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The Effectiveness of Chaining to Increase Complexity of Echoics in Children with Autism Spectrum Disorder and Language Delay

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The present study tests the effects of a chaining procedure to increase the complexity of correct echoic responses with multi-syllable words in two children with autism spectrum disorder (ASD) and language delays. Data on number of correct full echoics were collected within 1 or 2-min time blocks. During the intervention, each word was broken into two to four smaller segments and a chaining procedure was used to teach to echo the segments of a word in which a correct echoic of each segment functioned as a cue to move to echoing two segments together, and then move to echoing all of the segments of the word, which was the terminal response of the chaining procedure. Generalization of full echoic behavior was tested with a novel word. Results indicated clear differences in the level of correct responding between baselines and intervention conditions across the first two words with both of the participants. The percentage of correct full echoics with the word used for generalization probe increased from 10% to 100% with the participants.

Keywords: autism, chaining, complexity, echoics, language, verbal

Language is the cornerstone of human learning and a critical foundation of knowledge in typically developing children (Greer & Ross, 2008). However, language skills are a major deficit in children with autism spectrum disorders and therefore should be one of the major goals of any intervention program (Sundberg & Michael, 2001). Skinner (1957) defined Echoic as a verbal operant in which the topography has point-to-point correspondence and formal similarity to the antecedent. Echoing vocal models that children hear within their environment is one of the major ways to learn to speak in typically developing children. If a child's echoic repertoire is limited because the child cannot echo specific sounds, then the probability of those sounds occurring in verbal responses is low, thus impacting further development of speech and language (Sundberg & Michael, 2001).

A behavior chain is a series of discrete behaviors that occur in a specific sequence in which a response becomes the discriminative stimulus for the next sequential response (Cooper, Heron, & Heward, 2007). Verbal behaviors require chaining of phonemes and syllables to make words, chaining of words to make sentences, and chaining of sequential information to engage in

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verbal exchanges between two people (Sundberg & Michael, 2001). In order to develop communicative skills in children with delays, one must first teach vocalization, shape sounds into words, and then teach the children to expand speech and language skills by building complexity of mastered skills. Teaching to generalize the language skills within function is another important segment in intervention for children with language delay. These efforts help the children with language delays approach or match to typical communicative behaviors found in the children's verbal community (Sundberg & Michael, 2001).

Researchers have demonstrated that children's speech sounds can be shaped into accurate and complex topographies, and in turn facilitate further language development (Esch, Carr, & Grow, 2009). For example, studies have shown that automatic reinforcement of speech sounds using stimulus-stimulus pairing has increased vocalizations (Sundberg, Michael, Partington, & Sundberg, 1996; Yoon & Bennett, 2000). However, Sundberg et al. (1996) recommend echoic prompting and direct reinforcement because the effectiveness of automatic reinforcement may vary between individuals.

Some children may echo discrete auditory stimuli such as phonemes, but may not be able to echo full words or phrases (Tarbox, Madrid, Aguilar, Jacobo, and Schiff, 2009). One procedure implemented by Tarbox et al., (2009), broke longer auditory stimuli into smaller units and taught echoics using a chaining procedure, teaching each unit and combining them into full words. The chaining procedure increased complex echoics by combining mastered vocalizations with novel units within words.

Chaining has been used to teach tasks that consist of a series of discrete behaviors. Sautter, LeBlanc, Jay, Goldsmith, and Carr (2011) taught preschoolers to perform a series of discrete behaviors using self-questioning skills for problem-solving. Children were successfully taught to ask and answer a chain of questions as they solved a problem. Teacher modeling and echoic training on the target responses were used as interventions.

