom order by an instructor using flashcards. Each visual stimulus was presented as the correct comparison on six of the 18 trials and as the incorrect comparison on the remaining 12 trials. The position of the correct comparison in the array was counterbalanced so that each stimulus appeared in the right, middle and left position for an equal number of trials. Three sets of three stimuli were used in this study. They studied the efficacy of using a picture-prompt faded with the use of a delayed prompting procedure. A baseline condition involving no differential consequences for comparison selections verified at or below chance-level responding for both participants.

In the picture-prompt condition, the instructor initially provided the picture that matched the correct comparison immediately after presenting the sample. The picture-prompt was presented immediately after the sample for the first three sessions. In the following sessions, the prompt was presented at a delay of 2 s. After three consecutive sessions at 88% correct (both independent and prompted correct), the delay was increased to 4 s. Independent and prompted correct responses resulted in the delivery of praise and an edible item and incorrect responses were followed by an error correction trial, where the picture-prompt was presented at 0 s. In addition, for one of the two participants, a differential observing response (see below) was added after the mastery of the first set. That is, the participant was required to name the auditory sample before the comparisons were presented. Results indicated that the use of a picture-prompt in a delayed prompting procedure was effective. Both participants met mastery criterion (88% independent correct responses across three consecutive sessions) albeit one of the two participants needing a modification in the procedure. Therefore, not only is scanning of the comparison array essential when learning conditional discriminations, ensuring that the learner have attended to the sample stimulus is just as important. In auditory-to-visual MTS tasks, the auditory sample is fleeting and and learners are not able to refer back to the sample when making a selection, hence a differential observing response may help ensure that they have attended to the sample.

Differential Observing Response

In order to be successful in making conditional discriminations, it is imperative that the learner has observed the sample. A differential observing response (DOR) consists of a unique response that the learner makes before or during a trial and may be used while teaching conditional discriminations to increase the probability that the learner attends to the relevant features of the sample (Grow & LeBlanc, 2013).

Carp et al. (2015) compared the effects of three least-to-most teaching procedures in an auditory-to-visual MTS task where one of the procedures made use of a DOR. Each session consisted of 16 trials where a four-comparison array was used and a different set of comparisons were used for each condition. The sessions were delivered by an instructor using flashcards while seated at a table with the participants. A 5-year-old girl and a 3-year-old boy with ASD participated in this study. Each trial commenced with the presentation of an auditory sample (i.e., "Touch [target]") following the presentation of the four comparison array. The location of the correct comparison was counterbalanced across trials. Following the presentation of the comparison array, the auditory sample was repeated every 2 s until the participant touched one of the comparisons or after 5 s had elapsed. In the first condition, touching the correct comparison resulted in praise and a small food item. If the participant touched an incorrect comparison, the instructor presented the next trial. In the second condition, selection of the correct comparison resulted in praise and a small food item. On the other hand, when the participant selected the incorrect comparison, the instructor presented the same trial and modelled the correct response by pointing to the correct comparison. If the participant followed the model and touched the correct comparison, the instructor delivered praise but did not offer a food item. Lastly, in the third condition, in addition to the instructor modelling the correct response by pointing to the correct comparison when an error was made, the instructor had the participant repeat the auditory sample (e.g., "say [target]") before the presentation of the comparison array. One of the two participants performed at chance level throughout the evaluation in the first two conditions and met the mastery criterion in the condition where an echo of the auditory sample was required with a model from the instructor when an incorrect comparison was selected. Accuracy in the first condition for the second participant was stable at about 50% throughout the evaluation. Although the second participant met the mastery criterion in both the second and third conditons, he met the mastery criterion in fewer trials in the second condition than in the third condition (i.e., took longer to meet mastery criterion in the procedure that included the use of a DOR than in the procedure that did not). One factor that may have resulted in the differences in performance of the two participants is that although every effort was made to ensure that the difficulty of the conditional discriminations assigned to each condition was the same, some sets of relations may have been easier to acquire than others. The participants' ability to repeat words accurately and fluently was also not formally assessed; therefore, how well the participants were able to repeat words may impact on the effectiveness of requring an echo of the auditory sample when learning the relations. It was noted that the second participant's ability to repeat words was less accurate and fluent than the first participant. In particular, the second participant also took longer to repeat the auditory sample which may have weakened the relationship between the sample and the correct comparison.

Vedora et al. (2017) compared the use of a DOR when teaching auditory-to-visual MTS using an adapted alternating treatments design (Sindelar et al., 1985) and a most-to-least teaching procedure. The evaluation of the effects of a DOR was sequentially replicated within participants (i.e., two sets of comparisons). Two male students, one diagnosed with ASD and the other with Down Syndrome, were recruited to participate in this study. Each session consisted of 12 trials involving a three comparison array. Each comparison served as the correct comparison on four trials and the incorrect comparison on eight trials. The positions that the comparisons appeared were counterbalanced across trials. Picture-prompts were used in both the no-DOR and the DOR condition and faded using a progressive time delay. In the no-DOR condition, the instructor presented the instruction, "Touch [name of flag]", and then the comparison stimuli. Following that, a picture identical to the correct comparison was held up at eye level in front of the students to prompt correct selection. The picture-prompt was presented immediately, after the sample was presented for three sessions and the delay was increased to 2 s in the fourth session. Following two consecutive sessions where the participants scored more than 92% correct (unprompted and prompted), the delay was increased to 4 s. In the DOR condition, the same procedure (i.e., use of a picture-prompt faded out using progressive time delay) described above was used. The difference here was that the participants were required to repeat the name of the flag before the presentation of the sample ("Touch [name of flag]") and the comparison stimuli. Results from the first pair of comparisons for both participants support the use of a DOR. Specific error patterns (i.e., position biases) were identified in the no-DOR conditions and, in contrast, position biases did not persist in the DOR conditions. Both participants also met mastery criterion in fewer trials in the DOR conditions than in the no-DOR conditions. The results in the second pair of comparisons were less clear. The participant with ASD met mastery in slightly fewer trials in the no-DOR condition and the participant with Down Syndrome withdrew from the study prior to meeting mastery criterion; however, the percentage of independent correct responses was higher in the DOR condition.

A recent study by Fisher et al. (2019) designed and evaluated a set of procedures that aimed at teaching auditory-visual MTS tasks to novice learners (learners who demonstrated no history of having mastered conditional discriminations) with ASD. This components of the procedures involved (1) the presentation of a three comparison array, (2) the presentation of a spoken sample, (3) the requirement of a DOR in which the participant echoed the spoken sample within 5 s, (4) a picture-prompt that is identical to the correct comparison faded using a progressive delayed prompting procedure, (5) an error correction procedure that involved repeating the trial in which the participant made an error on until the participant made an independent correct response for that trial, and (6) access to a preferred edible and/or 20 s on the iPad® following both prompted and independent correct responses until the participant was correct (independent) on 44% of trials before delivery was discontinued for prompted correct responses.

Four children with ASD participated in this study. Three participants learned three sets of three targets and the fourth participant learned two sets of three targets. A concurrent multiple-baseline design across stimulius sets was used to evaluate the effectiveness of the set of teaching procedures. Each session consisted of nine trials and the position of the comparisons was counterbalanced so each comparison appeared in each position (right, middle and left of the participant) three times in each set of nine trials. At the start of each trial, the therapist placed the comparison stimuli on the table in front of the participant and gently blocked any attempt by the participant to touch the cards by placing a hand on his or her hands. The vocal sample (e.g., “[target]”) followed and when the participant independently repeated the sample within 5 s, the researcher removed their hand and so the participant was able to make a selection. A vocal-prompt (e.g., “say [target]”) was provided when the participant failed to repeat the sample within 5 s. Following the vocal-prompt to repeat the sample, the participant was given the opportunity to make a selection regardless of the participant’s response to the vocal-prompt. A prompted correct or independent correct response would result in praise and access to a tangible (i.e., an edible item and/or 20 s on the iPad®). When the participant selected an incorrect comparison or the prompt delay interval elasped, the therapist held up a picture identical to the correct comparison in a position that is not aligned with any of the three comparisons. The therapist delivered praise and access to tangible for prompted correct responses until independent and correct responding was recorded on at least four of the nine trials in one session. Thereafter, praise and access to a tangible was only provided following independent correct responses. When the participant did not make a selection within 5 s of the picture-prompt, the therapist physically guided the partipant to make a correct response. After an incorrect trial was recorded, the therapist removed the comparisons and re-presented the same trial that the participant made an error on (i.e., comparisons placed in the same position and the same vocal sample was presented) using the same prompting methods and prompt delay until the participant made an independent correct response or the therapist presented the same trials five times, whichever came first. Sessions continued until the participants responded independently and correctly on at least 89% of the trials (i.e., eight out of nine trials) on at least two consecutive sessions. In some cases, the mastery criterion was extended to three consecutive sessions where the participants scored at least 89%. For one set for one participant, the treatment phase ended when the participant scored 89% on one session due to an error on the part of the therapist.

Supplemental procedural changes were introduced for three of the four participants. For example, analysis of the data showed that one participant consistently made errors (i.e., selected incorrect comparisons) with the targets *neck* and *desk.* Her echoic responses for both words were very similar and thus it was hypothesized that she had difficulty differentiating between the two vocal samples. Therefore, to make the difference between the two samples more saliant, the therapist emphasized the “sk” sound in *desk* elongating the word and shortened the “ck” in *neck* to make it more succinct. With this procedural change, the participant’s echoic responses matched the form of the sample presented. This change was introduced from Session 13 of the second treatment phase and continued until the mastery criterion was met. The participant started making independent correct responses after the change was made. A second participant who was observed to have consistently and independently scanned the comparison array before the presentation of the vocal sample was less likely to respond correctly than when he scanned the comparison after the sample was presented. It was not clear how it was determined that the participant did engage in independent scanning before or after the sample was presented. Starting from Session 19 of second treatment phase and Session 13 of the third treatment phase, the therapist required scanning before the sample was presented. The comparisons were removed when the participant did not scan the array within 5 s of the presentation. The therapist then turned away from him for 5 s before re-presenting the array. The therapist continued to do this until the participant scanned the array before presenting the vocal sample. A third participant demonstrated a positional bias. Specifically, he consistently selected the comparison that was located in the middle of the array. Thus, starting from Session 22 of the first treatment phase, the therapist systematically controlled the location of the correct comparison. That is, if the participant selected the incorrect comparison specific to the location (e.g., selected the wrong comparison in the middle position) on three consecutive trials, the therapist would not place the correct comparison in that position until a correct response, prompted or unprompted, had been provided on three consecutive occasions. This change was applied for intial trials and for error correction trials. The change was effected only for the remainder of the first treatment phase and the therapist carried out the following two treatment phases using the original procedures.

The treatment package alone did not always result in an increase in independent responding to mastery criterion. However, with the modifications described above, all participants reached mastery criterion across all 11 treatment phases. The results implied that the treatment package, with procedural changes, was fairly successful in teaching novice learners with ASD auditory-to-visual conditional discriminations. However, further analysis revealed that one of the participants met mastery criterion on all three sets of stimuli despite having only echoed the vocal sample irregularly (i.e., 18% of trials in the first treatment phase, 15% of trials in the second treatment phase and 21% of trials in the third treatment phase) suggesting that for this participant, repeating the vocal sample may not have been necessary as part of the treatment package. (The other participants repeated the sample 100% or close to 100% of the trials.) All four participants responded correctly to prompted responses when the picture-prompt was used. In addition, following an error, three of the four participants made an independent correct response on the first repetition of the trial on 84.9% of the error-correction trials. This suggests that the picture-prompt reliably resulted in an increase in independent correct responses and hence helped facilitate the acquisition of the conditional discriminations. However, this only occurred on 21% of the trials for the participant that demonstrated a position bias. Following the procedural change to help with the position bias, this percentage increased to 66% (this participant received teaching only on two sets of stimuli). This increase probably suggests that with practice, the procedure became more effective or the procedural change altered the effectiveness of the picture-prompt.

Given the number of components in the package, it is difficult to determine which of these components have a beneficial effect on learning effectiveness and efficiency. Although the researchers identified that one participant might not have required a DOR component, it is unclear if the other participants required all six components of the package to be successful in learning these conditional discriminations. Not requiring all components will decrease the duration of teaching time required to learn these discriminations which will result in greater efficiency. The researchers also noted that this treatment package will be difficult to apply to learners that do not speak. Lastly, this treatment package used a procedure where the comparisons were presented before the sample. Some research has shown that presenting the sample before the comparisons was more efficient (Petursdottir & Aguilar, 2016; Schneider, et al., 2018).

Order of Stimulus Presentation

Petursdottir and Aguilar (2016) compared the effects of presenting the sample before the comparisons (sample-first) and presenting the comparisons before the sample (comparison-first) when teaching auditory-to-visual MTS to three typically-developing male kindergarteners. Each session consisted of 16 trials where a four-comparison array was used. The sample and the comparisons were presented using Microsoft PowerPoint slideshows. In the sample-first procedure, trials began with the delivery of the sample and immediately after the sample was played, the comparisons were presented. A correct selection was followed by a 4 s computer animation accompanied by a sound clip and incorrect responses or when the learner did not respond within 10 s produced a black screen for 4 s. In the comparison-first procedure, trials began with the delivery of the four-comparison array and after the presentation of the comparions (1,670 ms), the sample was played. Selctions prior to the delivery of the sample were not taken into account for. Similar to the sample-first procedure, a correct selection was followed by an animation and a sound clip and incorrect responses or when the learner did not respond produced a black screen. No prompt fading procedure or error-correction procedure was used in both conditions. All three participants reached mastery criterion (defined as 3 consecutive sessions in which independent correct responses were made on at least 14 of 16 trials) sooner in the sample-first than in the comparison-first procedure. This result was replicated by Schneider et al. (2018) using procedures similar to that of Petursdottir and Aguilar (2016) except for the inclusion of a prompt and prompt fading method and an error correction procedure.

The Present Studies

The present studies look at comparing different components of the treatment package conducted by Fisher et al. (2019) while extending the work conducted previously (Carp et al., 2012; Carp et al., 2015; Fisher et al., 2007; Vedora & Barry 2016; Vedora et al., 2017). Although the studies above provide support for the use of a picture-prompt to encourage scanning of the comparison array and the inclusion of a DOR to ensure attending to the sample stimulus, the methodological procedures of previous research that used a picture-prompt made it unclear as to which component of the prompting procedure was responsible for learning and the studies that looked at the inclusion of a DOR returned mixed results. The rationales for each of the two experiments are presented in more detail within Chapter 2 and Chapter 3.

A most-to-least teaching procedure, the delayed prompting method, has been selected for these studies as it has been shown to be more efficient when teaching auditory-to-visual MTS (Gast et al., 1988; Godby et al., 1987) and associated with fewer errors and hence, fewer maladaptive behaviours (Heckaman et al., 1998). Of all the most-to-least teaching procedures, the delayed prompting method has been selected as it is the only method out of a range of most-to-least and least-to-most prompting methods mentioned above that allows for the shift in stimulus control from the prompt to the sample to be measured (Touchette, 1971). A sample-first procedure has also been chosen given that it has been found to be the more efficient method when compared to a comparison-first procedure (Petursdottir & Aguilar, 2016; Schneider et al.,2018).

The studies were conducted using a single-case experimental design that involves repeated measures of trials on the auditory-to-visual MTS task and where the independent variable is the type of prompt used. In particular, a version of the reversal design that compares two experimental conditions (e.g., B_1-C_1-B_2-C_2) was chosen (Lobo et al., 2017). Including five participants and randomly allocating the participants to receive one of two orders of condition (i.e., B_1-C_1-B_2-C_2 or C_1-B_1-C_2-B_2) controlled for potential carry-over or order effects associated with this design. Lobo et al. (2017) also stated that single-case design studies are usually presented graphically and visual analysis of graphed data is the traditional method of evaluating treatment effects, hence, data were analysed primarily using visual analysis. Single-case experimental design studies can be used to demonstrate strong internal validity when assessing the effects of intervention on outcomes and external validity for generalizability of results when study designs include replication, randomization to conditions and multiple participants (Kratochwill & Levin, 2010).

The experimental sessions in both experiments were delivered using a purpose-written computerised software to control for procedural integrity. Arbitary relations were used to teach these auditory-to-sample MTS to control for differences in difficulty across stimulus sets and for learning outside of experimental sessions. Specifically, the children would not contact these relations in the natural environment and hence these relations could not be learned or practised outside of the experimental sessions.

Due to the importance of learning auditory-to-visual discrimination skills (Green, 2001), the difficulty that children with ASD have with learning these skills

(McIlvane et al., 1990; Perez-Gonzalez & Williams, 2002; Saunders & Spradlin, 1989) and associated maladaptive behaviours (Heckaman et al., 1998), it is imperative to formulate strategies for effective and more efficient teaching of discriminative relations for children with ASD.

Chapter 2: Experiment 1: Visual Prompting Methods in Auditory-to-Visual MTS

Embedding a picture-prompt in a least-to-most procedure as part of an error correction procedure has been found to produce faster learning with fewer errors for children with ASD when compared to the use of a finger-point-prompt (Carp et al., 2012; Fisher et al. 2007). Specifically, in both studies, the three experimental conditions were delivered in an identical manner. In particular, one condition involved no feedback to responses made and the second involved a finger-point-prompt used in a least-to-most procedure when teaching an auditory-to-visual MTS task. However, the third condition was similar to the second condition except that when an error was made, a picture-prompt was used. The difference between the two studies was that the Fisher et al. (2007) study did not use a balanced design whereas the Carp et al. (2012) did. The instructor held up a picture identical to that of the correct comparison and says "this is ____" while pointing to the picture in hand and then said, "point to ____ like this" while pointing to the correct comparison in the array. The inclusion of a finger-point-prompt in the picture-prompt condition used in the Fisher et al. (2007) and Carp et al. (2012) studies resulted in an effective procedure that facilitated the selection of the correct comparison when used as part of an error correction procedure and fewer trials to criterion than when a picture-prompt was not used. However, the inclusion of a finger-point in the procedure does not necessitate the scanning of the comparison array, which is a pre-requisite to learning auditory-to-visual MTS tasks and confounds the procedure. Specifically, it is unclear if the picture-prompt alone, the finger-point-prompt alone or both, in combination, that contributed to the selection of the correct comparison in the error correction trial. Also, in the picture-prompt conditions, the auditory sample was presented twice in the error correction procedure, as opposed to only once in the finger-prompt conditions. Participants may have learnt the auditory-to-visual MTS tasks quicker because the sample was repeated more often in the picture-prompt conditions than the finger-prompt and no-feedback conditions.

In addition, although Vedora and Barry (2016) have examined the effectiveness of the use of a picture-prompt faded using the delayed prompting method (i.e., most-to-least procedure) when teaching auditory-to-visual MTS, they did not compare its efficiency to any other teaching procedures. Therefore, to date, no research have looked at comparing the use of a picture-prompt versus the use of a finger-point-prompt in a most-to-least teaching procedure.

Fisher at al. (2019) looked at a package that incorporated six components, which made it difficult to determine which component was effective in producing learning. Not requiring all components will decrease the duration of teaching time required to learn these discriminations, which will result in greater efficiency. Time saved on teaching conditional discrimination of each set of stimuli may be used to teach conditional discrimition of other stimuli or other language and activities of daily living skills.

This study aimed to extend prior work carried out by Fisher et al. (2007), Carp et al. (2012) and Vedora and Barry (2016) and to evaluate the effectiveness of individual components of the teaching package put together by Fisher et al. (2019) by comparing the effectiveness and efficiency of an picture-prompt to an arrow-prompt (which is analogous to a finger-point prompt) when teaching an auditory-to-visual MTS task to children with ASD. A balanced design with a three-comparison array, a most-to-least teaching procedure and where the sample will be presented before the comparisons and only once were used in both procedures.

It was hypothesized that the use of a picture-prompt will be more effective than an arrow-prompt. A picture-prompt should lead to quicker acquisition of these relations because selection of the correct comparison upon the presentation of a picture-prompt would facilitate the scanning of the comparisons and hence ensure that the participant was attending to the pertinent features of the comparisons. Specifically, participants should require fewer sessions to meet mastery criterion (three consecutive sessions of at least 17 out of 18 correct) in the picture-prompt conditions than in the arrow-prompt conditions when learning the auditory-to-visual MTS tasks. The transfer of stimulus control, as measured by the number of trials to first independent correct response, should also be seen earlier in the picture-prompt conditions than in the arrow-prompt conditions. Lastly, effective transfer of stimulus control (i.e., more fluent and accurate responding) should also result in fewer errors and shorter response latencies in the picture-prompt conditions than in the arrow-prompt conditions.

Method

Research Design

Each participant received both experimental conditions (arrow-prompt, or B condition, & picture-prompt, or C condition) twice in a single-case reversal design (e.g., B_1-C_1-B_2-C_2; Lobo et al., 2017). The order in which the conditions (B_1-C_1-B_2-C_2 or C_1-B_1-C_2-B_2) were presented and the stimulus sets allocated to each condition were counterbalanced across participants.

Participants

Four boys with a formal diagnosis of Autism Spectrum Disorder (ASD) and one typically developing (TD) boy between the age of three and eight years participated in this study. A typically developing child was included in the study to increase the sample size and for a preliminary comparison of learning trends that might or might not be different between typically developing children and children with ASD. In Western Australia, a multidisciplinary team that includes a Paediatrician, Speech Pathologist and a Psychologist is required to carry out an assessment for ASD and all three professionals need to agree that an individual meets criteria for ASD. The boys with ASD were recruited via written advertisements provided to early intervention service providers in Perth and a post on a Facebook Closed-Group page while the TD boy was a child of the investigator's friend. (There were no girls who expressed interest in participating in the study.) Each participant was required to demonstrate the ability to match identical picture cards to meet inclusionary criterion to participate in the study. This was assessed using flash cards on a table top at the initial meeting before the administration of the following assessments.

Assessments

The Peabody Picture Vocabulary Test 4th Edition (PPVT-IV; Dunn & Dunn, 2007) and three domains of the Vineland Adaptive Behaviour Scales II (VABS-II; Sparrow, Cicchetti & Balla, 2005), namely, Communication, Daily Living and Socialisation, were administered to characterise the receptive vocabulary and adaptive skills of each participant. Both tests were administered by the researcher following standardised procedures.

The Peabody Picture Vocabulary Test IV

The PPVT-IV (Dunn & Dunn, 2007) was used to measure the participants' receptive vocabulary and involved the child pointing to the picture of an orally named item. The PPVT-IV provided a standard score (M = 100, SD = 15) and a percentile score. Test-retest reliability of the PPVT-IV has been shown to be high

(.93) and correlation studies provided convergent evidence of the validity of PPVT-IV scores as measures of vocabulary as reported in the manual (Dunn & Dunn, 2007).

