The effect of cue type on directive-following in children with moderate to severe autism spectrum disorder

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Abstract

For this study, 11 children with moderate to severe autism spectrum disorder (ASD) were given directives containing prepositions in three cue conditions: (a) spoken alone, (b) a short video clip along with spoken cues, and (c) a sequence of three graphic symbols accompanied by spoken cues. Participants followed directives significantly more accurately with the video clip than with spoken cues only, and significantly more accurately with spoken cues only relative to the sequence of graphic symbols. Results suggest that the short video clip along with spoken cues may be an optimal mode for enhancing learners' ability to follow directives containing prepositions. In addition, results reveal three statistically significant correlations between participants' preexisting skills and directive-following accuracy: a positive correlation between spoken preposition preassessment total score and accuracy in the spoken-alone condition; a positive correlation between spoken noun preassessment total score and accuracy in the video-clip condition; and a positive correlation between ASD severity and the need for repetition in the video-clip condition. Results also suggested that, for children with more severe ASD symptoms, the video clips require repetitions so that the relationships illustrated within it can gain more semantic salience. Implications for clinical practice and future research are discussed.

Keywords: Aided language; augmentative and alternative communication (AAC); augmented input; autism spectrum disorder; receptive language

Autism spectrum disorder (ASD), which occurs in an estimated 1 out of 54 children (Centers for Disease Control and Prevention, 2020), is characterized by persistent differences in social interaction as well as repetitive patterns of behavior (American Psychiatric Association, 2013). It is estimated that 30–50% of individuals with ASD present with little or no functional speech and may experience concurrent intellectual disability (Tager-Flusberg & Kasari, 2013; Prizant & Wetherby, 2005). Though many early language interventions for this population focus on expressive language, receptive language difficulties may be present as well, but are largely ignored in interventions (Dada et al., 2020; Hudry et al., 2010; Muller & Brady, 2016; Weismer et al., 2010). The receptive language skills of children with moderate to severe ASD are often characterized by over-representation of nouns, difficulty comprehending abstract language concepts such as prepositions, and difficulty understanding the rules governing language form (Shane et al., 2014; Swensen et al., 2007). Children with ASD and concurrent intellectual disability show greater weakness in sentence comprehension than would be expected due to their cognitive differences alone (Kover et al., 2014). Due to differences in communication and interaction, they may depend on context and routines to understand what is being said, rather than processing the structure and content of incoming linguistic input, particularly when language contains abstract concepts such as prepositions (Mechling & Hunnicutt, 2011; Prizant, 1983; Shane et al., 2014; Vicker, 2004).

One potential impact of these differences is difficulty comprehending spoken instructions that are ubiquitous in educational, vocational, and social settings. For instance, communication partners might describe the location or desired location of an object, or tell someone where to go (Egel et al.,1984; Glover et al., 1987), without the message being understood. Difficulty understanding directives can have a significant impact on behavioral and communicative functioning. Given that directive-following skills are critical for success both in and out of the classroom (Gill et al., 2003; Glover et al., 1987; Hicks et al., 2016), improved skills in this area would have far-reaching implications including increased independence, decreased communicative burden on the caregiver, as well as reduced communication breakdowns and frustration.

Research over the last several decades has identified augmentative and alternative communication (AAC) interventions as a promising means of improving functional communication in persons with ASD (Alzrayer, 2020; Gevarter et al., 2020; Holyfield et al., 2017; Muharib et al., 2019; Schlosser & Koul, 2015; Sigafoos, et al., 2014; Van der Meer & Rispoli, 2010). AAC approaches that augment spoken language with visual cues have been more successful than approaches that intensively target auditory skills (e.g., Mechling & Gustafson, 2008; Peterson, et al., 1995), likely because children with moderate to severe ASD have difficulties processing language (Quill, 1995). Visual supports are more successful than spoken supports alone because individuals with ASD often display strengths in detail-oriented visual capabilities and visual processing (Dakin & Frith, 2005; Samson et al., 2012; Quill, 1995) as well as exhibit a preference for visual input (Shane & Albert, 2008). Furthermore, visual information is relatively permanent (i.e., the individual can revisit the content more than once), unlike spoken language, which is transient over time (Shane et al., 2014). Beukelman and Garrett (1988) first suggested the term *augmented communication input* (subsequently used in this paper as “augmented input”) to describe supplementation of spoken language with visual supports presented via an AAC system. Augmented input is meant to enhance spoken messages and not replace verbal input (Wood et al., 1998). Research evidence suggests that augmented input has positive effects on language comprehension (Dada et al., 2020; Drager et al., 2010).

Traditional visual cues frequently used for augmented input involve graphic symbols or so-called language element cues (ECs). ECs are two-dimensional photographs or line drawings used to represent specific vocabulary, with each graphic symbol representing a particular item or concept (Shane & Weiss-Kapp, 2008). When sequenced into an EC string, the individual elements represent the grammatical parts of a sentence, with each graphic symbol signifying a single grammatical unit such as a noun, verb, or preposition. Strings of graphic symbols are organized into left-to-right sequences corresponding to spoken word order in sentences. ECs may be presented via low-tech printed displays (e.g., static communication board) or via static images on a screen (e.g., in a message window on an electronic AAC system). When using ECs as augmented input, the communication partner points to ECs simultaneously while talking to the child. For example: *Oh, {you YOU}* {*want WANT*} *the {red RED*} {*ball BALL*}. The ostensible goal of augmented input via ECs is to help the child learn language (Goossens', 1989).

