Journal of
Applied Behavior Analysis

JOURNAL OF APPLIED BEHAVIOR ANALYSIS 2019, **9999,** 1–21 NUMBER 9999 ()

Teaching children with autism spectrum disorder to ask "where" questions using a speech-generating device

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Children with autism spectrum disorder (ASD) who have limited speech are often taught to communicate using a speech-generating device (SGD). We evaluated procedures for teaching a mand for information (i.e., *Where* is [item]?) using an interrupted behavior chain procedure. In Experiment 1, all participants (3 children with ASD who communicated using an SGD) acquired the target mand but transfer to a novel stimulus did not occur. In the second experiment, 2 participants were taught to approach alternative communication partners when the first partner did not provide the information. The second experiment also included procedures to test whether the responses were under the control of appropriate motivating operations (MOs). Generalization across communication partners occurred with both participants, but transfer across behavior chains with only 1 participant. The results of both experiments suggest that teaching multiple behavior chains and evaluating MO control may be necessary to establish generalized manding for information.

Key words: autism, behavior-chain interruption, mands for information, motivating operations, speech-generating device

Asking questions (e.g., "Where do you keep your spoons?") can be conceptualized as manding for information. Like other mands, mands for information are emitted primarily under the control of motivating operations (MOs)(Skinner, 1957; Sundberg, Loeb, Hale, & Eigenheer, 2002). As an example, a speaker may need a spoon to eat a highly preferred food (e.g., ice cream), but cannot find one. Asking the question, "Where do you keep your spoons?" may result in the provision of the desired information from a knowledgeable listener (e.g., "The spoons are in the top right drawer"), which in turn enables the speaker to access the spoon and eat the ice cream. In this example, the information (i.e., the answer provided by the listener) functions as conditioned reinforcement, deriving its reinforcing value from the association with the primary reinforcer, the ice cream. Being able to ask such questions and act upon the resulting information is important for social interactions, and perhaps essential for effective functioning across a range of environments (Brown, 1968; Ostryn & Wolf, 2011; Raulston et al., 2013).

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This study was supported by a Ph.D. Scholarship awarded to the first author from Victoria University of Wellington. The study was based in part of the first author's Ph.D. thesis. We acknowledge and thank the children, their families, and the school staff who participated in this study.

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doi: 10.1002/jaba.663

Children diagnosed with autism spectrum disorder (ASD) often present with limited manding repertories (Shafer, 1994), including manding for information (Raulston et al., 2013). Fortunately, there have been some successful demonstrations of teaching question-asking skills. Overall, there are at least 23 published studies that have focused on teaching mands for information to children with ASD (Lechago & Low, 2015). In a review of these studies, Lechago and Low (2015) concluded that various types of interruption strategies, such as the interrupted behavior-chain procedure, have been effectively used to teach "What?" and "Where?" question asking.

Endicott and Higbee (2007) evaluated the effects of an interrupted behavior-chain procedure for teaching two mands for information ("Where?" and "Who?"). The participants were four children diagnosed with ASD. Experimental sessions involved (a) giving brief access to a preferred item, (b) directing the participant away from the instructional area while the item was hidden, and (c) bringing the participant back to the instructional area and asking them to "Get [item]." At this point, participants were prompted to ask a question taking the form of "Where [item]?" All four children learned to emit the mand as a result of the intervention. Additionally, for two of the three participants, the mand transferred to situations in which a less-preferred item was missing, and also from the clinic to the home setting. Participants also successfully learned to ask, "Who has [item]?" when the item was in another person's possession.

In another relevant study, Lechago, Carr, Grow, Love, and Almason (2010) successfully employed an interrupted behavior-chain procedure and echoic prompts to teach three children with ASD to mand "Where?" and "Who?" Sessions involved presenting various activities (e.g., making a volcano, playing with a doll, eating ice cream) that were interrupted by hiding a needed item (e.g., spoon) or giving the item to someone else, so that the child could not continue the activity without manding for information. All three children learned to emit both the "Where?" and "Who?" mands for information for one behavior chain. Further, the mands generalized to the same item across establishing operations (EOs) (i.e., multiple behavior chains).

It is estimated that 30% percent of children diagnosed with ASD do not develop functional vocal speech repertoires (Anderson et al., 2007; Wodka, Mathy, & Kalb, 2013), and might therefore benefit from learning alternative communication modalities (Ganz, 2015). To date, approximately 30 studies have demonstrated effective procedures for teaching basic manding skills to children with ASD who are minimally vocal and learning to communicate using speech-generating devices (SGD) or other augmentative and alternative communication modalities (see Lorah, Parnell, Whitby, & Hantula, 2014; Schlosser & Koul, 2015; van der Meer & Rispoli, 2010 for reviews). However, relatively few studies have included children who had minimal vocal speech and who would, therefore, require an alternative communication modality (Lechago & Low, 2015; Raulston et al., 2013). Ostryn and Wolfe (2011) evaluated procedures for teaching the mand for information, "What's that?" to three young children with autism who used picture exchange as their primary communication modality. Intervention sessions consisted of the experimenter holding a bag that contained an unknown toy. Participants were taught to mand for information by pointing to a card with a pictorial representation of the mand "What's that?" and then point to the item. The experimenter also modeled the vocal response "What's that?" Mands resulted in the experimenter showing the participant the item and stating the item name (e.g., "It's a blue flashlight"). All participants acquired the pointing response quickly, and picture communication was faded within a few sessions for all three participants as they began to vocally emit the target response (or an approximation thereof). However, the researchers did not systematically evaluate whether the information (i.e., the answer to the "What's that?" question) functioned as a reinforcer for the participants, nor did they systematically evaluate the presence of a relevant MO. Thus, it is not clear whether the target response truly functioned as a mand for information.

To date, only two studies (Carnett & Ingvarsson, 2016; Shillingsburg, Marya, Bartlett, & Thompson, 2019) have evaluated teaching mands for information to children who communicate using an SGD. Carnett and Ingvarsson (2016) extended the findings of Ingvarsson and Hollobaugh (2010) by teaching an 11-year-old boy with a diagnosis of ASD to mand for answers to unknown questions. The intervention resulted in the acquisition of the mand, "I don't know, please tell me" when presented with unknown questions. Further, the participant acquired some of the intraverbal responses (i.e., the answers to the questions) as a result of being provided with the requested information. However, the transfer of the mand for information to novel unknown questions was limited. Shillingsburg et al. (2019) taught three children with ASD, who used an SGD to communicate, to mand for information in the form of "Who" and "Which" questions. Each participant showed differentiated responding across conditions in which the information was needed (establishing operation condition) versus conditions in which the information had already been provided (abolishing operation condition), indicating that the mands for information occurred under the appropriate control of motivating operations. Given the scarcity of literature on advanced mands with individuals who communicate using an SGD, additional research on mands for information with this population is warranted.

The purpose of the current study was to further evaluate procedures to teach mands for information to children with ASD who had minimal vocal speech and were learning to use an SGD. We conducted two experiments to evaluate procedures to teach three participants to ask for the location of a missing item. Experiment 1 evaluated procedures to teach the mand frame "Where is [item]" and transfer of the mand frame to novel stimuli. Experiment 2 focused on the extent to which the mands for information generalized to a different listener when the first listener did not provide the requested information, as well as transfer across different behavior chains. We also conducted posttests to evaluate whether the mands were under the appropriate control of MOs.