Literature indicates that after the acquisition of a pool of vocalizations by a child, complexity and functional language behavior can be taught using echoics, direct reinforcement, and chaining procedures (Cooper, Heron, & Heward, 2007; Greer & Ross, 2008; Sundberg & Michael, 2001). Tarbox, Madrid, Aguilar, Jacobo, and Schiff (2009) successfully used the behavior treatment of chaining phonemes and syllables to increase complexity of echoics in children with autism. The procedure was effective for all participants and gains were maintained after treatment. Complex words were broken into phonemes or syllables and each part was taught with echoics and reinforcers. As the child demonstrated mastery of the sequential parts of the word, the full word was taught using echoic training.

The present study replicates this chaining procedure used by Tarbox, Madrid, Aguilar, Jacobo, and Schiff (2009) to increase complexity of echoics in children with autism and language delay. In addition, the study examines the generalization of complex echoic vocalizations using novel words without direct chaining instruction.

Method

Participants and Settings

Two children with autism and language delays participated in the study. Participant A was enrolled in a day school program in a residential treatment center that uses elements of behavioral methods. He was a male, 10 years of age, diagnosed on the autism spectrum with speech impairment, developmental speech delay, and intellectual and learning disabilities. Participant A echoed words heard, request desired items using phrases, and showed decoding skills with CVC words. Participant A scored 85 out of 100 with Early Echoic Skills Assessment (EESA). EESA an evaluation tool for echoic behavior and it is a part of the Verbal Behavior Milestones Assessment and Placement Program (VB-MAPP, Sundberg, 2007). The VB-MAPP is an assessment tool for language and social skills for children with autism and other developmental disabilities. With Participant A, the study was conducted in regular instructional rooms during the participant's normal instruction time. Participant B was 8 year old boy diagnosed with autism. He attended at a private learning centers for children with ASD. He received behavioral educational services for social, academic, language, motor, and self-help skills. Participant B echoed words or phrases, labeled presented objects or pictures orally within full sentences, and requested with sentences. Participant B scored 91 out of 100 on the EESA. The study was conducted in the regular therapy room during regular instruction time with Participant B.

Stimuli

One set of four words was used during the intervention sessions and the probe sessions for each participant. The selection of target words was based on parent and teacher suggestions for each participant. Words used during the intervention were divided into segments by the investigator. No phonetic rules were followed when dividing into parts. The investigator divided the words according to the most simple and natural flow of verbal production. Some parts were later changed to address the abilities of the individual student to echo accurately. For example, excellent was changed from ex-ce-lent to ex-cel-ent when it became apparent that the child had trouble with initial 'l' sound, but not the final 'l' sound. The lists of the words trained to echo with each participant are shown in Table 1.

Response Definitions and Data Collection

For Participant A, data were collected within 1-minute time blocks and within 2-min time blocks for Participant B across the baseline, intervention phase, and probe sessions for generalization. A correct response during baseline and intervention conditions was echoing a vocal model (whole words) presented by the investigator in one-to-one correspondence within 5 seconds. An incorrect response was emitting any other vocal responses other than the vocal model presented by the investigator. If the participant did not respond within 5 seconds of a presentation, it was considered to be an incorrect response.

In baseline, whole words were presented without breaking down into smaller segments. The investigator said the target word, waited 5 seconds for an echoic response, and praised for

correct responses. The investigator noted "+" for the correct response on a data sheet with a pen. For incorrect responses, the investigator noted "-" and a correction procedure was conducted in the same way as during the regular instruction: the investigator presented an echoic model and waited five seconds. If the participant did not respond correctly to the initial correction, a second correction was presented. If the participant did not respond correctly to the second correction, the investigator moved to the next teaching trial.

During intervention, chaining procedure was implemented with the same words used during the baseline. The syllables of the target words were broken into two to four segments and echoing each segment allowed the chaining to move to echoing next segment and then move to echoing the whole words, the terminal behavior. When the participants emitted a correct full echoic of a whole word, the investigator immediately praised and noted "+" on a data sheet using a pen. If the echoic of the full target word was incorrect or if the participants didn't emit echoics within 5 seconds, the investigator noted "-" and presented a correction once and a second time if necessary, and began a new teaching trial. Data were reported as percentage of correct echoics of the full word during each time block and represented on the graph as one data point for each time block.