While evidence suggests that using ECs may improve communication outcomes in single-word receptive vocabulary (Cafiero, 2001; Dada & Alant, 2009; Harris & Reichle, 2004; Wolff Heller et al., 1995), no studies to date have examined the impact of ECs on supporting phrase or sentence level comprehension (Allen et al., 2017; Sutton et al., 2002; Trudeau et al., 2010). This is surprising, given how ubiquitous ECs are in the clinical practice of augmented input. On theoretical grounds, the use of ECs to enhance sentence-level comprehension might be challenged. Though there is empirical support for using a single EC for requesting and labeling concrete entities such as people or objects, it is more difficult to represent abstract concepts (verbs, prepositions, adjectives) with graphic symbols (Schlosser & Sigafoos, 2002; Sutton, 2008; Sutton et al., 2010). Shane et al. (2014) have postulated that interpreting ECs relies to some extent on the same language processing mechanisms as spoken language. Even though augmented input via ECs provides visual information, some interpretation of syntax (word order) and semantic relationships is required to understand a sequence of ECs, such as those present in a directive. Children with moderate to severe ASD have particular difficulty interpreting semantics and syntax, so while an individual may know component symbols, knowing the individual elements in a directive does not guarantee their comprehension when they are combined to form a sentence (Boyer et al., 2012). For instance, if given dollhouse figurine toys with the directive *PUT-THE-BOY-BEHIND-THE-LAMP* represented as an EC sequence, an individual may already understand the words *boy, behind,* and *lamp,* but place the lamp behind the boy because they do not understand the meaning signified by the word order. ECs, despite being visual, do not explicitly show the relationships between or among the elements involved.

Shane and Weiss-Kapp (2008) proposed the use of scene cues (SCs) as a different type of visual cue to provide augmented input. SCs are images that portray relevant concepts and their relationships in context through pictorial forms. SCs may be dynamic (a short video clip) or static (still photograph). SCs can depict the directive in a concrete manner (Schlosser et al., 2013). Dynamic SCs are a core component of video modeling, but are not the same as video modeling, which is an entire intervention technique and always includes a model (i.e., self, peer) (Schlosser et al., 2013). Please consult Schlosser et al., 2013 for a complete discussion of the similarities and differences. The reasoning behind SC use is based on dual coding theory, which postulates that there are two systems that process cognitive information: the verbal/linguistic system and the nonverbal system (Harmon et al., 2014; Paivio, 1986; Yovetich & Young, 1988). Shane et al. (2014) propose that SCs are a more helpful visual cue type for learners with ASD than ECs, because SCs can be understood without reliance on the verbal/linguistic system. Unlike ECs, SCs make explicit the relationship among objects and agents of a directive, so the ability to interpret syntax and semantic relationships is not required. Thus, SCs may help learners compensate for difficulties in interpretation of spoken directives. They are also highly contextual, making them well-suited to personalized interventions that incorporate a learner's individual strengths and interests. Increasingly, the importance of individual differences leading to personalized interventions among children with ASD is being recognized (Lanou et al., 2012).

Initial evidence supports the hypothesis that SCs are effective in facilitating directive following. Two previous studies examined children and adolescents with ASD, varied levels of functioning, and difficulty with spoken comprehension. Participants were asked to follow directives containing prepositions when presented via speech alone and when augmented with SCs; accuracy was significantly higher in the augmented input condition (Remner et al., 2016; Schlosser et al., 2013). Shane et al. (2014) also postulated that, though SCs will result in better directive-following than ECs, use of ECs should result in an improvement in understanding over speech alone, because preferences for the visual modality are common in persons with ASD (Shane & Albert, 2008). The effects of ECs and SCs have not yet been directly compared, and there is no evidence to support or refute this hypothesis. Comparison of performance in EC and SC conditions therefore has the potential to advance our understanding of communication strategies in persons who have ASD and limited verbal comprehension skills.

In addition to comparing the effects of different types of cues on directive following, the current paper additionally explores relationships between participants' preexisting skills and dimensions of their performance (speed, degree of accuracy, amount of repetition required) in the directive-following task. For instance, imitation skills are often impaired in young children with ASD (Bartak et al., 1975) and have been linked to development of representational thought, symbolic functioning, as well as language (Dawson & Adams, 1984; Stone & Yoder, 2001); thus, a child with ASD who has relatively strong imitation skills might be expected to perform better on the directive-following task than a child with lower imitation skills. Furthermore, because following a dynamic SC essentially involves imitating motor actions seen in a short video clip, children with high imitation skills might be expected to respond better to dynamic SCs than those with low imitation skills (Schlosser et al., 2013). Another possible indicator of success for directive-following might be the individual's prior receptive identification, or lack thereof, of the nouns and prepositions involved in the task. It is conceivable that a child who can receptively identify nouns and prepositions would have more success in directive-following. Finally, nonverbal cognitive skills such as analysis and problem-solving skills unrelated to language may impact performance on the directive-following task; as a result, participants with higher nonverbal cognitive skills might be expected to demonstrate stronger performance than those with lower nonverbal cognitive skills.

