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A Component Analysis of Response Interruption and Redirection for Vocal Stereotypy in Children with Autism Spectrum Disorder

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by

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Abstract

Response Interruption and Redirection (RIRD) was compared to no-interaction, continuous neutral sound, and contingent neutral sound in order to determine the mechanism by which RIRD functions to suppress vocal stereotypy in children diagnosed with autism spectrum disorder. A neutral sound was determined through the use of a preference assessment of various sounds. Use of a neutral sound did not suppress vocal stereotypy in participants. Manipulating the amount of time with a sound playing did not have an effect on vocal stereotypy either. These results suggest that it is unlikely that RIRD suppresses vocal stereotypy through an extinction-like effect. Rather, it is more likely that RIRD suppresses vocal stereotypy through a punishment-like effect.

Introduction

Stereotypy is a class of repetitive behaviors that typically persists in the absence of social consequences (Rapp & Vollmer, 2005). Stereotypy is seen in multiple disorders including autism spectrum disorder (ASD; American Psychiatric Association, 2013), and can present with both motor and vocal topographies. Vocal stereotypy (VS) is defined by Ahearn, Clark, MacDonald, and Chung (2007) as any noncontextual speech or sounds that serve no social function. Vocal stereotypy can be problematic for individuals with ASD because it may interfere with skill acquisition (Lovaas, et al., 1966), performance (Morrison & Rosales-Ruiz, 1997), and may have negative social implications (Ahearn et al., 2007). Further, stereotypy is often targeted for reduction because it may be disruptive to the individual engaging in the behavior, as well as others in the environment (Lydon, Healy, O'Rielly, & McCoy, 2013). However, stereotypy is a difficult behavior to reduce, precisely because it is typically maintained by automatic reinforcement (Vollmer, 1994).

Response interruption and redirection (RIRD) was first described by Ahearn et al. (2007) as a treatment for VS. Response interruption and redirection is a treatment package that involves interrupting VS and redirecting the individual towards an appropriate vocal response. For example, a child engaging in VS was interrupted by the primary investigator (PI) stating the child's name, making eye contact, and instructing the child to say "ah", "moo", and "hi," and then providing social praise after the child complies with the vocalizations. Response interruption and redirection has been shown to suppress VS (Ahearn et al., 2007; Ahearns et al., 2011; Casella Sidener, Sidener, & Progar, 2011; Love, Miguel, Fernand, & LaBrie, 2012; Martinez, unpublished dissertation; Pastrana, Rapp, & Frewing, 2013). Response interruption and redirection was originally developed under the assumption that response interruption (RI) would work to stop VS because RI is an extension of response blocking. Response blocking has on occasion been shown to be an effective treatment for some forms of automatically reinforced behavior (Fisher, Grace, & Murphey, 1996; Lerman & Iwata, 1996; Reid, Parsons, Phillips, & Green, 193; Smith, Russo, & Lee, 1999), presumably through the use of punishment (Lerman & Iwata, 1996). Response interruption and redirected has been shown to be effective in reducing both vocal (Ahearn et al., 2007; Love, Miguel, Fernand, & LaBrie, 2012) and motor (Ahearns, Lerman, Kodak, Worsdell, & Keegan, 2011) stereotypy. Response interruption and redirection can be adapted to the skill level of the individual, (i.e., non-verbal individuals can be redirected to a motor task and still experience decreases in VS; Casella, Sidener, Sidener, & Progar, 2011; Pastrana, Rapp, & Frewing, 2013). Response interruption and redirection has also been shown to be effective in conjunction with matched auditory stimulation (Love et al., 2012).

Ahearn et al. (2007) stated that RIRD is effective in decreasing VS because it is a variation of response blocking. One possible mechanism that has been suggested to underlie reductions associated with blocking is punishment (Lerman & Iwata, 1996). It has been hypothesized that VS is decreased through punishment (Ahearns et al., 2011); Martinez, unpublished dissertation) however, it has not been confirmed whether RIRD decreases behavior through the interruption component or the redirection component, or it both components are necessary for behavior change.

Martinez (unpublished dissertation) compared RIRD to reinforcement of appropriate vocalizations (e.g. vocalizations that are relevant to the context) alone and found that reinforcement alone does not decrease stereotypy. Martinez also compared redirection alone to RIRD and concluded that redirection seems to be the critical component of response interruption and redirection. Martinez came to the conclusion that RIRD works because redirection functioned as punishment for engaging in VS. However, Martinez' study lacked an interruption component and thus did not directly compare interruption to redirection, a relationship which is explored in the present study.

Evidence in the literature is inconsistent about the function of punishment in response interruption and redirection. Martinez (unpublished dissertation) compared effects of contingent redirection to more aversive and less aversive task demands and concluded that there was no difference in levels of VS between the more and less aversive task demands. This outcome contradicts their conclusion because the more aversive tasks might be expected to produce a greater decrease than the less aversive tasks if redirection truly functioned as punishment. However, Ahearns and colleagues (2011) found that increasing the schedule of RIRD delivery further decreased the rate of vocal stereotypy. There were some instances in which RIRD did not produce reliable decreases in VS (Carroll & Kodak; 2014; Dickman, Bright, Montgomery, & Miguel, 2012; Martinez, unpublished dissertation,). It is possible that RIRD did not function as punishment for these participants: however, it is unclear why behavior did not decrease for these participants. Another possibility is that RIRD could potentially produce decreased rates of stereotypy through extinction. Interrupting VS may modify the automatic reinforcement that comes from hearing one's own voice. Vocal stereotypy remaining at high rates for some participants could constitute an extinction burst or an inability to completely stop the individual from engaging in VS, and thus not extinguish the behavior. A study by Carroll & Kodak (2014) observed higher rates of VS when RIRD was conducted when compared to a no-interaction in a multi-element design. This study potentially suggests that levels of VS were high due to intermittent reinforcement.

The purpose of this study is to identify the components of RIRD that work to decrease VS, investigate the role of extinction in RIRD and to examine the use of neutral sound to suppress VS in children with autism spectrum disorders. It is hypothesized that the redirection component decreases VS because it functions as a weak form of extinction. The present study also examines the use of neutral sounds to suppress VS. It is hypothesized that a decrease in VS when a neutral sound is played supports an extinction-based interpretation of RIRD if the decrease is comparable/similar to those observed when RIRD is implemented.

Method

Participants, Settings, and Materials

Participants were three males, Dillon, age 5, Blake age 10, and Aaron age 11, diagnosed with ASD, who engaged in VS, and who were able to follow simple instructions as reported by their BCBA. All three participants were reported for problematic levels of VS. Sessions were conducted by the PI in a closed room. The room in which Dillon's sessions were conducted included a cot, an empty bookshelf, and two filing cabinets. Aaron and Blake's sessions were conducted in an observation room with a one-way mirror, two tables, four chairs, and a large fireproof cabinet. Participants were recruited from a behavior analysis center based on recommendation by BCBAs at the center and via a flyer sent out to parents of eligible children at the center.

Session materials included toys, a smartphone, and different colored shirts to signal conditions. The toys were low-preferred (identified via a preference assessment; described below) and present during all sessions. The smartphone was used to play sounds during the sound assessment and the interference conditions, and to record the intensity of participant's VS using a decibel-meter application.

Target Behavior

Vocal stereotypy is defined as any instance of noncontextual speech or speech that serves no social purpose, including singing, babbling, repetitive grunts, squeals, "scripted" talk, and phrases unrelated to the present situation (Ahearn, 2007; Ahearns, et al., 2011). Dillon's VS was defined as repetitive singing of preferred songs (e.g. "Ten in the Bed"), humming, giggling without an observable cause, and repetitive high pitched sounds. Aaron's VS was defined as singing short segments of preferred songs and scripting (out loud or whispering) segments of preferred shows (e.g. The Wiggles). Blake's VS was defined as yelling or prolonged noises without a social function and laughing with no observable cause. Volume of VS was recorded in decibel levels. For Dillon it was 64, for Aaron 61, and for Blake 86 decibels.

Response Measurement and Interobserver Agreement (IOA)

Sessions were video recorded using a Sony Cyber-shot DSC-W810 digital camera, and the videos were scored for the purposes of data collection, treatment integrity, and IOA. The decibel meter app was used during an initial interaction with the participant to record the peak volume of the participant's stereotypy. This information was used to determine the volume of the sounds being played during the sound assessment and interference conditions.