Interobserver Agreement

Interobserver agreement (IOA) was obtained by having second independent observer collect data simultaneously during the sessions. IOA was collected during 33% of the time blocks during each phase. Agreement was calculated using interval-by-interval IOA for the number of correct or incorrect echoics during each time block. For Participant A, the second observer was an administrator at the center. For Participant B, the second observer was a special education teacher who trained in the procedure. The number of agreements as correct or incorrect was divided by the total number of echoics and multiplied by 100. IOA for Participant A was: Word 1 90%, 100% with a mean of 95% and a range of 80-100%; Word 2 100% and 92% with a mean of 96% and a range of 80-100%; Word 3 96% and 90% with a mean of 93% and a range of 80-100%; and Word 4 90% with a mean of 87% and a range of 80-100%. IOA for Participant B was: Word 1 96%, 97%, 100% with a mean of 98% and a range of 80-100; Word 2 100%, 92% with a mean of 96% and a range of 80-100; Word 3 96%, 95% with a mean of 96% and a range of 80-100; Word 4 96%, 100% with a mean of 98% and a range of 80-100.

Experimental Design

The intervention design is a multiple baseline across behaviors within Participant A. The design was replicated with Participant B in the study. The baseline phase presented a full model of the target words. In order to demonstrate functional relations between the chaining procedure and increase in correct echoics of the whole words, the timing of onset of intervention with each word was staggered across Word 1, Word 2, and Word 3 during the chaining procedure: When level of correct responding during baseline stabilized with Word 1, intervention began with Word 1 as baseline continued for Word 2 and Word 3; When a participant showed a steady rate of correct responding with Word 1, intervention with the second word began. The intervention with the third word followed in order. Each child received instruction on three words. When mastery criterion of 90% accuracy across two consecutive time blocks was reached, the

intervention ended for the mastered word. A generalization probe session with Word 4 followed when the participants reached to the criteria with each word.

Procedure

.**Baseline.** During the baseline, the investigator said the whole target word, waited 5 seconds for an echoic response, and praised correct responses. For incorrect responses, a correction procedure was conducted: the investigator presented an echoic model and waited five seconds. If the participant did not respond correctly to the initial correction, a second correction was presented. If the participant did not respond to the second correction, the investigator moved to the next teaching trial.

Chaining procedure. The target word(s) were taught in 1-minute or 2-minute time blocks. For participants A and C, time blocks were held each weekday for 25-30 minutes, one to three times per day. For participant B, time blocks were held 3-4 days per week, 3 times per day. During a 1- or 2- minute block, the investigator presented the first part of the word, waited five seconds for an echoic response and repeated until the part was said correctly by the child whereby they received praise. Immediately, the next part was taught in the same manner. If the next part was incorrect, the investigator began the echoic procedure with the first part, reinforced a correct response with praise and then proceeded to the next part. The cycle continued until all parts were consecutively correct. At that point, the investigator immediately presented the full target word, waited 5 seconds for an echoic response and presented praise for the correct response. For incorrect responses, a correction procedure was conducted: the investigator presented an echoic model and waited five seconds. If the participant did not respond correctly to the initial correction, a second correction was presented. If the participant did not respond correctly to the second correction, the investigator moved to the next teaching trial. After the correction, the procedure began again with the beginning part. At the end of 1- or 2- minute block, the chaining procedure stopped and the number of correct echoic responses to full vocal model was totaled, divided by the total number of whole echoic presentations and multiplied by 100. The percentage correct was recorded on a graph with one data point signifying the percent correct in one time block of 1 or 2 minutes. The student was given a 1 minute break before the next time block began. A mastery criterion for each target word was 90% correct echoic responses of the full target word across two consecutive time blocks.