In this study, background data on the preexisting skills of the participants, gathered before administration of the directive-following task, were analyzed in relation to dimensions of directive-following performance. Specifically, the analysis explored relationships between participants' performance on pre-assessment tasks of preposition knowledge, motor imitation, nonverbal cognitive, and match-to-sample skills as well as their speed, accuracy, and directive-repeating scores on the directive-following task. Identifying such relationships could provide preliminary insight about which cue types to use based on patterns in clients' baseline skills. This would be valuable given the considerable heterogeneity in persons with ASD, and the lack of guidelines for prescribing specific treatment methods for clients with different characteristics. Researchers have successfully found some ways to reliably distinguish babies who will develop ASD from those who will not, such as shorter durations of gaze to caregivers during an activity (Bhat et al., 2010) and slower learning of initiation of joint attention (Szatmari et al., 2016); however, there is sparse information available on what skill profile best matches a given treatment modality, for example, type of visual cue. In addition, there is limited research relating multi-dimensional performance factors (speed, degree of accuracy and whether directive-repeating was needed) on a directive-following task to performance on pre-assessment measures of imitation, preposition knowledge and match-to-sample skills. Identifying relationships between participants' preexisting skills and their performance on the directive-following task could indicate optimal augmented input strategies for different children with ASD. Thus, the purpose of this study was to (a) evaluate the effects of three cue types (spoken alone, dynamic SCs plus spoken, and ECs plus spoken) on the accuracy of directive-following in children with moderate-to-severe ASD and (b) explore correlations among relevant preexisting skills and directive-following outcomes. It was hypothesized that accuracy would be highest in the SC condition as this cue type was the most concrete, followed by the EC condition - which, though not as concrete, still provided a visual cue - and lowest in the spoken-alone condition

Method

Participants

A sample of 11 participants with ASD was recruited from patients being evaluated in an urban hospital in Massachusetts. Inclusion criteria were as follows: (a) a diagnosis of ASD by a developmental pediatrician; (b) a reported interest in electronic screen media based on the program's standard intake questionnaire; (c) chronological age between 4 and 10 years, based on medical record; (d) difficulty following spoken directives of one or more steps, based on intake questionnaire or parent report; (e) no history of systematic instruction with SCs, based on parent report, intake questionnaire; (f) no uncorrected vision or hearing problems, based on medical record; (g) no other comorbid medical condition or neurological damage; (i) a passing score on a screening of match-to-sample (MTS) skills; (j) confirmed severity of autism symptomatology based on the Childhood Autism Rating Scale 2 Standard Version Rating Booklet (CARS2-ST) (Schopler et al., 2010); and (k) confirmed presence of comorbid intellectual impairment based on the Matrices subtest of the Kaufman Brief Intelligence Test 2 (KBIT-2) (Kaufman & Kaufman, 2004).

CARS2-ST raw scores in this sample ranged from 34.5 to 43.5, with a mean of 38.7. For children of the included age range, a CARS2-ST total raw score between 30–36.5 indicates a mild-to-moderate level of behaviors related to autism, and a total raw score between 37–60 points indicates a severe level of behaviors related to autism (Schopler et al., 2010). KBIT-2 standard scores in this sample ranged from 40 to 55, with a mean standard score of 48.7. The ages of the participants ranged from 4;0 (years;months) to 9;9. Informed, written consent was obtained from the parents of all participants.

Setting

The study was carried out in the participants' homes, in an area with minimal distractions determined by the parent. Extraneous objects were removed from the area and attempts were made to minimize environmental noise. The first author, a certified speech-language pathologist with extensive experience serving children with ASD, served as the experimenter.

Research design

A within-subjects design was conducted to examine the effects of cue type on directive-following performance (accuracy, speed, and whether a repeated directive was needed). There were three cue conditions: spoken input alone (SPO), dynamic scene cue (SC), and element cue (EC). For a given participant, each set of directives (A, B, and C) was assigned to one of three conditions (see Table S1, Supplementary materials). To control for possible order effects, a Latin Square was created, such that each condition and each set of directives occurred once in each column and once in each row (Richardson, 2018), which resulted in six possible orders (see Figure S1, Supplementary materials). The study was approved by the Institutional Review Board of Boston Children's Hospital.

Measures

There were three dependent measures: accuracy of 1 (*accurate*) or 0 (*inaccurate*); speed (seconds between examiner finishing presentation and participant ceasing hand contact with the object), and whether repetition of the directive was needed: 1 (*repeated directive*) or 0 (*non-repeated directive*). Speed was measured via stopwatch, from the end of the examiner's utterance to the time the child ceased hand contact with the object(s). A response was considered accurate if the participant positioned the object relative to the location specified by the preposition. For instance, if the participant, in response to the directive *Put the boy behind the box*, placed the figurine boy behind the box, it was scored as accurate; if the participant placed the figurine boy in any other position relative to the box (e.g., in front of, beside), it was scored as inaccurate. If the child failed to respond after one repetition of the directive (did not pick up the figurine), the item was scored as inaccurate. If the child began their response before 10 s, the response was coded as "non-repeated directive." If a participant did not begin responding within 10 s, or did not cease hand contact with the object(s) (e.g., picked up an object and held it without placing it somewhere), the directive was repeated, and the timer restarted; this was coded as "repeated directive."

Materials

Materials were an iPad2[1] and an iPhone6[1]; the Motor Imitation Scale (Stone et al., 1997); objects and photographs; directives; and visual cues for each condition.

iPad2 and iPhone

An iPad2 running iOS 10 was used to create and present the visual cues (described in the section, Visual Cues). The iPad2 was chosen because of its convenient size for table-top use and the built-in iOS Photos application. An iPhone 6 in airplane mode on a tripod, running iOS 11, was used to video-record all sessions for analysis.

Motor imitation scale

The Motor Imitation Scale was developed by Stone et al. (1997) as a research tool to assess motor imitation skills in young children with ASD. It was used in the current study as a pre-assessment measure of imitation skills.