EXPERIMENT 1

Method

Participants. Three children diagnosed with ASD who had minimal vocal speech and were learning to use an SGD were recruited for the study. For all three children, the decision to implement SGDs was made prior to the study by individuals who were not directly affiliated with the study (e.g., parents, teachers). The severity of their autism symptoms was evaluated using the Childhood Autism Rating Scale (CARS; Schopler, Reichler, Devellis, & Daly, 1980). Adaptive functioning was assessed using the second edition of the Vineland Adaptive Behavior Scales (Vineland-II; Sparrow, Cicchetti, & Balla, 2005). Each child was also assessed using the Verbal Behavior Milestone Assessment Placement Program (VB-MAPP; Sundberg, 2008).

Ryan was a 10-year-old boy with a diagnosis of ASD. He used an SGD to communicate, because he had not developed spoken communication. Prior to the start of the study, he had been using an SGD for approximately 2 years. He scored 42.5 on the CARS, which indicated severe autistic symptoms. On the Vineland-II, his age equivalency was 1:11 and 2:1 (year: month) on the receptive and expressive domains, respectively. For written communication, his age equivalency was 7:1, indicating moderately low adaptive functioning. On the VB-MAPP, he was rated at an emerging level 2, indicating that his expressive language development was at the 18-months age equivalency level. He used an SGD primarily to mand for items that were not visually present by stating the name of the item and its features (e.g., color, size, quantity). He manded for approximately 15 missing items, for actions, and independently manded for 50 different items using his SGD.

Franny was a 13-year-old girl diagnosed with ASD and Down Syndrome. She was selected to participate in this study because she used an SGD to communicate. On some occasions she did attempt to use vocal speech, however her articulation was not understandable to listeners. She had been using an SGD for approximately 1.5 years prior to the start of the study. She scored 46 on the CARS, indicating severe autistic symptoms. On the Vineland-II, her age equivalencies on the receptive and expressive domains were 1:4 and 1:3, respectively, indicating low adaptive functioning. For written communication, her age equivalency was 3:10, indicating low adaptive functioning. On the VB-MAPP, she scored at the beginning stages of level 2 (i.e., age equivalency of about 18 months). For example, she used an SGD and a picture exchange communication system to mand for items not visually present, for actions, and to independently mand for at least 15 different items.

Seth was a 5-year-old boy with a diagnosis of ASD. He was also selected to participate in this study because he used an SGD to communicate, and had not developed spoken communication. He had been using an SGD for approximately 1.5 years prior to the start of the study. He scored 43.5 on the CARS, indicating severe autistic symptoms. On the Vineland-II, his age equivalencies were 1:1 and 0:8 for the receptive and expressive domains, respectively, indicating low adaptive functioning. For written communication, his age equivalency was 3:5, indicating moderately low adaptive functioning. On the VB-MAPP, his manding repertoire was at emerging level 2 (i.e., age equivalency of about 18 months). Specifically, he used an SGD to mand for at least five missing items, for actions, and to independently mand for at least 15 different items.

Setting and sessions. Sessions for Ryan and Franny were conducted in a small conference room at their respective schools. The rooms were equipped with a table and chairs, cabinets, and shelves. Sessions for Seth were held in a university-based clinic room (4 x 6 m) equipped with child-sized chairs, a cabinet, and a two-way mirror. Sessions occurred two to three times per week, two or three times per day, and lasted approximately 5 to 10 min. Each session consisted of completing one activity that required the child to engage in a behavior chain (e.g., playing a board game). Participants sat across from the experimenter at the table and a second experimenter typically sat a few feet away. The second experimenter collected treatment fidelity and interobserver agreement data.

Speech-generating devices. Each participant was taught to use an Apple iPad® mini equipped with the speech synthesizing application Proloquo2Go® (McNaughton & Light, 2013; Sennott & Bowker, 2009). Ryan used the keyboard feature of Proloquo2Go® to type his targeted mand (i.e., typing the targeted mand form, inserting the composed mand form into the sentence strip, and then activating the sentence strip to produce the corresponding synthesized speech output). Franny and Seth used symbolic icons, selected from the Proloquo2Go® database, except for cases in which relevant icons were not found in the library. In those cases, the experimenters created the icons and added them to the library. Additional icons that were related to navigation across the different screen pages (e.g., an icon

Table 1
Description of Targeted Behavior Chains

Participant	Behavior Chain	Steps of the Activity	Terminal Reinforcer
Ryan	Sneaky Squirrel Game	1. Gets game from shelf 2. Takes it to the table 3. Opens game box 4. Sets up game board (game board, acorns, tree logs, spinner) 5. *Acorns are missing 6. Plays board game	Play game
Seth	Make Lemonade	1. Takes items out of bin (drink powder, water, spoon) 3. Opens drink powder mix 4. *Spoon is missing 5. Scoops drink powder in cup 6. Pours water and stirs mix 7. Drinks lemonade	Drink lemonade
Franny	Don't Spill the Beans game	1. Gets game from shelf 2. Takes it to the table 3. Opens game box 4. Takes out game pieces (pot, stand, beans) 5. *Beans are missing 6. Plays game	Play game

Note. * Indicates the point of interruption in the behavior chain.

representing a "*BACK*" function) and the mands for information, "Where?" and "Why?" were programmed from the library. Seth and Franny were required to engage in several steps to construct their response: (a) navigate across screens by selecting the relevant folder, (b) select the correct icon from the screen (which resulted in the icon being placed into the sentence strip), and (c) activate the sentence strip to produce the synthesized speech output. Both Seth and Franny had to discriminate between items that were related to the activity (e.g., spoon, cup, drink powder). See Supporting Information A for further details on the screen display types and response steps used within the SGD display configurations.

Identifying preferred activities. Preferred activities were identified using a two-part preference assessment (Kang et al., 2013). Teachers or parents were interviewed using the Reinforcer Assessment for Individuals with Severe Disabilities (Fisher et al., 1992) to obtain a list of potentially preferred activities. This was followed by a paired-choice preference assessment (Fisher et al., 1992). We conducted three sessions, each consisting of six trials. Based on the results, we identified one highly preferred activity (i.e., the item that was selected most often). Ryan's most preferred activity was a board game, The Sneaky Squirrel Game®, which Ryan chose on nine out of nine trials. Seth's most preferred activity was making lemonade, which he chose on nine out of nine trials. For Franny, her most preferred activity was also a board game, Don't Spill the Beans®, which she chose on eight out of nine trials. Throughout the course of the study, extra-experimental exposure to the items was restricted.

Behavior chains. Table 1 outlines the behavior chains for each participant. Materials for the selected activities included the board games, the items that were needed to make lemonade (i.e., water pitcher, two cups, spoon, and lemonade mix), and various colored (i.e., blue, green, purple, and pink) containers that were used to hide the missing items for Seth and Franny.