Generalization. Probes for generalization of taught responses (i.e., accurate echoics) with an untrained word were conducted with Word 4 each time when the participants reached to the criterion with Word 1, Word 2, and Word 3. The procedure for generalization probe was same as that of baseline. The entire word was presented and the investigator waited 5 seconds. If the word was echoed correctly, the participant received praise. If the word was echoed incorrectly, a correction procedure was provided.

Maintenance. Maintenance data was collected for Participant B. The procedure for maintenance probe was same as that of baseline. One feature of the maintenance probe procedure which was different from that of baseline was that the investigator prompted the student to repeat

the word by saying the first part and waiting for an echoic response. The child echoed the first part and completed the word without further prompts. The investigator praised the correct verbal behavior. This procedure continued for 2 minutes or until the word was said correctly.

Results

Figure 1 for participant A demonstrates the percentage of correct echoics for each full target word per one-minute session. For each target word, correct full echoics increased during intervention with Word 1. For Word 1 (living room) and Word 2 (umbrella), no correct full echoics were emitted during baseline. After the chaining procedure was introduced, responding showed an increasing trend and the participant acquired the correct full echoic within 10 of 1-minute block for Word 1 and 13 blocks for Word 2. During the baseline, Word 3 (summertime), showed variable responding. The correct full echoic for Word 3 was acquired within 31 time blocks. Word 4 (family) was used to test generalization while intervention with the other three words in progress. Average correct echoic of the full target for Word 4 was 35%.

Figure 2 shows the percentage of correct full echoics for Participant B in 2-minute blocks. Word 1 showed an increase in level of correct responding from baseline to intervention and an increasing trend in correct full echoics of the target word. Word 1 was mastered in 13 time blocks. The mean percentage of correct responses was 61% with a range from 20 to 100. Word 2 was mastered within 23 time blocks. The mean percentage of correct responses was 65% with a range from 0 to 100.The participant showed higher level of correct echoic responding with Word 3 than with Word 1 and Word 2 during the baseline and showed rapid increase in level of correct full echoics during the intervention. Word 3 was mastered in 8 time blocks. The mean percentage of correct responses was 84% with a range from 25 to 100. Word 4 remained in baseline as a measure of generalization and showed little improvement until session 16 and rapidly reached mastery. The mean percentage of correct responses was 19% with a range from 0 to 100.change percentage into the frequency.

Discussion

Participant A acquired accurate echoics of all three words when responses were taught using the chaining procedure. Word 1 and 2 showed no correct responding during baseline and an increasing trend to criterion during intervention. Word 3 showed variable responding in baseline and an initial increasing trend after intervention was introduced with variability and overlap in data points between baseline and the chaining procedure. Participant A required 31 time blocks in order to reach to the criterion with Word 3. Considering that the participant reached to the criterion within 10 time blocks with Word 1 and 13 with Word 2, a considerable difference between the numbers of blocks required across the words was noted. In the study conducted by Tarbox, Madrid, Aguilar, Facobo, and Schiff (2009), this pattern was also reported with the word that remained in baseline for the longest period of time. There are three possible explanations concerning variable responding for Word 3 during the baseline with Participant A. First, due to the baseline condition which lasted longer than other words, the participant may have initially generalized the echoic chaining procedure to the third word but did not maintain responding due to lack of motivation. Second, the participant's articulation of the *r* sound was

weak at the beginning of the study and thus, each word contained a medial *r* sound to test the effectiveness of increasing the complexity of echoics. The r-controlled vowel in the medial syllable of 'summertime' may have impacted the participant's ability to produce a correct full echoic and contributed to variability in responding. Third, due to the subjective nature of collecting data on echoic responses, observer drift may have influenced the interpretation of the correct full echoic for this word, especially when compared to the two previous words which were established relatively quickly. Participant A showed an increase in percentage of correct full echoics during the generalization probe with Word 4. Participant A also scored a 94 on the EESA, an increase of 9 points when compared to results prior to the treatment. This result may contribute to a collateral effect of the intervention.