The Vineland Adaptive Behaviour Scales II

The VABS-II (Sparrow, et al., 2005) provided a measure of the participants' current level of functioning in three domains including Communication, Daily Living and Socialisation and was administered via a semi-structured interview with a parent of the participant. A standard score for each domain (M = 100, SD = 15) was obtained and grouped into qualitative descriptors. A standard score of 20 to 70 indicates a low adaptive level, a standard score of 71 to 85 indicates moderately low adaptive level, a standard score of 86 to 114 indicates adequate adaptive level, a standard score of 115 to 129 indicates moderately high adaptive level and a standard score of 130 to 140 indicates high adaptive level. The mean test-retest reliability for the age group 3-6 is .88, with coefficients ranging between .84 and .92, and reliability for the age group 7-13 is .75, with coefficients ranging between .69 and .75, as reported in the manual (Sparrow, et al., 2005).

Participants Characteristics

Table 1 shows the age of each participant, a code to denote that participant, and scores on the PPVT and the VABS. P1 and P2 scored low in the communication, daily living, and socialisation domains of the VABS and received a standard score of 49 and 81 and an age-equivalent score of 3:5 years and 4:8 years, respectively on the PPVT. P3, P4, and P5 scored adequate or moderately low in the communication, daily living, and socialisation domains of the VABS and received an age-equivalent score that is close or above their chronological age.

Table 1

Scores on the PPVT and VABS for Participants Who Took Part in Experiment 1

Participant/ Diagnosis	Gender	Chronological age	PPVT		VABS					
			Standard score	Age-equivalent score	Standard scores			Adaptive level		
					Communication	Daily Living	Socialisation	Communication	Daily Living	Socialisation
P1 (ASD)	M	8:5 yrs.	49	3:5 yrs.	61	29	63	Low	Low	Low
P2 (ASD)	M	8:6 yrs.	81	4:8 yrs.	72	66	61	Low	Low	Low
P3 (ASD)	M	6:8 yrs.	104	6:7 yrs.	106	101	72	Adequate	Adequate	Moderately low
P4 (ASD)	M	3:5 yrs.	106	6:0.5 yrs.	87	85	83	Adequate	Moderately low	Moderately low
P5 (TD)	M	3:2 yrs.	124	4:8 yrs.	97	100	96	Adequate	Adequate	Adequate

Apparatus

Purpose-written software using MATLAB™ installed on a Dell Latitude™ D630 laptop was used to control the MTS tasks, present the auditory stimuli, and record each participant's stimulus selections on each trial. Each participant interacted with the computer via a 15-inch ELO™ touchscreen (Model #1515L). This touchscreen displayed images on an LCD at 1024 by 768 pixel resolution and used surface-acoustic-wave detection technology. Thus, any contact of the screen by any part of the body and with any amount of force was registered as a response by the software. Audio files used during the testing sessions were digitised in WAV format, using a stereo computer headset microphone and RecordPad™ software, and presented to each participant using the internal speakers on the laptop.

Stimulus Materials

Each of the four conditions used a unique set of comparisons. The three comparisons in each set were similar cartoon characters where each character was posing differently and as if they were performing a different action. Thus, many features (e.g., block colours used, size on screen, white background to character) were common to all three comparisons and they differed with respect to only a limited number of specific features. A fifth set of comparisons was used for preliminary training.

Table 2 shows the samples (i.e., the spoken names) and comparison stimuli (i.e., pictures) used in the preliminary training and MTS tasks of this experiment. Each of the three pictures in a set of comparisons measured approximately 70 mm x 50 mm when displayed on the touchscreen during the MTS tasks. The comparison stimuli used were obtained from copyright-free internet sources.

Table 2

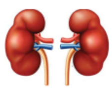
Comparisons and Samples Used in the MTS Tasks in Experiment 1

Stimulus set	Comparisons and Samples		
Preliminary training			
Boys	"Boasting"	"Blurting"	"Bragging"
			
Girls	"Expanding"	"Explaining"	"Expressing"
			
Ninjas	"Advancing"	"Arresting"	"Attacking"
			
Penguins	"Complaining"	"Competing"	"Completing"
			

Four participants (P1, P2, P3 & P5) received the stimulus sets described above. However, one participant (P4) failed to meet mastery criterion on all four conditions after 10 sessions per condition using the above stimuli and received four additional stimulus sets (see Table 3). The samples and comparisons in these sets were the spoken names and pictures of nouns that he failed to identify during administration of the PPVT. The differences between the comparisons were more salient relative to the stimulus sets in Table 2.

Table 3

Comparisons and Samples Used in the MTS Tasks for P4 in Experiment 1

Stimulus set	Comparisons and Samples		
Organs	"Kidney"	"Lungs"	"Heart"
			
Landscape	"River"	"Swamp"	"Valley"
			
Plants	"Roots"	"Thorns"	"Vines"
			
Occupations	"Athlete"	"Carpenter"	"Plumber"
			

Procedure

Setting for Initial Assessments and Testing Sessions

All sessions were conducted at a table or desk at the participant's home or after-school-care facility. The same room and table were used for each session provided to a specific participant. For each participant, the setting was generally similar across sessions. For example, the room was generally quiet with minimal distractions for P1, P4, and P5. A parent might be present during sessions for these three participants but watched from at least 2 m away. However, all of P2's sessions were held at home in the evenings where his parents were preparing meals and his younger sister was moving around the home. Also, most of P3's sessions were held at his after-school-care facility where there were other children playing in the same room.

Administration of the VABS, PPVT, and preliminary training, in that order, were completed in a single session lasting no more than 2 hours. Advice from parents regarding foods that might be effective reinforcers for preliminary training and experimental conditions was also sought during this first session.

Preliminary Training

Preliminary training involved two phases: (a) training to select whichever image on the touchscreen that was identical to the one presented (picture-prompt phase of preliminary training); and (b) training to select whichever image on the touchscreen that was immediately beneath a downward-pointing arrow (arrow-prompt phase of preliminary training). The preliminary training varied slightly across participants depending on their verbal ability. Initially, all participants received a simple spoken instruction upon presentation of the 3-stimuli array (e.g., "touch the one that is the same" or "touch the one below the arrow) and graduated guidance was used when the participant did not respond accurately to the spoken instruction. Although the foods that were used as rewards for correct responses varied across participants, each participant received the food type for correct responses (both prompted and independent) that would later be used in experimental conditions.

The sequence of events defining a trial in both phases of preliminary training were as follows: once the participant had refrained from touching the touchscreen for at least 5 s, a circular red button measuring 30 mm in diameter appeared in the centre of the touchscreen for 0.5 s. So long as no screen touches were detected, the button turned orange and 45 mm in diameter for 0.5 sec, and then green, 65 mm in diameter and with the text “GO” superimposed on it. The green button remained on the screen until the moment a participant touched it. It then disappeared and an audio file that said, “ready, set, go” played. Immediately after the audio file ceased playing, pictures appeared on the touchscreen. In the picture-prompt MTS phase of preliminary training, a sample picture was displayed in the centre of the top half of the screen and three comparison pictures appeared horizontally aligned and spaced equally apart on the bottom half of the screen (see Figure 1). One of the comparisons in the array was identical to the sample at the top of the screen, but its position (left, centre or right) varied unpredictably across trials. Touching the sample (picture displayed on the top half of screen) and any part of the black screen had no effect. However, the moment the participant touched any one of the three comparisons, all screen images disappeared and the screen either stayed black for 2 s (when the wrong comparison had been touched) or a 2-s animation of coloured stars and an auditory jingle ensued (when the correct comparison had been touched). The researcher praised the participant and provided the food item around 0.5 to 1.0 s after the stars and jingle began playing but remained silent and did not interact with the participant when an error had produced the black screen.

In the arrow-prompt MTS phase of preliminary training, each trial started as it did in the picture-prompt phase (i.e., the appearance of a red button, followed by an orange button and the green “GO” button) and involved only the pictures that appeared in the comparison array on trials of the picture-prompt phase of preliminary training (i.e., pictures appeared horizontally aligned and spaced equally apart on the bottom half of the screen). Similarly, the green button remained on the screen until the moment a participant touched it. It then disappeared and an audio file that said, “ready, set, go” played. In contrast to the picture-prompt phase, immediately after the participant touched the green button, a white arrow (measuring 45 mm high and 25 mm wide) appeared 12 mm above one of the three pictures simultaneously with the appearance of the comparisons (Figure 2). The participant touching the arrow and any part of the black screen had no effect. However, the moment he touched the comparison adjacent to the arrow, all screen images disappeared, and the 2 s animation of coloured stars and an auditory jingle ensued. When he touched either of the other two comparisons, all screen images disappeared, and the screen remained black for 2 s. Again, the researcher praised the participant and provided the food item between 0.5 to 1 s after the stars and jingle began playing but remained silent and did not interact with the participant when an error had produced the black screen.

Figure 1

Example of Touchscreen Display in the Picture-Prompt MTS Phase of Preliminary Training

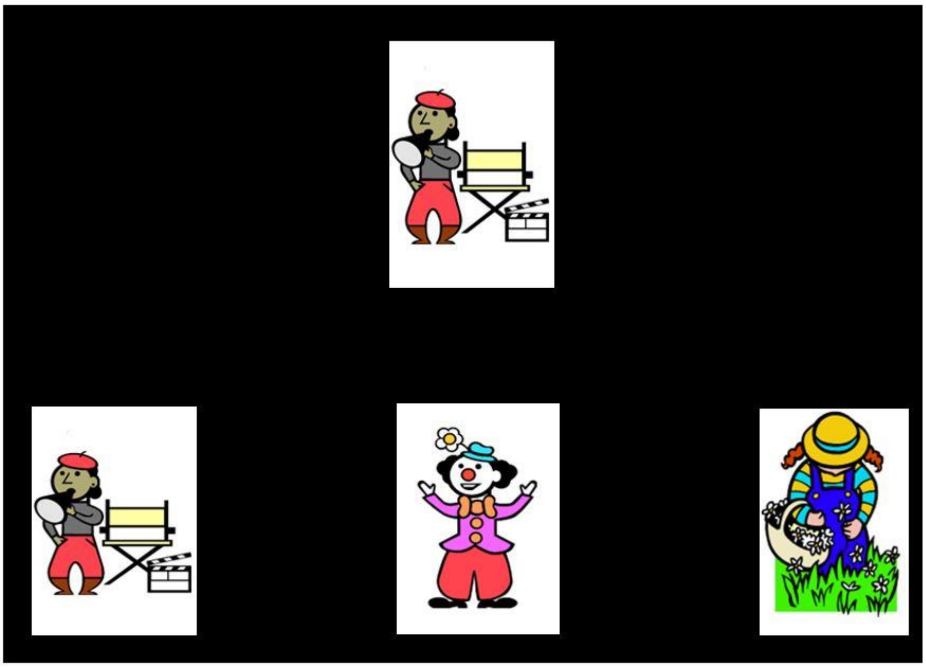
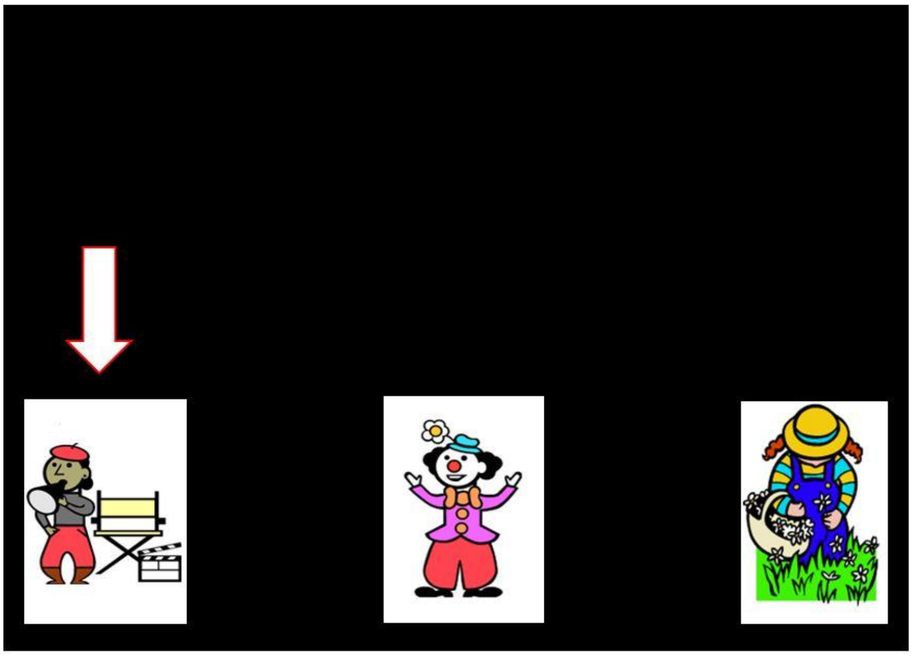


Figure 2

Example of Touchscreen Display in the Arrow-Prompt MTS Phase of Preliminary Training



There were six unique trials in relation to the positions that the comparisons can be presented and each of these trials was presented three times in a block. The computer shuffled the 18 trials and generated a unique trial sequence on every block with the constraint that no one sample, and no one position could be correct on more than three consecutive trials. Each sample was presented six times and was correct twice in each position (i.e., the correct comparison was presented twice in the left, middle and right). The durations, across participants, taken to complete each block of 18 trials ranged from approximately 3 to 8 mins with an average of approximately 5 mins.

Training in each phase was deemed sufficient once a participant had selected the correct comparison on all 18 trials presented in a block. For all participants, no more than two blocks of 18 trials per phase were required.

Experimental Conditions

Unlike during the preliminary training where consecutive blocks of 18 trials were delivered until each participant selected the correct comparison on all 18 trials, each session in an experimental condition involved only one block of 18 trials (excluding error correction trials). Trial blocks were generated in the same manner they were generated for the preliminary training. At least three sessions per week were conducted for each participant and more than one session per day might have been provided so long as at least 1-hr elapsed between the end of one session and the beginning of another. Each session, including the setting up and packing up of materials, lasted approximately 15 min.

With one exception, participants continued receiving sessions in a condition until either they were correct on 17 out of 18 trials on three consecutive sessions or 10 sessions had been provided, whichever occurred sooner. An exception was made for P3 in that he was given more than 10 sessions to reach criterion of correct on 17 out of 18 trials on three consecutive sessions. This was because he was very close to mastery by 10 sessions (e.g., 17/18 on two consecutive sessions, but 16/18 correct on the next session). Therefore, it was decided to increase the number of sessions to allow the participant to demonstrate mastery. Not all conditions required this modification for P3; condition 3 was completed in six sessions. Two participants (P2 and P5) failed to reach the mastery criterion after receiving 10 sessions, both on an arrow-prompt condition. Unlike P3, P2 and P5 were not close to the mastery criterion by 10 sessions in these conditions. These participants, however, did receive a fifth condition, where the same set of samples and comparisons that they failed to master with an arrow prompt, which was delivered using a picture-prompt to further evaluate the effectiveness of the picture-prompt. Table 4 shows the order in which conditions were presented to participants and the stimulus set associated with each condition.

Table 4

Order in Which Conditions and Stimulus Sets Were Presented in Experiment 1

Participant	Condition no.	Condition	Stimulus set
P1	1	Picture	Girls
	2	Arrow	Boys
	3	Picture	Penguins
	4	Arrow	Ninjas
P2	1	Arrow	Girls
	2	Picture	Boys
	3	Arrow	Penguins
	4	Picture	Ninjas
	5	Picture	Penguins
P3	1	Picture	Boys
	2	Arrow	Girls
	3	Picture	Ninjas
	4	Arrow	Penguins
P4	1	Arrow	Organs
	2	Picture	Landscape
	3	Arrow	Plants
	4	Picture	Occupations
P5	1	Arrow	Boys
	2	Picture	Girls
	3	Arrow	Ninjas
	4	Picture	Penguins
	5	Picture	Ninjas

The sequence of events defining a trial in the experimental conditions was the same as that arranged in the trials of the preliminary training except that one of three auditory samples (rather than “ready, set, go”) played as soon as the participant touched the “GO” button. That is, when the participant touched the green button, one of three auditory samples (i.e., “point to [target]”) played on the laptop. Immediately after the sample had finished playing, three comparisons appeared on the bottom half of the screen. Touching the comparison that had been defined as correct after that sample earned the coloured stars, the jingle, and a food item from the researcher. Similarly, touching one of the two incorrect comparisons earned a black screen for 2 s and then an error-correction trial (see below).

Prompting Methods. Trials provided in the two types of experimental conditions differed from each other (and from preliminary training trials) with respect to how the selection of the correct comparison was prompted after the sample played. In the arrow-prompt conditions, the same white arrow used in preliminary training appeared 12 mm above the correct comparison (see Figure 2). In contrast, in the picture-prompt conditions, a picture that was identical to the correct comparison appeared 50 mm above the middle comparison (see Figure 1) as per trials in the picture-prompt phase of preliminary training.

Prompt-Fading Strategy. Despite different methods of prompting correct selections, the same prompt-fading strategy was used in the two types of experimental conditions. On each trial, the computer began timing the delay until presentation of the prompt immediately after the sample finished playing, all the while waiting for a touch to be registered within the area occupied by the three comparisons. If the prompt delay timed out before a touch was registered, then a prompt of the designated type was provided. Five prompt delays were used: 0.001, 1, 2, 4 and 8 s with 0.001 s timing resolution. The prompt was presented at a delay of 0.001 s on the first seven trials of each experimental condition (i.e., near simultaneously with the comparison array) to minimise the opportunity for errors to occur. On the eighth trial, the prompt delay increased to 1 s and remained there until either seven consecutive prompted correct selections (comparison selections after the prompt appeared) or four consecutive independent correct responses (comparison selections before the prompt appeared) had been recorded. The prompt delay increased to the next level (i.e., the prompt appears 2 s after the sample finished playing) when either of the criteria above had been satisfied. The same criterion was used to increase the time delay until the prompt was delivered 8 s after the sample played. The prompt delay decreased to the previous value (or remained at 0.001 s during the first 8 trials) when an error was made on two consecutive trials, or two errors were made on non-contiguous trials involving the same sample stimulus at the current prompt delay within the same session. If the criterion for completion of an experimental condition (see above) was not reached within a session, the prompt level used in the next session was the level the participant finished on the session before.

Response Contingencies. The same contingencies of reinforcement were arranged for comparison selections whether a comparison was touched before or after the prompt was delivered and all errors (incorrect selections) earned the same consequence. When an error was made, an error-correction trial followed. During the error-correction trial, the sample and comparisons for that trial were repeated, the prompt was delivered at 0.001 s, and the incorrect comparisons were dropped so that only the correct comparison remained on the screen. Selections of the correct comparison during these error-correction trials were followed with the animation and the jingle but not the tangible reinforcer. In other words, correct responses on the error- correction trials were not rewarded with the delivery of a preferred edible.

Results

The following measures were calculated separately for each participant and will be described below: (a) number of sessions to criterion, (b) number of independent correct responses per session, (c) number of cumulative independent and correct responses, (d) number of errors, and (e) comparison selection latencies.

Number of Sessions to Criterion

Figure 3 shows the number of sessions that each participant required in each condition to meet the mastery criterion. The data were plotted per condition in the order in which conditions ran. In general, all participants required more sessions to meet the mastery criterion in the arrow-prompt conditions than in the picture-prompt conditions. For example, P1 required five sessions to meet the mastery criterion in the first condition, which was a picture-prompt condition, and six sessions to meet the mastery criterion in the second condition, which was an arrow-prompt condition. When the picture-prompt condition was reimplemented he again needed ony five sessions to meet the criterion. Returning to the arrow-prompt condition saw an increase in the number of sessions to meet the mastery criterion. This effect was replicated across the four other participants regardless of the order in which the conditions were ran.

In addition, two of the participants mastered a stimulus set with the picture-prompt that they had previously failed to master with the arrow-prompt (i.e., the fifth condition for P2 and P5, marked with an asterisk on Figure 3) demonstrating the effectiveness of an picture-prompt when they did not learn the relations with the use of an arrow-prompt.

Number of Independent Correct Responses per Session

The number of independent correct responses per session for the arrow-prompt and picture-prompt conditions are presented in Figure 4. The data were plotted per condition in the order in which conditions ran. Data points from the arrow-prompt conditions are shown by solid grey lines whereas data points from the picture-prompt conditions are shown by solid black lines.