Prerequisite assessment and training. After the preference assessments were completed, we assessed whether each participant could respond as listeners to the items that were required for their behavior chains (e.g., the game-related pieces, cup, spoon, etc.). For the listener probes, each discrete trial was conducted at a table where the child and experimenter sat directly across from one another. Trials consisted of the experimenter placing an array of three picture cards in a straight line in front of the child, within reach, in random order. Each trial began after the array had been placed on the table and experimenter said, “Give me [item name].” The participant was given 10 s to respond. Correct responses were defined as the participant independently picking up and handing the corresponding picture to the experimenter. Correct responses were followed by descriptive social praise (e.g., “Good job. That is a spoon”). Incorrect responses were defined as selecting the item that did not correspond to the vocal discriminative stimulus (S^D). If incorrect responses had been observed they would have been ignored. Social praise historically functioned as a reinforcer for all of the participants, as reported anecdotally by their teachers and parents. Additionally, we conducted probes to ensure that Seth and Franny could respond as listeners to the colored boxes that were used to hide the missing items. Probes were procedurally identical to those described above. Each participant showed 100% accuracy on the listener probes.

We also assessed whether Ryan could identify locations in the conference room where the items were to be hidden (e.g., the desk, windowsill, and cabinet). During these probes, Ryan was asked to walk to the targeted location periodically throughout the assessment sessions to ensure he could respond as a listener to the location by name. Vocal praise was delivered for correct listener responses. Ryan did not require any training to correctly identify these locations. The experimenters also assessed whether Ryan could correctly type the names of the materials included in his preferred activity. These tact probes consisted of the experimenter holding up a picture card and asking, “What’s this?” A correct response was defined as independently typing the correct word and pressing the sentence strip feature of his SGD to produce the synthesized speech. Correct responses were followed by praise (e.g., “Good job. That is a spinner”). Incorrect responses were defined as incorrect spelling of the word, incorrect tact (e.g., typing the wrong word), or no response. Incorrect responses were ignored. Results showed that Ryan could type the names of all of the items except *acorn* and *spinner*. The experimenters conducted errorless training sessions, which consisted of providing a vocal model of the word and vocal prompts for each letter of the word until he was able to type the words correctly and independently across five consecutive trials.

Lastly, the experimenters assessed whether each participant could complete their preferred behavior chain when there was no interruption (i.e., no missing items). If they were unable to complete the behavior chain independently, training was conducted. Training consisted of total task presentation to complete the full activity (i.e., behavior chain) and thus accessing the terminal reinforcer (i.e., playing a board game and drinking lemonade). The experimenters used least-to-most prompting (i.e., verbal, gestural, and physical prompts) to train the behavior chains and delivered verbal praise for completing each step of the chain (e.g., “Nice job getting out the game pieces”). The mastery criterion for behavior-chain completion was completing each step independently across three consecutive sessions. Each participant mastered the behavior chains within no more than six training sessions.

Behavioral definitions and data collection. The primary dependent variable was emitting the mand frame, “Where [item name]?” Ryan typed his responses using his SGD. His target response was, “Where is the spinner?” Seth and Franny responded by navigating through category folders on their SGDs and selecting picture icons. Seth's target mand was, "Where drink powder?", and Franny's target mand was, "Where beans?" Observers recorded whether the participant independently produced the mand within 5 s of the behavior chain interruption and whether the mand was emitted following a prompt. Responses were coded independent (IND) if the participant emitted the mand within 10s of the point of interruption. A prompted mand was defined as a correct mand emitted by activating the SGD within 5 s of a response prompt. For each session, observers also scored the level of prompting. Prompted responses were recorded as *F* when a full prompt was needed (i.e., full physical guidance with verbal prompt), *P* when a partial physical prompt was needed, *V* when a vocal prompt was used (i.e., "Press [symbol name]" or "Say, where is the spinner?"), and *G* when a gestural prompt was used (i.e., gesturing towards the device or appropriate symbol). Incorrect responses (i.e., activating an irrelevant symbol) were coded as *IR*.

Interobserver Agreement

A second independent observer collected data on the participant's responses, and the level of prompting used during each session and each phase of the experiment. An agreement was recorded if the scores of the experimenter and the independent observer were identical for a given trial. Any discrepancy was counted as a disagreement. The following formula was used to calculate a percentage of agreement for each session and each participant: Agreements/[Agreements + Disagreements] x 100. For Ryan, the independent observer collected data during 55% of sessions, with a mean agreement of 97% (range, 80 to 100%). For Seth, the independent observer collected data during 68% of his sessions, with a mean agreement of 98% (range, 80 to 100%). For Franny, the independent observer collected data during 57% of the sessions, with a mean agreement of 97% (range, 80 to 100%). IOA was collected for at least 44% of sessions in every phase for each participant.

Procedural Fidelity

During sessions in which IOA data were collected, the independent observer also assessed procedural fidelity using a checklist that included the procedural steps for the current experimental condition. These steps included: 1) delivering an instruction to signal the start of the behavior chain, 2) ensuring the availability of the iPad during the activity, 3) presenting each step of the behavior chain, 4) saying, "Something is missing" at the point of interruption, 5) waiting for 5 s for the targeted mand, 6) providing prompts as necessary, 7) delivering verbal praise, and 8) delivery of the requested information. The mean percentage of correct implementation across sessions was 98% (range 88 to 100%) across all participants.

Experimental Design

A concurrent multiple baseline design across participants was used to evaluate the effect of the intervention (Gast & Ledford, 2009). The design included the following sequence of phases: (a) baseline, (b) intervention, and (c) training with a second item.

Procedures

For each session, the following variables remained constant: (a) time of day, (b) the selected behavior chain and materials used within the chain, and (c) presence, location, and display settings on the SGD. Specifically, each child had their SGD located next to them on a desk or table. The device was set to their home screen that included various activity folders (Seth and Franny) or the typing screen (Ryan).

Baseline. Each session began with the experimenter giving an instruction (e.g., "Let's play the Sneaky Squirrel Game!") to initiate the behavior chain. The experimenter delivered descriptive verbal praise for completing each step of the chain before the point of interruption (e.g., "Nice job getting out the game pieces"). At the point of interruption (when a needed item was missing) the experimenter said, "Oh no, something is missing." The participant had 10 s to emit the targeted mand for information, "Where [item]?" The experimenter did not deliver any prompts, but any independent response (e.g., "Where is the spinner?") would have resulted in the experimenter providing the location of the missing item (e.g., "It's in the cabinet"). If the child did not make an independent response within 10 s (or if he or she produced an incorrect response), the experimenter terminated the activity and presented an uninterrupted activity (e.g., puzzle or coloring book). This was done in an effort to preserve the reinforcing value of the behavior chain by reducing repeated exposure that might abolish the reinforcing value of the preferred behavior chain.

Intervention. The intervention was similar to baseline, except that at the point of interruption of the behavior chain (see Table 1), the experimenter prompted the participants to emit the target mand for information. Because baseline data suggested that independent responding was unlikely, the experimenters provided a prompt if an independent mand did not occur within 5 s of the interruption. If the participant responded incorrectly, the experimenter followed a least-to-most prompting hierarchy (gesture, vocal, partial physical, and full physical) until the participant successfully emitted the response. If the participant did not begin to respond correctly to each prompt within 5 s, the experimenter advanced to the next level of prompting until the participant produced the correct mand. When the mand for information occurred either independently or at any level of prompting, the experimenter provided the information about the location of the missing item (e.g., "The ___ is in the blue bin"). The location of the item changed in each session.