Vocal stereotypy was recorded using continuous-duration recording by having data collectors score the onset and offset of VS using smartphones running data collection software (Countee App). In addition, data collectors scored the onset and offset of RIRD, and the frequency of RIRD and contingent sound. The percentage of time spent engaging in VS was calculated in each session by dividing the number of seconds spent engaging in VS by total number of seconds within a session and multiplying by 100. Data on duration of VS observed both during and out of RIRD were also collected. As Carrol and Kodak (2014), showed, differences between the measures can reveal the degree to which RIRD produces artefactual decreases in VS simply because the procedure itself often historically coincided with the cessation of measurement of VS.

Three observers scored 32.7% of all sessions. The observers were students from the Applied Behavior Analysis program at the University of South Florida and one student from the department of Psychological and Brain Sciences at Indiana University. IOA was calculated using the block-by-block method in which a 5 min observation period is divided into consecutive 10 s blocks. For each block, the smaller value was divided by the larger value. The value from each block was summed and then divided by the total number of blocks, and subsequently converted to a percentage (Page & Iwata, 1986). IOA averaged 91.3%% (80% to 100%).

Treatment Integrity

Treatment integrity was recorded for 25% of sessions. Treatment integrity averaged 99% and ranged from 90% to 100%.

Preference Assessment

The purpose of this assessment was to identify a low-preferred toy or item to include in the sessions. A Multiple Stimulus Without Replacement (MSWO) was conducted in which the participant chose one item from an array of seven to eight items arranged in a line in front of him. The participant had access to each item for 5 s prior to being instructed by the PI to choose one item from the array. Once the item was chosen, the participant had access to the item for 30 s. The item as not replaced into the array, the array was shuffled, and the PI instructed the participant to choose another item from the array until all of the items were selected once or until the participant did not make a selection from the array within 30 s of being asked to choose a new item. If items were no longer being selected, the trial ended and all remaining items were marked as not selected (DeLeon & Iwata, 1996). Items included in this assessment were based on the participants' BCBAs' reports of preferred items.

Sound Assessment

A preference assessment of eight sounds was conducted in two conditions, sound-off and sound-on, in order to determine a neutral sound to be played during experimental conditions. Prior to conducting the sound assessment, the following training was provided. The participant was trained to touch a red piece of paper on the table in front of him to turn the sound off and a green piece of paper to turn the sound on. During the sound-off condition training, a sound was played and the participant was physically prompted to touch the red paper. Once the participant touched the paper, the PI immediately turned the sound off for 10 s. In the sound-on condition training, the participant was physically prompted to touch the green paper. Once the participant touched the green paper, the PI immediately turned the sound on for 10 s. Each condition was run until the participant touched the paper ten times.

Prior to each sound-off session, the participant was pre-exposed to a sound for 10 s. Following the pre-exposure, the participant was told, “If you want to turn the sound off, you can touch the red paper,” and the PI played the sound. If the participant touched the red paper, the PI turned the sound off for 15 s. If the participant did not touch the red paper during the 5 min session, the sound was not turned off and the session was terminated at the end of the 5 min.

Once a sound was assessed in this manner, the sound was subsequently assessed again in the sound-on condition. In this condition, a sound was played for 10 s and then turned off. The PI then told the participant, “If you want to turn the sound on, you can touch the green paper.” If the participant touched the green paper, the PI turned the sound on for 15 s. If the participant did not touch the green paper during the 5 min session the sound was not turned on and the session was terminated. Sound-on and sound-off sessions were alternated in a multi-element design for each sound.

For one participant, Blake, the sound assessment papers were modified in order to help him better differentiate the sound-off condition from the sound-on condition. In the sound-off condition, a pause symbol was drawn onto the red paper with the word “pause” written underneath and he was instructed, “If you want to stop the sound you can press pause.” During the sound-on condition, a play symbol was drawn onto the green paper with the word “play” written underneath and he was instructed, “If you want to hear the sound you can press play.” Blake had previous experience with an iPad, which influenced the decision to modify the sound assessment for him.

Neutrality of a sound was determined by subtracting the number of times a sound was turned off from the number of times a sound was turned on. If the sum of the frequency was negative, the sound was considered non-preferred. If the sum was positive, the sound was considered preferred. Sounds that were considered neutral were as close to a zero sum as possible. If the data paths of two sounds were close, the raw data was looked at in order to determine which sound was closest to a zero sum. It was also important to identify preferred and non-preferred sounds because a failure to show consistent responding to either turn on or turn off a stimuli might simply suggest a skill deficit rather than anything about the stimuli themselves.

Phase 1: Evaluate RIRD as an Intervention

The purpose of Phase 1 was to provide preliminary evidence that RIRD is effective in decreasing VS in participants before moving on to Phase 2. The effectiveness of RIRD was evaluated using a multi-element comparison of RIRD and a no-interaction control.

No-interaction. No-interaction sessions were 5 min and consisted of the participant and the PI in a closed room. The PI did not engage with or respond to the participant, however, the participant was able to engage with the low-preferred toy. No programed consequences were implemented contingent on vocal stereotypy. Occurrence of VS during the no-interaction condition suggests that VS is maintained by automatic reinforcement (Iwata, Dorsey, Silfer, Bauman, & Richman, 1994; Rapp & Vollmer, 2005).

RIRD. Sessions during the RIRD condition were 5 min. During the RIRD condition, VS was interrupted immediately by stating the participant's name and making eye contact. Then the participant was redirected to another vocalization selected from a list of mastered echoics provided by the participant's BCBA. The criterion for terminating RIRD was a sequence of three echoics without the occurrence of vocal stereotypy. If the participant did not comply with the alternative vocalization following three presentations of the discriminative stimulus from the PI, he was redirected to a sequence of three motor imitation tasks. Once the participant complied with the redirection sequence without VS, he was provided with vocal praise. A flowchart of the procedures in RIRD is displayed in Figure 1.

Phase 2: Component Analysis of RIRD (Extinction)

The purpose Phase 2 was to determine if response suppression during RIRD phases can be attributed to the interference-like effects of providing additional sounds on a response-independent schedule. If VS is automatically reinforced by the sound of one's own voice, then having additional sounds played continuously in the background may reduce the participant's ability to contact the reinforcing effects of VS in way similar to extinction, or a net-reduction in reinforcer magnitude. We chose to provide the sounds noncontingently to more easily distinguish the effects from response-contingent punishment.

Phase 2 was assessed in two parts: A and B. In condition A, VS was examined in a multi-element comparison of three conditions: continuous sound, RIRD, and no-interaction. In condition C, intermittent sound was assessed. The percentage of the session with sound was manipulated (0%, 10%, 20%, 40%, 80%, 100%) across sessions in ascending order twice. Each session was 5 min. If participants were more likely to engage in VS when sound was not playing, then it supports the notion that extinction might underlie the effectiveness of RIRD.

Throughout this phase, sounds were played at a volume of VS comparable to that observed in the no-interaction phase, or at 80 decibels, five decibels below the level at which hearing protection is necessary (Occupational Safety & Health Administration [OSHA], 2002) if those observed during no-interaction exceed the aforementioned safety limits.

Continuous Sound. In the continuous sound condition, a neutral sound was played continuously throughout the session. It was hypothesized that in this condition, participants would not engage in VS if the sound interfered with the reinforcement provided by vocal stereotypy. If VS occurred in this condition, RIRD was not implemented.

RIRD. The RIRD condition in Phase 2 was conducted as it was in Phase 1.

No-interaction. The no-interaction condition in Phase 2 was conducted as it was in Phase 1.

Phase 3: Component Analysis of RIRD (Punishment)

The purpose of this phase was to determine if response-contingent presentation of a neutral sound produced a decrease in stereotypy similar to those obtained when using RIRD, which could provide support for a punishment-like effect. Contingent sound, RIRD, and no-interaction were examined using a multi-element design.

Contingent Sound. The purpose of this condition was to see if contingent masking produced decreases in VS, which might provide support for a punishment-like effect. In the contingent sound condition, a neutral sound was played for 5-7 s contingent on the occurrence of Vocal stereotypy. The duration of the sound was calculated based on the median number of seconds participants spent in each RIRD sequence. For Dillon, Aaron, and Blake, these were 6 s 7 s, and 5 s respectively.

RIRD. The RIRD condition in Phase 3 was conducted as it was in Phases 1 and 2.