Figure 3

Number of Sessions Required to Reach Mastery Criterion per Condition for Experiment 1

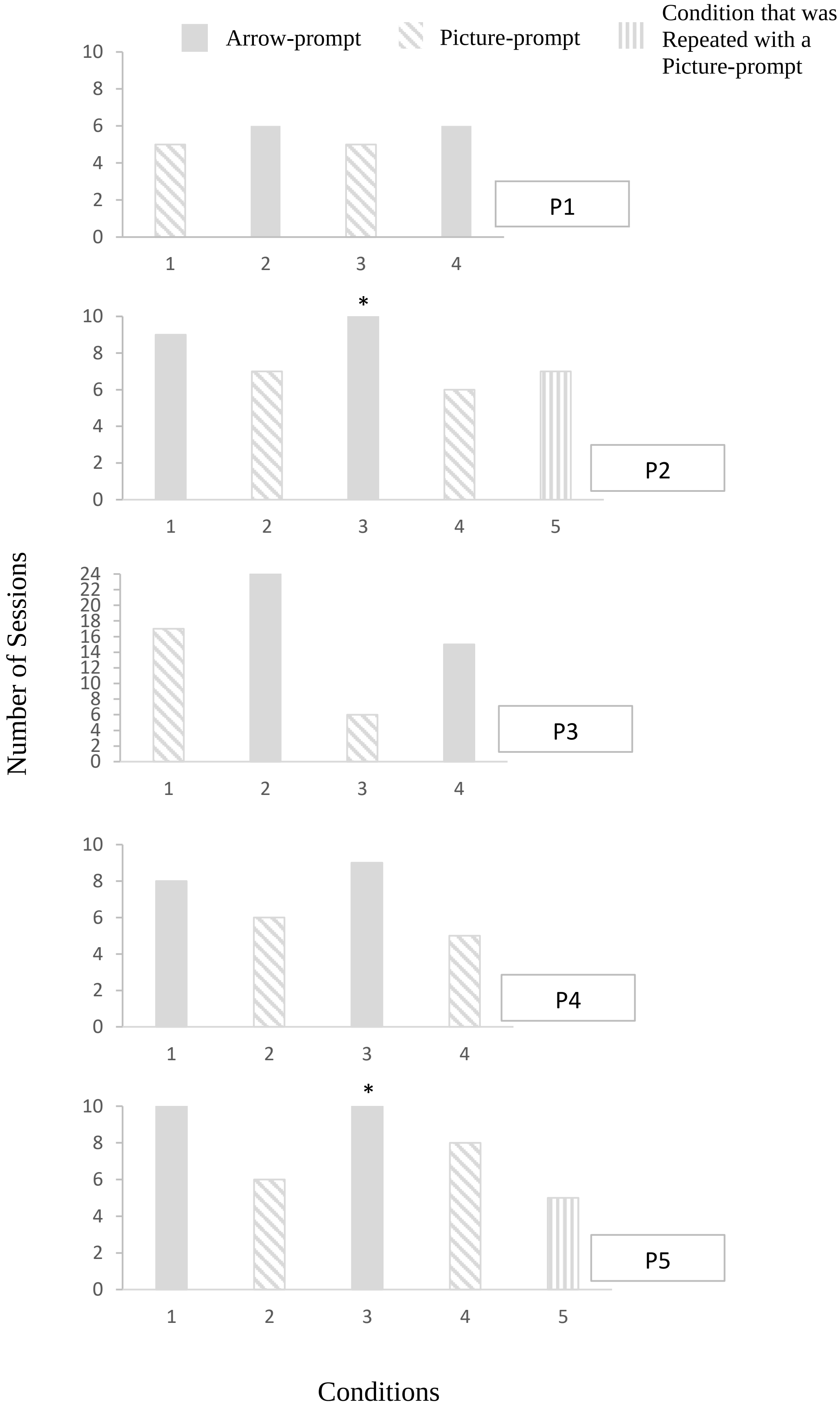
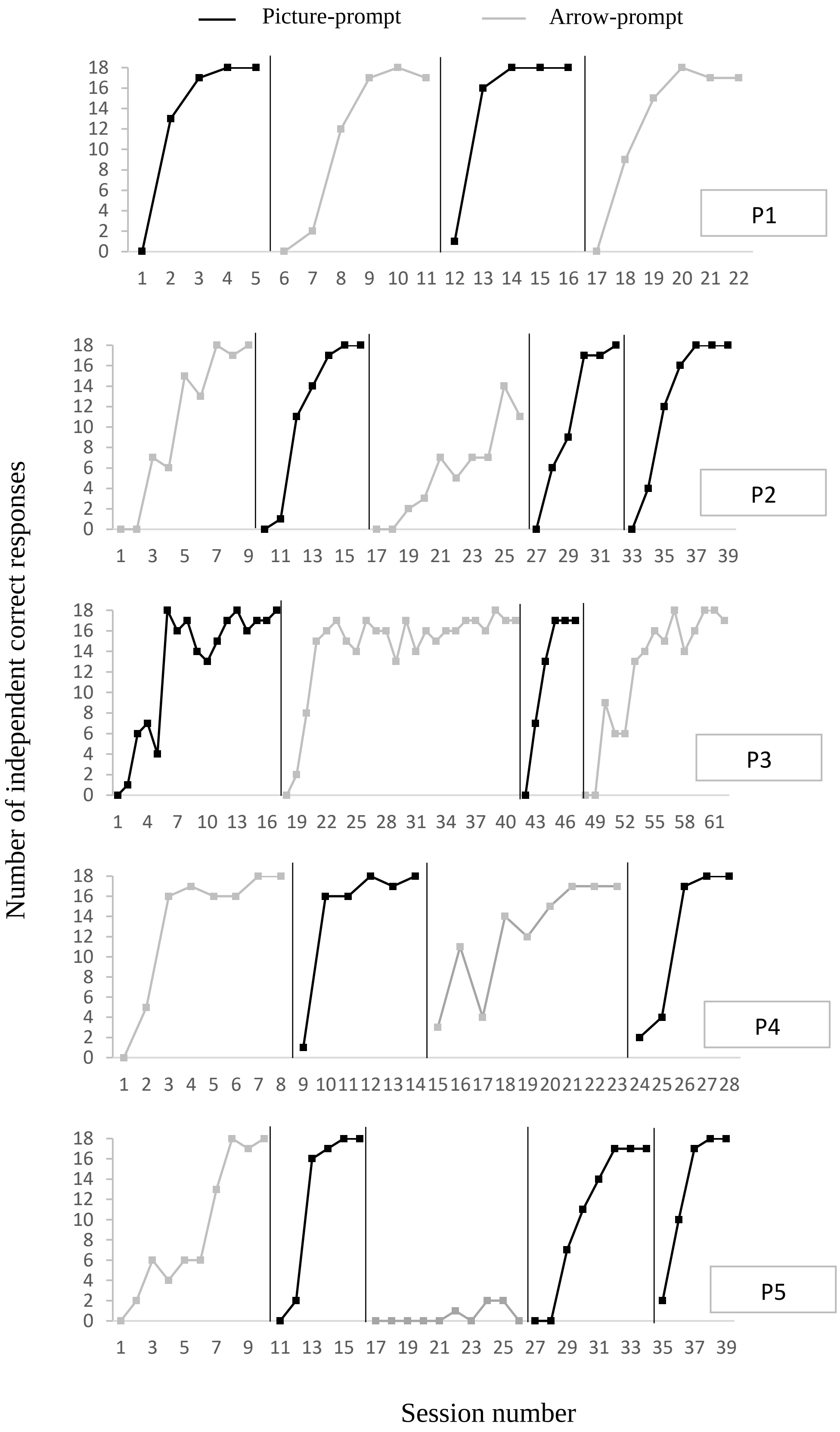


Figure 4

Number of Independent Correct Responses per Session for Experiment 1



In general, Figure 4 shows a steeper slope in the earlier sessions which indicates a greater increase in independent correct responding in the picture-prompt conditions as opposed to a gentler slope in the arrow-prompt conditions. For three of the five participants (i.e., P2, P4 & P5) with the condition order B_1-C_1-B_2-C_2, a gentler slope was seen in the first arrow-prompt condition as compared to the following picture-prompt condition, where the slope was steeper. In the return to the arrow-prompt condition, there was either the replication of the gentle slope or no mastery achieved. The replication of the picture-prompt condition saw the change in gradient of the slope similar to the first picture-prompt condition, where the slope was steeper. This effect was replicated in P1's results except that he received the picture-prompt first (i.e., C_1-B_1-C_2-B_2). P3's first condition, the picture-prompt, showed a moderate slope to mastery. Data points showed a steeper slope in the second condition where an arrow-prompt was used but mastery took a number of sessions to achieve as used as compared to the first picture-prompt condition. However, in the return to the picture-prompt condition, a steeper slope was seen as compared to the second condition and in the fourth condition when the arrow-prompt was reintroduced.

For all participants there was also less variance in the scores in the later sessions in the picture-prompt conditions than in the arrow-prompt conditions which indicates more fluent responding.

Cumulative Independent and Correct Responses

Figure 5 shows the cumulative number of independent correct responses made by each participant in each condition plotted as a function of trial number in a condition. Like with Figure 4, data points from the arrow-prompt conditions are shown by solid grey lines whereas data points from the picture-prompt conditions are shown by solid black lines.

Figure 5 showed that for three of the five participants (i.e., P1, P2, & P5), the cumulative data from conditions involving the picture-prompt appeared above the data from conditions involving the arrow-prompt; that is, independent and correct selections of a comparison stimulus occurred sooner in conditions involving the picture-prompt. The relative frequency of these selections remained higher in picture-prompt conditions throughout repeated sessions in that condition.

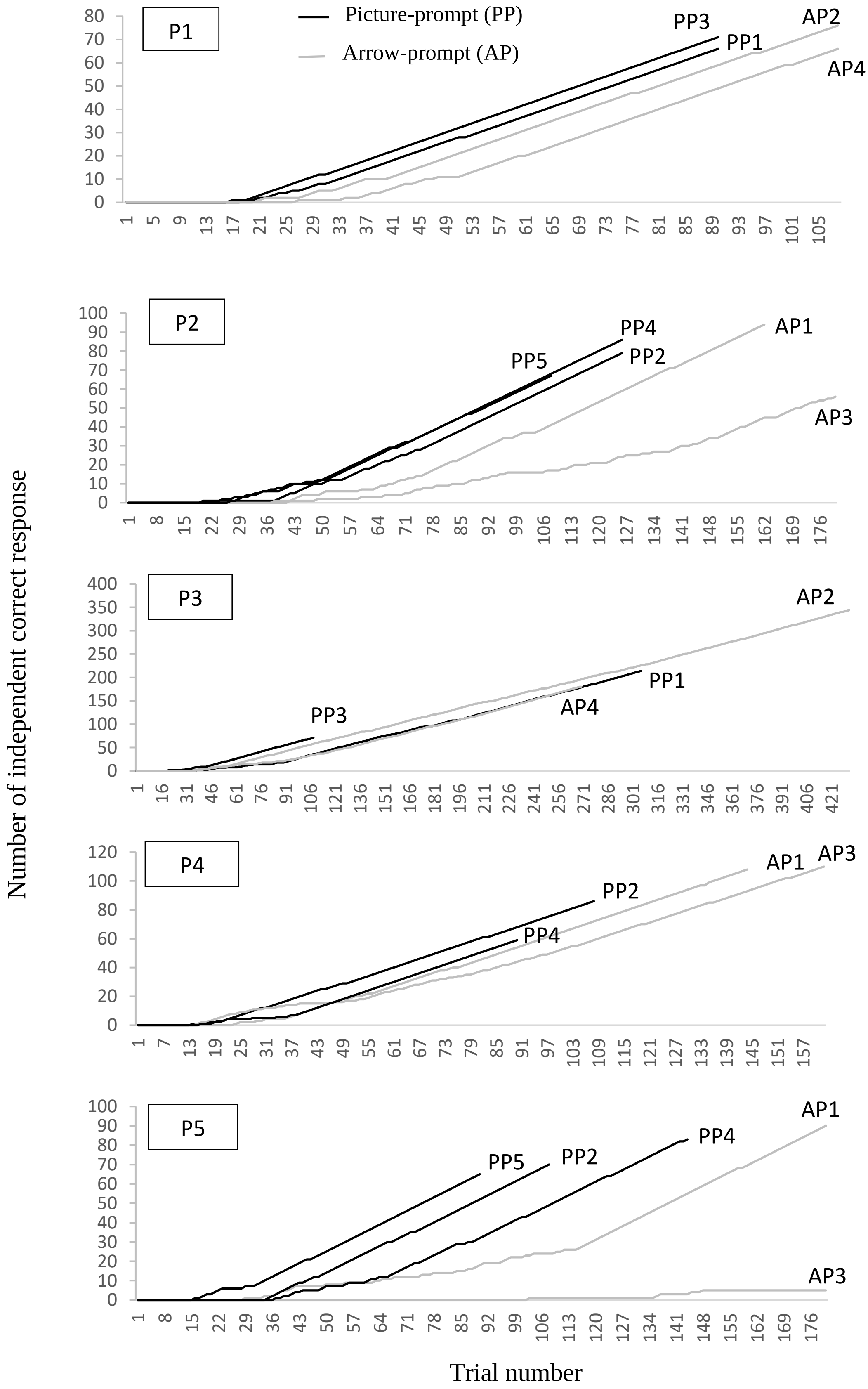
Specifically, P1's data indicated steady independent correct responding shown by a relatively smooth upward slope after the initial horizontal line (i.e., no independent correct responses recorded) for all conditions. A smooth upward slope indicated continuous independent and correct responding. That is, after the initial prompted correct trials, P1 consistently made independent and correct responding with minimal prompted or incorrect responding until mastery criterion was met.

On the other hand, P2's data showed a stepwise upward slope in the four conditions (AP1, PP2, AP3, PP4) after the initial horizontal line. This stepwise upward slope indicated independent correct responding with trials of prompted correct or incorrect responding as shown by the horizontal lines. In other words, P2 continued to make prompted correct or incorrect responses after the initial independent correct response. Data points from PP5 showed a relatively smooth upward slope after the initial horizontal line.

For P3, the data from PP3 appeared above those from AP2 and both appeared above those from PP1 and AP4, which showed similar trajectory. Data points from these all conditions showed a relatively smooth upward slope indicating steady independent correct responding after the initial horizontal line.

Figure 5

Cumulative Number of Independent Correct Responses for Experiment 1



P4's data from PP2 and PP4 appeared and remained above the data points from the AP1. The data from AP3 appeared above the data from AP1 and PP4 after the initial horizontal line. In other words, initially, there were more independent and correct selections of a comparison stimulus in AP3 in the earlier trials than in AP1 and PP4. Similar to P3, data from all conditions showed a stepwise upward slope after the initial horizontal line before a smooth upward slope appeared, indicating a mix of independent correct, prompted correct, and/or incorrect responses.

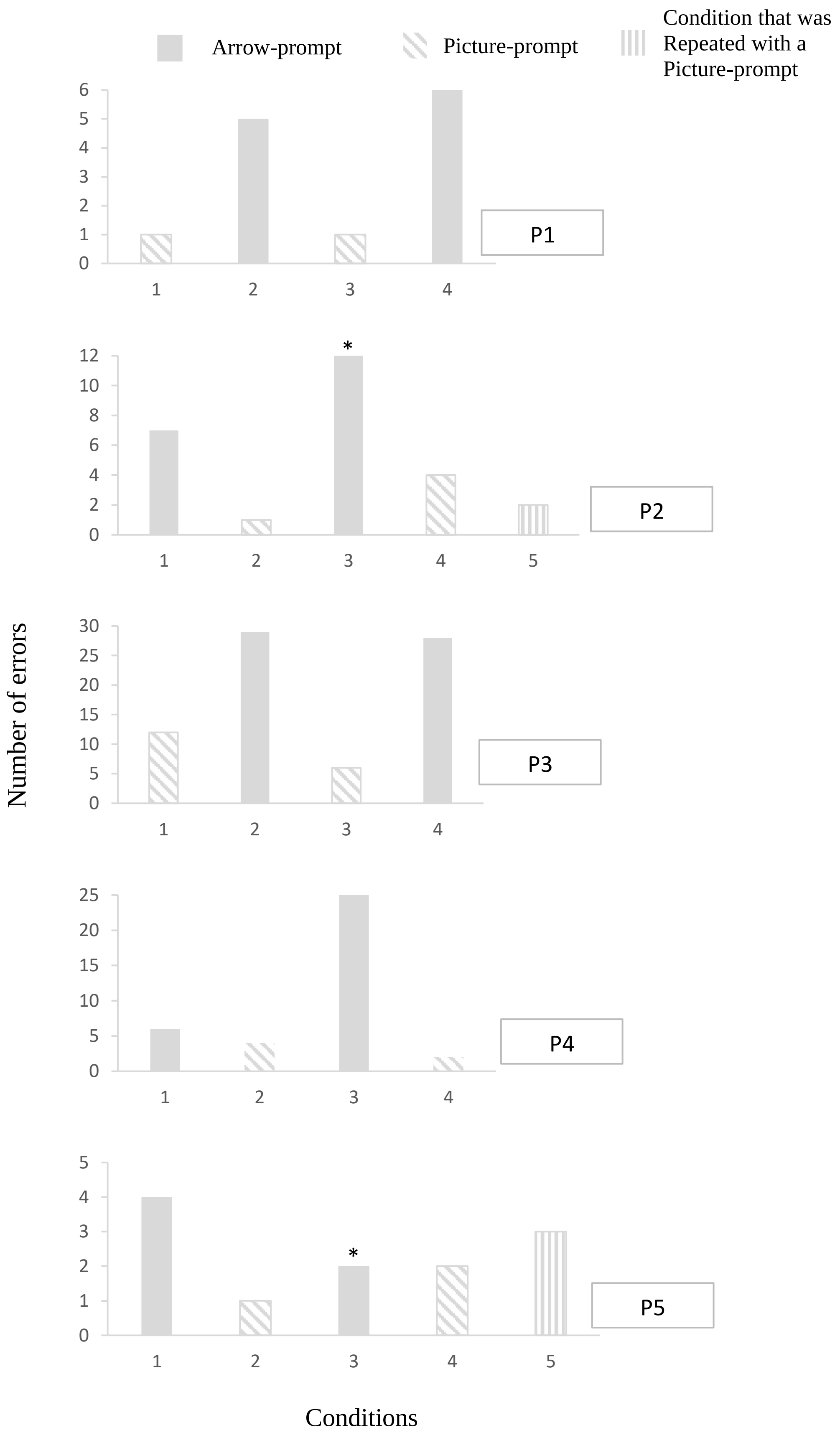
P5's data points from the picture-prompt conditions appeared and remained above the data from the arrow-prompt conditions. Data showed a stepwise upward slope after the initial horizontal line before a smooth upward slope appeared for all four conditions.

Number of Errors

Figure 6 shows the number of errors that each participant made in each condition. The data were plotted per condition in the order in which conditions were conducted. Four of the five participants made fewer errors in the picture-prompt conditions than in the conditions involving the arrow-prompt. For two of the three participants (i.e., P2 & P4) who received the arrow-prompt as the first condition, there were a higher number of errors when compared to the following picture-prompt condition. The participants again made more errors when the arrow-prompt was reintroduced. In returning to the picture-prompt condition the number of error decreased and were similar to the preceeding picture-prompt condition. The same effects were seen in P1's and P3's data except that the picture-prompt was used in the first condition.

Figure 6

Number of Errors made per Condition in Experiment 1



P5's data showed a slighlty different pattern. Similar to the other participants, the first arrow-prompt condition had a high number of errors. The introduction of the picture-prompt condition resulted in a low number of errors. The reintroduction of the arrow-prompt condition showed an increase in the number errors. However, when the picture-prompt condition was reintroduced the number of errors were similar to the previous arrow-prompt condtion. Finally, he made more errors in the additional picture-prompt condition (where the same stimulus set was used in the arrow-prompt condition).

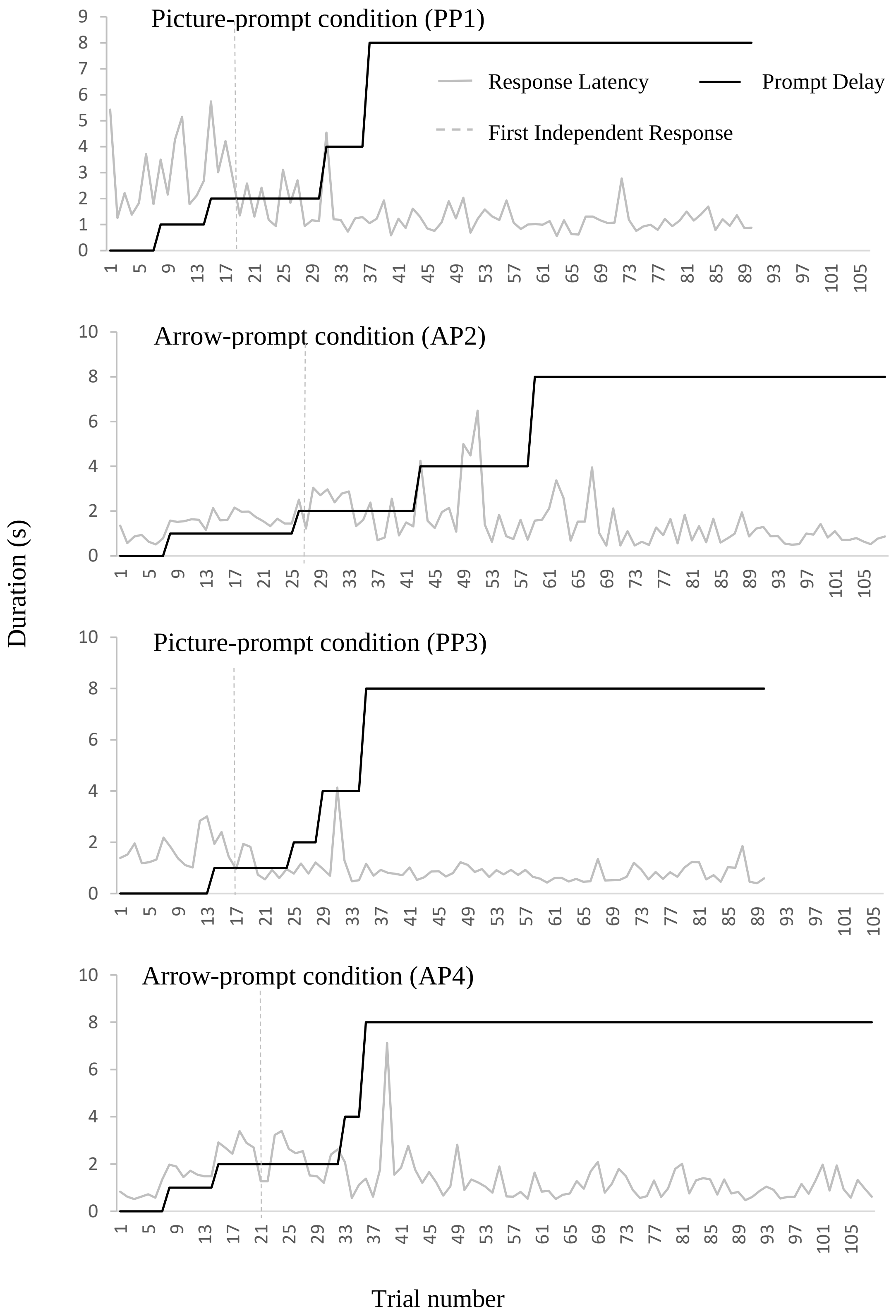
Comparison-Selection Latencies

Time-event records of each session were used to calculate the time from the appearance of comparison stimuli on a trial until one of the comparisons was touched (i.e., the comparison-selection latency on a trial). Figures 7 through 11 show the comparison-selection latencies on every trial for each successive session per participant as represented by a grey solid line. Each figure also shows the time from comparison appearance until a prompt was either presented on a trial if a comparison had not yet been touched or was scheduled to occur if a comparison had been touched prior to its presentation. This is represented on the figures by a solid black line. Comparison selections were defined as independent whenever the comparison-selection latency on a trial was less than the scheduled prompt delay on a trial, and as prompted whenever the comparison-selection latency exceeded the prompt delay. Incorrect responses could occur before or after the prompt was presented. The first independent correct response in each condition is represented by a vertical grey dash line.