The prompting procedures were based on a prior evaluation of participants' reactions to gesture, vocal, and physical prompts. Gesture prompts included pointing to the device, correct navigational button, or the correct symbol. The verbal prompts involved modeling the correct mand (e.g., "Say, where is the spinner?" or "Press the *where* symbol"). The two levels of physical prompting included the least amount of physical guidance necessary (partial physical) or full hand-over-hand guidance. For Ryan, verbal prompts also included the spelling of the word "where" if needed. Prompted responses resulted in neutral verbal praise (e.g., "The spoon is in the blue bin"), and independent responses resulted in enthusiastic verbal praise (e.g., "Nice asking! The acorns are on the desk"). The mastery criterion was three independent mands for information prior to starting the intervention for the next participant in order to meet single-case experimental design standards.

Transfer probes. During baseline and intervention phases, the establishment of higher-order operants was assessed by withholding a different item required to complete the targeted behavior chain. For Ryan, the game spinner was missing from The Sneaky Squirrel Game™ during training sessions. During transfer probes, the spinner was present, but the game pieces (i.e., acorns) were missing. For Seth, the drink mix was missing rather than the spoon. For Franny, the stand on which to place the beans was missing instead of the game pieces.

Training with a second item. The experimenters conducted this training phase if the transfer of the mand frame was not observed during transfer probe trials. The procedures were identical to those described during the intervention phase, except that the interruption was arranged with a different missing item within the same behavior chain.

Results and Discussion

Figure 1 displays the type of response (i.e., level of prompting) recorded for each session.

None of the participants engaged in the target mand for information during baseline, but all three showed an immediate increase in prompted responding when the intervention was implemented. Independent responding was observed for Ryan (upper panel) after 12 intervention sessions. He did not mand for information with a novel item during the transfer probes (See Supporting Information B for details on errors during transfer probes); thus, the experimenters implemented an additional training phase, resulting in an immediate increase in prompted responding. Independent responding was observed after 11 training sessions. Seth (middle panel) showed independent responding after 28 intervention sessions, but manding for information did not transfer to a different stimulus. During the second training phase, he showed an immediate increase in prompted responding and demonstrated independent responding after 10 sessions. Franny (bottom panel), showed independent responding after 13 sessions in the intervention phase. Manding for information did not transfer to a different item, but the second training phase resulted in an immediate increase in prompted responding and she demonstrated independent responding after 12 training sessions.

The results of this experiment suggest that children with ASD who have minimal vocal speech and are learning to communicate using an SGD can acquire a "Where" mand for information using an interrupted behavior-chain procedure and least-to-most prompting. These findings suggest that an effective MO can be contrived by using the missing-item format of the interrupted behavior-chain procedure, and that a "Where" question can be taught by using a combination of prompt delay, least-to-most prompting, and natural reinforcement (i.e., providing the requested information). These findings are consistent with previous research that has used similar procedures to teach SGD-based manding to children with ASD who have minimal vocal speech (Lorah et al., 2013; Sigafoos et al., 2013; van der Meer, Didden, et al., 2012; van der Meer, Kagohara, et al., 2012; Waddington et al., 2014) as well as previous research evaluating teaching mands for information to children with ASD (e.g., Koegel, Koegel, Green-Hopkins, & Barnes, 2010; Lechago et al., 2010).

It is useful to conceptualize mands for information in terms of autoclitic control (Lechago et al., 2010). In this case, the mand frame ("Where is ____") functions as a relational autoclitic (a partial autoclitic frame), influencing the behavior of the listener by specifying relations between actions and features of the situation (Skinner, 1957). It may be necessary to teach multiple exemplars of the autoclitic frame (e.g., "Where is the block?" "Where is the ball?" "Where is the doll?"), before the participant can emit novel mands for information without direct teaching. In Experiment 1, each participant acquired the targeted mand form with a single missing item, but did not show a transfer of the autoclitic mand frame to a second item. This finding demonstrates the importance of implementing transfer probes to evaluate the establishment of the autoclitic mand frame as a higher-order operant (Catania, 1998). Higher-order operants are response classes that include other distinct operant classes. In the current case, manding for missing items using the autoclitic frame "Where is _____" could be a higher-order response class, containing a number of individual operant classes (e.g., manding for specific missing items). The higher-order class would be demonstrated if teaching and reinforcing one exemplar (i.e., manding for one missing item) resulted in the emergence of manding for different missing items without direct training. However, this did not occur in Experiment 1, suggesting that teaching a single response exemplar was insufficient to establish manding for missing items as a higher-order operant class. Previous research has found evidence of higher-order operants when teaching the mand for information across multiple behavior chains (Lechago et al., 2010; Lechago, Howell, Caccavale, & Peterson, 2013).