No-interaction. The no-interaction condition in Phase 3 was conducted as it was in Phases 1 and 2.

Data Analysis

Percentage of time with VS was analyzed as it was in Carroll and Kodak, 2014. Total session time (uninterrupted) and time in RIRD were analyzed. This is a more conservative measurement in order to ensure that the treatment effect of RIRD is not being exaggerated. Frequency of implementation of RIRD was also analyzed.

Results

MSWO

Results for the MSWO preference assessments are displayed in Figure 2. The low preferred items selected for the participants were the train for Dillon, the Bendeez for Aaron, and the DVD for Blake.

Sound Assessment

Results from the sound assessments are displayed in Figure 3. The sounds determined to be neutral were: ocean waves for Dillon, footsteps for Aaron, and lobby conversation for Blake.

Phase 1

For Dillon, Aaron, and Blake, total duration of VS was consistently higher in the no-interaction condition compared to the RIRD condition, suggesting 1) that VS was maintained by automatic reinforcement and 2) RIRD was effective at suppressing VS for all participants (Figure 4). For Dillon, frequency of VS increased in the no-interaction condition and decreased in the RIRD condition. Duration and frequency of RIRD implementation also decreased. For Aaron, frequency of VS stayed at similar levels in both no-interaction and RIRD. Frequency of RIRD implementation decreased slightly and duration of RIRD increased slightly before decreasing to a level below that of session 2 with RIRD (Figure 5). For Blake, Frequency of VS increased in the no-interaction condition but remained at a higher level in two out of three sessions in the RIRD condition (Figure 6). Duration and frequency of RIRD decreased noticeably in session 4, and then increased in session 6, but still remained below the levels seen in session 2. All subsequent data presentations will involve duration of VS as it was the most sensitive measure for assessing effects of RIRD.

Phase 2

Phase 2a. For Dillon, duration of VS decreased in all conditions. Levels of VS remained lowest in RIRD and were at similar levels in no-interaction and continuous sound conditions (Figure 7). Frequency of VS were at similar levels in all three conditions; however, frequency and duration of RIRD decreased throughout Phase 2a. For Aaron, duration of VS remained low in the RIRD condition, but was variable in both the no-interaction and continuous sound conditions with the highest duration being in the no-interaction condition (Figure 9). Frequency of VS was highest in the continuous sound condition and lowest in the RIRD condition. Frequency and duration of RIRD remained relatively stable throughout Phase 2a and was lowest in session 4, and highest in session 10. For Blake, duration of VS was lowest in the RIRD condition and highest in the continuous sound condition. Duration of VS increased in both the no-interaction and continuous sound conditions (Figure 10). Frequency of VS was highest in the continuous sound condition and was at similar levels in no-interaction and RIRD conditions. RIRD remained at a similar duration and frequency, then decreased before increasing to levels observed in the first session of Phase 2a.

Phase 2b. Dillon was the only participant with which Phase 2b was run because he was the only participant who showed a decrease in VS during the continuous sound condition. For Dillon, the percentage of the session with VS decreased as the percentage of the session with sound increased the first time. When the series was repeated, the percentage of the session with VS was lower in the second series than in the first series, until the 80% and 100% of the session with sound, where the percentage of the session VS increased above what was observed in the first series (Figure 8). Manipulating the amount of time in which sound was presented produced no consistent effect on Dillon's vocal stereotypy.

Phase 3

For all three participants, duration of VS was lowest in the RIRD condition. For Dillon, duration of VS decreased in both the no-interaction and contingent sound conditions. Duration of VS was initially higher in the no-interaction condition, but decreased to levels similar to those observed in the contingent sound condition (Figure 11). Frequency of VS was variable in all conditions, but had a slight decreasing trend in both RIRD and contingent sound conditions. However, frequency of VS in the no-interaction condition overlapped with levels seen in both contingent sound and RIRD. Frequency and duration of RIRD had a slight decreasing trend in Phase 3 and frequency of contingent sound also had a decreasing trend.

For Aaron, duration of VS was variable in both no-interaction and contingent sound. In the contingent sound condition, duration of VS was variable throughout the phase, but in the no-interaction condition, duration of VS was similar to levels observed in the RIRD condition and increased at session 7 to levels similar to those of the contingent sound condition (Figure 12). Frequency of VS was lowest in the RIRD condition and was variable in the RIRD and contingent sound conditions. Duration of RIRD was variable, and frequency of RIRD was variable with an increasing trend. Frequency of contingent sound was variable throughout the phase.

For Blake, duration of VS was variable in the contingent sound and no-interaction conditions with similar patterns of variability. Both conditions initially had a decreasing trend, peaked, and then decreased again (Figure 13). Frequency of VS was variable in all conditions with similar levels across all conditions. Frequency and duration of RIRD were relatively stable throughout the phase and frequency of contingent sound had a decreasing trend, then peaked, followed by another decreasing trend.

Discussion

Vocal stereotypy occurred across all conditions and all phases with each participant, suggesting that VS was maintained by automatic reinforcement. Duration of VS for all participants was lowest in the RIRD condition throughout all phases when compared to a no-interaction condition, which is consistent with findings from previous studies (Ahearn et al., 2007; Ahearns et al., 2011; Casella Sidener, Sidener, & Progar, 2011; Love, Miguel, Fernand, & LaBrie, 2012; Martinez, unpublished dissertation; Pastrana, Rapp, & Frewing, 2013) showing that RIRD decreases levels of vocal stereotypy. Phase 1 of this study established that RIRD was effective at decreasing the duration of VS in participants.

The purpose of Phase 2 was to determine if noncontingent sound presentation could reduce participants' VS. If so, this might provide support for an interference or extinction-like effect of RIRD (e.g., perhaps instructions delivered during RIRD interfere with a person's ability to contact automatic reinforcement for VS). In this phase, duration of VS only decreased for one participant when comparing no-interaction to continuous sound and RIRD, suggesting that the neutral sound did not have an effect on the automatic reinforcement provided by VS for two participants. For Dillon, however, the decrease in duration of VS while a continuous sound was playing suggests that there may have been some interference effect from the sound on the auditory input of his vocal stereotypy. One interpretation of this decrease might be that the continuous sound interfered with Dillon's ability to contact the automatically maintained reinforcement for VS. It is possible that Aaron and Blake were more habituated to an environment with a higher amount of background noise, and thus a continuous neutral sound did not have the same auditory impact that it did on Dillon. This could be especially true of Blake, whose VS decibel level was higher than the threshold for a neutral sound to be played.

The purpose of Phase 3 was to determine if response-contingent presentation of a neutral sound could decrease VS to levels observed in RIRD. Duration of VS had a more substantial decrease in Phase 3 that occurred across all conditions. For participants Aaron and Blake, a neutral sound did not seem to have an effect on their levels of stereotypy. It is possible that one reason why we did not see a difference between the no-interaction and sound conditions was the use of a neutral sound as opposed to an aversive sound.

An alternative reason why the use of a sound did not work to suppress VS was that VS was not maintained by an auditory input, but rather by a vocal output. Vocal stereotypy may be maintained by the proprioceptive stimuli associated with producing the sounds rather than the sounds themselves. Similarly, it is possible that the reason why RIRD is effective at suppressing VS is that RIRD requires an effort to be made on the part of the participant. RIRD requires the participant to be prompted to engage in another behavior. The instructions in RIRD may be aversive and work through social punishment rather than automatic punishment.

One limitation of this study was the use of the sound preference assessment to identify neutral sounds. Neutral stimuli are difficult to detect using assessments because responses that produce or remove them would necessarily be weak in comparison to stimuli that are effective reinforcers or strongly aversive. We tried to accommodate this by including a variety of sounds, some of which we believed were likely to function as reinforcers. But, the differences we obtained between responses to turn on and off the various sounds were small in comparison to responses maintained by food or to escape academic demands. As a result, the assessment needed to be lengthy in order to try to detect those more effective stimuli and, therefore, its lengthiness might be a limitation. Future research might address this by including stimuli from other modalities that are already known to be effective reinforcers.

The current study is consistent with existing literature suggesting that RIRD decreases VS through a punishment-like effect. Alternatively, the current data do not support an extinction-like effect for the effectiveness of RIRD.

Future research using sounds to suppress VS should consider using non-neutral sounds, or compare more aversive and preferred sounds to a neutral sound to determine their effects on VS suppression. Future research could also compare other sounds to sounds that have been previously shown to decrease VS, such as toys that produce sound (Love, Miguel, Fernand, & LaBrie, 2012; Rapp, 2007), a recording of the participant’s own vocal stereotypy, or music (Saylor, Sidener, Reeve, Fetherston, and Progar, 2012).