Figure 7 shows when the first independent correct response occurred, response latencies and prompt delays for each condition for P1. The first

Figure 7

Point of Transfer of Stimulus Control, Response Latencies and Prompt Delay per Trial for P1 in Experiment 1

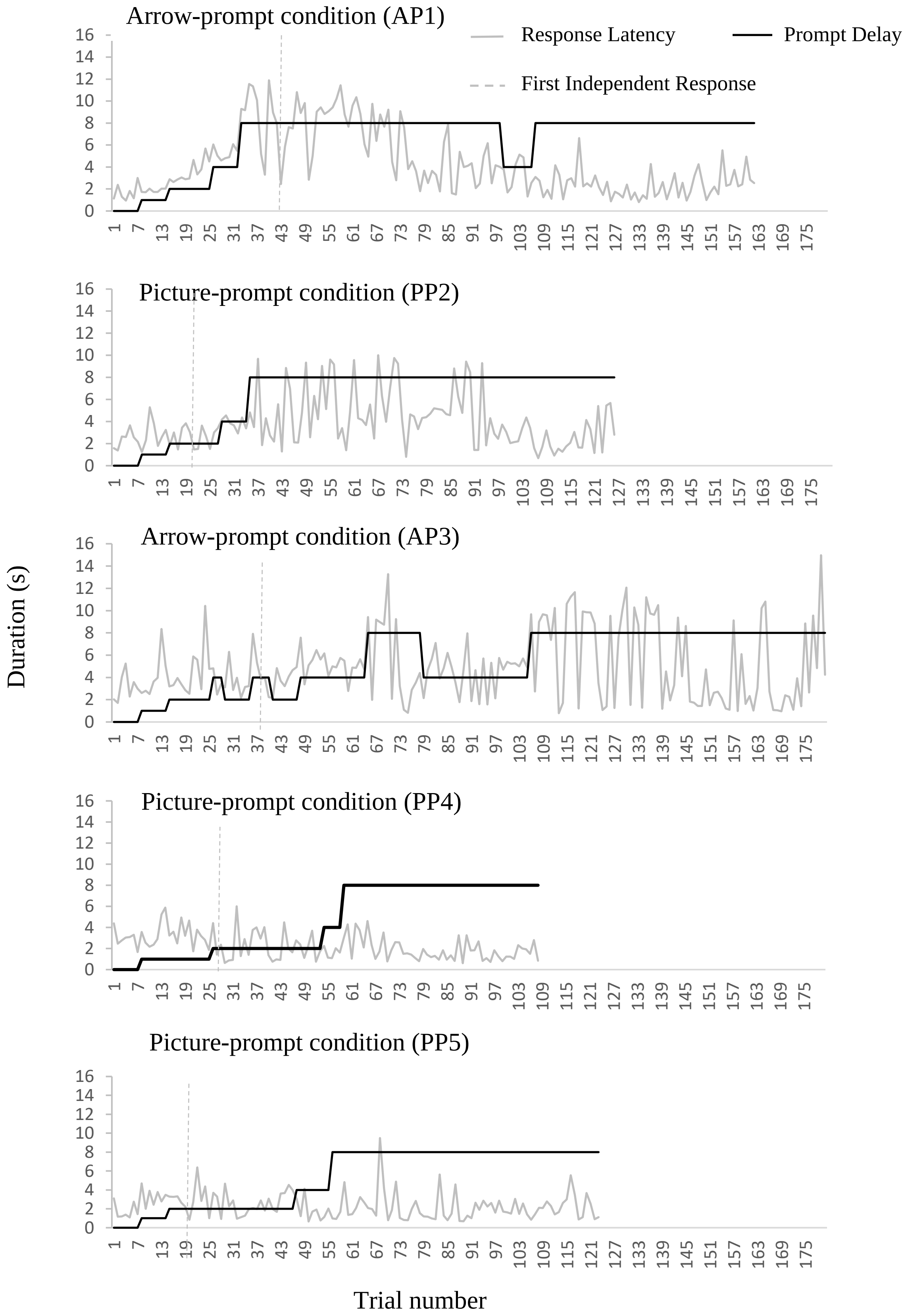


independent correct response, hence the transfer of stimulus control, occurred sooner in the first condition (PP1) than in the second condition (AP2). When the picture-prompt was reintroduced in the third condition (PP3), the transfer of stimulus control occurred earlier than in AP2 and AP4. In addition, the transfer of stimulus control occurred ealiest of the four conditions in PP3 and occurred earlier in AP4 than in AP2 but both later than in PP1. The response latencies from when the prompt was delivered were longer leading up to the first independent correct response in the picture-prompt conditions than in the arrow-prompt conditions. Response latencies in the later trials showed less variance indicating more fluent responding in the picture-prompt conditions than in the arrow-prompt conditions. There were also fewer prompted correct responses after the first independent correct response in the picture-prompt conditions than in the arrow-prompt conditions (as indicated by data points above the solid black line). The prompt level was not required to be decreased for any of the four conditions which meant that, in a session, there were no errors made contiguously or with the same sample twice.

The point where the first independent response occurred, response latencies, and prompt delays for P2 are as shown in Figure 8. The transfer of stimulus control showed the same trend as P1 where it occurred sooner in the picture-prompt condition (PP2) than in the arrow-prompt condition (AP1). This effect was replicated when the arrow-prompt was reintroduced in AP3, and the transfer of stimulus control occurred later than in PP2. When the picture-prompt was used again in PP4, the transfer of stimulus control occurred earlier than in AP3. In terms of response latencies, whilst it showed a similar trend where longer response latencies from when the prompt was delivered leading up to the first independent correct response in the picture-prompt conditions (PP2 & PP4), response latencies

Figure 8

Point of Transfer of Stimulus Control, Response Latencies and Prompt Delay per Trial for P2 in Experiment 1



for AP3 (the condition that P2 failed to master) was variable throughout where most responses were prompted. The prompt delay was decreased once in AP1 and three times in AP3 and none in PP2 and PP4, which meant that errors were either made contiguously or with the same sample in the arrow-prompt conditions.

Figure 9 shows when the transfer of stimulus control occurs, response latencies, and prompt delays for P3. The transfer of stimulus control occurred one trial sooner in AP2 than in PP1. When the picture-prompt was reintroduced, the transfer of stimulus control occurred sooner than in AP2 and in AP4 when the arrow-prompt was reintroduced. Response latencies showed larger variance in PP1 and AP2 and there were also more prompted responses. There was much less variance in the later trials of PP3 and AP4. The prompt delay was decreased once in both the picture-prompt conditions and twice in both the arrow-prompt conditions.

Figure 10 shows when the transfer of stimulus control occurs, response latencies, and prompt delays for P4. The transfer of stimulus control occurred sooner in PP2 than in AP1. When the arrow-prompt was reintroduced, the transfer of stimulus control occurred one trial later than in PP2. Unlike the other participants, the transfer of stimulus control occurred one trial later in PP4 than in AP3. Response latencies leading up to the first independent correct response were generally longer in the picture-prompt conditions than in the arrow-prompt conditions and there was more variance in the later trials of the arrow-prompt conditions than in the picture-prompt conditions.

Lastly, the point where the first independent correct response occurred, response latencies, and prompt delays for P5 are shown in Figure 11. The transfer of stimulus control was seen earlier in AP1 than in PP2. However, when the arrow-prompt was reintroduced in AP3, the transfer of stimulus control occurred much later

Figure 9

Point of Transfer of Stimulus Control, Response Latencies and Prompt Delay per Trial for P3 in Experiment 1

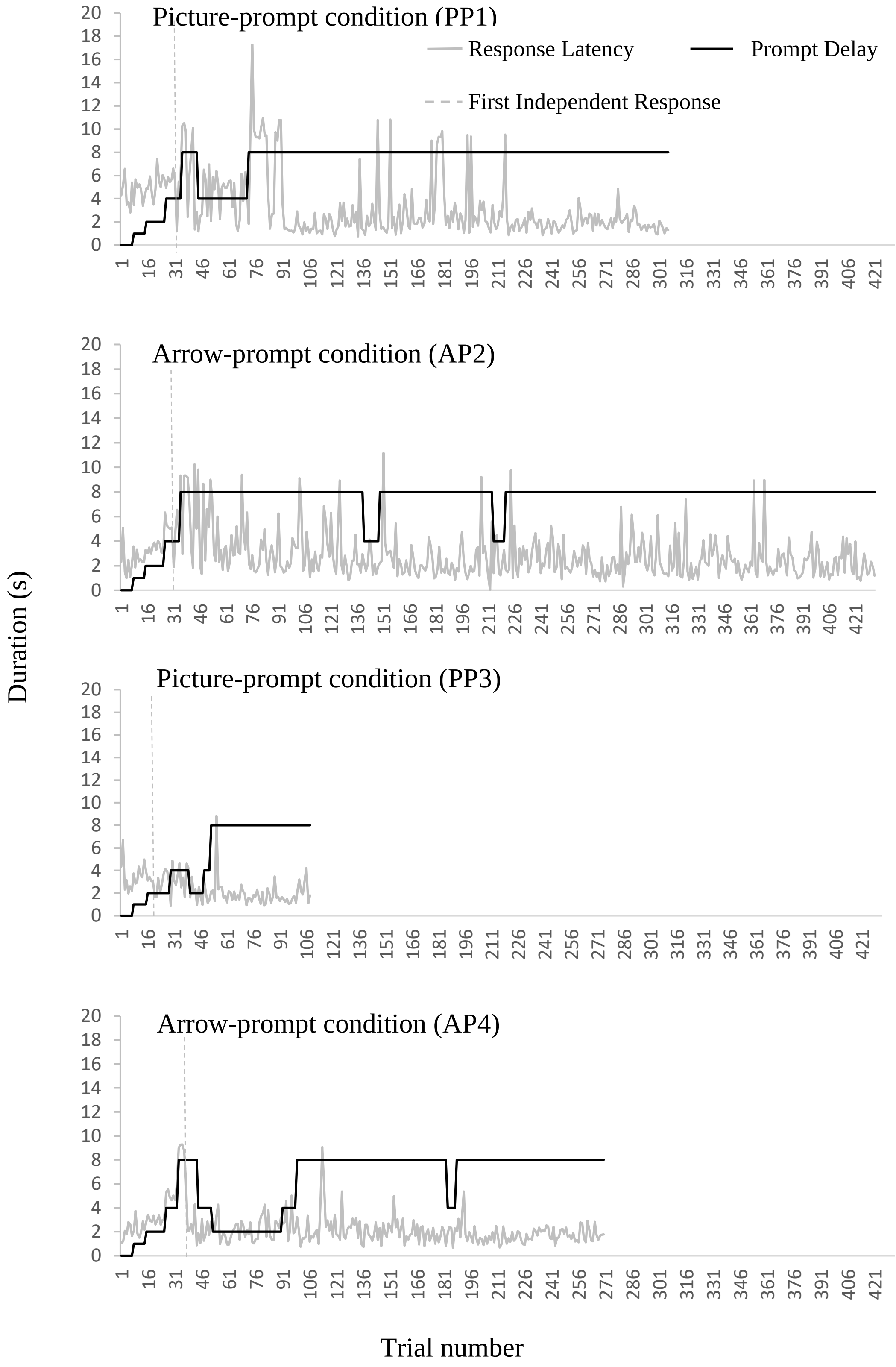


Figure 10

Point of Transfer of Stimulus Control, Response Latencies and Prompt Delay per Trial for P4 in Experiment 1

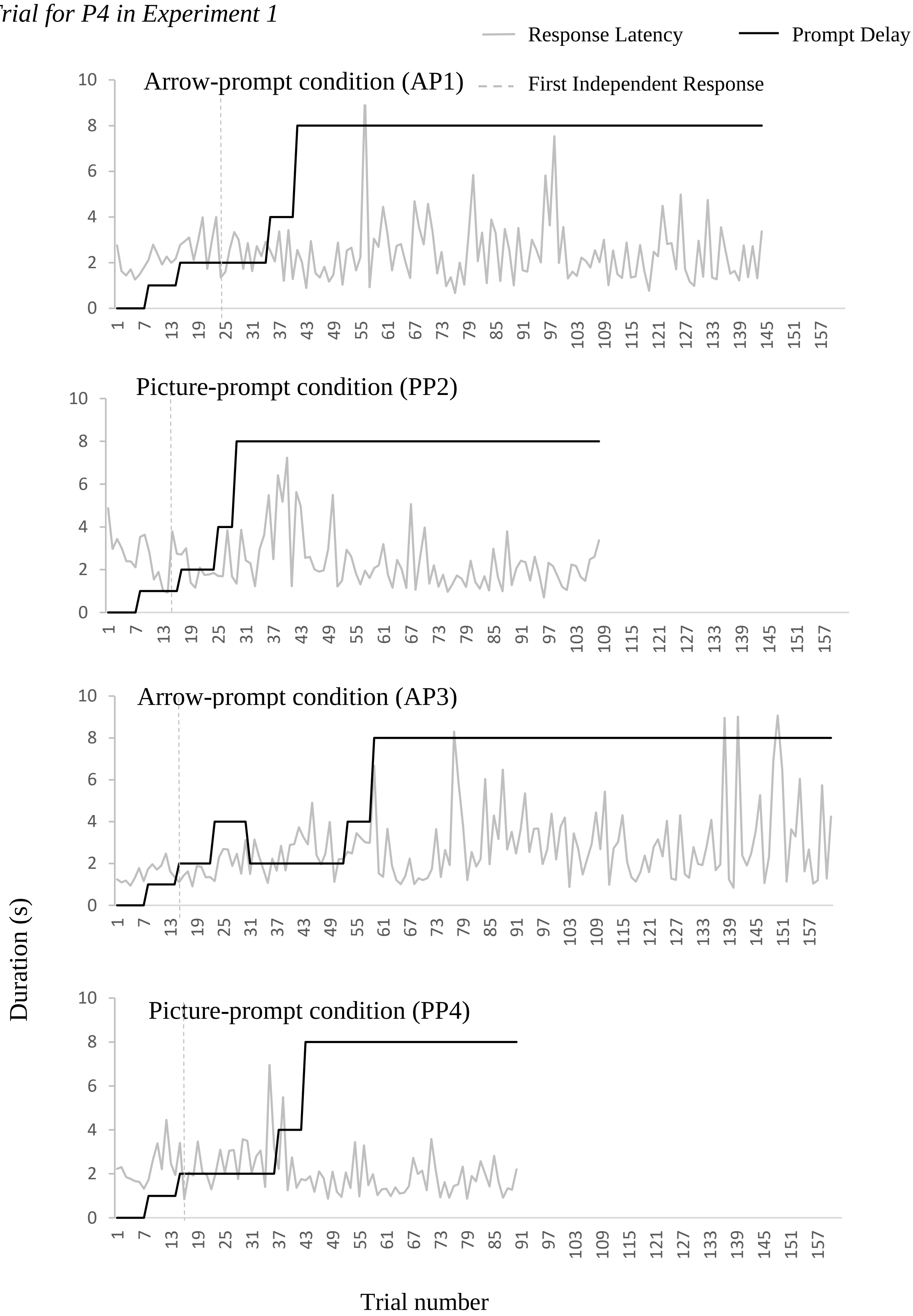
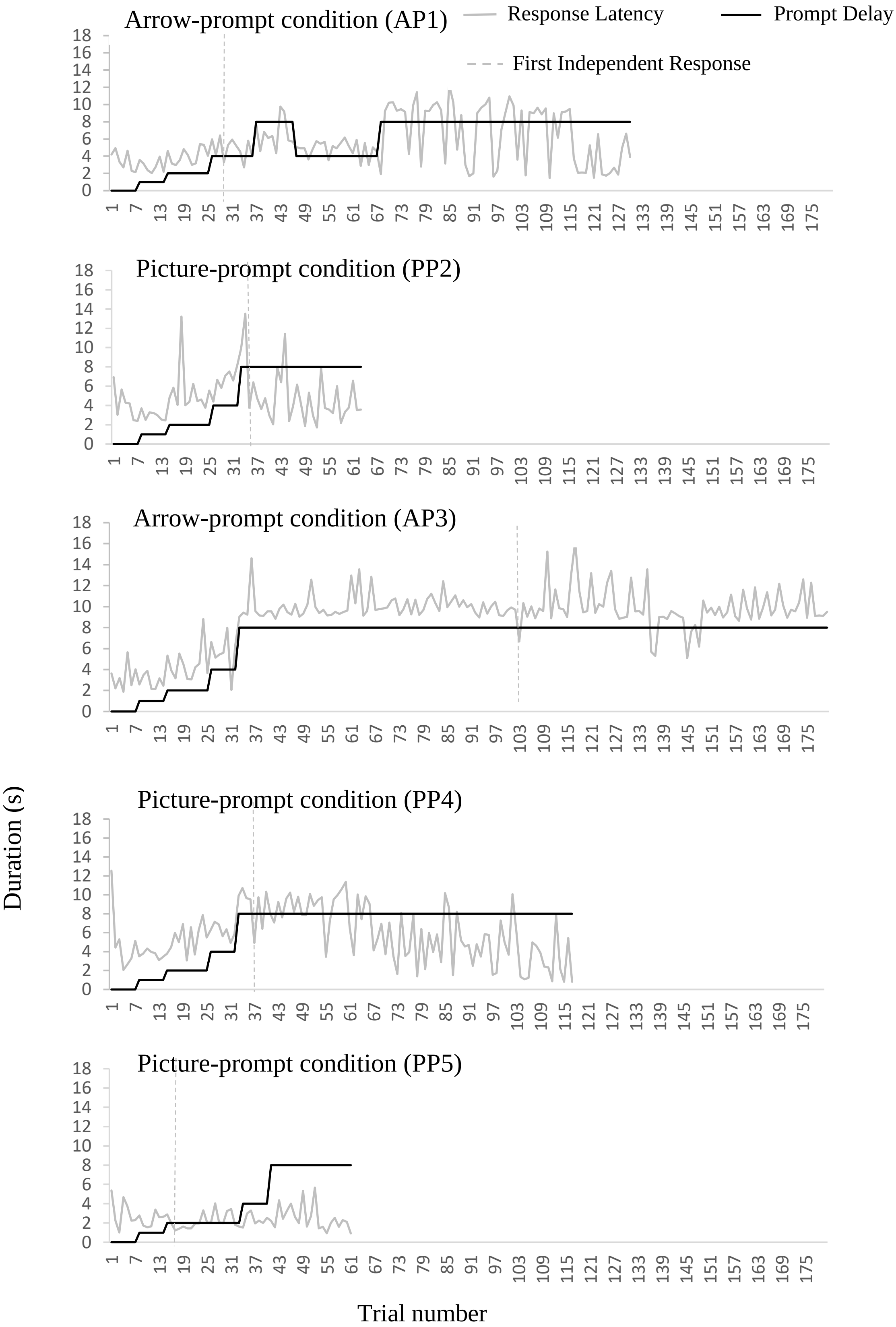


Figure 11

Point of Transfer of Stimulus Control, Response Latencies and Prompt Delay per Trial for P5 in Experiment 1



than in PP2. This effect was replicated when the picture-prompt was reintroduced, and the transfer of stimulus control occurred earlier in PP4 than in AP3. There was much more variance in the response latencies from the first independent correct response across the first four conditions; whereas for PP5, the data showed lesser variance. Most of the responses were prompted in AP3, which the participant failed to master. There were also more prompted correct responses in AP1 than in PP2 and PP4. The prompt delay was decreased once in AP1 and did not have to be decreased in the other conditions.

Table 5 records the number of trials to the first independent correct response across the first four conditions and across the two prompt conditions. In general, for all participants, response latencies from when the prompt was delivered for trials leading up to the first independent correct response were longer in the picture-prompt conditions than in the arrow-prompt conditions for all participants. However, in the later trials, response latencies were shorter in the picture-prompt conditions than in the arrow-prompt conditions for four of the five participants.

Table 5

Number of Trials to First Independent Correct Response in Experiment 1

Participant	First PP condition	First AP condition	Second PP condition	Second AP condition
P1	19	27	17	21
P2	20	42	27	38
P3	32	31	20	37
P4	14	24	16	15
P5	35	29	37	103

Discussion

The present findings indicated that the use of a picture-prompt in a most-to-least teaching procedure was effective and more efficient than the use of an arrow-prompt when teaching an auditory-to-visual MTS task to four children with ASD and one typically developing child. All five participants required fewer sessions to reach mastery criterion in the picture-prompt conditions than in the arrow-prompt conditions. The cumulative data from conditions involving the picture-prompt appeared above the data from conditions involving the arrow-prompt; that is, independent and correct selections of a comparison stimulus occurred sooner in conditions involving the picture-prompt for four of the five participants. The relative frequency of these selections remained higher in picture-prompt conditions throughout repeated sessions in that condition. These results suggest that the picture-prompt was the more efficient method of teaching the sample-comparison relations that defined each auditory-to-visual MTS task. There were also fewer errors associated with the picture-prompt conditions compared to the arrow-prompt conditions and the transfer of stimulus control from the prompt to the auditory sample (i.e., learning) was seen earlier in the picture-prompt conditions than in the arrow-prompt conditions. Lastly, longer response latencies from when the prompt was presented leading up to the first independent response occurred in the picture-prompt conditions. This result is consistent with the use of a picture-prompt which encourages participants to scan the comparison array before initiating a response, thereby increasing response latencies in comparison to the arrow-prompt condition where scanning of the array was not encouraged. Shorter and less varied response latencies in the picture-prompt conditions than in the arrow-prompt conditions in the later trials suggests more fluent responding.

Overall, these results support previous findings that the inclusion of a prompt that requires attending to pertinent features of the comparisons (i.e., a picture-prompt) is effective and more efficient than a prompt that does not (i.e. an arrow- or a finger-point-prompt) when teaching auditory-to-visual MTS tasks (Carp et al., 2012; Fisher et al., 2007). Picture-prompts require conditional discriminations to engage in correct prompted responses which encourages scanning of the comparison array and attending to discriminative features of the comparisons early on in the learning trials. An arrow-prompt (or a finger-point prompt) only requires a simple discrimination (i.e., a three term contingency that does not require the presence or context of a stimulus) which does not require attending to discriminative features of the comparisons and scanning may not take place till a prompt delay has been introduced or later in the teaching trials.

Experiment 1 was able to assess the effect of the type of prompting by holding constant the number of times the sample was presented on each trial, using distinct prompting styles, and using a most-to-least teaching procedure. The methodological procedures of previous research made it unclear as to which component of the prompting procedure was responsible for learning (Carp et al., 2012; Fisher et al., 2007). First, the picture-prompt in the Fisher et al. (2007) and Carp et al. (2012) studies was used as part of an error correction procedure and not part of the teaching procedure, and both studies included an unequal number (two vs. one) of presentations of the sample between experimental conditions. This limitation was addressed in the procedures used in Experiment 1, which involved presenting the sample once per trial in both experimental conditions. In Experiment 1, the sample was delivered followed by the presentation of the comparison pictures and then prompts were delivered and faded out in an identical manner in both experimental conditions. This eliminates the possibility that faster learning could have occurred due to multiple presentations of the sample.