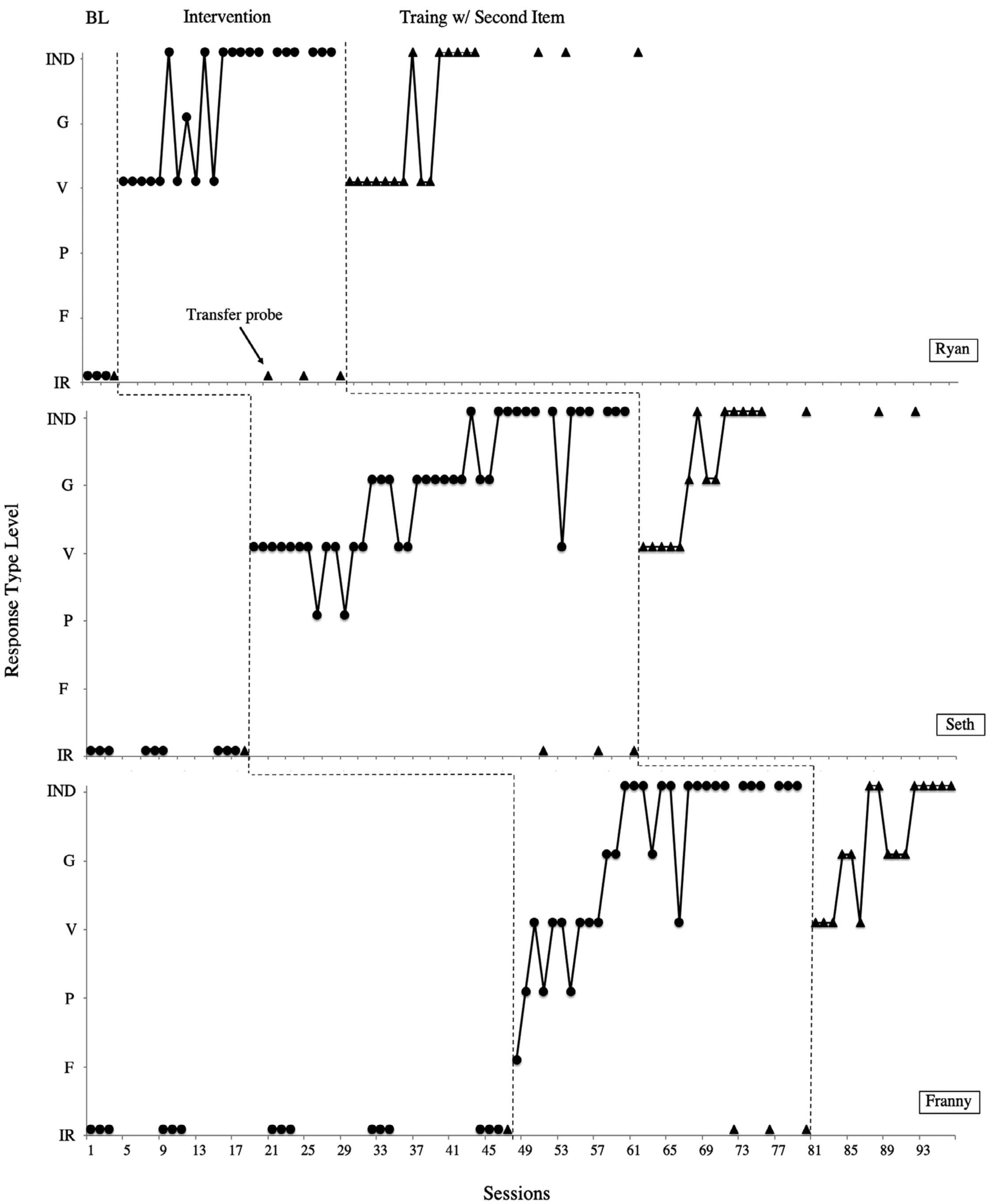

Figure 1. Mands for information response by type (IND = Unprompted; G = Gesture; V = Verbal; P = Partial; F = Full) across sessions for each participant in Experiment 1.

Another limitation of Experiment 1 is the possibility that the statement, “Oh no, something is missing,” may have exerted stimulus control over the putative mand at the point of interruption. This may have interfered with or prevented the desired MO control (i.e., control by the missing item). However, this concern is somewhat mitigated by the fact that the verbal statement did not evoke the putative mand for information during transfer probes to the second missing item in the activity chain. It is possible that MOs and discriminative stimuli (e.g., the specific items that were present during the initial intervention) interacted to evoke the target response for the original missing item (Lotfizadeh, Edwards, Redner, & Poling, 2012; Miguel, 2017). Such concerns could be alleviated by interspersing abolishing operation (AO) trials (i.e., completed chains), and by alternating missing stimuli when targeting this skill. The emergence of a higher-order operant would then be evident when a mand occurs in novel contexts or with novel stimuli.

In Experiment 2, we sought to address the limitations of Experiment 1 through two procedural modifications. First, two behavior chains were included for each participant to evaluate further the emergence of mands for information as a higher-order operant. Second, we implemented a posttest in which we omitted the verbal statement (“Oh no, something is missing”) at the point of interruption and alternated EO and AO trials in an attempt to further isolate MO control.

An additional purpose of Experiment 2 was to evaluate the persistence of the mand for information when the original communication partner does not provide reinforcement. It is likely that this happens in many naturalistic situations because the first person one approaches may not have access to the required information. Thus, the experimenters evaluated if the participants could be taught to seek out and repeat the mand for information with additional communication partners when the first communication partner did not provide the requested information.

EXPERIMENT 2

Method

Participants, settings, sessions, and SGDs. Ryan and Seth from Experiment 1 participated, but not Franny because she had moved to a different school. The settings, sessions, and SGDs were identical to those in Experiment 1.

Behavior chains. In order to introduce new behavior chains, the experimenters identified two new preferred activities using the same preference assessment methods described in the previous experiment. Ryan’s preferred activities were building a marble tower and playing the game Don’t Break the Ice™. Seth’s preferred activities were playing the game Don’t Spill the Beans™ and playing with a set of toy cars and garage. Before baseline, we conducted assessments and training (as needed) on the steps in each behavior chain using procedures identical to Experiment 1. Table 2 describes the behavior chains.

Listener behavior and tact probes. Prior to baseline, the experimenters assessed whether the participants could respond as listeners to the items associated with their respective behavior chains. The experimenters also assessed whether Ryan could tact the materials. Procedures for these assessments were identical to Experiment 1. Each participant responded with 100% accuracy on the listener tests. However, Ryan needed five training trials on the spelling of the phrase “ice blocks”.

Prerequisite training for “where” mands. Prior to baseline, the experimenters taught the mand, “Where [item]?” using the two selected behavior chains using a single conversation partner. The training was procedurally identical to the intervention phase of Experiment 1, and continued until the participants’ responding had reached the criterion of three consecutive independent mands for information (i.e., manding

Table 2
Description of Targeted Behavior Chains

Participant	Behavior Chain	Steps of the Activity	Terminal Reinforcer
Ryan	Behavior Chain 1 Marble Tower	1. Gets the bin from the shelf 2. Takes the bin it to the table 3. Opens bin 4. Takes out pieces (tubes, stands, runs, marbles) 5. Builds tower 6. *Marbles are missing 7. Plays with the marble tower	Plays marble tower
Ryan	Behavior Chain 2 Don't break the Ice game	1. Gets game from shelf 2. Takes it to the table 3. Opens game box 4. Takes out game pieces (ice cubes, hammers, stand) 5. *Hammers are missing 6. Plays game	Plays game
Seth	Behavior Chain 1 Don't Spill the Beans game	1. Gets game from the self 2. Takes it to the table 3. Opens game box 4. Takes out game pieces (pot, stand, beans) 5. *Beans are missing 6. Plays game	Plays game
Seth	Behavior Chain 2 Toy car garage	1. Get garage from the shelf 2. Takes it to the table 3. Opens garage door 4. *Cars are missing 5. Plays with toy car garage set	Plays with car set

at the IND level) across both behavior chains. Ryan required six training sessions to mand for information for his first behavior chain, and eight training sessions for his second behavior chain. Seth required nine training sessions to reach independent responding for his first behavior chain, and 11 training sessions to reach independent responding for his second behavior chain.

Response definition and data collection. The dependent variable was defined as repeating the mand for information, "Where [item name]?" to a relevant (i.e., second or third) communication partner (i.e., mand persistence). The observers scored a correct response when the participant approached the target communication partner and stated the mand within 10 s of the original communication partner's response. The observers coded the participants' responses using the same categories specified in Experiment 1 (IR, G, V, P, F, and IND). Additionally, observers recorded whether the participants made errors of commission (i.e., manding for the wrong item, See Supporting Information B and C).

Interobserver Agreement

IOA was assessed and calculated in the same way as in Experiment 1. IOA data were collected for 100% of the sessions for Ryan, and 52% of sessions for Seth. IOA collected per phase ranged from 45% to 71% of sessions for Seth. For Ryan, the mean agreement was 99% (range, 80 to 100%). For Seth, the mean agreement was also 99% (range, 80 to 100%). IOA was collected for at least 45% of the sessions in every phase for each participant.

Procedural Fidelity

Procedural fidelity was assessed in the same way as in Experiment 1. The steps were the same as in Experiment 1, except reinforcement was only provided for emitting the targeted mands in the presence of the specified communication partner (i.e., the second or third communication partner, depending on the condition). The mean percentage of correct implementation across sessions for Ryan was 97% (range, 88% to 100%) and for Seth 96% (range, 88% to 100%).