Figures

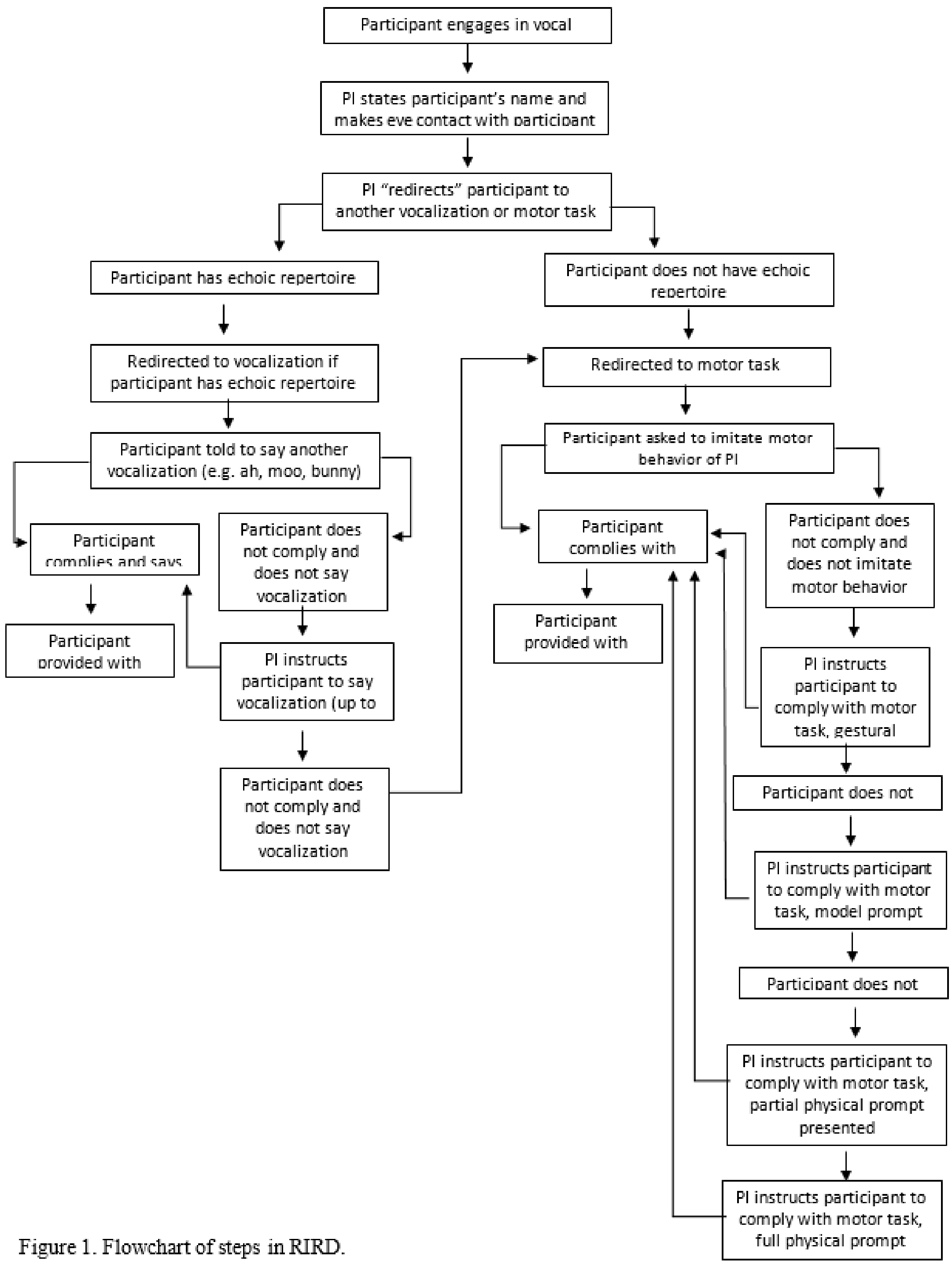

Figure 1. Flowchart of steps in RIRD.

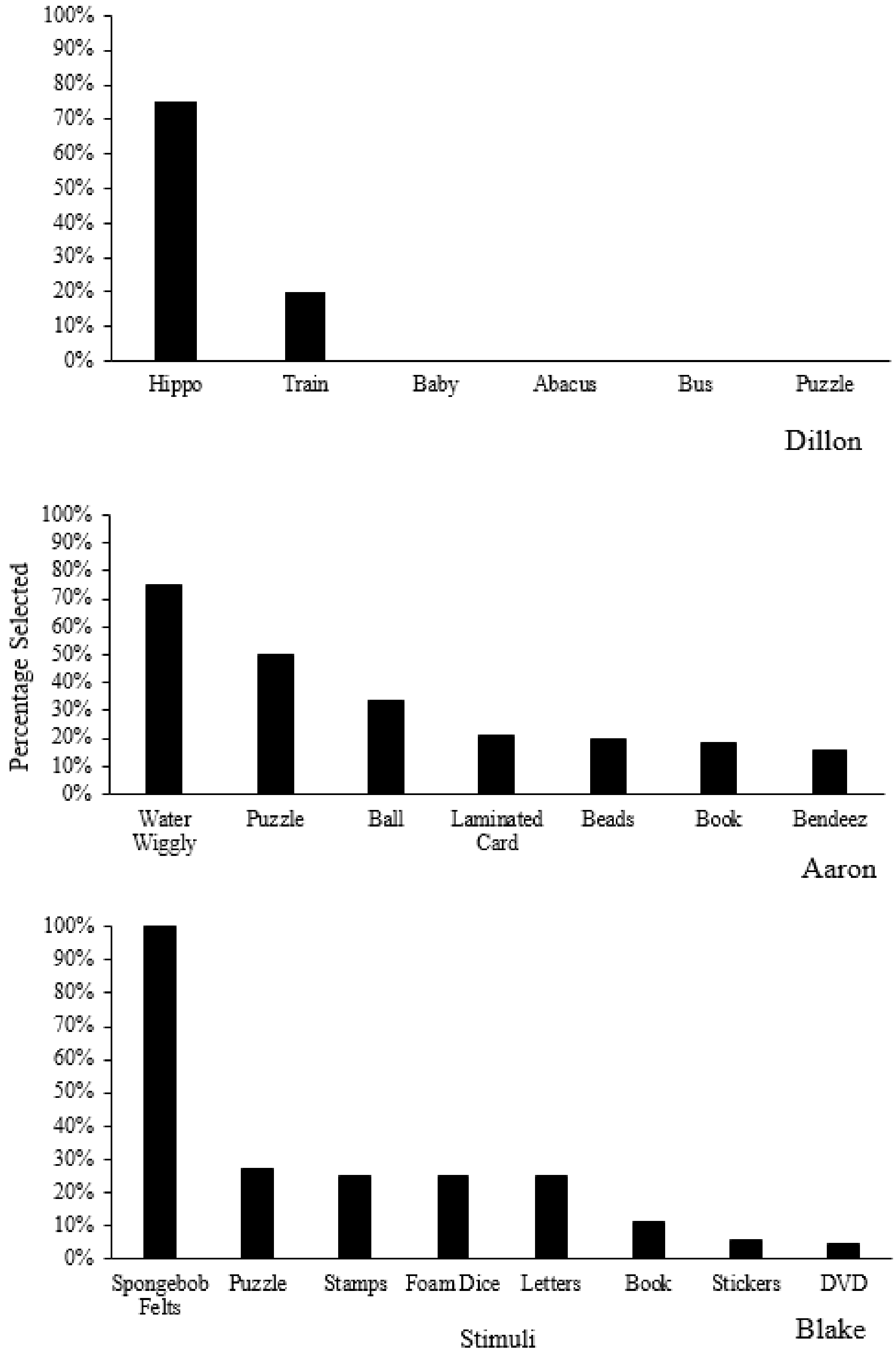

Figure 2. MSWO results for Dillon, Aaron, and Blake. Percentage selected for each stimulus.