Objects and photographs

Objects were utilized for both the pre-assessment and the experimental task. For the pre-assessment, the following objects were used: a Gumby[2] figurine, a Pokey[2] figurine, a dollhouse table, and a dollhouse bed. Objects specified by Stone et al. for use in the Motor Imitation Scale were a rattle, toy car, cup, dog figurine, hairbrush, small block, and string of play beads. For the experimental task, the same objects used by Schlosser et al. (2013) were included: a girl figurine, boy figurine, man figurine, a small plastic box a plastic spoon, a plastic bowl, and the following figurines from a dollhouse: a lamp, a chair, and a pillow. A digital photograph of each object was stored in the iOS photos. In terms of strings of element cues, screencaps of ECs in three-part sequences representing each directive (see Visual Cues section) were prepared and stored in the iOS Photos application.

Directives

The same 12 target sentence directives used in Schlosser et al. (2013) were used for this study. Each included the carrier phrase, *Put the…*; a character object (boy, girl, man); a spatial preposition (next to, on, under, beside); and a location object (box, bowl, lamp). These 12 directives were arranged into three sets of four (Sets A, B, and C) in a way that minimized the possibility that some sets could be developmentally easier than others; each set had a comparable average age of acquisition of prepositions (no greater than 5 months' difference among any of the sets) (see Table S1, Supplementary materials). Additionally, each set had the same mean number of syllables; two or three different character objects; three different spatial prepositions; and three different location objects (Schlosser et al., 2013). Each participant experienced each condition once, with four trials per condition.

Visual cues prepared for each condition

Visual cues were prepared for the EC condition and the scene cues condition; the spoken cue condition was without visual cues. The ECs were three-part sequences created via screenshot using the following graphic symbols from the Picture Communication Symbol set (Mayer-Johnson, Inc., 2002) *BOWL, BOY, BOX, GIRL, LAMP, MAN, NEXT-TO, ON, UNDER* (see Table S1, Supplementary materials). Dynamic SCs were short video clips that illustrated the directive, and were created via the iOS camera[1] app (Figure 1), with the frame showing the objects plus an actor's hand. Each video began with the target object in the middle of the screen in its starting positions. The hand came into the camera frame from the side, picked up the character object, and moved it in relation to the location object to show the spatial location concept represented by the preposition; then the actor released the character object and removed their hand, leaving the two objects in its ending spatial relationship for 2 s. The videos were recorded without sound.

SC / set A	SPO / set C	EC / set B
EC / set C	SC / set B	SPO / set A
SPO / set B	EC / set A	SC / set C

Figure 1. Latin Square Design with conditions and directive sets. SC: scene cues; EC: element cues; SPO: spoken input alone. 6 possible orders: 1. SC(A), SPO(C), EC(B) (2 participants). 2. EC(C), SC(B), SPO(A) (4 participants). 3. SPO(B), EC(A), SC(C) (2 participants). 4. SC(A), EC(C), SPO(B) (1 participant). 5. SPO(C), SC(B), EC(A) (1 participant). 6. EC(B), SPO(A), SC(C) (1 participant)

Procedures

All tasks were video-recorded. Before each task, the experimenter used speech, gesture, and/or physical means to focus the participant's attention on the table top (e.g., *Look*, pointing to table top, repositioning chair). During each task, the experimenter provided nonspecific feedback as well as visual supports to indicate expectations and the number of remaining trials (e.g., visual schedules, countdown boards). For instance, if needed, a participant was invited to choose a reward from a choice board, and then shown a visual schedule that indicated, "First 10 questions, then [reward]." Participants were given breaks if needed or requested. Additionally, a parent observed the session and was asked to tell the researcher if the child was expressing a refusal to participate; if so, the session was discontinued.

Pre-Assessments

Match-to-Sample (MTS) screening

Participants were first administered the MTS screening task that required the participant to choose an object corresponding to a photograph of that object shown by the examiner. Screening of MTS skills consisted of six trials, one for each target noun. Trials were preceded by two familiarization items, each involving three practice objects (plastic spoon, doll pillow and doll chair) in random order. The researcher tested for MTS skills by stating, *Give me this* or *match* (for participants whose parents indicated their child would better recognize that wording) while presenting a photo of the target object and one foil and holding out a hand expectantly. The participant had 10 s to respond. A response was scored as correct if the participant gave the target object to the examiner, and incorrect if the participant gave an incorrect object to the examiner. If a participant failed to respond, the directive was repeated once; if the participant responded correctly, the item was scored as correct. After a 5-s inter-trial interval (ITI), the researcher presented the successive six items. Nonspecific intermittent encouragement was provided to maintain participation, as noted above. A passing score on the screening was four out of six trials (66.67%) correct. A passing score verified that participants could match three-dimensional objects with pictures depicting those objects in two-dimensional form; thus, participants would likely have the potential to match two-dimensional objects shown in an SC with their three-dimensional counterparts presented at table top (Schlosser et al., 2013).

Spoken noun pre-assessment

Assessment of spoken noun knowledge consisted of six trials, one for each target noun to be used in the experimental task. Participants were presented with three target objects, in random order. The researcher tested receptive knowledge of object names by stating, *Give me the* ____ and holding out a hand expectantly. The participant had 10 s to respond. A response was scored as correct if the participant handed over the target object, and incorrect if the participant handed over another object. If a participant failed to respond, one repetition was permitted. After a 5-s ITI, the researcher presented the next item, until all six items were presented. Total possible score ranged from 0–6.