Experimental Design

A concurrent probe/multiple baseline design across behavior chains, embedded in a multiple baseline across participants design, was used to evaluate the effects of the intervention on acquisition and generalization of the "where" mand for information (Gast & Ledford, 2009). The design included the following sequence of phases: (a) baseline, (b) intervention, (c) training with additional behavior chains (Ryan only), (d) follow-up, and (e) EO/AO posttests.

Procedures

The variables held constant during each session were identical to those specified in Experiment 1.

Baseline. Procedures were identical to Experiment 1 with the following exceptions. A second communication partner was present during each session. If the participant manded for the location of the missing item, the experimenter (first communication partner) responded by saying, "I don't know." The participant then had 10 s to approach the second communication partner and repeat the mand.

Intervention (second communication partner). The intervention phase was similar to baseline, except after the experimenter (first communication partner) responded by saying, "I don't know" to the child's initial mand, the experimenter taught the participant to approach the second communication partner and emit the mand using a 5-s constant time delay and least-to-most prompting. For example, if the participant did not respond to a gesture prompt (pointing towards the second communication partner) within 5 s, the experimenter advanced to the next level of prompting (i.e., a vocal prompt, "Ask Alicia") until the participant produced the mand to the second communication partner. The first and second communication partners were always the same people. If the participants had approached the person designated as the second communication partner first, that person would have said "I don't know" and the other communication partner (the experimenter) would have provided the information instead. However, this never occurred.

Generalization probes. Two types of generalization probes were conducted. The first type involved a new and unfamiliar communication partner (i.e., the third communication partner) who replaced the second communication partner. During this probe, the first and third communication partners were present in the room with the participant and only the third communication partner reinforced the mand for information by providing the information. If the participant emitted the mand to the first communication partner, she said, "I don't know." The purpose of this probe was to evaluate whether the effects of the intervention would generalize to new person.

The second type involved a fourth communication partner. During this probe, three persons were in the room with the participant: The first, second, and fourth communication partners. Only the fourth communication partner reinforced the mand for information. If the participant emitted the "Where" mand to the first or second communication partners, they said, "I don't know." If the participant persisted and emitted the mand to the fourth communication partner, she provided the information. The purpose of this probe was to evaluate persistence of the mand in response to multiple instances of extinction (i.e., two

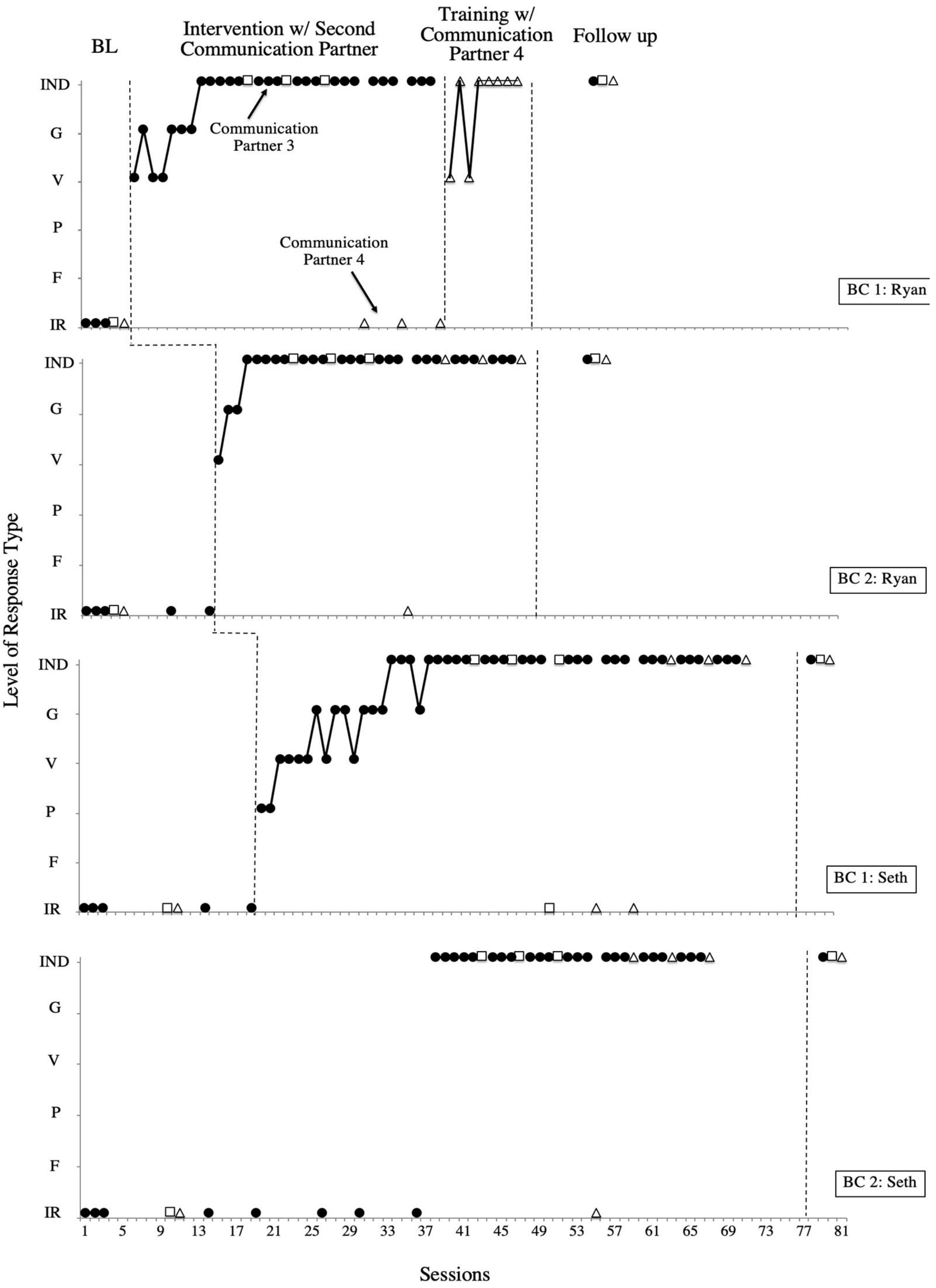

Figure 2. Manding for information with alternative communication partners across behavior chains (BC) for both participants in Experiment 2 (IND = Unprompted; G = Gesture; V = Verbal; P = Partial; F = Full). Responding with the original communication partner was established prior to baseline and is not shown in the graph.

people who had previously provided the information would now answer, "I don't know").

Other than the varying number of communication partners and the differential consequences provided by each, the procedures during generalization probes were identical to baseline.

Training with the fourth communication partner (Ryan only). Training with the fourth communication partner was conducted for Ryan because generalization was not observed in the first behavior chain. These training sessions were similar to the intervention phase, except that after asking the second communication partner, "Where [item]?" and being told, "I don't know," the participant was prompted to ask the third communication partner, using a 5 s time delay and least-to-most prompting.

Follow-up. The experimenters conducted three follow-up probes for both behavior chains 1 month after the intervention. Follow-up probes were conducted to evaluate whether the mand maintained over time, and to evaluate whether the participants would still approach alternative communication partners and emit the mand if the initial communication partner did not reinforce the mand. The procedures were identical to baseline and generalization probes.