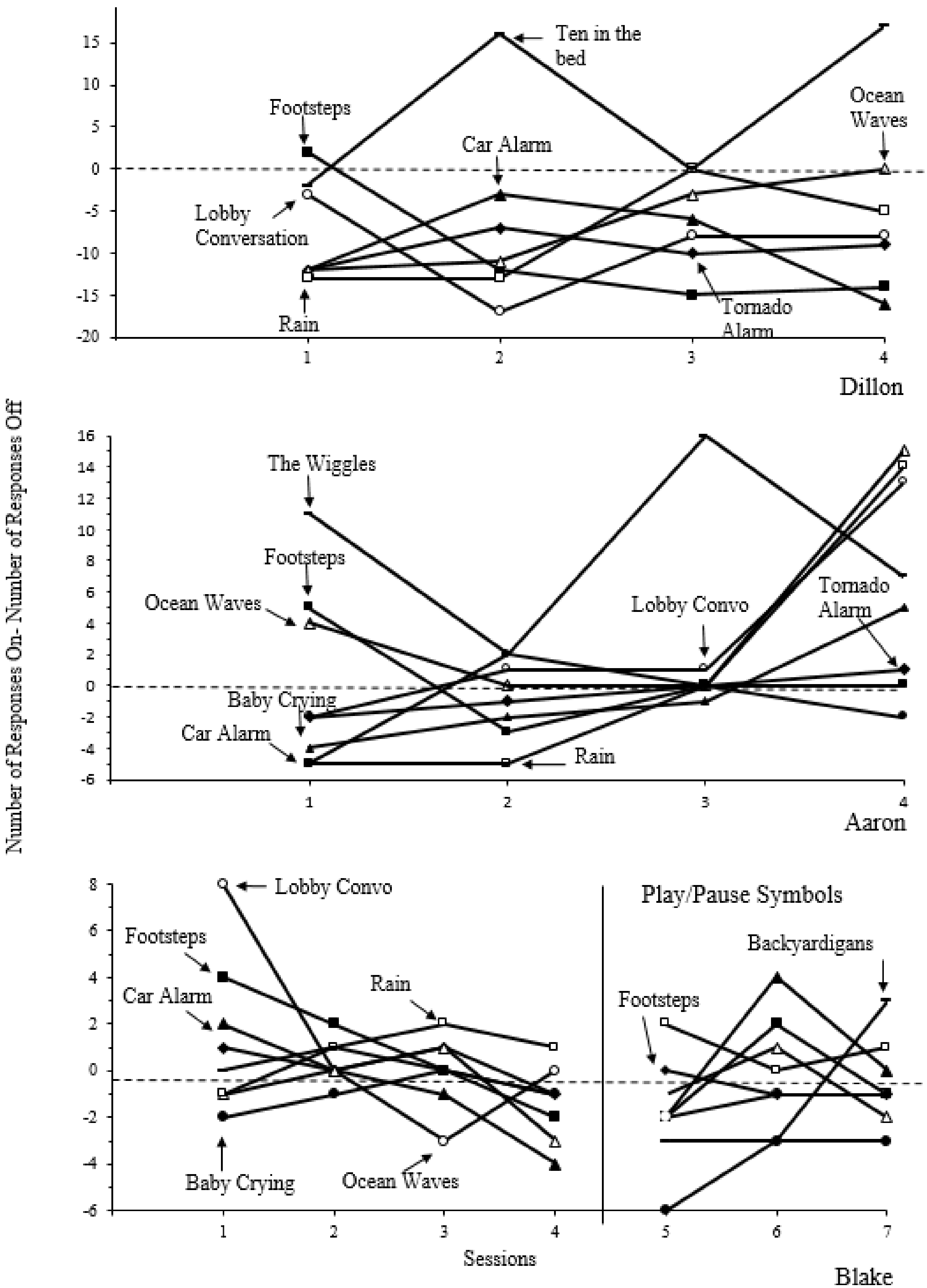

Figure 3. Sound assessment results for Dillon, Aaron, and Blake. Difference of responses on and off.

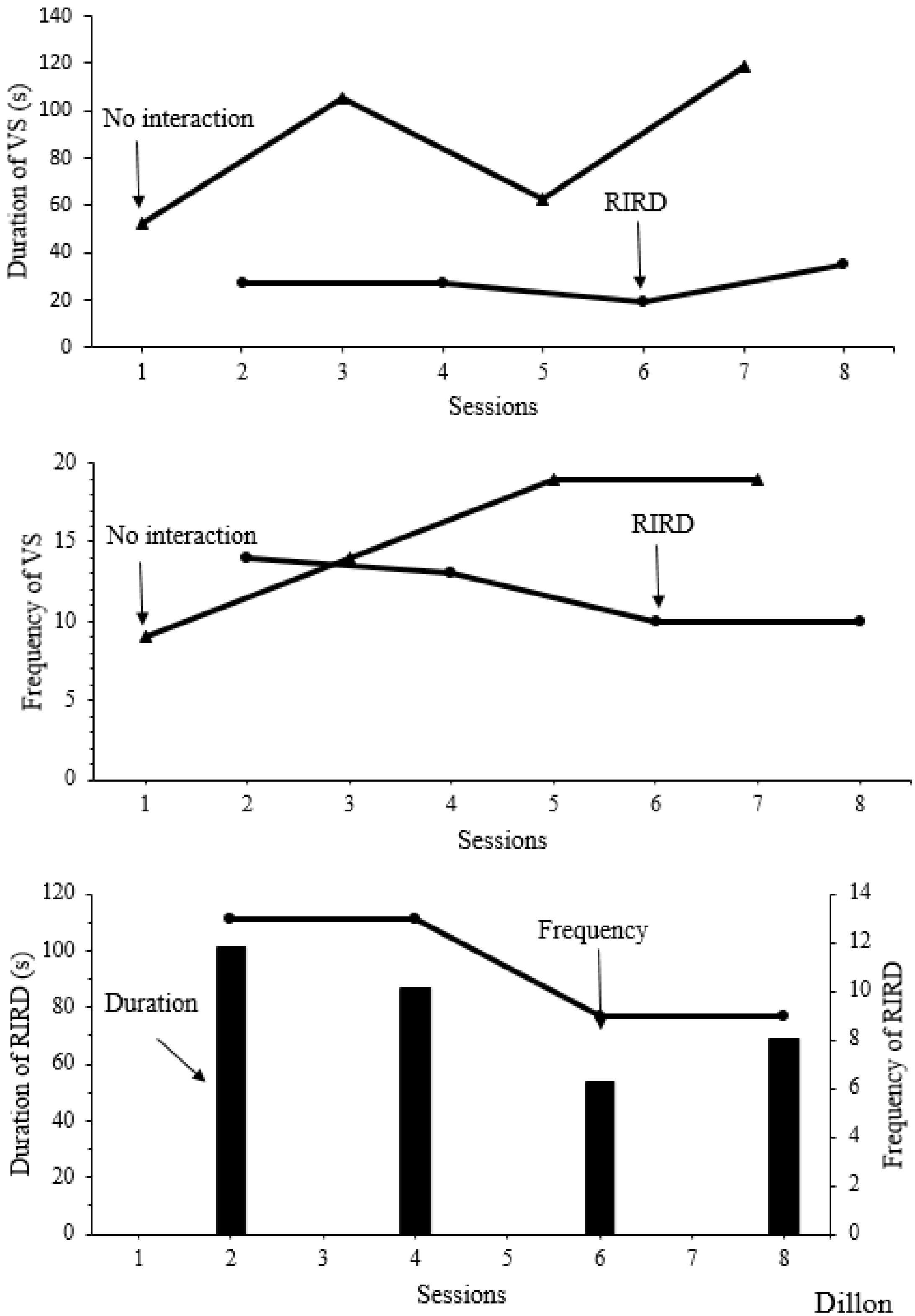

Figure 4. Phase 1 results for Dillon. Duration of vocal stereotypy in seconds (top). Frequency of vocal stereotypy (middle). Duration of RIRD in seconds and frequency of RIRD (bottom).