Spoken preposition pre-assessment

Assessment of spoken preposition knowledge consisted of eight trials, two for each target preposition used in the experimental task (behind, on, next to, under). For each preposition, one directive involved a Gumby[2] figurine and a dollhouse table, and the other a Pokey[2] figurine and a dollhouse chair (e.g., *Put Gumby behind the bed; Put Pokey behind the chair*). Directives were presented in random order. The experimenter placed the two involved objects (i.e., figurine, furniture) in front of the child from left to right but in random order, then presented the spoken directive. If the participant placed the figurine in the specified location within 10 s, that item was scored as correct; after an ITI of 5 s, the next item was presented. If the participant put the figurine in an incorrect location within 10 s, the response was scored as incorrect, and after an ITI of 5 s, the next item was presented. If the participant made no response within 10 s, or repetitively held or manipulated the object for longer than 10 s, one repetition was given. Nonspecific intermittent encouragement was provided to maintain participation. After a 5-s ITI the researcher presented the next item, until all eight items were presented. Total possible score ranged from 0–8.

Imitation skills assessment

Each participant's motor imitation skills were assessed with the Motor Imitation Scale. The participant was seated at a table top. The experimenter modeled each of the 16-single-step actions and said, *Now you do it!* or *Your turn!* Three trials for each item were permitted; each was scored as Pass (2), Emerge (1), or Fail (0) according to the scoring guidelines for each item; the participant's best response for each item was scored and summed to yield the total score, which could range from 0–32 (Stone, 2015).

Experimental task

Following completion of the previously described pre-assessment tasks, the main directive-following task was administered, yielding data on the following variables: speed on the directive-following task (average speed across all trials of that cue type), accuracy on the directive-following task (total score 0–4 in each cue condition), and directive-repeating, i.e., whether a repetition of the directive was needed on the directive-following task (total score 0–4 in each cue condition). Participants were administered the directive-following task at the table top. Beforehand, the experimenter used speech, gesture, and/or physical means to focus the participant's attention on the table top (e.g., *Look*, pointing to table top, repositioning chair). During the task, the researcher provided nonspecific feedback as well as visual supports to indicate expectations and the number of remaining trials as needed (i.e., visual schedules, countdown boards). For instance, if needed, a participant was invited to choose a reward from a choice board, and then shown a visual schedule that indicated, "First 10 questions, then [reward]." For each directive, the researcher placed the relevant objects (character object, location object) from left to right in random order on the table in front of the participant, and focused the participant's attention by stating their name and gesturing toward the table top.

Spoken-Alone (SPO) condition

The researcher spoke the directive aloud while showing the participant a blank screen on the iPad. The blank screen controlled for possible effects of the iPad's presence in the two visual cue conditions.

Dynamic scene cue plus spoken (SC) condition

The researcher spoke the directive aloud while presenting a dynamic scene cue on the iPad.

Element cue plus spoken (EC) condition

The researcher spoke the directive aloud while presenting one image of the three applicable element cues in a row (i.e., character object, preposition, location object) on the iPad, pointing to each element cue while saying the spoken words. The iPad was always shown in a horizontal orientation. The researcher began timing upon finishing presentation. The participant had 10 s to carry out the directive. If the participant placed the figurine in the specified location within 10 s, that item was scored as correct and non-repeated; after a 5-s ITI, the next item was presented. If the participant put the figurine in an incorrect location within 10 s, the response was scored as incorrect and non-repeated, and after an inter-trial interval of 5 s, the next item was presented. If the participant made no response within 10 s, or repetitively held or manipulated the object for longer, the directive (with blank screen, SC, or EC) was repeated once and the item was scored as repeated. If the participant continued to respond incorrectly after the repeated directive, the item was scored as incorrect and repeated. Other than nonspecific intermittent encouragement, to maintain participation, no feedback was provided.

Data analysis

Individual total scores for accuracy (total score 0–4 in each cue condition) and directive-repeating (total score 0–4 in each cue condition) were also calculated. Mean speed (averaged over four trials) in each of the three conditions (SC, EC, and SPO) was calculated as well for 10 of the 11 participants (a video malfunction resulted in the inability to confirm speed data for one participant). Additionally, total scores were calculated for each of the pre-assessments: noun knowledge (total score of 0–6), preposition knowledge (total score of 0–8), MTS (total score of 0–6), imitation (total score of 0–32), and nonverbal cognitive skills (total possible standard score of 50–150). Because two of the outcomes measured (accuracy and directive-repeating) were ordinal variables, and because of the small sample size, Friedman's ANOVAs were conducted to compare the effect of input conditions (spoken, scene cues, element cues) on three aspects of directive-following performance. Wilcoxon signed-rank tests were used to follow up the ANOVAs, with a Bonferroni correction (alpha = .017); to estimate effect sizes of significant findings, z-scores were converted into the effect size estimate r (Field, 2005; Rosenthal, 1991). Wilcoxon signed-rank tests are appropriate when the data is ordinal or when there is a small sample size (Field, 2005). Additionally, exploratory correlation matrices (Spearman's rank correlation coefficient) were run to determine whether pre-assessment skills were related to directive-following performance. Based on the directive-following task, the dependent variables were: speed (average speed across all trials of that cue type), degree of accuracy (total score 0–4 in each cue condition) and directive-repeating (total score 0–4 in each cue condition).

Inter-observer agreement and procedural integrity

An independent observer (speech-language pathologist unfamiliar with the specific research aims of this study) reviewed videos of 36% of the sessions (selected randomly). This observer scored participants' performance on the directive-following task in terms of accuracy and directive-repeating, which were then compared to those of the experimenter.

Inter-observer agreement (IOA) was calculated by dividing the number of agreements by the number of agreements plus disagreements, multiplied by 100. IOA for accuracy ranged from 92% to 100% with a mean of 98%, and IOA for directive-repeating ranged from 92% to 100% with a mean of 98%.