Second, another strength of this study was that the picture-prompt condition also did not include a finger-point component in the procedure. The previous studies included a combination of both prompting methods (picture- and finger-point) during the error correction procedure. In other words, the picture-prompt during the error correction procedure was paired with a finger-point prompt. The combination of both prompting procedures made it difficult to assess the efficacy of each type of prompt. Experiment 1 was able to assess the effects of the use of only a picture-prompt versus the use of only an arrow-prompt. The results allow for better understanding of how learning developed under these conditions. Lastly, it should be noted that the auditory-to-visual MTS tasks in Experiment 1 were delivered under a most-to-least teaching procedure rather than a least-to-most teaching procedure used in the Fisher et al. (2007) and Carp et al. (2012) studies.

The longer response latencies leading up to the first independent response in the picture-prompt conditions compared to the arrow-prompt conditions suggests that learning might have been enhanced by using a prompt that necessitates the discrimination of relevant features. For three of the five participants, the first independent correct response occurred sooner in the picture-prompt conditions than in the arrow-prompt conditions. With the remaining two, the transfer of stimulus control occurred earlier in the first arrow-prompt condition but when it was reintroduced again, it occurred earlier in the picture-prompt than in the arrow-prompt condition. Response effort is believed to be higher in the picture-prompt condition as conditional discrimination is necessary for the prompt to be effective as compared to the arrow-prompt where only a simple discrimination is necessary. Response effort is defined as the amount of effort an individual puts forth to successfully complete a specific task (Friman & Poling, 1995). Despite the use of a prompt that requires higher response effort, the picture-prompt together with the use of a prompt delay facilitated a transfer of stimulus control to the auditory sample effectively and in a more efficient manner when compared to the arrow-prompt. In contrast to this, other research suggests that there are undesired consequences of learning under conditions of increased response effort, including (a) response rates decrease with increasing efforts (Adair & Wright, 1976), (b) extinction (i.e., cessation of responding) occurs more rapidly (Capehart, Viney & Hulicka, 1958), (c) an increase in disruptive behaviours including attempts at escaping the task (Miller, 1968a; Miller, 1968b), and (d) participants prefer lower effort responding to higher effort responding (Perone & Baron, 1980). Therefore, in general, decreasing response effort at the start of teaching is recommended. It should be noted that the level of discrimination, and hence response effort, required to complete the auditory-to-visual MTS tasks in this study is relatively high given that within a stimulus set, the comparisons differ from each other only by a very limited number of features and the samples are also similar (e.g., all begin with the same phoneme and end with the same inflectional morpheme "ing").

However, P4 required different stimulus sets where the differences between the comparisons, and hence samples, were more saliant compared to the stimulus sets used for the other four participants. He failed to master any of the arbitary relations in the original stimulus sets within ten sessions although he successfully followed the picture- and arrow- prompts on at least 95% of the trials in all conditions. There was minimal independent responding and when independent responses were made, they were often errors. Failure to master the original stimulus sets may be due to not having discriminated between the samples because the child was relying on the picture- and arrow- prompts to make a correct response, the response effort was too high, the lack of motivation or the reward provided was not potent enough. Neef, Shade and Miller (1994) suggested that behaviour is imbedded in an economic matrix based on costs and benefits in the form of response effort, rate of reinforcement, the quality of reinforcer and delay to reinforcement. Manipulation of these variables have been found to be effective in producing desired rates and temporal patterns of responding. Reducing the response effort by increasing the saliancy of the comparisons and the samples, while holding constant the rate of reinforcement, the quality of reinforcer and the immediacy of reinforcement, resulted in P4 mastering the four new stimulus sets. Like the other participants, he required fewer sessions to meet mastery criterion and made fewer errors in the picture-prompt conditions than in the arrow-prompt conditions.

In addition, P3 required more than 10 sessions to meet mastery criterion. Unlike P4, he scored higher than chance level in the later sessions. That is, he scored between 15 and 18 independent correct responses out of a possible 18. He also often scored at least 17 out of 18 on two consecutive sessions and missed on the third session by one point. Therefore, the requirement to reach mastery criterion by 10 sessions was relaxed and the sessions continued until he reached mastery criterion. (P3 required between 6 and 24 sessions to meet mastery criterion.) Possible reasons for this variability in responding, despite him being on the cusp of mastery, might be competing stimuli from the environment and/or waning motivation. All sessions for P3 were held at an after-school facility where there were other children engaging in various activities in close proximity that might be distracting. It could also be that the reward given (a piece of chocolate drop) was not potent enough or that he might have experienced satiation despite chocolate being his favourite treat. However, sessions continued as designed to hold constant the environmental factors and rewards used across all conditions and allow for the assessment of the type of prompts used. P3 did master the arbitrary relations between the sample and the comparisons albeit requiring more sessions than the other participants to meet mastery criterion. It should be noted that a preference assessment was not conducted for all participants as part of this experiment due to time constraints and this will be discussed further in the General Discussion (Chapter 4) below.

In conclusion, the results are consistent with the proposition that the use of a picture-prompt facilitated scanning of the comparison array and, consequently, participants learned the arbitrary relations in fewer sessions when compared to an arrow-prompt condition. There may be increased response effort was required, at least initially, in the picture-prompt condition compared to the arrow-prompt condition. The longer response latencies and faster learning in the picture-prompt condition are consistent with there being an additional process such as scanning and/or greater attention given to discriminative features of the comparison array in the picture-prompt conditions, which is absent in the arrow-prompt conditions. The use of the picture-prompt proved effective when two of the participants failed to master the relations with the use of an arrow-prompt. P5's (TD) data showed similar trends to the other four participants (ASD) which suggests that learning in the auditory-visual MTS task occurs in a similar manner. The limitations of the study will be considered in detail in the General Discussion (Chapter 4) below.

Chapter 3: Experiment 2: The Effectiveness of Naming when Teaching Auditory-to-Visual MTS

Attending to defining features of the sample is necessary in order to master auditory-to-visual conditional discriminations. Carp et al. (2015) and Vedora et al. (2017) both examined the effect on learning in auditory-to-visual MTS tasks of a DOR that involves a distinctive response, in this case a vocal response, a learner makes in relation to the sample stimulus.

Carp et al. (2015) compared the effects of three least-to-most teaching procedures when teaching auditory-to-visual MTS tasks. In one condition, the selection of the correct comparison resulted in the delivery of praise and a small food item and the selection of an incorrect comparison resulted in the presentation of the next trial. In the second condition, the selection of the correct comparison resulted in the delivery of praise and a small food item and the selection of an incorrect comparison resulted in an error correction trial. Specifically, the instructor represented the same trial and modelled the correct response by pointing to the correct comparison. In the third condition, similar to the first and second condition, the selection of a correct comparison resulted in the delivery of praise and a small food item. However, in addition to the model prompt, a DOR was included as part of the error correction procedure. That is, the instructor had the participant repeat the auditory sample before the presentation of the comparison array followed by the instructor pointing to the correct comparison. One of the two participants did not meet mastery criterion in the first two conditions but met the mastery criterion in the condition where a DOR was included. The second participant met mastery criterion in the second and third condition, however, he met mastery criterion in fewer trials in the condition that did not require a DOR as compared to the condition that did. In the DOR condition, the second participant made articulation errors and required more time when repeating the sample, which may have weakened the relationship between the sample and the comparison and hence, hindered learning. This could have occurred due to the increased effort to engage in the DOR and holding the reinforcement contingency consistent. In addition, including a requirement to repeat the sample may have been thought to have functioned as a DOR but because the requirement was contingent on incorrect responses, there was a possibility that performance was influenced by negative reinforcement. In other words, there was a higher motivation to avoid errors so as not to have to repeat the sample (Rogers & Iwata, 1991) and hence, the repeating of the sample did not serve as a DOR.

Vedora et al. (2017) required the participants to repeat the auditory sample before the presentation of the comparison array so as to evaluate the effects of repeating the sample as a DOR in a most-to-least teaching procedure in an auditory-to-visual MTS task. The participants were taught to select a flag from an array when the flag was named (i.e., "Touch [name of flag]"). A picture-prompt was used and faded using a progressive time delay employing an adapted alternating treatments design (Sindelar et al., 1985). The evaluation of the effects of a DOR was sequentially replicated within participants (i.e., two sets of comparisons) and the results were not consistent. Both participants met mastery criterion quicker in the condition that included a DOR as compared to the condition that did not in the first comparison. However, in the second comparison, mastery criterion was met quicker in the condition that did not include a DOR than in the condition that included a DOR for one participant and the second participant withdrew from the study prior to reaching mastery criterion in both conditions.

The use of a DOR in the Carp et al. (2015) and Vedora et al. (2017) studies returned inconclusive results. The beneficial effect on learning when a DOR was required was not consistent across the participants with ASD in both studies, but the benefit found for some participants provide a basis for further research. In addition, each participant's ability to repeat words was not formally assessed in both studies and this may be an important requirement for repetition of the sample for the DOR to be effective.

Experiment 2 of this study aimed to evaluate the effectiveness of the inclusion of a DOR when teaching auditory-to-visual MTS tasks to children with ASD using a single-case experimental design but with more participants to replicate the effect than has been used in the previous studies using a most-to-least teaching procedure. An arrow-prompt (which is analogous to a finger-point prompt) identical to that used in the arrow-prompt condition of Experiment 1 was used in both conditions of Experiment 2 and faded using a delayed prompting procedure. The arrow-prompt was adopted as part of Experiment 2 primarily because the results of Experiment 1 were not known at the onset of testing sessions of Experiment 2 and to keep the comparison condition of the experimental factor of interest consistent in both experiments. Participants were also assessed in their ability to repeat spoken words using the Early Echoic Skills Assessment (ESSA) of the Verbal Behaviour Milestone and Placement Program (VB-MAPP; Sundberg, 2008), which is neccesary to implement the DOR.

In the "say" condition, the participants were required to immediately repeat aloud the auditory sample before the comparisons were presented. In the "listen-to" comparison condition, the participants remained silent for 2 s after the sample was played and before the comparisons were presented. The 2 s wait in the "listen-to" condition was included to match the temporal delay between hearing the original sample and the presentation of the comparison stimuli between the two conditions. The inclusion of a DOR requires attending to defining features of the sample, which is a pre-requisite skill to learning auditory-to-visual MTS tasks, and was predicted to result in more efficient learning, as measured by fewer sessions to meet mastery criterion (three consecutive sessions of at least 17 out of 18 correct), when compared to learning of the auditory-to-visual MTS tasks in the absence of a requirement for a DOR. The transfer of stimulus control, as measured by the number of trials to first independent correct response, should also be seen earlier in the "say" condition than in the "listen-to" condition. Lastly, effective transfer of stimulus control (i.e., more fluent and accurate responding) should also result in fewer errors made in the "say" conditions than in the "listen-to" conditions.

Method

Research Design

As in Experiment 1, each participant received both experimental conditions ("say", or B condition, & "listen-to", or C condition) twice in a cross-over B-C-B-C single-case experimental design (Lobo et al., 2017). The order in which the conditions (B_1-C_1-B_2-C_2 or C_1-B_1-C_2-B_2) were presented was counterbalanced across participants, and stimulus sets were also counterbalanced across conditions.

Participants

Four boys with a formal diagnosis of ASD and one typically developing boy were recruited using methods similar to that in Experiment 1. All but one participant (who was diagnosed with ASD) that took part in Experiment 2 also took part in Experiment 1. Each participant was required to demonstrate the ability to imitate single and combination sounds which was assessed using the EESA of the VB-MAPP (Sundberg, 2008).

Assessments

Early Echoic Skills Assessment

The EESA of the VB-MAPP (Sundberg, 2008) was used to quantify the participants' ability to imitate single and combination sounds. The EESA is a norm-referenced test and only items from Group 1-3 of the EESA was administered because they assessed the minimum degree of vocal imitation required. The EESA involved the participants having to repeat 1-, 2- and 3-syllable sounds, words, or phrases (e.g., "say *ah"*). A maximum score of 85 could be obtained. To be eligible to participate in Experiment 2, participants needed to score at least 70 on Group 1-3 of the EESA. As four of the five participants in Experiment 1 also opted to participate in Experiment 2, the EESA was administered immediately after the administration of the VABS and the PPVT before the preliminary training for Experiment 1. All four participants accurately repeated all items receiving the maximum score possible (i.e., 85) and hence were eligible to participate in Experiment 2. For the participant that was recruited only for Experiment 2, P6, the EESA was first administered. When he received the maximum score possible on the EESA, the VABS and the PPVT were administered as in Experiment 1.

Participant Characteristics

Table 6 shows the age of each participant and their assessment results. For the four of the five participants that also participated in Experiment 1 (P1, P2, P4 and P5), scores on the PPVT and the VABS were duplicated from Chapter 2. P6 received a standard score of 35 and an age-equivalent scored of 2:8 years on the PPVT, showing well below normal receptive vocabulary skills. He also scored low

Table 6

Scores on the PPVT, VBAS and the EESA for Participants Who Took Part in Experiment 2

Participant /Diagnosis	Gender	Chronological age	PPVT		VABS						EESA
			Standard score	Age-equivalent score	Standard scores			Adaptive level			
					Communication	Daily Living	Socialisation	Communication	Daily Living	Socialisation	
P1 (ASD)	M	8:5 yrs.	49	3:5 yrs.	61	29	63	Low	Low	Low	85
P2 (ASD)	M	8:6 yrs.	81	4:8 yrs.	72	66	61	Low	Low	Low	85
P6 (ASD)	M	6:9 yrs.	35	2:8 yrs.	65	60	72	Low	Low	Moderately low	85
P4 (ASD)	M	3:5 yrs.	106	6:0.5 yrs.	87	85	83	Adequate	Moderately low	Moderately low	85
P5 (TD)	M	3:2 yrs.	124	4:8 yrs.	97	100	86	Adequate	Adequate	Adequate	85

or moderately low in the communication, daily living, and socialisation domains of the VABS.

Apparatus

The same software and laptop used in Experiment 1 were used to write the programs for Experiment 2, which presented the auditory stimuli and recorded the participant's stimulus selections on each trial.

Stimulus Materials

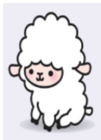
As in Experiment 1, each of the four conditions used a unique set of samples and comparisons. The three comparisons in a set were similar cartoon characters where each character was posing differently and as if they were performing a different action. Hence, they shared many common features and differed with respect to only a limited number of specific features. A fifth set of comparisons was used for preliminary training.

Table 7 shows the samples (i.e., the spoken name) and comparison stimuli (i.e., the array of pictures presented) used in the preliminary training and MTS tasks of this experiment. Each of the three pictures in a set of comparisons measured approximately 70 mm x 50 mm when displayed on the touchscreen during the MTS tasks. The comparison stimuli used were obtained from copyright-free internet sources.

The sample stimuli used in the four experimental conditions consisted of pre-recorded audio clips that were approximately 1 second in duration using the same recording method and equipment used in Experiment 1. Each sample (auditory) stimulus in a set was paired with one comparison (picture) stimulus in that set and this pairing was kept constant for all participants. Thus, each of four sets of samples consisted of three different audio clips. All audio clips involved the same narrator

Table 7

Comparisons and Samples Used in the MTS Tasks in Experiment 2

Stimulus set	Comparisons and Samples		
Preliminary training	"Director"	"Performer"	"Picking"
			
Cats	"Suspecting"	"Succeeding"	"Suspending"
			
Sheep	"Installing"	"Inspecting"	"Instructing"
			
Ninjas	"Preparing"	"Preserving"	"Presenting"
			
Foxes	"Attempting"	"Attaching"	"Attending"
			

speaking and were recorded using two carrier phrases (i.e., "listen to…" and "say…") followed by a unique 3-syllable verb. Each stimulus set was allocated to an experimental condition (i.e., two to a condition that required a DOR and two to a condition that did not require a DOR) and these allocations or these stimuli sets were counterbalanced across participants. Each of the spoken verbs began with the same phoneme and ended with the present progressive inflectional morpheme (e.g., “installing”, “inspecting” and “instructing”). Therefore, the samples were phonologically similar, differing in the stressed syllable only by 2-3 phonemes, including the vowel, in most cases.

Four participants (P1, P2, P6 and P5) received the stimulus sets described above. As in Experiment 1, P4 received the same stimulus set during preliminary training but during the experimental conditions, he received four additional stimuli sets (see Table 8). The samples and comparisons in these sets were spoken names and pictures of nouns that he failed to identify during administration of the PPVT. The difference between the comparisons were more salient relative to the stimulus sets in Table 7.

Table 8

Comparisons and Samples Used in the MTS Tasks for P4 in Experiment 2

Stimulus set	Comparisons and Samples		
Round objects	Globe	Compass	Timer
			
Birds	Emu	Ostrich	Flamingo
			
Rock structures	Boulder	Pyramid	Pillar
			
Fruits	Kiwi	Citrus	Squash
			

The same set of three pictures prepared for preliminary training in Experiment 1 using the touch screen were used for preliminary training in Experiment 2. In addition, the audio for each sample stimulus used in the preliminary training had the same form as the test samples, that is, “listen to [target]” and “say [target]”.

Procedure

Setting for Initial Assessments and Testing Sessions

All sessions were conducted at a table or desk at the participant’s home under similar conditions to those described in Chapter 2 for Experiment 1. The same room and table were used for each session provided to a specific participant. For each participant, the setting was generally similar across sessions. For example, the room was generally quiet with minimal distractions for P1, P4, P5, and P6. A parent might be present during sessions for three participants but watched from at least 2 m away. However, all of P2’s sessions were held at home in the evenings where his parents were preparing meals and his younger sister was moving around the home.

Administration of the EESA, VABS, PPVT and preliminary training, in that order, for P6 were completed in a single session lasting no more than 2 hours. Advice from the parents regarding foods that might be effective reinforcers for preliminary training and experimental conditions was also sought during the first session.

Preliminary Training

Preliminary training followed immediately after the administration of the initial assessment for P6. For the four boys that participated in Experiment 1, preliminary training was conducted in the session after the final session of Experiment 1. Preliminary training for Experiment 2 involved two phases: (a) training to repeat the target in the "say" condition and (b) training to remain silent in the "listen-to" condition. The training varied slightly across participants depending on their verbal ability. Initially, a spoken instruction was given (e.g., "say the word that you hear") before the "say" condition block of trials was presented. When the participant did not respond accurately or did not respond within the time frame given, the researcher modelled the response required. Additional instructions or prompts to select the comparison below the arrow as shown in Figure 2 were not required for P1, P2, P4 and P5. They selected the correct comparison on all trials following the instruction in both phases of the preliminary training. P6 was instructed to select the comparison below the arrow and required a model prompt on the first trial when he did not respond to the spoken instruction. As in Experiment 1, each participant received the food type that would later be used in the experimental conditions when they responded accurately during the preliminary training.

The sequence of events defining a trial in both the "say" and "listen-to" conditions of preliminary training was identical to that of Experiment 1. That is, a circular red button appeared, followed by an orange button and the green "GO" button. In the "say" condition, when the participant touched the green button, the green button disappeared, leaving a black computer screen, and an audio file that said, "say [target]" was played. The participant was given 2 s to repeat the target and the screen remained black during this time. Also, during this 2 s interval, the researcher indicated that the correct response had been made by pressing the enter button on the laptop keyboard. When the participant failed to respond or did not repeat the target sample with sufficient accuracy within 2 s (allowance for systematic speech error patterns were made so long as their articulation of each sample was distinct from the other two), the experimenter held back from pressing enter and the touchscreen stayed black for 5 s in total and the green button appeared again. The same trial with the audio sample was presented again, and the researcher prompted the correct response by providing a verbal model. To complete the MTS task the comparisons appeared horizontally aligned and spaced equally in the bottom half of the screen (see Figure 1) 2 s after the audio file had been played (provided the enter button had been pressed by the experimenter during that 2 s window). A white arrow appeared above the target picture simultaneously with the appearance of the comparisons. The moment the participant touched the comparison adjacent to the arrow, all screen images disappeared, and the 2 s animation of coloured stars and an auditory jingle ensued. The researcher praised the participant and provided the food item between 0.5 to 1 s after the stars and jingle began playing. If he touched either of the other two comparisons, all screen images disappeared, and the screen remained black for 2 s and the food item was not presented. The researcher remained silent and did not interact with the participant while the screen was black.

In the “listen-to” condition, each trial started as in the “say” condition of the preliminary training. However, this time the audio file “listen-to [target]” was played and the trial proceeded with the comparisons and white arrow appearing on the touchscreen when the participant remained silent for 2 s. As in the first phase, the researcher praised the participant and provided the food item between 0.5 to 1 s after the stars and jingle began playing when the correct comparison was chosen and the researcher remained silent and did not interact with the participant when an error (i.e., the participant repeated the sample or made a wrong selection) was made. The arrow prompt appeared simultaneously with the comparisons on every trial in both conditions of the preliminary training.

There were 18 trials within a block, and the blocks ran within a session were structured identical to that of preliminary training in Experiment 1. That is, there were six unique trials in relation to the positions that the comparisons can be presented and each of these trials was presented three times in a block and the computer shuffled the 18 trials and generated a unique trial sequence on every block with the constraint that no one sample, and no one position could be correct on more than three consecutive trials. Each sample was presented six times and was correct twice in each position (i.e., the correct comparison was presented twice in the left, middle and right position). The same mastery criterion also applied. Specifically, training in each phase was deemed sufficient once a participant had responded to the sample (i.e., the audio) accurately and selected the correct comparison on all 18 trials presented in a block. For all participants, no more than three blocks of 18 trials were required.

Experimental Conditions

Unlike during the preliminary training where consecutive blocks of 18 trials were delivered until each participant selected the correct comparison on all 18 trials, each session in an experimental condition involved only one block of 18 unique trials (excluding repeated and error correction trials). Trial blocks were generated in the same manner they were generated for the preliminary training. At least three sessions per week were conducted for each participant and more than one session per day might have been provided so long as at least 1-hour elapsed between the end of one session and the beginning of another. Each session, including the setting up and packing up of materials, lasted approximately 15 min.

All participants repeated the target sample with sufficient accuracy on at least 98% of the trials and none were missed due to having repeated the wrong sample.