Establishing operation (EO)/abolishing operation (AO) posttests. After training, posttests were conducted to assess whether the mand for information was under the functional control of the putative MO rather than the verbal cue, "Oh no, something is missing" that was used by the experimenter to signal the interruption. For posttest 1, conditions were similar to baseline, except that the experimenter did not deliver the verbal statement, "Oh no, something is missing." The experimenters conducted three such trials for each participant. During posttest 2, the experimenters alternated EO trials, in which the item was missing, with AO trials, during which the item was present. The consequences for correct and incorrect responses during EO trials were identical to the baseline and generalization trials in Experiment 1 (i.e., information was provided for correct responses, and no programmed consequences for incorrect responses). If the mand did not occur during AO trials the experimenter did not provide programmed consequences and allowed the participant to complete the steps of the behavior chain to contact the terminal reinforcer. If the mand occurred during AO trials, the experimenter responding by saying, "The [item name] is right here, so you do not have to ask for it." The experimenters conducted 10 trials (5 EO trials and 5 AO trials) across both behavior chains. The EO and AO trials were randomly alternated, with the restriction that no more than three trials of the same condition could occur consecutively.

Results and Discussion

Ryan did not engage in the target response during baseline (with the second communication partner) for his first behavior chain (Figure 2, upper panel). During intervention with the first behavior chain, he began independently directing his mands to the second communication partner after eight training sessions. His responding generalized to the third communication partner, but not to the fourth communication partner. Thus, training with the fourth partner was conducted, and independent responding occurred after three training sessions. For Ryan's second behavior chain (Figure 2, second panel), he did not independently respond during baseline. During the intervention phase, he began independently responding after three training sessions. For the second behavior chain, his responding generalized to the additional communication partners. Ryan made two errors of commission (i.e., manding for the wrong item). One error occurred in session 2 and one in session 29 (see Supporting Information C).

During baseline with Seth's first behavior chain (Figure 2, third panel), independent responding was not observed. He required

15 intervention sessions until independent responding was observed. For his second behavior chain, he did not independently respond initially. However, he did not require any training sessions with this behavior chain because he began to emit the "Where" mand with the second communication partner before the planned intervention was implemented. Thus, generalization across behavior chains was observed with Seth. Generalization with additional communication partners was also observed across both behavior chains. Seth never manded for an incorrect item.

Figure 3 displays the results of the EO/AO posttests. For the initial EO posttest (posttest 1), Ryan emitted the targeted mand for information during 100% of trials (i.e., the three test trials). During the initial EO/AO test (posttest 2), Ryan responded correctly during EO trials, whereas he mostly responded incorrectly during AO trials (i.e., he responded with a mand for information during 80% of these trials). This suggests that his manding was not exclusively under the control of the missing item. Therefore, the experimenters implemented training to teach him to mand for information during EO trials, only. The training was similar to the EO/AO tests; however, AO conditions included error correction with a verbal prompt (i.e., he was told, "The [item name] is right here, so you do not have to ask for it.") if he attempted to mand for information. The experimenters implemented the error correction only once (in the first AO trial) and he did not emit the mand for information during subsequent AO trials. Instead, he proceeded to set up the game when he saw that the item was present. After he responded correctly for five consecutive AO trials, the experimenters presented a second set of randomized EO/AO posttest trials (posttest 3), during which Ryan responded with 100% accuracy. Seth's responding was 100% correct in both posttests, suggesting that the original training established appropriate MO control over his behavior.

The results demonstrated that the intervention was successful in teaching the participants to continue to mand "Where?" to available communication partners, after the first (and sometimes second) communication partner was unable to provide the reinforcer (information about the location of the item). The intervention procedures also resulted in transfer of the targeted mand across behavior chains for Seth. The relevant influence of the MO on the mand seems to have occurred as a function of the intervention for Seth, in that he emitted the mand when the MO (EO condition) was present but not when the MO was absent (AO condition). For Ryan, brief training was required to gain proper MO control over the mand for information. These results are consistent with previous research that has evaluated teaching mands for *where* to children who communicate using spoken language using the interrupted behavior-chain procedure to contrive the MO (Betz, Higbee, & Pollard, 2010; Raulston et al., 2013; Sigafoos et al., 2013; Sundberg et al., 2002).

The current findings highlight the need to assess whether acquired mands for information are under appropriate MO control. One of the two participants in this study (Ryan) required additional training for manding to come under the control of the MO. Insufficient MO control may have contributed to the lack of transfer across behavior chains for Ryan. That is, the mand may have been primarily evoked by the presence of the stimuli associated with the first behavior chain, rather than the interruption of the behavior chain, per se. Therefore, it may be beneficial to teach the mand for information across multiple stimulus conditions (e.g., physically dissimilar chains; Betz et al., 2010; Lechago & Lowe, 2015). In light of Ryan's results, it may be prudent to intersperse the EO/AO assessments from the start of training, rather than as a posttest. Training across EO/AO conditions would likely serve to establish the desired MO control in the