Additionally, the observer assessed procedural integrity for each of the following procedural steps (Peterson et al., 1982; Schlosser & Sigafoos, 2002): (a) place objects in random order on the table top, (b) focus participant's attention via gestural and simple spoken methods (e.g., *Look*), (c) say spoken directive or *Do this* while presenting the iPad with correct cue format (blank screen, SC or EC) on screen, (d) provide 10 s for the participant to respond and 5-s ITI, (e) repeat presentation if no response, (f) provide nonspecific intermittent feedback, (g) provide count-down board as needed to sustain participant motivation. A percentage of steps followed correctly was calculated by dividing the number of steps followed correctly by the total number of steps, multiplied by 100. Procedural integrity ranged from 86% to 100% with a mean of 96%.

Results

Descriptive statistics are summarized in Table 1. Regarding accuracy, the SPO condition yielded a mean of 1 (25% accuracy; range: 0–3 correct out of 4) and a mean rank of 1.86; the SC condition yielded a mean of 2.91 (72.8% accuracy; range: 1–4 correct out of 4) and a mean rank of 2.95; and the EC condition resulted in a mean of 0 (0% accuracy; no participants got any items correct in the EC condition) and a mean rank of 1.18 (see Table 1). The mean ranks of the conditions differed significantly, $\chi^2(2) = 19.846$, $p < .001$. Post-hoc comparisons of the mean ranks using the Wilcoxon Signed Ranks Test indicated three statistically significant comparisons: participants followed directives significantly more accurately ($p = .003$; $Z = -2.968$ based on negative ranks; $r = -.633$) in the SC condition ($Mdn = 3.000$, $SD = 1.221$) than in the EC condition ($Mdn = 0$, $SD = 0$); participants followed directives significantly more accurately ($p = .004$; $Z = -2.844$ based on positive ranks; $r = -.606$) in the SC condition ($Mdn = 3.000$, $SD = 1.221$) than in the SPO condition ($Mdn = 1.000$, $SD = 1.000$); and participants followed directives significantly more accurately ($p = .016$; $Z = -2.414$ based on negative ranks; $r = -.515$) in the SPO condition ($Mdn = 1.000$, $SD = 1.000$) than in the EC condition ($M = 0.000$, $SD = 0.000$).

With respect to directive-repeating, the SPO condition yielded a mean of 1.09 (27.3% directive-repeating, range: 0–3) and a mean rank of 1.73; the SC condition yielded a mean of 1.09 (27.3% repeated; range: 0–3) and a mean rank of 1.73; and the EC condition yielded a mean of 2.27 (56.8% repeated; range: 0–4) and a mean rank of 2.55 (see Table 1). The mean ranks of the conditions were significantly different, $\chi^2(2) = 6.750$, $p = .034$. Post-hoc comparisons of the mean ranks using the Wilcoxon Signed Ranks Test indicated one marginally statistically significant comparison when the Bonferroni correction was applied: participants required more directive-repeating in the EC condition ($Mdn = 2$, $SD = 1.49$) than the SPO condition ($Mdn = 1$, $SD = 1.14$) ($p = .018$; $Z = -2.372$ based on negative ranks; $r = -.506$). There was no significant difference in directive-repeating required between the SC and SPO conditions ($p = .854$; $Z = -.184$ based on negative ranks) or between the SC and EC conditions ($p = .080$; $Z = -1.750$ based on positive ranks).

Table 1. Descriptive statistics.

Variable	*N*	*Range*	*M*	*Mdn*	*SD*
Noun screening	11	0–6	3/6 (50% correct)	3/6	2.236
Preposition screening	11	0–5	2/8 (25% correct)	2/8	1.549
MTS	11	4–6	6 (100% correct)	6/6	0.674
MIS	11	4–32	23.090/32 (72% correct)	26/32	9.104
KBIT-2 Matrices (standard scores)	11	40–55	48.73	52	6.182
CARS2-ST (T-score)	11	44–56	49.36	49	3.585
Total repeated directive	11	2–11	4.27/12	3/12	2.724
Total correct	11	1–7	3.91/12	4/12	1.758
Mean speed	10	3.52–8.51	6.418 s	6.535 s	1.744 s
SPO-directive-repeating	11	0–3	1.09/4 (27.25% repeated)	1/4	1.136
SPO-speed	10	3.48–10.00	5.819 s	5.33 s	2.120 s
SPO-accuracy	11	0–3	1/4 (25% correct)	1/4	1
SC-directive-repeating	11	0–3	1.09/4 (27.25% repeated)	1/4	1.136
SC-speed	10	4.12–9.58	6.279 s	6.385 s	1.76197 s
SC-accuracy	11	1–4	2.910/4 (72.8% correct)	3/4	1.221
EC-directive-repeating	11	0–4	2.27/4 (56.75% repeated)	2/4	1.489
EC-speed	10	2.42–10	7.158 s	7.158 s	2.71502 s
EC-accuracy	11	0	0/4 (0% correct)	0/4	0

MTS: match-to-sample score; MIS: Motor Imitation Scale; KBIT-2: Kaufman Brief Intelligence Test 2; Intelligence Test; CARS2-ST: Childhood Autism Rating Scale 2, Standard Rating booklet; SPO: spoken condition; SC: scene cue condition; EC: element cue condition.

Regarding speed, the SPO condition yielded a mean of 5.82 s and a mean rank of 1.45; the SC condition yielded a mean of 6.28 s and a mean rank of 2.20; and the EC condition yielded a mean of 7.16 s and a mean rank of 2.35. The mean ranks of the conditions were not significantly different, $\chi^2(2) = 4.769$, $p = .092$.