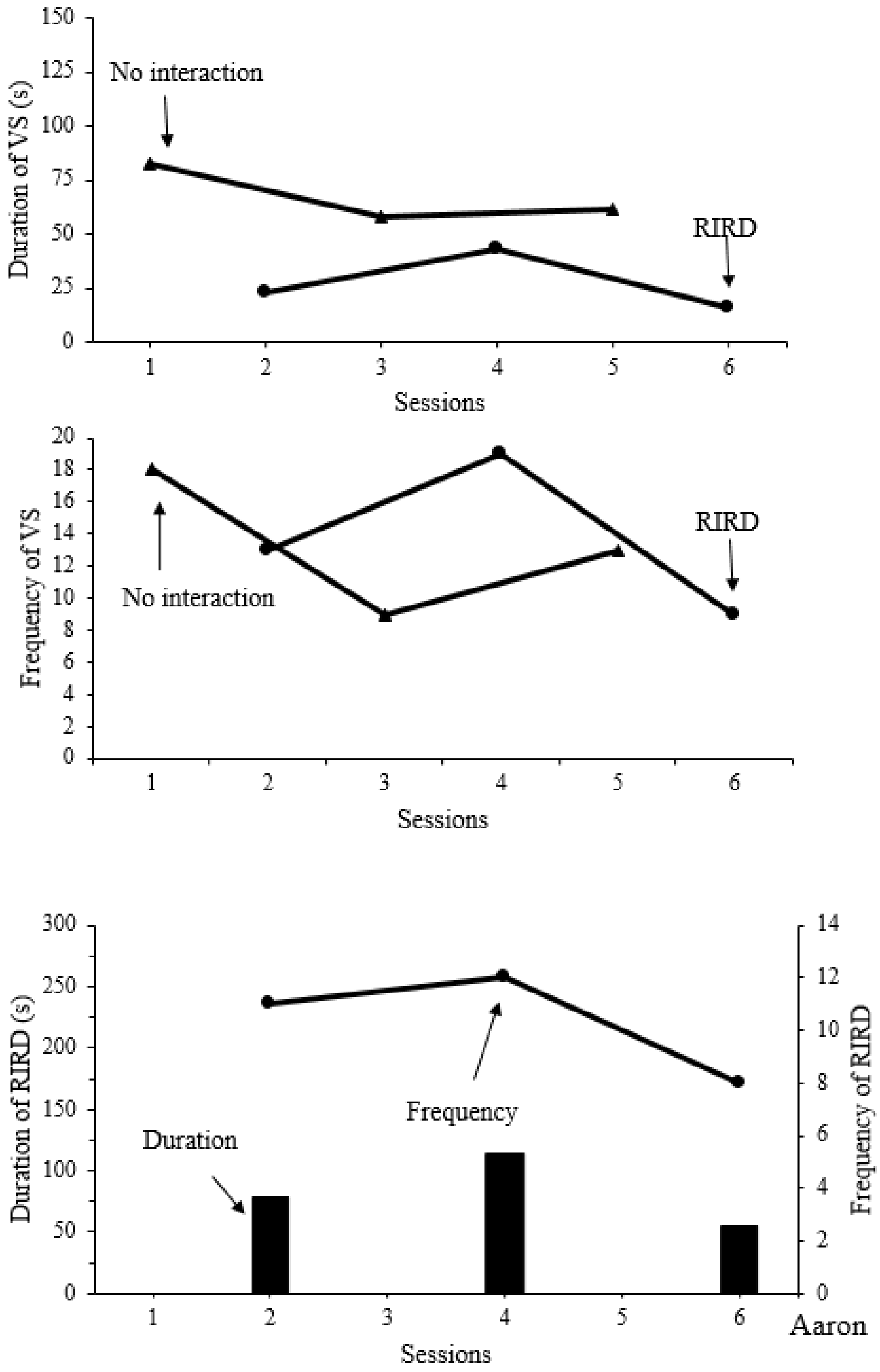

Figure 5. Phase 1 results for Aaron. Duration of vocal stereotypy in seconds (top). Frequency of vocal stereotypy (middle). Duration of RIRD in seconds and frequency of RIRD (bottom).

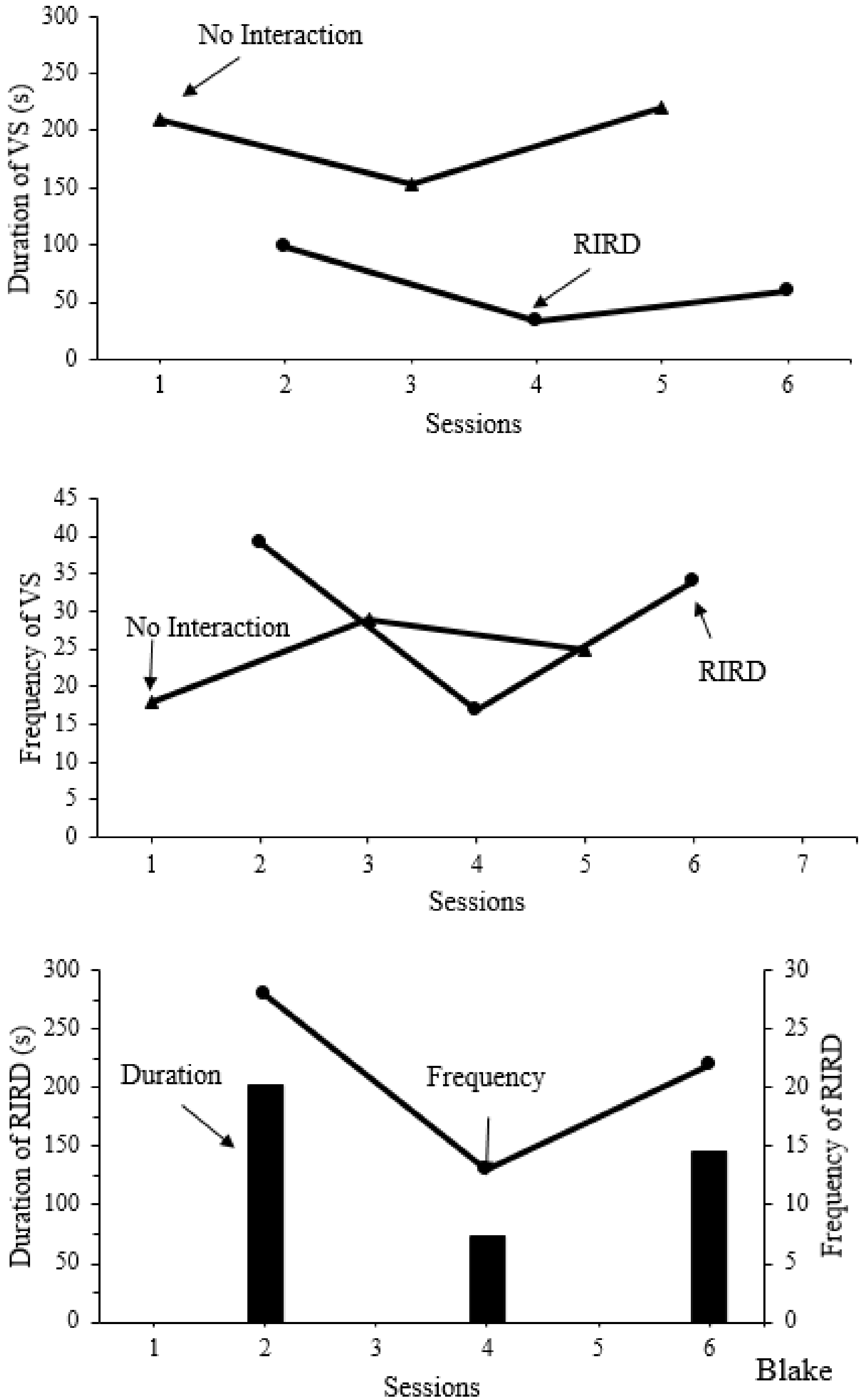

Figure 6. Phase 1 results for Blake. Duration of vocal stereotypy in seconds (top). Frequency of vocal stereotypy (middle). Duration of RIRD in seconds and frequency of RIRD (bottom).