Participant B also showed mastery of target words using the chaining procedure. Word 1 (snack) showed a steady increase with less variability than Word 2 and 3. This may be due to the fact that it was a shorter word and he only failed to say the initial-s in snack. Word 2 (excellent) required the most time blocks and showed the most variability in correct responding. He had difficulty with two particular parts of the word, the 'x' and 'l' pronunciation. In Session 27, the investigator changed the division of the parts to model the 'l' sound at the end of a part instead of the beginning, and his pronunciation of the whole increased to mastery. Word 3 (independent) increased rapidly from a variable baseline. This was a pattern seen with participant A in this study and with participants in Tarbox et al. (2009). Rapid mastery with the word "independent" may also be due to the fact that the word didn't contain the x and l sound that was difficult for the participant. With the generalization Word 4 (toothbrush) the participant showed the same level of responding as with Word 3 (independent) at the end of baseline for independent. Participant B mastered Word 1 (snack) and Word 3 (independent) during intervention. However, the skills mastered were not generalized in daily conversation. During the maintenance probe, the teacher needed to provide prompts by saying the first part of the word. Participant B echoed the first part and completed the word on his own. This procedure may have affected the mastery of Word 2 and Word 4 with additional teaching procedure.

Results of the present are consistent with those of Tarbox, Madrid, Aguilar, Jacobo, & Schiff (2009), who successfully used the behavior treatment of chaining phonemes and syllables to increase complexity of echoics in children with autism. In comparison, the procedure was effective for all participants, each child demonstrating mastery of the full word using the echoic chaining procedure. In Tarbox, et al. (2009), four time blocks of 1 minute each were used as was the case in this study for participant A. In this study, longer time blocks of 2 minutes were used with participants B. It is inconclusive whether this longer time increased acquisition or generalization.

Further research may be done to determine how many words each participant requires using echoic training to show a generalization of accurate echoic responses to a novel word. The present study incorporated generalization probes concurrently with intervention using the untrained stimuli, Word 4 . For Participant A, the percentage of correct full echoic with Word 4 ranged from 0 to 35%. Participant B showed a clear generalization by emitting 100% of correct echoics. Further research may determine whether present level of verbal behavior of children co-vary with the number of words taught to echo correctly before they generalize an accurate echoic response to a novel word. Generalization may be further examined by using a within-subject

design while delaying or eliminating the prompting procedure and adding more generalization words and training multiple targets of complex echoics. While the chaining procedure worked to increase complexity of trained responses, generalization across words, which is embedded in the design, should have emerged more readily. The variable(s) affecting the necessary intensity to promote generalization and the way to test for this intensity of intervention should be identified in future studies for increasing an individual's generalized ability to echo complex stimuli. In this direction, future research should be conducted to determine how many exemplars must be taught before response generalization emerges.

One of the limitations of the present study was the procedure for selecting target words. Instead of asking parents for target word suggestions, it would be better to use a tool for articulation assessment (e.g., Goldman-Fristoe Test of Articulation, 2011). The data were reported in percentage of correct whole echoics, replicating the original study. However, using frequency may reflect the changes in the target behavior more accurately.

The results contribute to the existing knowledge base on language interventions for children with autism and developmental disabilities by producing supporting results for the previous research in which the chaining procedure was implement in order to increase the complexity of utterances.

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Table 1
Lists of Words Used for Each Participant

Participant	Whole Word	Segment 1	Segment 2	Segment 3	Segment 4
A	living room	liv	ing	room	
	umbrella	umb	rel	la	
	summertime	sum	mer	time	
B	snack	s	nack		
	excellent	ex	ce	lent	
		ex	cel	ent	
	independent	in	de	pen	dent