When a participant made an error with the articulation of the sample, the response was a recognisable and distinct response from the other two samples. When the participants did not repeat the sample within the 2 s window, they appeared to have been distracted and they repeated it with sufficient accuracy on the second presentation of the trial.

The participants continued receiving sessions in a condition until either they were correct on 17 out of 18 trials on three consecutive sessions or 10 sessions had been provided, whichever occurred first. A participant was deemed to have failed to learn the arbitrary relations when they failed to meet mastery criterion after 10 sessions had been delivered.

Table 9 shows the order in which conditions were presented to participants and the stimulus set associated with each condition. The sequence of events defining a trial in the experimental conditions was similar to the preliminary training. For both the “say” and “listen-to” experimental conditions, a trial started with the animation of coloured disks in the centre of the screen once the participant had not touched the screen for 5 s. In the “say” experimental condition, when the participant touched the green button, an auditory sample in the form of “say [target]” was played. Immediately after the sample had finished playing, the participant was given 2 s to repeat the sample. When the researcher had judged that the participant had accurately repeated the sample, the researcher pressed the “enter” button on the laptop keyboard. Three comparisons appeared on the bottom half of the screen after 2 s had elapsed from when the sample finished playing (i.e., comparisons appeared 2 s after the audio file had been played regardless of when the participant repeats the sample and when the researcher pressed the enter button). When the participant did not repeat the sample within 2 s or repeated the sample incorrectly, the researcher did not press the "enter" button and the trial was terminated (i.e., the comparisons were not presented). The green "GO" button appeared in the middle of the screen again and the same trial was represented. Each participant was given three opportunities to proceed with the trial, that is, to repeat the sample accurately before the researcher terminated the session and returned to preliminary training. However, none of the participants required more than two presentations of the same trial to accurately repeat the sample within 2 s.

Table 9

Order in Which Conditions and Stimulus Sets Were Presented in Experiment 2

Participant	Condition no.	Condition	Stimulus set
P1	1	Listen	Cats
	2	Say	Sheep
	3	Listen	Ninjas
	4	Say	Foxes
P2	1	Listen	Sheep
	2	Say	Cats
	3	Listen	Foxes
	4	Say	Ninjas
P6	1	Say	Cats
	2	Listen	Sheep
	3	Say	Ninjas
	4	Listen	Foxes
P4	1	Say	Round objects
	2	Listen	Birds
	3	Say	Rock structures
	4	Listen	Fruits
P5	1	Say	Sheep
	2	Listen	Cats
	3	Say	Foxes
	4	Listen	Ninjas

Prompting Method. In both the "say" and "listen-to" conditions, an arrow prompt, same as the one used in preliminary training, appeared 12 mm above the correct comparison (see Figure 2).

Prompt-Fading Strategy. The same prompt fading strategy was used in the two experimental conditions in Experiment 2 as that used in Experiment 1. On each trial, the computer began timing the delay of the presentation of the prompt relative to the point of presentation of the comparisons (i.e., 2 s after the sample has been played), all the while waiting for a touch to be registered within the area occupied by the three comparisons. If the prompt delay timed out before a touch was registered, then an arrow-prompt was provided. Five prompt delays were used: 0.001, 1, 2, 4 and 8 s with 0.001 s timing resolution. The prompt was presented at a delay of 0.001 s on the first seven trials of each experimental condition (i.e., near simultaneously with the comparison array) to minimise the opportunity for errors to occur. On the eighth trial, the prompt delay increased to 1 s and remained there until either seven consecutive prompted correct selections (comparison selections after the prompt appeared) or four consecutive independent correct responses (comparison selections before the prompt appeared) had been recorded. The prompt delay increased to the next level (i.e., the prompt appeared 2 s after the sample h finished playing) when either of the criteria above had been satisfied. The same criterion was used to increase the time delay until the prompt was delivered 8 s after the sample was played. The prompt delay decreased to the previous value (or remained at 0.0001 s during the first 8 trials) when an error was made on two consecutive trials, or two errors were made on non-contiguous trials involving the same sample stimulus at the current prompt delay within the same session. If the criterion for completion of an experimental condition (see above) was not reached within a session, the prompt level used in the next session was the level the participant finished on the session before.

Response Contingencies. The same contingencies of reinforcement were arranged for comparison selections whether a comparison was touched before or after the prompt was delivered and all errors (incorrect selections) earned the same consequence. When an error was made, an error-correction trial followed. During the error-correction trial, the sample and comparisons for that trial were repeated, the prompt was delivered at 0.001 s, and the incorrect comparisons were dropped so that only the correct comparison remained on the screen. Selections of the correct comparison during these error-correction trials were followed with animation and the jingle but not the tangible reinforcer. In other words, correct responses on the error-correction trials were not rewarded with the delivery of a preferred edible.

Results

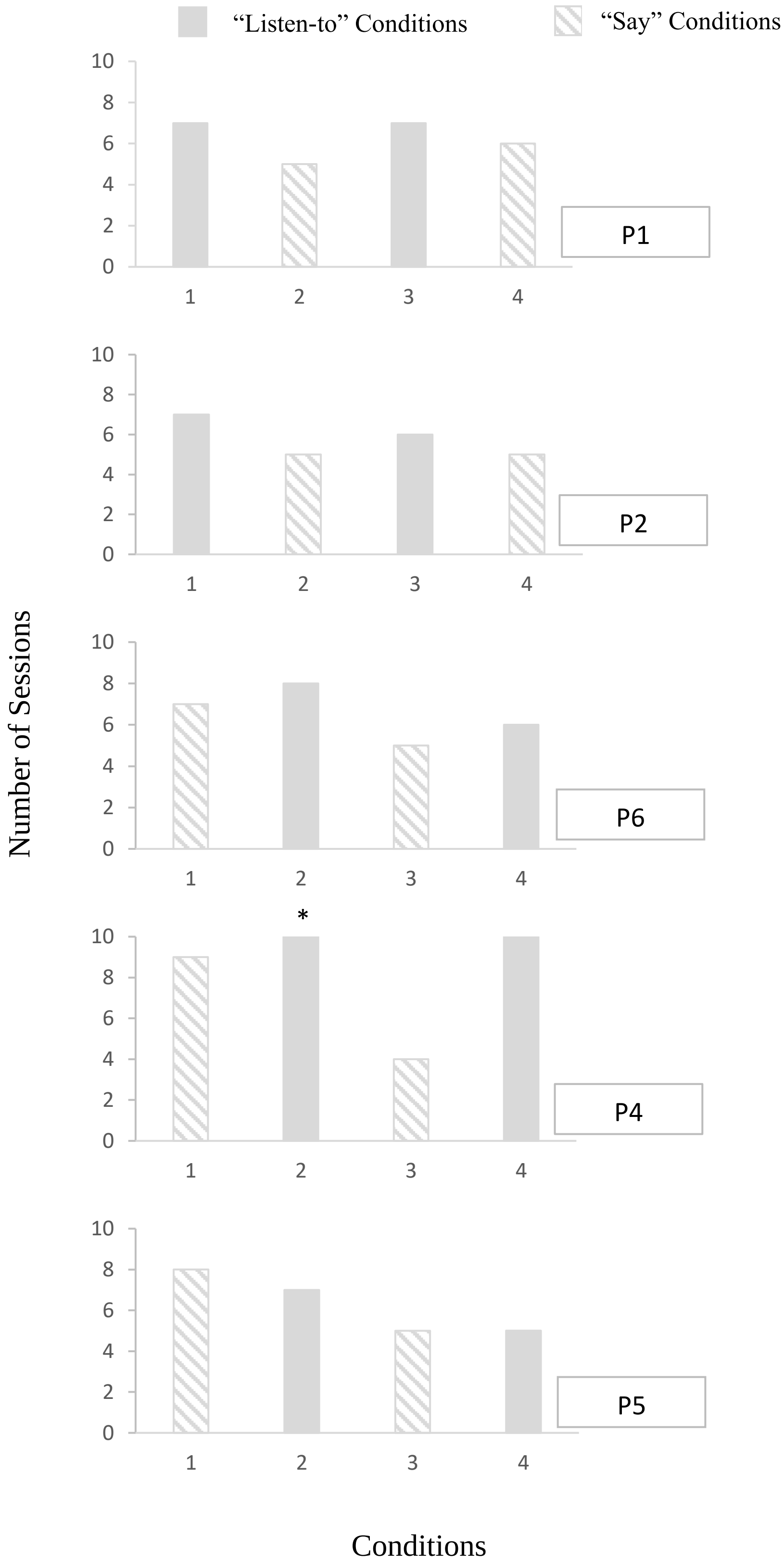
The following measures were calculated separately for each participant and will be described below: (a) number of sessions to criterion, (b) number of independent correct responses per session, (c) number of cumulative independent and correct responses, (d) number of errors, and (e) comparison selection latencies.

Number of Sessions to Criterion

Four of the five participants (P1, P2, P6, & P4) required fewer sessions to meet mastery criterion in the "say" conditions than in the "listen-to" conditions. This effect was replicated when each condition was reintroduced. For example, P1 required seven sessions to meet mastery criterion in the first "listen-to" condition, and five sessions to meet mastery criterion in the following "say" condition. When the "listen-to" condition was reimplemented, he had again needed seven sessions to meet criterion. Returning to the "say" condition saw a decrease in the number of sessions to five to meet the mastery criterion. The same changes between

Figure 12

Number of Sessions Required to Reach Mastery Criterion per Condition for Experiment 2



experimental conditions was seen for P2, P6, and P4. However, it should be noted that P4 failed to master a stimulus set within ten sessions in a “listen-to” condition.

P5’s data showed an exception where he required eight sessions to meet mastery criterion in the first “say” condition, and seven sessions to meet mastery criterion in the second “listen-to” condition. However, when the “say” condition was reimplemented, he required only five sessions to meet mastery criterion. He also required five sessions in the final “listen to” condition to meet mastery criterion.

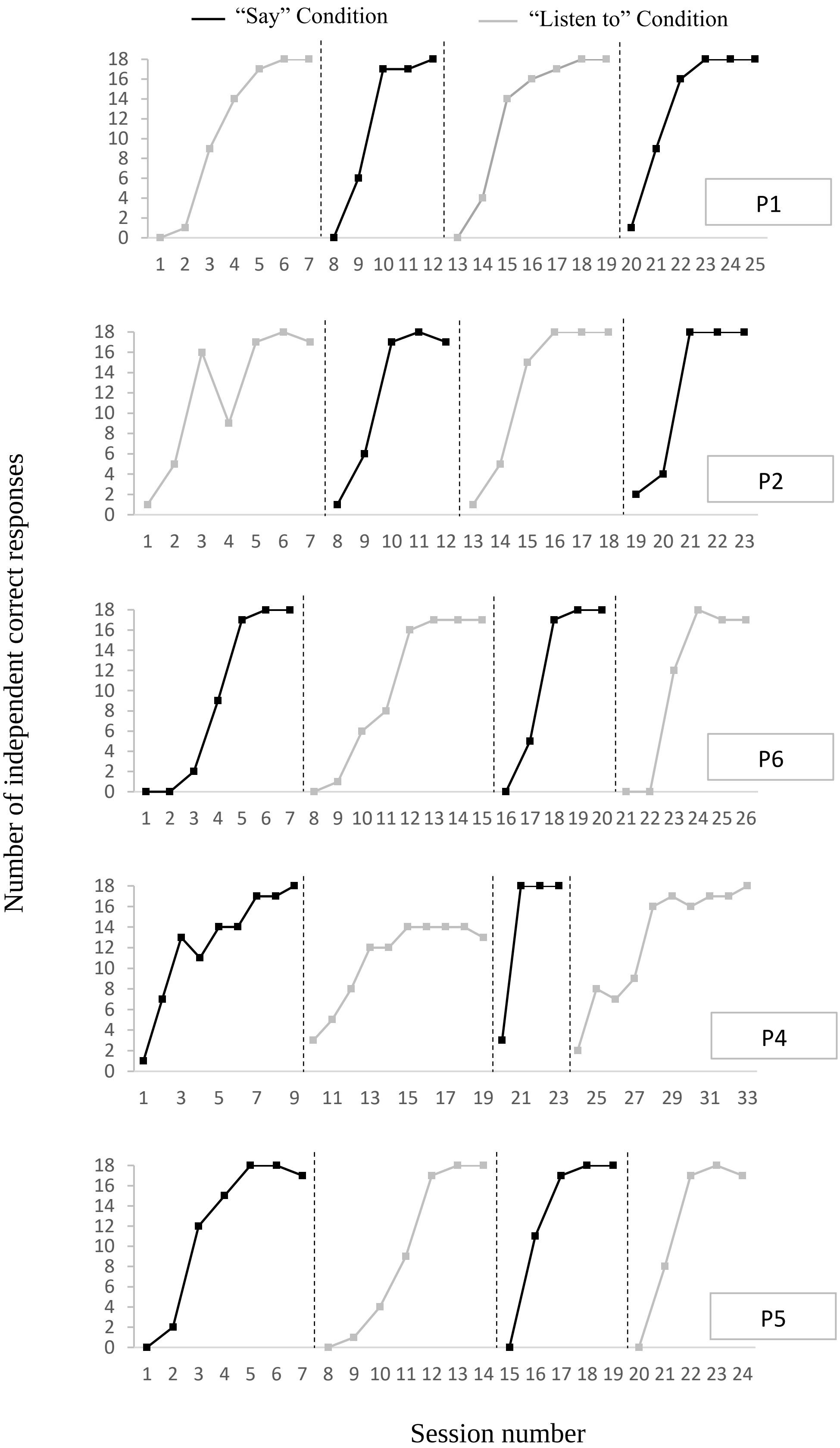
Number of Independent Correct Responses per Session

The number of independent correct responses per session for the “say” and “listen to” conditions are presented in Figure 13. The data were plotted per condition in the order in which conditions were ran. Data from the “say” conditions are shown by solid black lines whereas data from the “listen to” conditions are shown by solid grey lines.

In general, Figure 13 shows a steeper slope in the earlier sessions, which indicates a greater increase in independent correct responding, in the “say” conditions as opposed to a gentler slope in the “listen-to” conditions. For three of the five participants (i.e., P6, P4, & P5) who received the “say” condition first, a steeper slope was seen in the “say” condition than in the following “listen-to” condition. The slope was then again steeper in the third condition when the “say” condition was reintroduced and the gradient of the slope was reduced for the final “listen-to” condition. The gradient of the slope was similar to that of the third condition when the “listen-to” condition was reintroduced for P3. This change in gradient of the slope where the slope was steeper in the “say” condition than in the “listen-to” conditions was replicated with the reintroduction of each condition for P1 and P2 except that they received the “listen-to” condition first.

Figure 13

Number of Independent Correct Responses per Session for Experiment 2



Cumulative Independent and Correct Responses

Figure 14 shows the cumulative number of independent correct responses made by each participant in each condition plotted as a function of trial number in a condition. Like Figure 13, data from the "listen-to" conditions are shown by solid grey lines whereas data from the "say" conditions are shown by solid black lines.

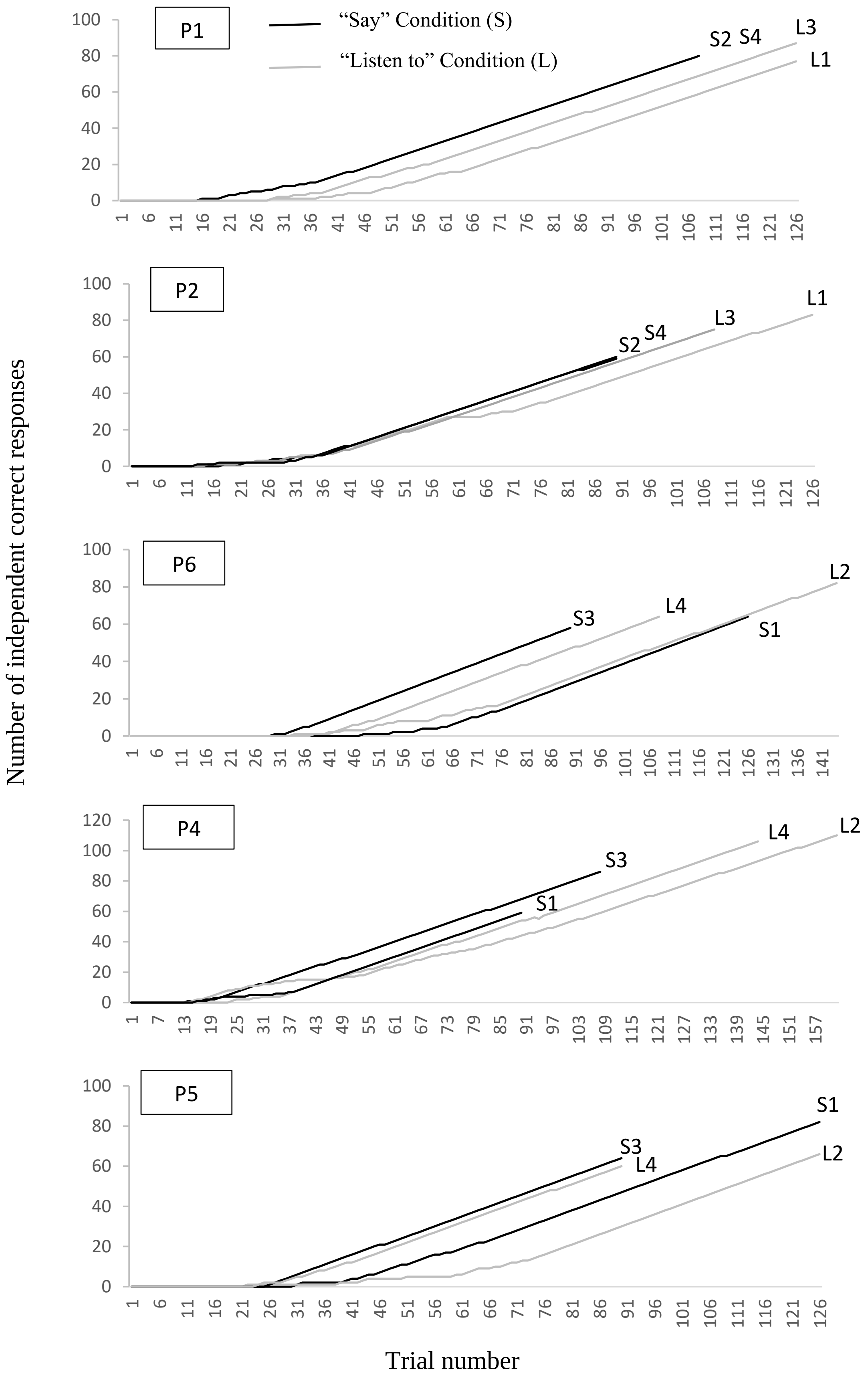
Figure 14 shows that for three of the five participants (P1, P2, & P4) the cumulative data from the "say" conditions appeared above the data from the "listen-to" conditions, that is, independent and correct selections of a comparison stimulus occurred sooner in the "say" conditions. The relative frequency of these selections remained higher in the "say" conditions throughout repeated sessions in those conditions.

Specifically, P1's and P2's data showed a relatively smooth upward slope for all conditions indicating steady independent and correct responding after the initial horizontal line (indicating no independent correct responding). P4's data from all conditions showed a stepwise upward slope after the initial horizontal line for three of the four conditions (S1, L2 & L4). This stepwise upward slope indicated independent correct responding with trials of prompted correct or incorrect responding as shown by the horizontal lines. In other words, P4 continued to make prompted correct or incorrect responses after the initial independent correct response in these three conditions. Data from S3 showed a relatively smooth upward slope indicating steady independent and correct responding after the initial horizontal line.

Data from S1 for P6 showed a stepwise upward slope after the initial horizontal line. L2 showed a similar pattern and data from L2 stayed slightly above that of S1 even though fewer trials were required to meet mastery criterion in S1 than L2. Data from S3 and L4 showed a relatively smooth upward slope. Data from S3

Figure 14

Cumulative Number of Independent Correct Responses for Experiment 2



appeared above the other three conditions. For P5, data from S3 and L4 showed a relatively smooth upward slope whereas data from S1 and L2 showed a stepwise upward slope after the initial horizontal line. Data from S3 appeared above that of L4 and data from S1 appeared above that of L2 even though the same number of trials was required to meet mastery criterion in the S3 and L4.

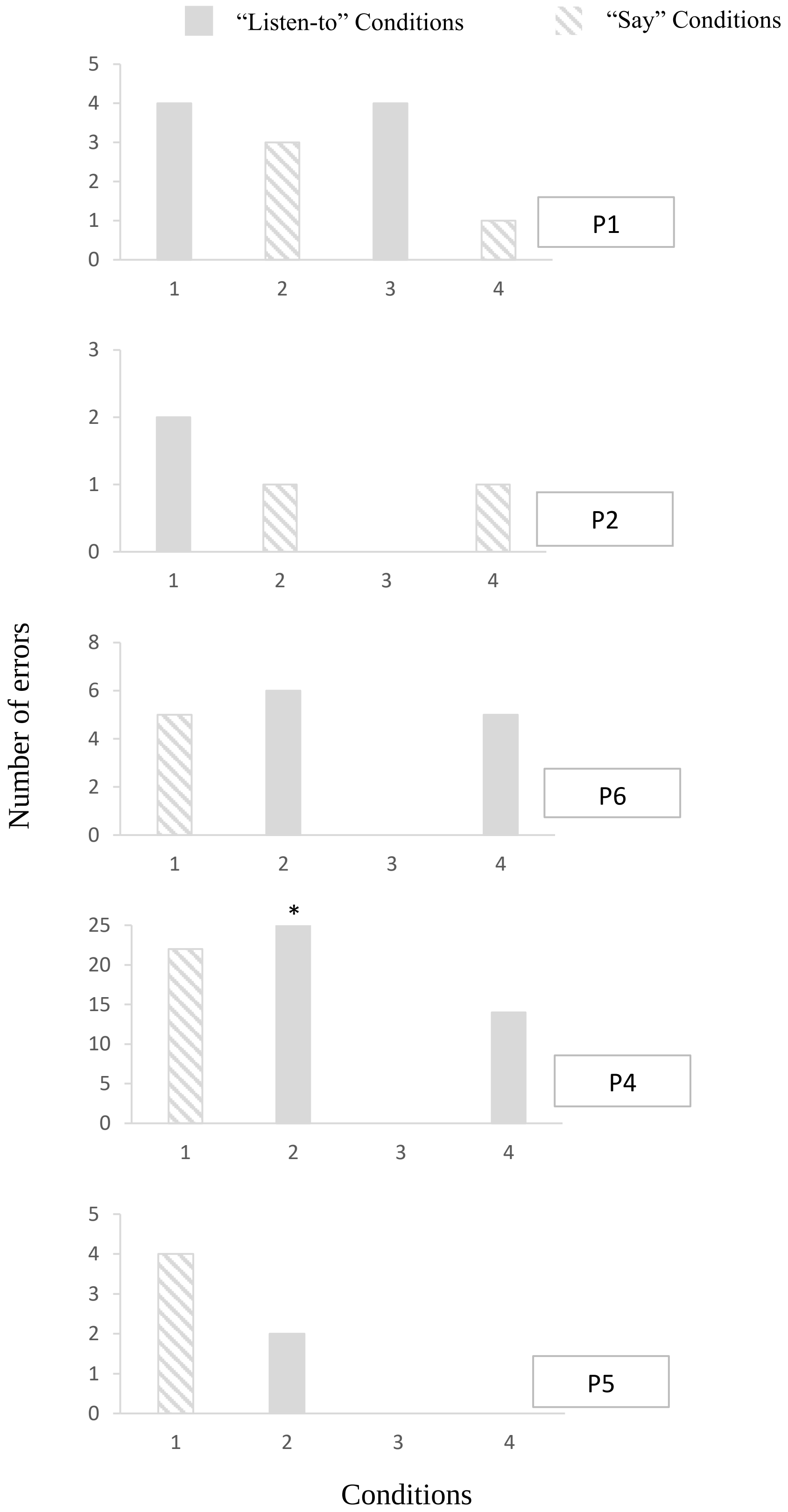
Number of Errors

Figure 15 shows the number of errors that each participant made in each condition. The data were plotted per condition in the order in which conditions were ran. On average, across the two experimental conditions, four of the five (P1, P6, P4, and P5) participants made fewer errors in the "say" conditions than in the "listen to" conditions. P2 made an equal number of errors, on average, across the two experimental conditions.