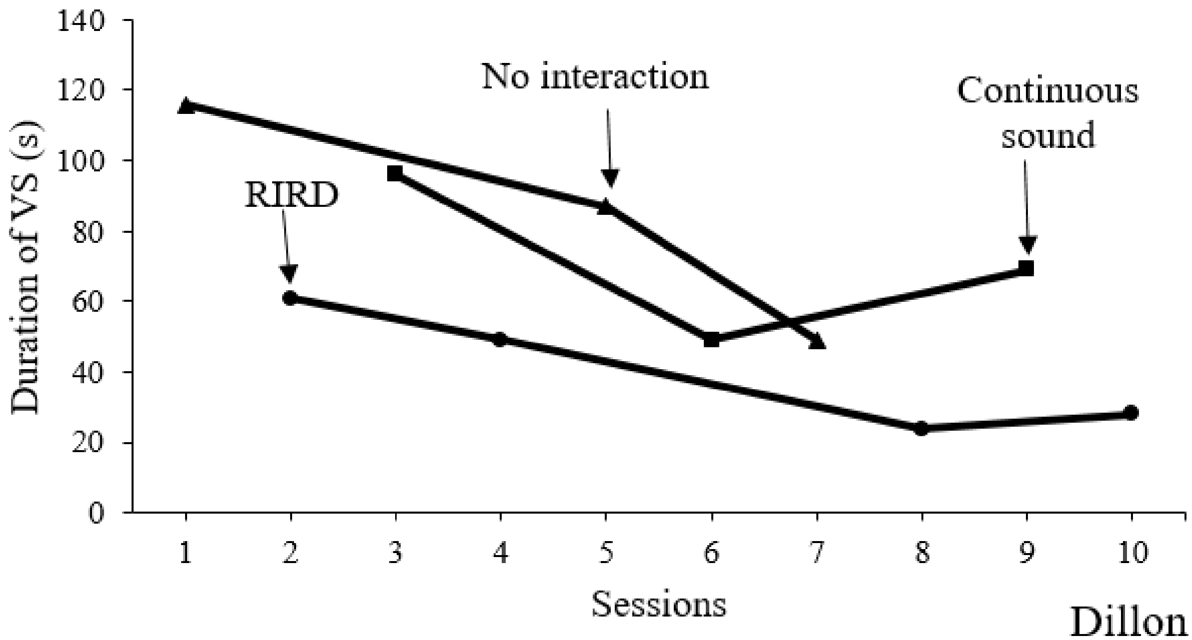

Figure 7. Phase 2a duration of vocal stereotypy in seconds.

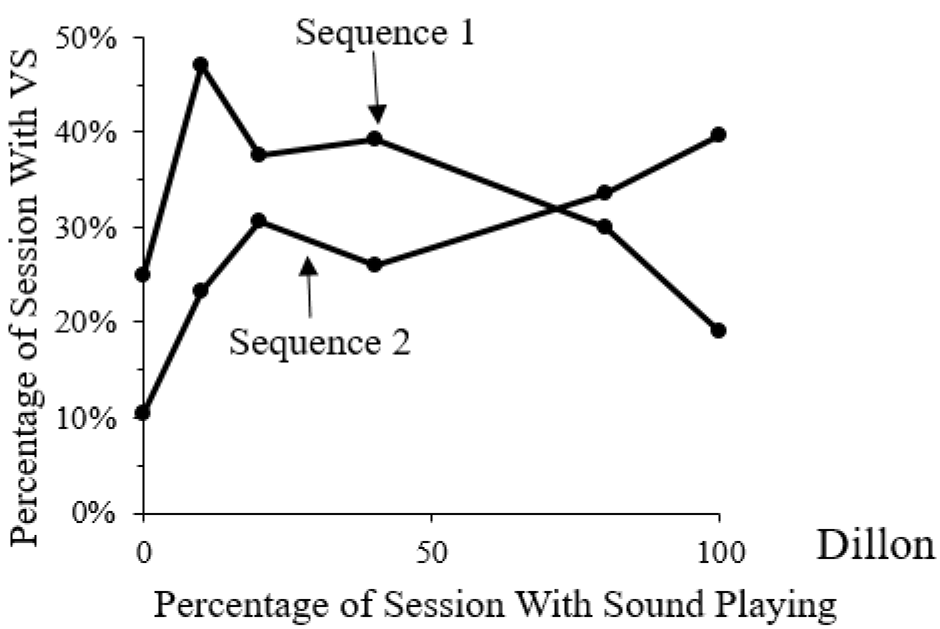

Figure 8. Phase 2b for Dillon. Percentage of session with vocal stereotypy as a function of percentage of session with sound playing.

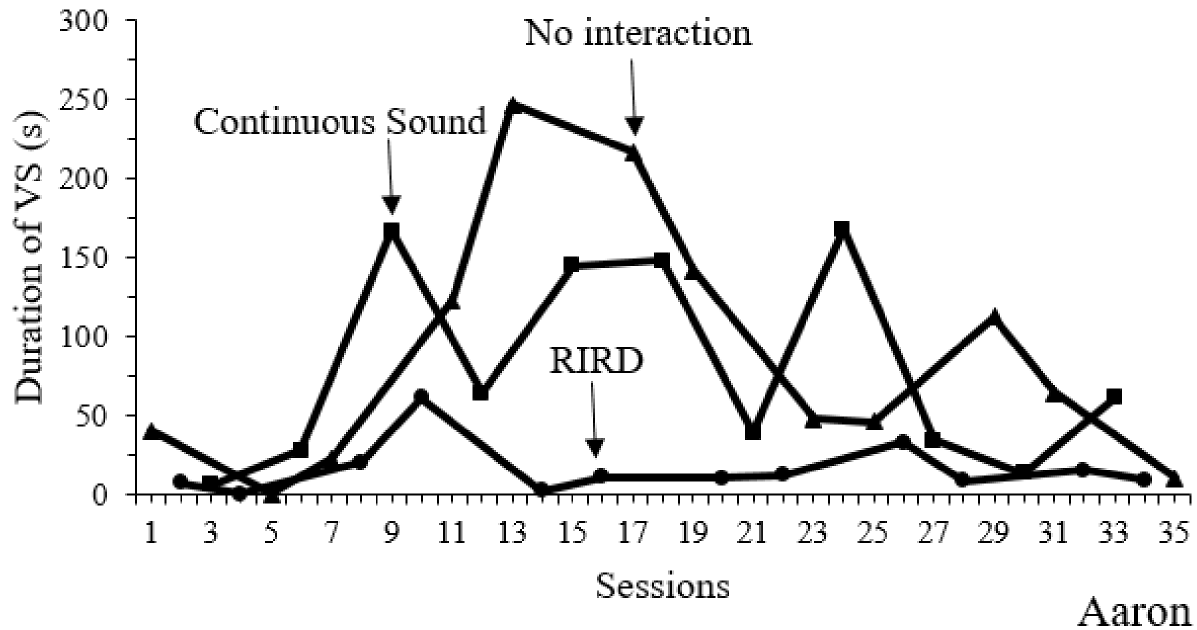

Figure 9. Phase 2a duration of vocal stereotypy in seconds.

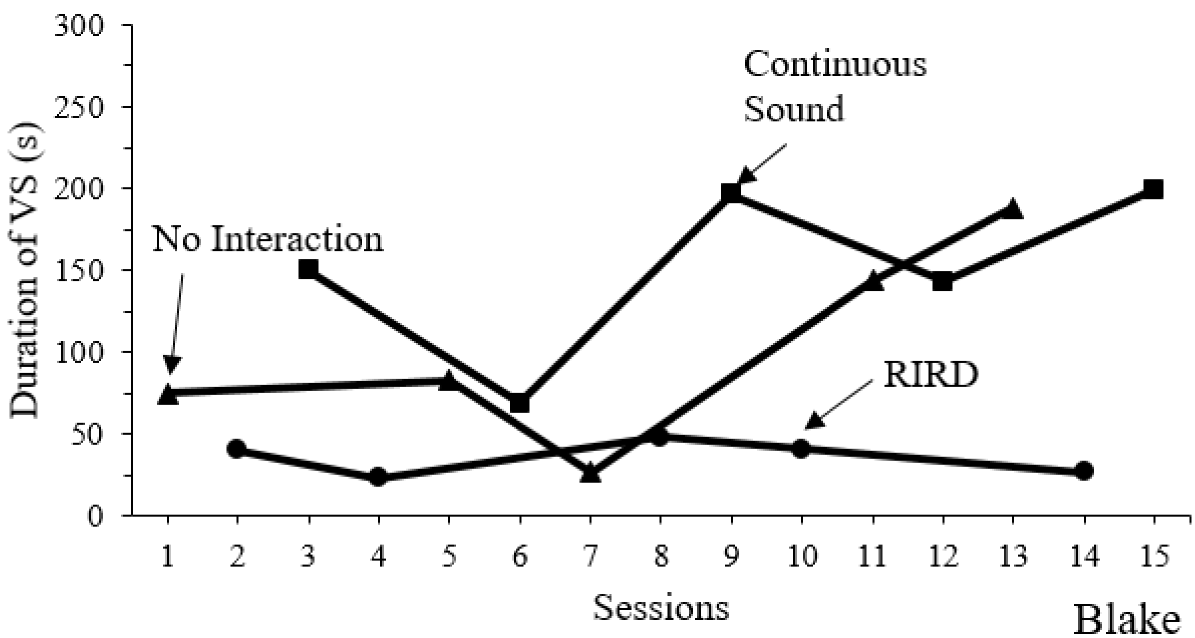

Figure 10. Phase 2a duration of vocal steteotypy in seconds.