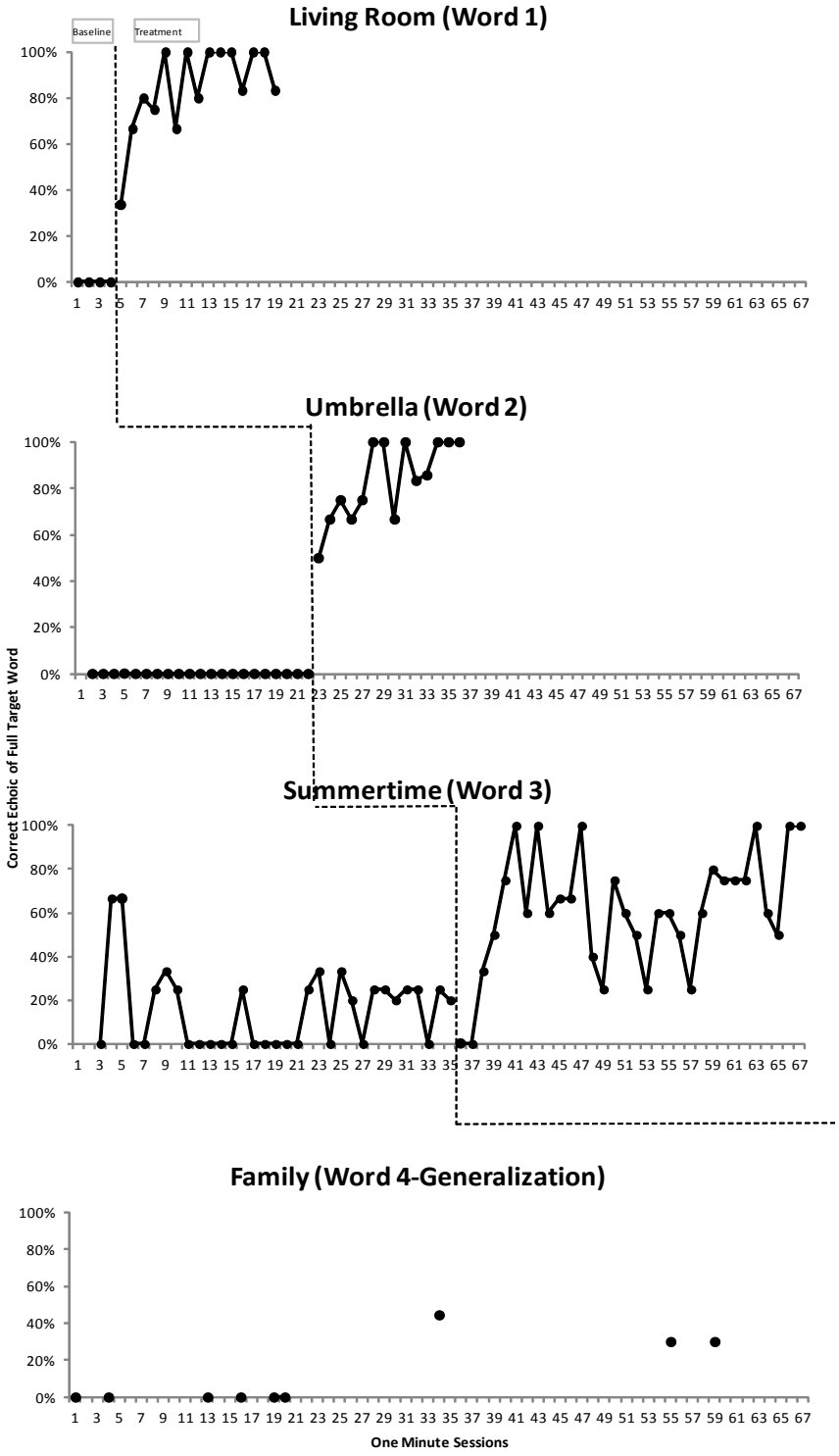

Figure 1. Percentage of correct responses across echoic behaviors for Participant A