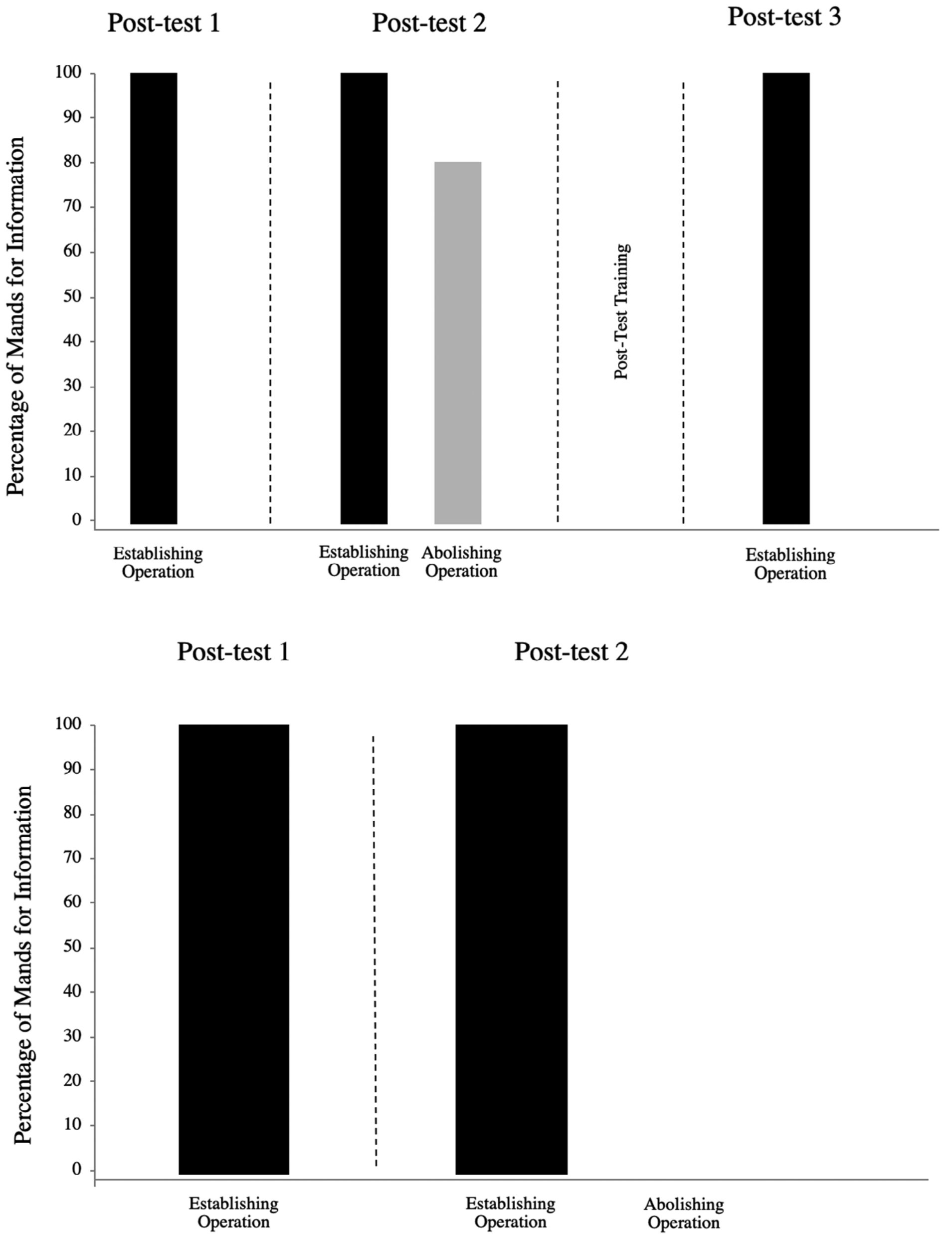

Figure 3. EO/AO posttest results from Experiment 2 for Ryan and Seth.

early stages of intervention and might prevent inappropriate antecedent control by task-related stimuli. Lastly, when evaluating and teaching the mand for information with additional communication partners, it would be beneficial to intersperse trials in which the initial communication partner delivers the information. This would allow for an evaluation of the influence of the relevant MO (i.e., the original listener not providing the answer) over the behavior of seeking out and asking additional listeners.

GENERAL DISCUSSION

We evaluated the use of an interrupted behavior-chain procedure to teach the "Where" mand for information to children with autism who were learning to use an SGD. In Experiment 1, the intervention resulted in the acquisition of a single "Where" mand with each participant, but no transfer of the autoclitic mand frame across items within a behavior chain. In Experiment 2, the experimenters included two behavior chains with each participant and evaluated the persistence of the mand when the first communication partner did not provide reinforcement. Following baseline, the experimenters taught the participants to approach a second communication partner and emit the mand. Transfer of the intervention effects across behavior chains occurred with one participant (Seth) but not the other (Ryan). Generalization to a novel alternative communication partner (i.e., the third communication partner) occurred with both participants, and to a fourth communication partner with Seth without additional training. During posttests to evaluate whether the mands were under appropriate antecedent control (the EO/AO test), both participants were able to emit the mands in the absence of the verbal cue used in the original training. Responding during alternating EO/AO trials suggested that Seth's mands were under MO control, but Ryan's mands may have been influenced by another variable. However, following only one additional training trial during the AO condition, Ryan's mands were shown to be under the appropriate MO control.

One critical feature of a behavior chain is that the stimuli that constitute each link in the chain are likely to become conditioned reinforcers due to their association with the terminal reinforcer (i.e., the completion of the behavior chain). The missing items likely functioned as transitive conditioned motivating operations (CMO-T; Michael, 1993), defined as events that establish the value of other events as reinforcers. In this case, the removal of necessary items likely established information about their location as a conditioned reinforcer.

To ensure that the relevant MO is in place, the value of the activity chain should be assessed and monitored by evaluating behavioral indicators (e.g., smiling when engaging in the activity, mands for the activity/game, high levels of engagement). If the value of the activity diminishes, so would the potential behavior-altering effects of the CMO-T (the missing item). Anecdotally, participants engaged in behavioral indicators of a MO during the activities. For example, when the experimenters arrived at Ryan's school, he often tried to take the game boxes from the experimenters or mand for the game. Seth was often observed running straight to the shelf where the activities were located, rather than sitting down at the table upon entering the clinic room. Systematic evaluation of behavioral indicators could be included in future studies.

Taken together, the results of Experiments 1 and 2 suggest that the interrupted behavior-chain procedure is effective for teaching the "Where" mand for information to individuals who use SGDs to communicate. However, practitioners and applied researchers should take care to establish the desired antecedent control (Miguel, 2017; Stokes & Baer, 1977; Sundberg et al., 2002). In naturally occurring behavior chains, there are likely to be many different antecedent variables that might gain influence over behavior (Miguel, 2017). To establish the appropriate antecedent control, it is necessary to alternate establishing operation (EO) trials and abolishing operation (AO) trials (Shillingsburg, Gayman, & Walton, 2016). In the case of "Where" mands, EO trials are those in which an item is missing from the chain, whereas the item is present during AO trials. If the mand topography continues to occur during AO trials, it is likely that the response is under the stimulus control of aspects of the teaching context (e.g., other items in the behavior chain) rather than the relevant CMO-T (the absence of the item). If the response topography is primarily under stimulus control rather than MO control, transfer to novel situations in which different items are missing is less likely (Sundberg et al., 2002).

Another approach is to randomly vary the missing item within the behavior chain. This procedure introduces incidental AO trials, because the same item is missing in some trials and present in others. It may also be beneficial to evaluate responding across multiple types of autoclitic mand frames (Lechago et al., 2013). For example, researchers could compare situations that occasion a “Where” frame (i.e., missing items) compared to situations that would call for a “When” frame (e.g., being asked to wait). It would be desirable to extend this research to individuals that use SGDs because there has been limited research on mands for information with this population. Additionally, future research could incorporate training across multiple behavior chains. For instance, practitioners could teach two or three behavior chains, randomly varying the missing item in each, and then probe for transfer of the mand for information with novel behavior chains. A combination of the procedures from Experiments1 and 2 could help promote spontaneous generalization.

Lastly, the different response modes used by the participants should be taken into account when interpreting these results. Ryan communicated via written expression (i.e., typing words from the keyboard feature of Proloquo2Go®), an example of topography-based responding. Seth and Franny, however, responded by selecting icons (selection-based responding; Michael, 1985). It is unclear whether the response modes might account for the varying rates of acquisition. Thus, future research on comparing topography-based and selection-based responses and acquisition rates in the context of SGDs might be beneficial.

The current findings extend the previous literature with children diagnosed with ASD who use SGDs by evaluating procedures to teach a more complex type of mand (i.e., mands for information), as compared to teaching a basic mand for highly preferred toys or edibles. As discussed by previous researchers (Lechago & Low, 2015; Raulston et al., 2013) manding for information is likely to be a valuable skill across a variety of contexts such as academics (e.g., asking questions to learn a new skill), social interactions (e.g., asking a friend to play), and community integration (e.g., asking for directions in an unfamiliar location). Persistence of manding for information is also likely to be a highly functional skill because it is likely that a specific listener might not always have the required information. In Experiment 2 of the current study, the participants learned to seek out a different person when the first communication partner was not able to provide the information. Future research should explore other types of mand persistence in the face of extinction (e.g., asking for more information when the initial answer is not sufficient).

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Received April 26, 2017
Final Acceptance August 8, 2019
Action Editor, Sarah Lechago

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