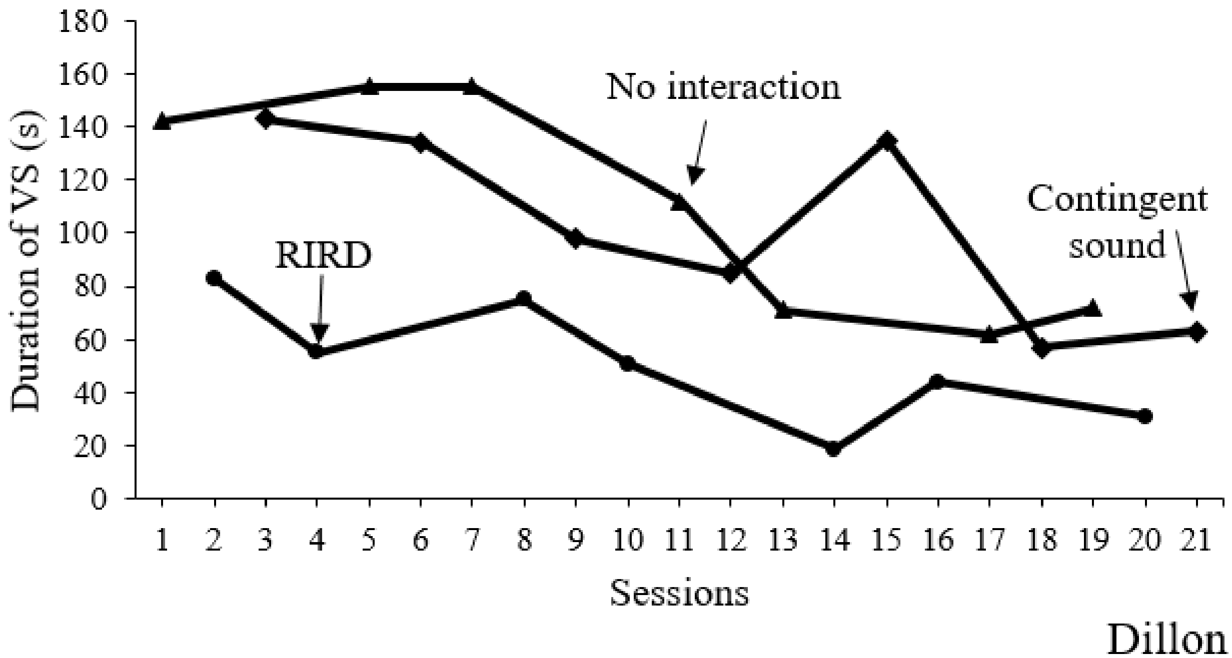

Figure 11. Phase 3 duration of vocal stereotypy in seconds.

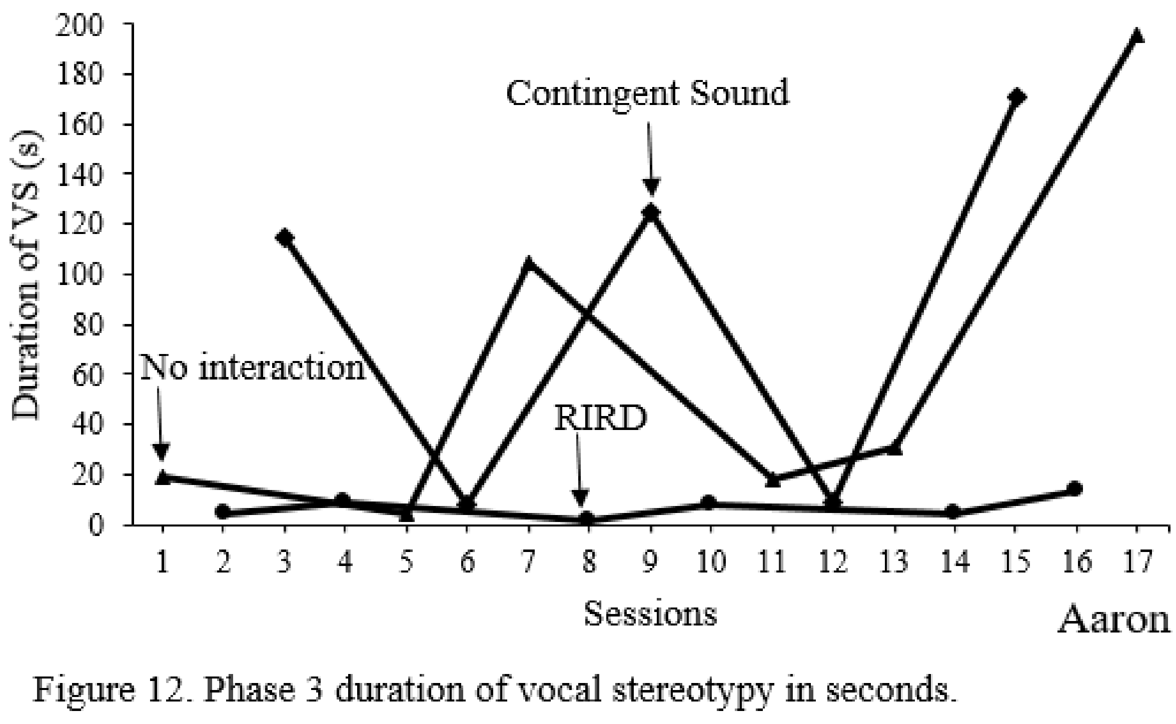

Figure 12. Phase 3 duration of vocal stereotypy in seconds.

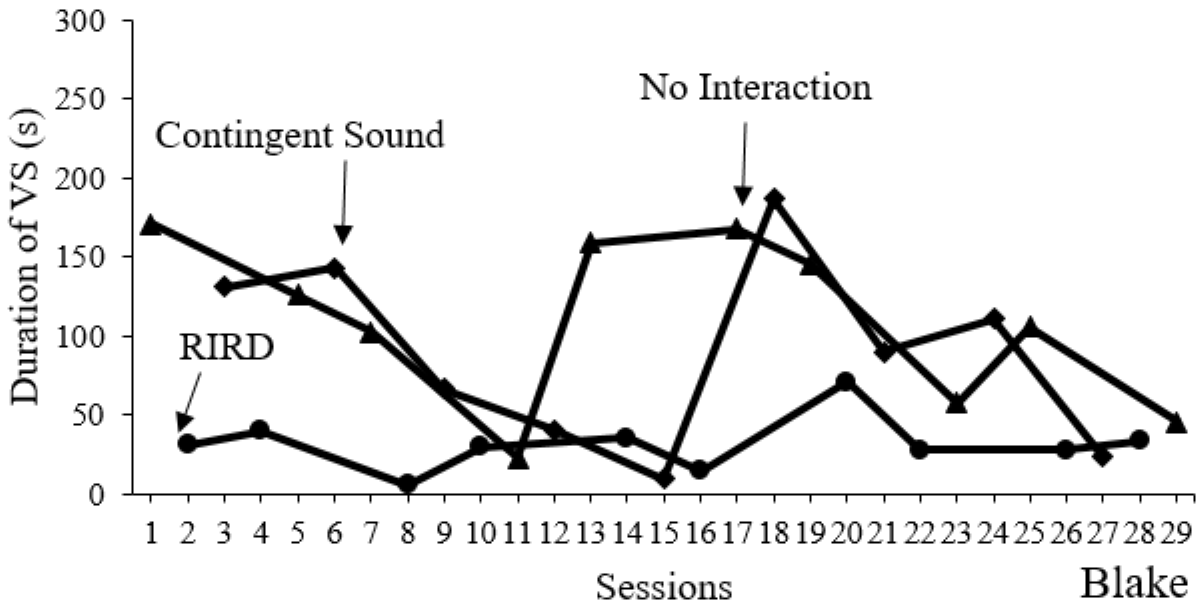

Figure 13. Phase 3 duration of vocal steteotypy in seconds.

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