For two of the three participants (i.e., P4 and P6) who received the "say" condition first, fewer errors were made compared to the following "listen-to" condition. These two participants also made fewer errors when the "say" condition was reintroduced and the final "listen-to" condition. The same effects were seen in P1's data except that the "listen-to" condition was introduced in the first condition. P2's data showed the same effects for the first three conditions and an exception was seen where he made more errors in the fourth condition when the "say" condition was reintroduced as compared to the preceeding "listen to" condition. An exception was also seen in P5's data where four errors were made in the first condition which was a "say" condition. Fewer (i.e., two) errors were made in the second condition which was a "listen-to" condition. When the "say" condition was reintroduced, no errors were made. No errors were made in the fourth condition when the "listen-to" condition was reintroduced too.

Figure 15

Number of Errors made per Condition in Experiment 2



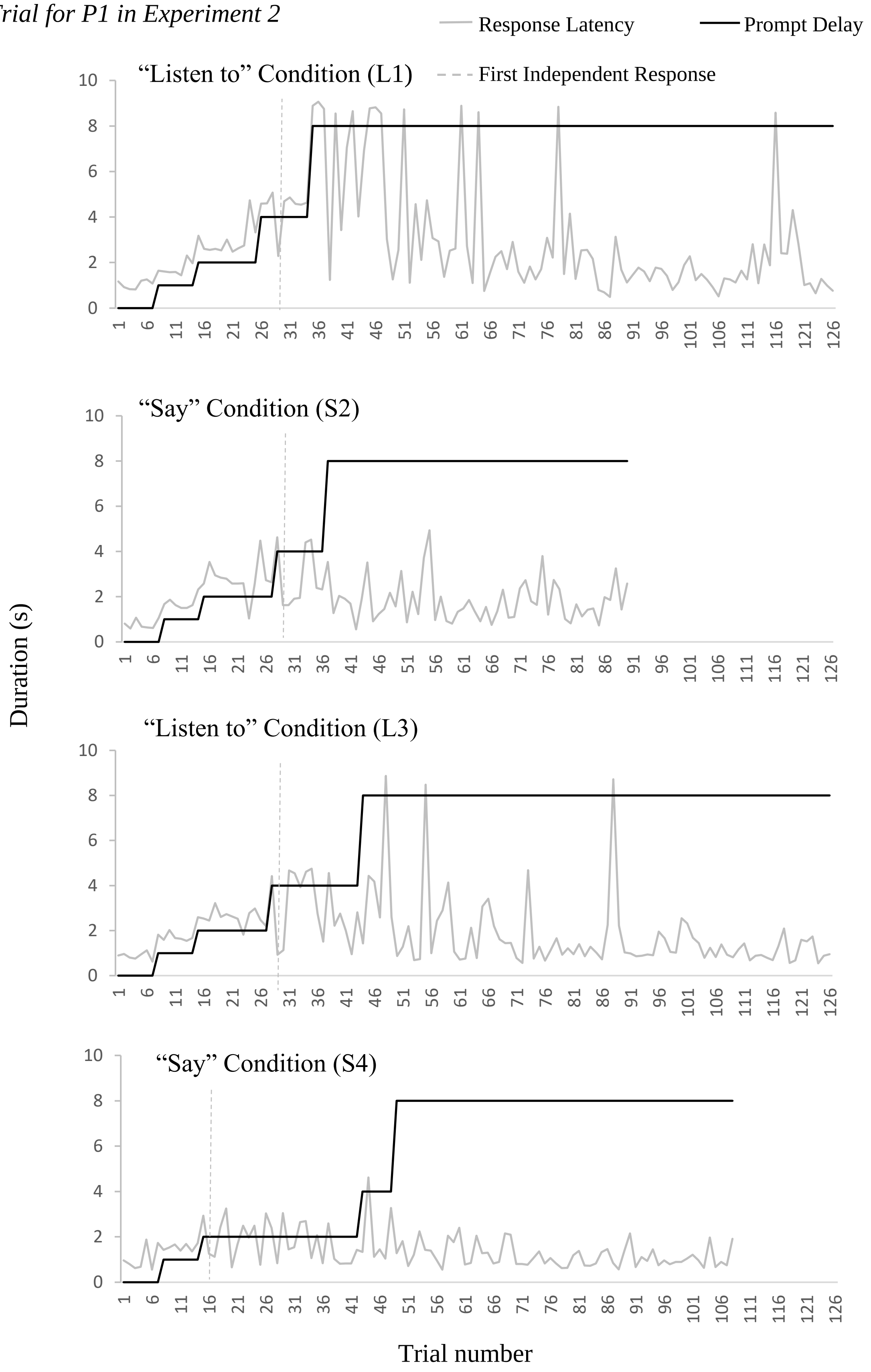
Comparison-Selection Latencies

Time-event records of each session were used to calculate the time from the appearance of comparison stimuli on a trial until one of the comparisons was touched. Figures 16 through 20 show the comparison-selection latencies on every trial for each successive session per participant as represented by a grey solid line. Each figure also shows the time from comparison appearance until a prompt was either presented on a trial if a comparison had not yet been touched or was scheduled to occur if a comparison had been touched prior to its presentation. This is represented on the figures by a solid black line. Comparison selections were defined as independent whenever the comparison-selection latency on a trial was less than the scheduled prompt delay on a trial, and as prompted whenever the comparison-selection latency exceeded the prompt delay. Incorrect responses could occur before or after the prompt was presented. The first independent correct response in each condition is represented by a vertical grey dash line.

Figure 16 shows when the first independent correct response occurrs, response latencies, and prompt delays for each condition for P1. The first independent correct response, hence the transfer of stimulus control, occurred at the same time in the first condition (L1), second condition (S2), and the third condition (L3). When the “say” condition was reintroduced in the fourth condition, the transfer of stimulus control occurred earlier than in L1, S2, and L3. Response latencies were similar from when the prompt was delivered in all four conditions before the point of transfer of stimulus control. Response latencies after the point of transfer of stimulus control showed less variance and fewer prompted responses in S2 and S4 than in L1 and L3, where P1 engaged in independent and correct responses, indicating more fluent responding in the “say” conditions. The prompt level was not required to be

Figure 16

Point of Transfer of Stimulus Control, Response Latencies and Prompt Delay per Trial for P1 in Experiment 2



decreased for any of the four conditions which meant that, in a session, there were no errors made contiguously or with the same sample twice.

Figure 17 shows when the transfer of stimulus control occurrs, response latencies, and prompt delays for each condition for P2. The transfer of stimulus control occurred at the same time in L1 and S2. When the “listen-to” condition was reintroduced in the third condition, the transfer of stimulus control occurred sooner than in the second condition, and when the “say” condition was reintroduced in the fourth condition, the transfer of stimulus control occurred sooner than in the third condition. Response latencies from when the prompt was delivered were longer in the “listen-to” than in the “say” conditions leading up to the point of transfer of stimulus control. Following the transfer of stimulus control, there was less variance and fewer prompted responses in S2 and S4 when independent and accurate responding occurred, indicating more fluent responding in the “say” conditions than in the “listen-to” conditions. The prompt level was not required to be decreased for any of the four conditions.

The point where the transfer of stimulus control occurs, response latencies, and prompt delays for P6 are shown in Figure 18. The transfer of stimulus control was seen later in S1 than in L2. However, when the “say” condition was reimplemented in S3, the transfer of stimulus control occurred sooner than in L2. When the “listen-to” condition was reimplemented and the transfer of stimulus control occurred earlier in S3 than in L4. Response latencies were similar across all four conditions leading up to the first independent correct response with the exeption of an outlier in L2. There was larger variance in the response latencies and more prompted correct responses from the first independent correct response in S1 and L2 compared to S3 where the “say” condition was reintroduced. Response latencies

Figure 17

Point of Transfer of Stimulus Control, Response Latencies and Prompt Delay per Trial for P2 in Experiment 2

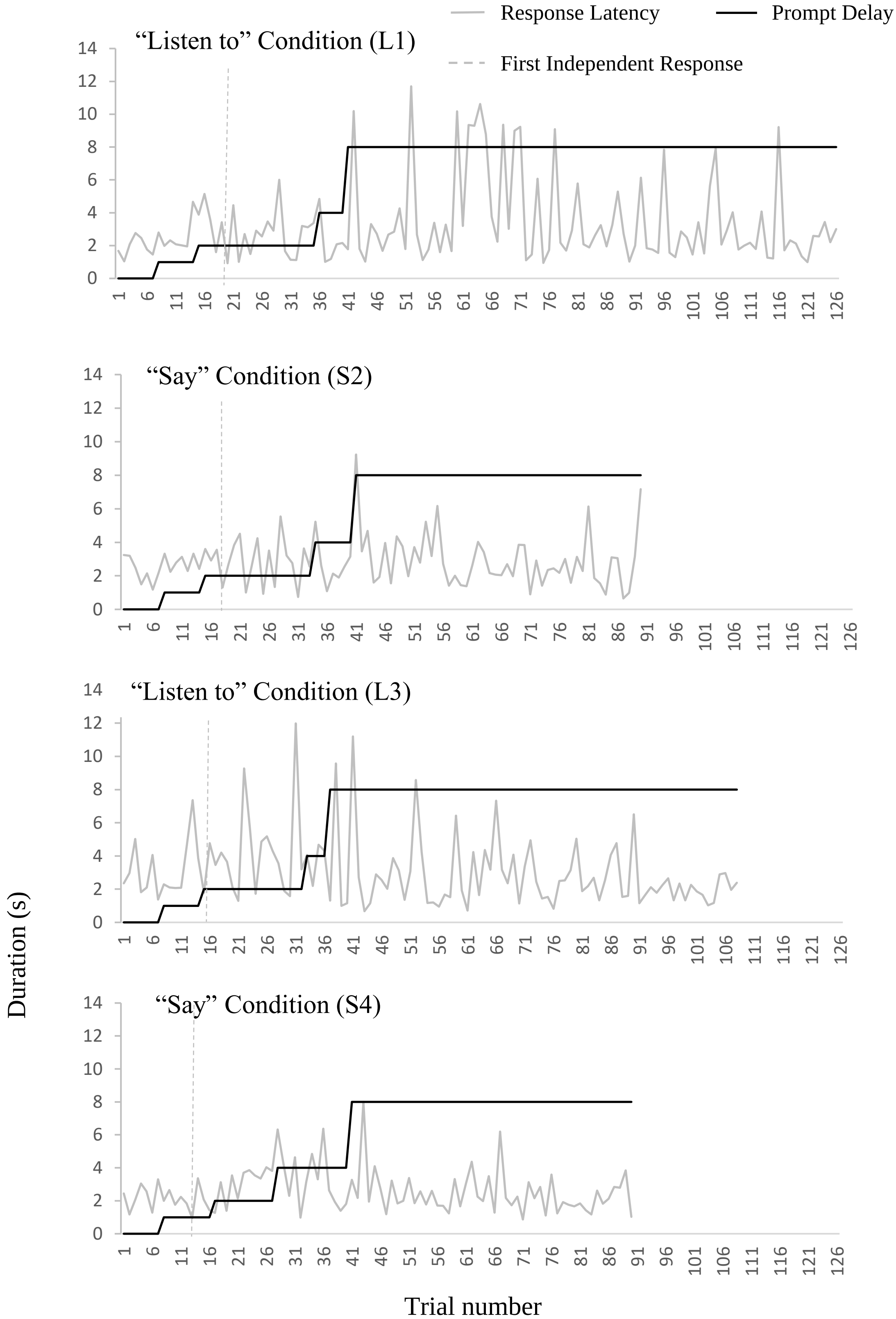
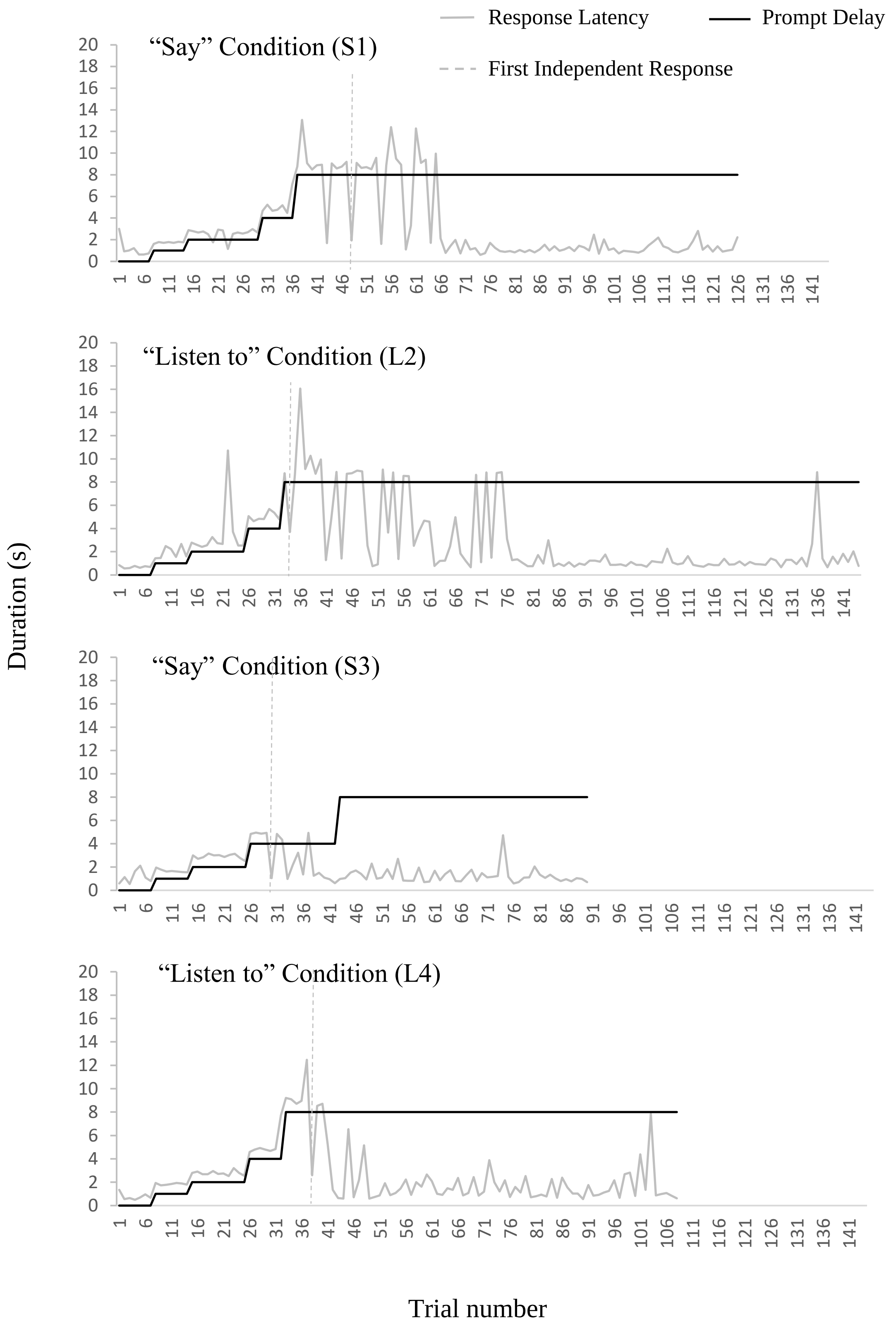


Figure 18

Point of Transfer of Stimulus Control, Response Latencies and Prompt Delay per Trial for P6 in Experiment 2



were short in trials after the transfer of stimulus control and when independent and correct responding occurred across all conditions. As with P1 and P2, the prompt delay was not required to be decreased for all conditions.

Figure 19 shows when the transfer of stimulus control occurrs, response latencies, and prompt delays for each condition for P4. Response latencies from when the prompt was delivered were similar in all four conditions leading up to the first independent correct response. The transfer of stimulus control occurred sooner in L2 than in S1. When the "say" condition was reintroduced (S3), the transfer of stimulus control occurred later in S3 than in L2 but sooner than in L4 when the "listen-to" condition was reintroduced. Response latencies were similar for all conditions leading up to the first independent response and there was more variance in the response latencies in the later trials in S1, L2, and L4 as opposed to S3. The prompt delay had to be decreased three times in S1 and L2 and did not have to be decreased in S3 and L4.

Lastly, the point where the first independent correct response occurs, response latencies, and prompt delays for P5 are shown in Figure 20. The transfer of stimulus control was seen earlier in L2 than in S1. When the "say" condition was reintroduced in S3, the stimulus control occurred later than in L2 and in L4 when the "listen-to" condition was reintroduced. Response latencies from when the prompt was delivered were similar in all four conditions leading up to the first independent correct response. The prompt delay was not required to be decreased for any of the four conditions.

Table 10 displays the number of trials to the first independent correct response across the first four conditions and across the two experimental conditions. In general, for all participants, response latencies from when the prompt was

Figure 19

Point of Transfer of Stimulus Control, Response Latencies and Prompt Delay per Trial for P4 in Experiment 2

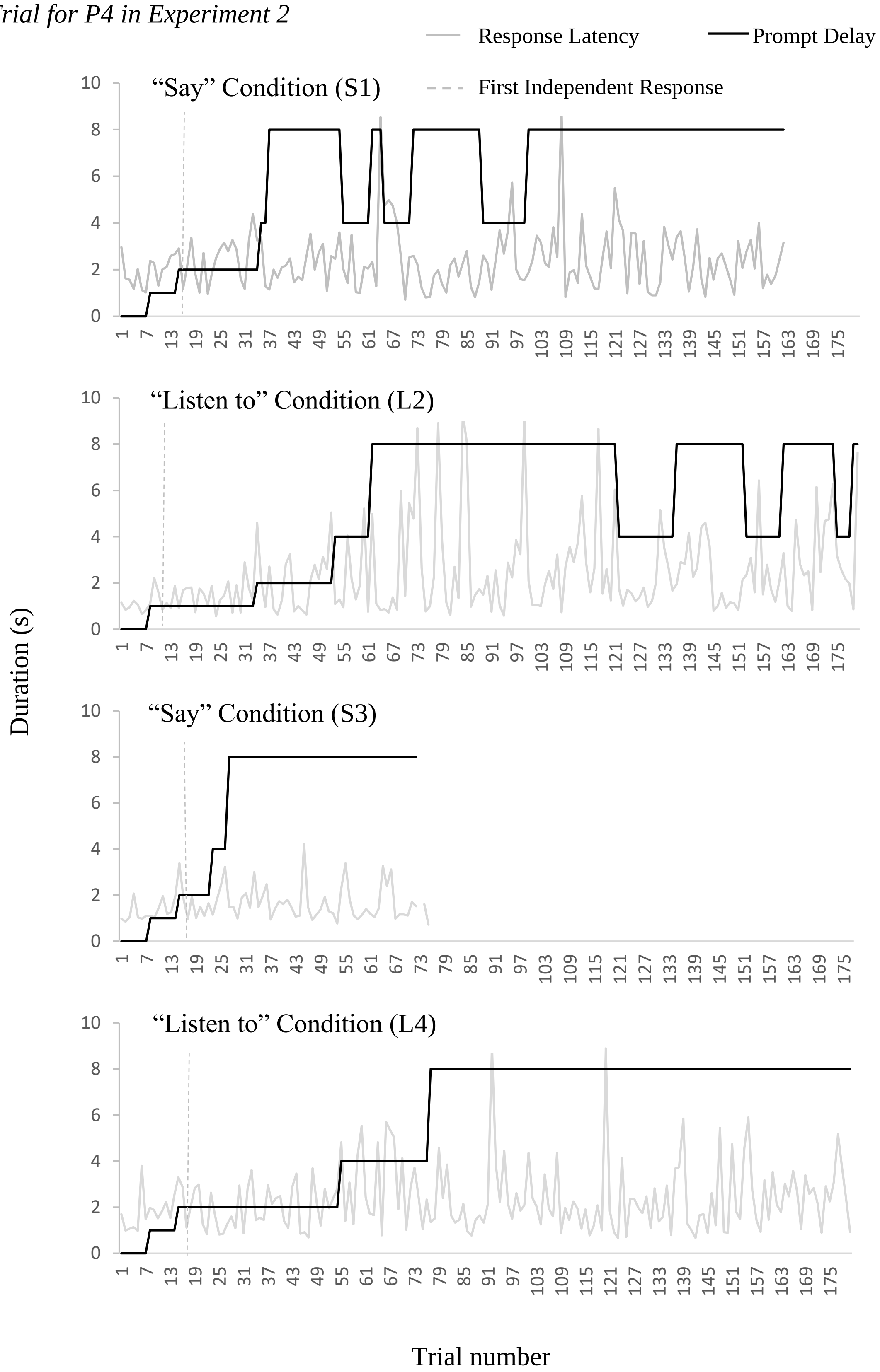
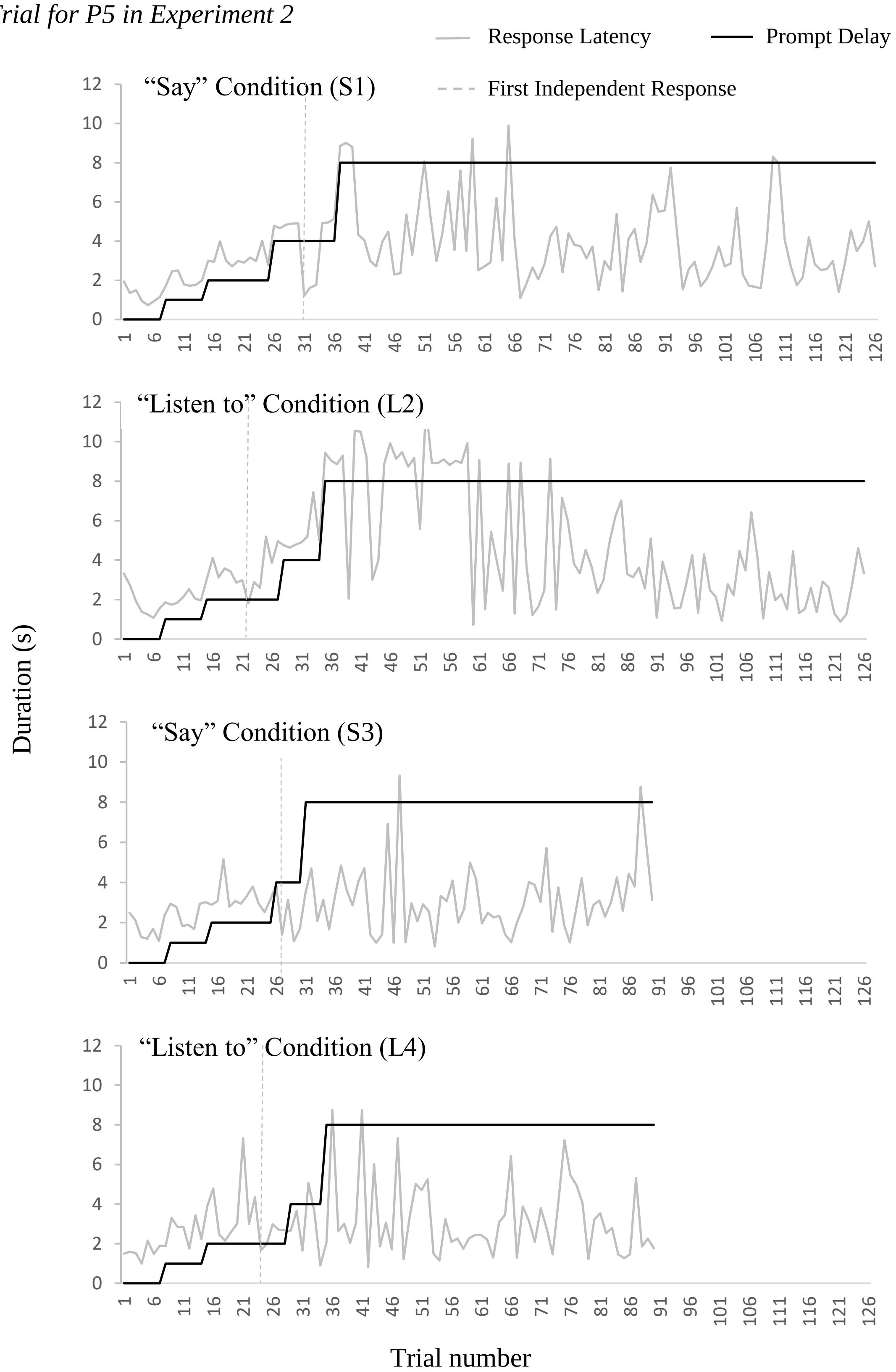