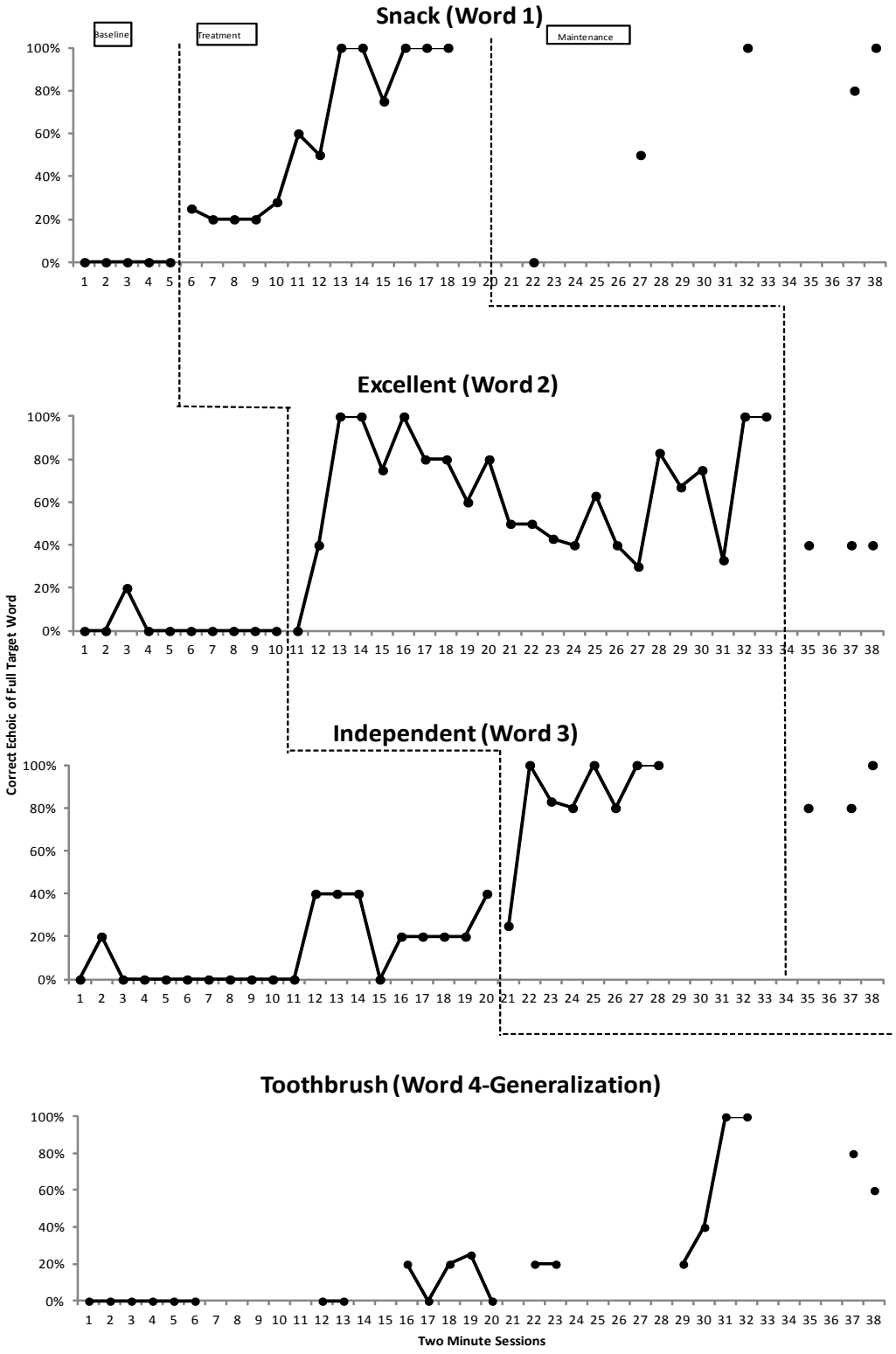

Figure 2. Percentage of correct responses across echoic behaviors for Participant B.