With respect to relationships between participants' preexisting skills and their performance on the directive-following task, three statistically significant correlations (see Table 2) were found: a positive correlation between spoken preposition preassessment total score and accuracy in the SPO condition, $r = .683$, p (two-tailed) $< .05$; a positive correlation between spoken noun preassessment total score and accuracy in the SC condition, $r = .615$, p (two-tailed) $< .05$; and a positive correlation between CARS2-ST score and directive-repeating in the SC condition, $r = .653$, p (two-tailed) $< .05$. As there was a floor effect regarding accuracy in the EC condition, correlations involving EC accuracy were not calculated.

Table 2. Correlation coefficients (spearman's rho).

Dependent variable	Match-to-sample	Spoken noun knowledge	Spoken preposition knowledge	Imitation	Nonverbal cognitive	CARS
SPO-Accuracy (*n* = 11)	−.101	.205	.683*	.316	.363	−.413
SPO-Directive-repeating (*n* = 11)	−.037	−.073	−.169	−.503	−.173	.332
SPO-Speed (*n* = 10)	−.225	−.227	−.485	−.334	−.152	.037
SC-Accuracy (*n* = 11)	.046	.615*	.343	.282	−.355	−.483
SC-Directive-repeating (*n* = 11)	.143	−.534	−.342	−.589	.262	.653*
SC-Speed (*n* = 10)	.045	−.591	−.372	−.375	.379	.263
EC-Directive-repeating (*n* = 11)	−.249	.294	.208	−.103	−.234	−.082
EC-Speed (*n* = 10)	−.417	−.191	−.284	−.238	−.034	.232

SPO: spoken condition; SC: scene cue condition; EC: element cue condition.
*$p > .05$; 2-tailed.

Discussion

The participants in this study exhibited significantly higher directive-following accuracy in the SC condition than in the SPO condition. This finding supports the hypothesis that SCs enhance directive-following in children with ASD. Additionally, it corroborates the findings of Remner et al. (2016) and Schlosser et al. (2013), where both studies found significant improvement in directive-following in the SC condition vs. the SPO condition. However, unlike prior studies, the current study adds an EC condition to the comparison. Interestingly, the results for this group of participants indicate that ECs did not improve accuracy of directive-following beyond speech alone (SPO). In fact, participants exhibited significantly *less* accuracy in the EC condition than in the SPO condition - contrary to our hypothesis - and participants required significantly *more* directive-repeating in the EC condition than in the SPO condition. These results do not support the commonly held belief that the ECs would have some benefit over a spoken-only presentation. These are interesting findings in light of the broad clinical acceptance and use of ECs as augmented input that are thought to generally improve the comprehension of persons with disabilities (e.g., depicting news events in symbols that complement text).

Allen et al. (2017), in a systematic review of augmented input for persons with developmental disabilities who use AAC, found that, though there is evidence that augmented input is effective in improving some communication outcomes (e.g., receptive and expressive vocabulary, expressive syntax), there is no evidence for improved or not improved comprehension of phrase- or sentence-level material. The current finding suggests that merely presenting ECs along with spoken input is not sufficient to improve directive-following accuracy beyond spoken input alone in this sample of children with ASD.

The question remains as to why ECs do not improve directive-following accuracy beyond spoken language alone. One possible explanation is that some of the component symbols may be difficult for children with ASD to comprehend. According to Sutton et al. (2010) some symbols are naturally easier to represent in pictorial form than others. For instance, noun symbols are more iconic compared to other parts of speech, including prepositions (Bloomberg et al., 1990; Schlosser & Sigafoos, 2002); thus, nouns may dominate symbol vocabularies (Sutton et al., 2002). As previously noted, children with ASD in particular have difficulty understanding abstract concepts like prepositions (Swensen et al., 2007). For example, for the spoken directive "put the man behind the lamp," a child might more readily understand the symbol for "man" and the symbol for "lamp" than the symbol for "behind," which would affect their ability to carry out that directive correctly; however, even if a child *does* understand the concept of "behind," their integration of the meaning of the sentence as a whole may be limited. In typically developing children, graphic symbol sequences are not automatically interpreted as sentences until around six years (Boyer et al., 2012), and evidence suggests that children with ASD show reduced syntax skills when compared to groups matched for receptive vocabulary and nonverbal intelligence (Eigsti et al., 2007). Furthermore, children with moderate to severe ASD may be using an AAC system while simultaneously learning language, which changes the language learning experience (Sutton, 2008) and may put them at risk for both receptive and expressive grammar difficulties (Binger & Light, 2008).

Regarding relationships among participants' preexisting skills and their performance on the directive-following task, it is not surprising that higher accuracy in pre-assessment spoken comprehension of prepositions was positively associated with higher accuracy in the SPO condition. In order to follow directives in the SPO condition accurately, participants would need to comprehend spoken prepositions. The two other significant positive associations found shed light on the possible mechanism by which SCs may improve directive-following accuracy. First, increased spoken noun comprehension was associated with increased accuracy in the SC condition. So, participants' having a higher receptive vocabulary knowledge of the objects in the study was associated with higher accuracy in the SC condition. When an individual begins to comprehend the meaning of a noun, they associate it with semantic features, and component meanings associated with that noun, such as a particular shape, function, or location (Jennings & Haynes, 2018); it follows, then, that learners with higher receptive vocabulary knowledge have more semantic feature knowledge. In the current study, higher receptive vocabulary was associated with greater directive-following accuracy in the SC condition. Perhaps SCs work to activate and tap into a child's semantic feature knowledge by illustrating the relationships among sentence components. If so, we can postulate that children who have greater receptive knowledge of the nouns involved will have more components of meaning that are activated, allowing them, in turn, to glean more information from the SC.