Figure 20

Point of Transfer of Stimulus Control, Response Latencies and Prompt Delay per Trial for P5 in Experiment 2



delivered for trials leading up to the first independent correct response were similar in both experimental conditions for all participants. However, in the later trials, response latencies were shorter in the “say” conditions than in the “listen-to” conditions for four of the five participants. The transfer of stimulus control also tended to occur sooner or at the same time in the “listen-to” conditions than in the “say” conditions.

Table 10

Number of Trials to First Independent Correct Response in Experiment 2

Participant	First “say” condition	First “listen-to” condition	Second “say” condition	Second “listen-to” condition
P1	29	29	16	29
P2	18	18	13	15
P6	48	34	30	38
P4	16	11	16	17
P5	31	22	26	24

Discussion

The present findings indicated that the inclusion of DOR when teaching auditory-to-visual MTS was effective and more efficient than not including a DOR for four of the five participants (P1, P2, P6, and P4). It is interesting to note that these four participants were diagnosed with ASD. These four participants required fewer sessions to reach mastery criterion in the first presentation of the condition that included the use of a DOR as compared to the first presentation of the condition that did not include a DOR, regardless of condition order. This effect was replicated when the DRO was reintroduced. On the other hand, P5 (TD) required more sessions in the first condition, which was a “say” condition, than in the second condition, which was a “listen-to” condition. However, when the “say” condition was reintroduced, he met mastery criterion in fewer sessions than in the second condition (first ‘listen-to” condition). When the “listen-to” condition was reintroduced, he required the same number of sessions to meet mastery criterion in that condition as in the third condition (“say” condition).

However, results of other measures were less inconsistent. There were fewer errors associated with the initial “say” conditions compared to the “listen-to” conditions for only three (P1, P6, & P4) of the five participants and this effect was replicated with the reintroduction of each experimental condition. In addition, the transfer of stimulus control from the prompt to the auditory sample (i.e., number of trials to the first independent correct response) occurred at the same time or sooner in the “listen-to” conditions than in the “say” conditions (opposite to the research hypothesis), more often than not. When the transfer of stimulus control occurred sooner in the “say” conditions, the difference in the number of trials compared to when it occurred in the “listen-to” condition was small. Lastly, response latencies, from when the prompt was presented, for the trials leading up to the first independent response were similar in both conditions for all participants. However, overall shorter and less varied response latencies were seen for trials after the first independent correct response in the “say” conditions as opposed to the “listen-to” conditions for P1, P2 and P4, suggesting more fluent and accurate responding after initial learning when a DOR was included in the teaching procedure, at least for three of the five participants.

Collectively, the results indicate that the DOR resulted in more efficient learning of the relations defined by each auditory-to-visual MTS task, at least for children with ASD. The inclusion of a DOR, which required participants to repeat the sample prior to the trial, ensured that the participants attended to the sample presented and this may have contributed to a more efficient teaching procedure compared to a procedure that did not require one (Vedora et al., 2017; Green, 2001).

That is, the inclusion of the DOR, despite not sharing any similar features to the visual comparisons, may have enhanced learning by requiring that the participants engage in active responding in the form of repeating the sample. Given that the sample is fleeting, the additional requirement to repeat the sample, in comparison to when the learner is just required to listen to the sample, may have led to an increased focus on the distinctive features of the sample, which in turn may have strengthened the association between the sample stimulus and the comparison and allowed the child to achieve mastery in the auditory-to-visual MTS tasks sooner.

The present study showed the procedure of including a DOR in the form of verbal repetition of the sample can be effective and more efficient in achieving mastery when the participants can fluently and accurately repeat words. All participants received the maximum score possible on Group 1, 2 and 3 of the EESA and thus have a relatively established echoic repertoire and were able to repeat accurately 1-, 2- or 3-syllable words or phrases. In addition, all participants repeated the sample in the 2 s time frame on at least 98% of the trials, and most were able to repeat the samples fluently and accurately. When the participants did not repeat the sample within the 2 s window, they appeared to have been distracted and they repeated it with sufficient accuracy on the second presentation of the trial. It was also noted that when a participant made an error with the articulation of the sample, (e.g., an incorrect consonant), the response was recognisable and distinct from the other two samples.

In contrast, Carp et al. (2015) and Fisher et al. (2019) found that a procedure that include a DOR requirement when teaching an auditory-to-visual MTS task was not as effective when the participants were unable to fluently or accurately repeat words. Carp et al. (2015) and Vedora et al. (2017) also returned mixed results in that the inclusion of a DOR in a teaching procedure was not always more efficient compared to the procedure without the inclusion of a DOR. In the Carp et al. (2015) study, the ability of both participants to repeat words accurately and fluently was not formally assessed and one participant was less accurate and fluent and took longer to repeat the auditory sample presented compared to the other participant. This participant met criterion in the condition that did not require him to repeat the sample sooner than in the condition that required him to repeat the sample. Therefore, the inclusion of a DOR that required participants to repeat the sample when they do not have the ability to repeat words accurately and fluently may have increased response effort too much to the point that it hindered learning. For the participant who was able to accurately and fluently repeat words, the requirement to repeat the sample as part of the MTS task resulted in quicker and accurate responding.

In the Vedora et al., (2017) study, one of the two participants demonstrated position biases in the no-DOR conditions. Specifically, he demonstrated specific error patterns when selecting a comparison which suggests faulty stimulus control. That is, the selection of a comparison was under the control of the position of the comparison and not the auditory sample. This error pattern, however, did not persist under the DOR conditions. He met mastery criterion sooner in the DOR condition than in the no-DOR condition during the first evaluation and in the second evaluation met criterion sooner in the no-DOR condition than in the DOR condition. The second participant also demonstrated position bias in the no-DOR condition which did not persist in the DOR condition. He also met criterion sooner in the DOR condition than in the no-DOR condition in the first evaluation but withdrew from the study before meeting mastery criterion in both conditions in the second evaluation. This suggests that the DOR may have enhanced stimulus control and strengthened the relationship between the sample and the correct comparison. The results of the present study suggest that none of the participants who took part in the study presented with position biases or faulty stimulus control when learning these auditory-to-visual MTS tasks. In addition, for children with ASD, results showed consistent benefit of a DOR on learning efficiency in an auditory-to-visual MTS task across a larger number of participants and with replication of the effect for each of those participants.

The transfer of stimulus control from the prompt to the auditory sample did not occur sooner in the "say" conditions when compared to the "listen-to" conditions which was opposite to what was hypothesized. The inclusion of a DOR in the teaching procedure did not result in quicker transfer of stimulus control but fewer sessions to criterion for four of the five participants and shorter response latencies for three of the five participants suggest that the inclusion of a DOR may still have enhanced stimulus control and strengthened the relation between the sample and the comparison after initial learning.

As in Experiment 1, P4 received different stimulus sets where the differences between the comparisons were more saliant compared to the stimulus sets used for the other four participants. The change in procedure was made without having first tried the stimulus sets that comprising of similar cartoon characters that were used for all other participants. It was assumed that the similarity between the stimulus sets used in Experiment 1 and Experiment 2 meant that P4 would have found learning difficult for the stimulus sets in Experiment 2 given that he failed to meet mastery criterion on all four of the stimulus sets used in Experiment 1. The comparison stimulus set used for P4 was to reduce the risk of increasing the time spent learning and the likelihood of disruptive behaviours including attempts at escaping the task when tasks are too difficult or when rate of reinforcement is low (i.e., too many errors made; Heckaman et al., 1998). It might have been worthwhile to have used the same stimulus sets the other participants received in Expierment 2 to see if failure to master the original sets of comparisons in Experiment 1 is attributed to not having discriminated between the samples.

In conclusion, the results of the study support the inclusion of a DOR with learners who demonstrate the ability to accurately and fluently repeat spoken words when teaching auditory-to-visual MTS tasks to children with ASD. In general, the inclusion of a DOR increases learning efficiency as measured by number of sessions to criterion and more fluent and accurate responding in the later stage of learning as indicated by lesser variance in scores in later sessions and shorter response latencies when independent correct responses were occurring. The DOR does not appear to benefit the initial stage of learning, where the relation between the sample and comparisons in the auditory-to-visual MTS task is first established. However, the learning pattern of P5 (TD) differed slightly from the other children in which the inclusion of a DOR did not always result in more efficient learning as measured by the number of sessions to criterion. The limitations of the study and further directions and clinical implications of the findings will be consideredin the General Discussion (Chapter 4).

Chapter 4: General Discussion

The results of the present studies provide support for the inclusion of teaching procedures and prompting methods that facilitate the attending to the auditory sample presented and the scanning and attending to pertinent features of the comparison stimuli, both which are crucial when learning auditory-to-visual MTS tasks. Despite this, there are several limitations and considerations for future research and clinical application that should be noted.

A limitation of the experiments was that a preference or reinforcer assessment was not conducted at the start of the studies, nor was either one conducted on a regular basis (e.g., at the start of each experimental session) due to time constraints (DeLeon & Iwata, 1996). Rather, advice from parents regarding foods that might function as reinforcers was sought. Experimental sessions were conducted at least three times per week either before or after school and around therapy commitments and after school activities. There was variability in responding in the later trials of each session or as the prompt was faded especially for P3 in Experiment 1 that suggested that learning was not robust. Although the tangible used appeared to be a preferred item, it might not be potent enough and this might have accounted for some of the variability. Due to the larger number of sessions, P3 may have experience satiation and the potency of the tangible might not be adequate. Sessions continued as designed to hold constant the environmental factors and rewards used across all conditions in both experiments to allow for the assessment of the type of prompts used in Experiment 1.

In both studies, each experimental block consisted of 18 trials which is more trials than that included in most previous studies. The number of trials included in each session, in the previous studies outlined above, ranged between 9 and 18.

Vedora et al. (2016) was the only study that also included 18 trials in an experimental block. In the Carp et al. (2012) study, reducing the number of trials per experimental block from 16 to 8 for one participant resulted in the participant successfully learning the relations. The inclusion of 18 trials in both Experiment 1 and Experiment 2 was to ensure a balanced design where the comparisons are positioned equal number of times on the left, middle and right and the sample is presented six times each and paired with the comparison on the left, middle and right an equal number of times (i.e., twice). Using a larger number of trials per block also allows for the prompt level to be increased at least twice and, hence, faded quicker if no errors were made in an experimental session. However, a larger number of trials may also lead to satiation and inattentiveness, which may account for the outliers (i.e., prompted correct responses) in the later trials. The results of the current experiments provide support that the use of a picture-prompt and the inclusion of a DOR enhanced stimulus control of the sample. Often, it seemed that the participants were distracted by something that occurred in their environment rather than the length of the sessions. They generally got through the block of trials relatively quickly (session duration varied between 4 - 8 min). The strict mastery criterion of at least 17 out of 18 trials on three consecutive sessions also demonstrated stimulus control by the sample stimuli. Therefore, in spite of using a relatively larger number of trials within a block, the teaching procedures used were effective in teaching auditory-to-visual MTS tasks to children with ASD.

The prompt fading procedures in both studies included the use of five prompt delays: 0.001, 1, 2, 4 and 8 s with 0.001 s timing resolution and the use of a prompt delay of 8 s may have result in a weakened relation between the auditory sample and the corresponding comparison. The relationship between the auditory sample and the correct comparison is especially important given that the auditory sample is fleeting (i.e., once it is presented, participants are unable to refer back to it). The inclusion of a time delay of 8 s is to avoid prompt dependency. However, more often than not, independent and correct responding often occurred before the prompt delay of 8 s was introduced across conditions in both experiments. Interestingly, Vedora and Barry (2016) used a progressive time delay with three prompt delays: 0, 2 and 4 s; which resulted in the transfer of stimulus control that provides some support that a shorter prompt delay may be possible for transfer and maintenance of stimlus control. More research is needed to understand the how the length of the delay to a prompt affects the transfer of stimulus control.

A non-differentiated reinforcement procedure was used in the two studies. That is, an edible was delivered for both prompted and unprompted correct responding (an edible was not delivered when an incorrect comparison was selected). Recent evaluations, however, have shown that the most efficient reinforcement procedure may vary across participants (Boudreau et al., 2015) and efficiency may also differ across skill type (Johnson et al., 2017). Johnson et al. (2017) performed an assessment of differentiated reinforcement procedures with non-differentiated reinforcement procedure to determine the most efficient procedure for three participants with ASD when learning auditory-to-visual MTS tasks. Specifically, the researchers manipulated the quality of the reinforcement (i.e., provided an edible and praise for unprompted correct responses and only praise for prompted correct response), the magnitude of the reinforcement (i.e., provided an edible and praise for unprompted correct responses and 1/8 of the edible and praise for prompted correct responses) and schedule of reinforcement (i.e., provided an edible and praise on every unprompted correct responses and every third prompted correct response).

They found that manipulation of the quality of reinforcement was the most efficient when teaching auditory-to-visual MTS tasks but was not always the most efficient when teaching labelling and responding to questions. It should also be noted that the undifferentiated reinforcement procedure was not found to be the least efficient of the four procedures but rather produced similar rates of learning as the procedures that manipulated the magnitude of the reinforcement and the schedule of reinforcement. A differentiated reinforcement procedure might contribute to more efficient learning and prevent development of prompt dependency (i.e., a phenomenon where a learner waits for a prompt). The results from both studies do not seem to support prompt dependency with the exception of the two conditions where P2 and P5 failed to master in Experiment 1. When a picture-prompt was introduced to teach the same arbitrary relations, the participants did not rely on the prompts and mastered the relations. Although it does not seem that the use of undifferentiated reinforcement procedure resulted in prompt dependency, a differentiated reinforcement procedure may lead to quicker learning and prevent failure to reach the mastery criterion or possibly prompt dependency in other learners.

In addition, both studies were conducted using a purpose-written software and presented using a touchscreen computer. This controls for differences in the delivery of the auditory-to-visual MTS tasks by an instructor from trial-to-trial and between sessions. It also helps maintain procedural integrity although this was not formally assessed in both the studies. However, much consideration will need to be given when trying to apply the procedures in clinical settings. A block of 18 trials may not be as effective and efficient compared to a block of fewer trials when delivered by an instructor using flash cards. Following a trial sequence to ensure a balanced design and the manipulation of the materials will lengthen the duration of the sessions and the longer inter-trial interval may lead to a lower rate of reinforcement and, hence, inattentiveness and satiation.

When applying these procedures in clinical settings, in particular, the positioning of the picture-prompt and the placement of the comparisons might require further research. In Experiment 1, the picture-prompt was displayed above the comparisons on a screen, so all four stimuli are presented at eye level. In clinical settings, comparison stimuli are often placed on the table and the picture-prompt is usually held up in front of the participant at eye-level as in the studies conducted by Carp et al. (2012) and Fisher et al. (2007). It is not clear if not presenting the comparison stimuli and the picture-prompt at eye-level will increase response effort and hence weaken the relation between the auditory sample and the correct comparison. Further research could look at the different placement of the comparisons and the prompt, specifically, if comparisons should be laid out and how they should be laid out (e.g., sequentially in a specific order) on the table with the picture-prompt held up in front of the participant, if the picture-prompt should be laid out on the table and placed above the comparisons, or if the comparisons should be presented on a board and hence presented simultaneously in front of the participants and with the picture-prompt held up in front of them. The delay in the presentation of the comparisons, when manipulated on tabletop, after the delivery of the auditory sample may weaken the relation between the sample and the comparison and affect the efficiency of the procedure.

It should also be noted that the novelty of the use of a purpose-written software and a touchscreen computer to deliver the MTS tasks as opposed to delivering the task using flash cards on tabletop probably added a fun factor for the participants. They appeared eager to learn (i.e., often sitting and waiting at the table while the equipment and software was being set up). That is, none of the participants engaged in any behaviours in attempt to escape or delay the task. Parents of the participants also reported that the participants looked forward to each experimental session. Therefore, the use of a computerized program may have increased the motivation of the participants to engage in the task and learn the arbitrary relations. More research is needed to understand how if using technology affects motivation during MTS task in relation to children, particularly those with ASD.

Lastly, although the use of a picture-prompt in one of the procedures in Experiment 1 and the inclusion of an echoic response as a DOR in one of the procedures in Experiment 2 both appeared to increase response effort, results suggest that the increase in response effort with the use of a picture-prompt occasioned quicker transfer of stimulus control while the increase in response effort in the form of requiring an echoic response as a DOR occasioned, if anything, it does not enhance the transfer of stimulus control (at least in the initial comparison of the “say” and “listen to” experimental conditions). The inclusion of the echoic response, on the other hand, is an observing response that shares no similar features to the comparisons and thus indirectly affects the learning of the relations. It requires that participants have a fluent echoic repertoire (i.e., repeat words fluently and accurately). Previous research suggests procedures that include verbal repetition as a DOR are not as effective when the learners have difficulty imitating the sample presented. In other words, the procedure is not as effective when learners are not as fluent when providing an echoic response (i.e., a longer time to repeat the sample; Carp et al., 2015) or not as accurate (i.e., inability to repeat the required words/sounds; Fisher et al., 2019). Many children with ASD experience impairments in speech sound acquisition and have difficulty emitting verbal responses (Esch, Carr & Michael, 2005), therefore, including a DOR that requires learners to provide an echoic response may increase response effort and decrease the effectiveness and efficiency of the procedure for a large group of children with ASD for those who do not yet have an ability to repeat vocal words. In addition, the procedure is not appropriate for children who have not yet established an echoic repertoire (i.e., children with ASD without vocal speech) may find auditory-to-visual MTS tasks difficult to acquire. This is in line with basic research that recommends decreasing response effort at the start of teaching (Perone & Baron, 1980; Adair & Wright, 1976; Capehart, Viney & Hulicka, 1958).

In conclusion, the results of the present studies provide support for prompting methods, specifically a picture-prompt, that facilitates the scanning and attending to pertinent features of the comparison stimuli, and the inclusion of a DOR that facilitates the attending to the auditory sample presented in teaching procedures, both which are crucial when learning auditory-to-visual MTS tasks. The use of a balanced design, strict mastery criterion and a computerized program decreased the possibility of faulty stimulus control and ensured treatment integrity. Teaching procedures that require fewer sessions, and hence shorter durations, for children with ASD to learn these MTS relations and strong stimulus control will result in savings in time spent teaching children who find conditional discriminations difficult to acquire. This is imperative given that conditional discriminations are required to complete many daily-living tasks. Further research should consider the practical applications of the procedures used in Experiment 1 in clinical settings, explore the use of technology that may be more accessible to clinicians and learners to deliver auditory-to-visual MTS tasks, and other forms of DOR that may be effective at increasing the efficiency of procedures used to teach auditory-to-visual MTS tasks to children without vocal speech or do not have a fluent echoic repertoire. A preference and/or reinforcer assessment should be conducted at regular intervals to ensure the potency of the rewards used.

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