Second, higher CARS2-ST scores were associated with needing directive-repeating in the SC condition. In other words, participants with more severe ASD symptoms (i.e., higher CARS2-ST scores) were more likely to require directive-repeating in the SC condition. This finding might indicate that, for children with more severe ASD symptoms, the SC requires repetitions so that the relationships illustrated within it can gain more semantic salience.

Implications for practice

Although the current study was not a treatment study, results do have implications for the teaching of prepositions. In general, there is a lack of research on effective instructional methods for teaching prepositions to children with developmental disabilities (Hicks et al., 2011). Yet concept words describing directives/prepositions are used very frequently in classrooms (Bracken & Crawford, 2010), and it is important for safety and participation reasons that children are able to access these words (Hicks, et al., 2016; McCarthy et al., 2017). The ability to understand and use prepositions also enables students to provide explanations to others and to participate in conversations and play (Hicks et al., 2016). Children with ASD, in particular, need to understand the language of directives instead of performing in a rote manner (Vicker, 2004).

Historically, teachers and clinicians have used verbal and physical prompts, reinforcement, and repetition to teach prepositions. They have also used repeated model-test procedures in which exemplars are modeled (e.g., "This is behind"; This is not behind") and then probes are administered (Hicks et al., 2011). Hicks et al. (2016) found that direct instruction can be an efficient way to teach directive-following in children with developmental disabilities, although they noted that children with ASD may require more naturalistic and incidental contexts. Conceivably, structured exposure to SCs that portray prepositional directives within a naturalistic context (e.g., meal preparation and clean-up), could support learning of prepositions. SCs are less intrusive than verbal or physical prompts, and can be repeated as many times as needed. They can also be easily customized to a learner's individual needs and interests; there is evidence that stakeholders value teaching strategies which help learners show their strengths (Clark & Adams, 2020). Prior research suggests that dynamic SCs could have other advantages over modeling in situ; for instance, Learmonth et al. (2019) found that children with ASD had less difficulty completing a visuospatial task when provided touch screen instruction vs. live instruction. There is also evidence to suggest that learners with ASD have preferences for, and respond well to, instruction based in electronic screen media (Charlop-Christy et al., 2000; Shane & Albert, 2008; Ploog et al., 2013; Sherer et al., 2001).

Limitations and future directions

The current study is limited by a small sample size; thus it is important to be cautious when interpreting the correlation coefficient. Additionally, while Z scores were calculated when possible, the language measures are not standardized so as to allow comparison with similarly performing children. While such data could potentially provide clarity on the profiles of learners for whom SCs are useful, it is a well-established clinical reality that learners with moderate to severe ASD are difficult to test reliably (Kasari et al., 2013). Language measures in the current study were criterion-referenced and geared toward actual study tasks in order to ascertain participants' knowledge base relative to those tasks.

Another limitation is the floor effect observed in the EC condition; that is, none of this study's participants accurately followed any directives in the EC condition. While the higher accuracy in the SPO condition than the EC condition is an interesting finding in terms of augmented input, an alternative explanation for this finding is that the participants possibly did not understand the expectations of the task in the EC condition; that is, when shown the EC and told, *Do this*, they were expected to manipulate the objects on the table. That explanation seems unlikely, however, given that there were other conditions in which they manipulated the table top objects. Still, this concern could be addressed in future studies by adding 1–2 familiarization items to the EC condition (and other conditions), such that participants would see a correct response modeled before beginning the four EC test items. Additionally, it would be informative to add a pre-assessment regarding comprehension of single preposition symbols.

Finally, one might argue that SCs should not be considered a valid directive-following aid, reasoning that learners could perform accurately in the SC condition without having to comprehend language at all; that is, all that children had to do in the SC condition was copy the displayed action. Though the study clearly demonstrated that SCs improve directive-following, further research will be needed to determine whether the underlying mechanism is improved comprehension or language-free imitation. In addition, the current study did not obtain data on social validity, which would be important to gather in subsequent studies.

Further research is needed to examine the effects of SCs as a teaching tool in ongoing intervention; the current study is limited by being a one-time assessment with only four trials per condition. For instance, what would be the longer-term outcomes in preposition comprehension after repeated structured exposure to SCs? This could be investigated first through direct instruction and then in naturalistic contexts such as meal preparation, community navigation, or vocational tasks, perhaps as part of a larger video modeling intervention. Once a learner becomes proficient with instruction-following using SCs, could a teaching method be developed to help learners transition from understanding SCs to understanding ECs, or potentially to speech alone? Additionally, valuable information about the mechanisms by which SCs are effective could be gained by expanding the investigation to learners of various ages and levels of functioning, as well as to other syntactic relationships besides preposition knowledge.

Conclusion

Results of this study indicate that SCs enhanced directive-following involving prepositions within this group of children who had moderate to severe ASD and difficulty following spoken directives. Though further research is needed to determine the effect of intervention using SCs on the learning of spoken prepositions, simply enhancing directive-following through use of SCs in this population promises to have great value. To be able to follow directives more effectively has the potential to increase independence, decrease caregiver burden, decrease physical prompts, and reduce communication breakdowns and frustration. Children with moderate to severe ASD have typically had many years of parents and teachers using language to instruct language, yet without effectively learning language. We would argue that SCs offer an alternative: a potential visual foundation for learning important language concepts such as prepositions in the case of this study.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Author contributions

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Notes

1 iPad, iPhone, and iOS Camera app are products of Apple Computers Inc., Cupertino, CA, www.apple.com

2 Gumby and Pokey are products of Prema Toy Company.

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