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Analysis of echoic properties in vocalizations of a preverbal child on the autistic spectrum

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ANALYSIS OF ECHOIC PROPERTIES IN VOCALIZATIONS OF A PREVERBAL CHILD ON THE AUTISTIC SPECTRUM

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Abstract

Echolalia, the echoing of words, is a hallmark of language in children with autism. Echolalia in autistic language is generally viewed as a manifestation of gestalt learning, a particular cognitive style that impacts language learning, memory, and overall cognition. While extensive research has investigated echolalia, research has not investigated non-word echoing.

This study analyzed the average pitch, pitch range, and length of utterances made by a preverbal child with hallmarks of autism under two conditions: with a communication partner speaking in an animated voice, and with a communication partner speaking in a monotone voice. Analysis of results looked for evidence that the child's intonation patterns echoed that of the adult communication partner.

Analysis of average pitch, pitch range, and length of utterance compared to condition yielded a statistically significant Condition effect caused by significantly lower average pitch of child vocalizations during the Monotone condition. No other statistically significant effects were found, and this main effect is not indicative of intonation echoing. However, qualitative evidence identified during analysis suggests some non-speech echoing.

Due to the extensive evidence in other literature of communicative and developmental function in echolalia, further study of nonverbal echoes is warranted. Further study should focus on identification and differentiation of nonverbal echoes, as well as possible functions of nonverbal echoes in children who are not speaking.

I. Introduction

Autism is one of many disorders on the autistic spectrum, a continuum of developmental disorders characterized by impaired social interaction and social use of language, a lack of developmentally appropriate imaginative activities, and restricted, repetitive patterns of behavior, interests, and activities (American Psychiatric Association [APA], 1994). Language development in children with autism is generally delayed and disordered (APA, 1994). One characteristic of language in children with autism is echolalia, the echoing of words and phrases. While some echoing is present in typically developing language, echolalia in autistic language is different: it makes up a larger proportion of the child's speech, shows minimal change or revision, and occurs much later in development, typically in preschool and school age children (Fay, 1969).

Echolalia has been shown to serve communicative functions in children with autism, including requesting, self-regulating, answering affirmatively, and turn-taking in a conversation (Prizant and Duchan, 1981, Prizant and Rydell, 1984). Echolalia also seems to show a developmental function: the frequency of echolalia and the percentage of utterances that are echolalic change as language competency increases. Also, mitigated echolalia, or echolalia with changes in words and sentence structure, increases along with language level and more appropriate use of language (McEvoy, Loveland, and Landry, 1988).

Acoustic studies of the non-word vocalizations of children with autistic spectrum disorders show that they are different from those made by typically-developing peers (Schoen, Paul, Chawarska, Klin, & Volkmar, 2007), but no studies have explored the possibility of echoes in the non-word vocalizations of preverbal children with autism. Are these children not yet able to comprehend and respond to their communication partners, or are they comprehending and responding in a way that is not yet understood? Having seen verbal echoes serve a developmental and communicative purpose in verbal children, this study seeks out nonverbal echoes for further study as a possible developmental stage or communicative act.

II. Purpose of Research

This case study analyzes the pitch and intonation patterns of vocalizations in a preverbal child on the autistic spectrum during interaction with adult speech and language clinicians. Since echolalia in verbal autistic children has been shown to be significant and functional, this study will investigate the possibility of echoes in intonation patterns in preverbal children. The ultimate goal of the study is to provide a springboard to better understanding of possible communication in children who cannot or will not speak.

III. Review of Relevant Literature

Understanding the language and language development of children on the autistic spectrum has long been a challenge, for researchers and caregivers alike. For many years, echolalia was seen as a problem to be suppressed. Modern research has shown that echolalia serves communicative and developmental purposes, and that it fits within a larger framework of cognition in children with autism. Within overall differences in cognition, differences in nonverbal productions are also in evidence.

Prizant and Duchan (1981) videotaped over 1,000 echoic utterances made by four boys diagnosed with autism in different situations and routines. Specifically, they recorded immediate echolalia: the repetition of another's statement immediately or shortly after it is made. They then analyzed the utterances in respect to communicative context, structural and grammatical characteristics, and latency between the end of the model utterance and onset of the echoic utterance. Communicative context included interaction on the adult's part, the child's behaviors and eye gaze, and the functionality of the echoic utterance.

Upon analysis, the utterances fit in to seven functional categories, dependent upon the child and adult behavior as well as other environmental factors at the time of the utterance. These functional categories were: non-focused, turn-taking, declarative, rehearsal, self-regulatory, yes-answer, and request. This study showed that some echolalia was being used to a communicative end in these children, who had little in terms of other means of communication.

In 1984, Prizant and Rydell applied a similar study of function to delayed echolalia, the echoing of an utterance at a time significantly later than it was first produced. Three boys with autism diagnoses were videotaped while they produced 378 instances of delayed echolalia. Instances of delayed echolalia were differentiated from creative speech primarily by investigating the grammatical complexity of utterances: delayed echolalia showed a level of grammatical complexity far greater than creative language and not appropriate to the apparent level of general functioning. After being identified, the utterances were analyzed along lines similar to the earlier study of immediate echolalia: interactiveness, evidence of comprehension, and relevance to the situation and context.

Prizant and Rydell found that delayed echolalia also served communicative purposes for children. The communicative purposes for delayed echolalia were: non-focused, situation associated, verbal rehearsal, self-directive, labeling, turn-taking, verbal routine completion, providing information, calling, affirmation, request, protest, and other-directive. Not all categories were displayed by all children. Some children only used a few categories, while others used delayed echolalia to fulfill a wide variety of functions. Again, speech that was apparently useless was shown to have a communicative purpose in these children.

Additionally, echolalia in verbal autistic children serves a purpose in language development. In 1988, McEvoy and Loveland studied eighteen children with autism who had some use of expressive language, even if it was only echolalia. The subjects exhibited a range of language skills (expressive and receptive) and nonverbal cognitive skills. Data was collected while each child interacted with both a parent and an examiner; 536 utterances were classified as immediate echolalia and examined. McEvoy and Loveland found that frequency of echolalia varied with receptive and expressive language skills in a roughly quadratic function: children with low language skills produced little echolalia, children with higher language skills had more, and the frequency of echolalia dropped off in the children with highest language levels. Furthermore, the percentage of echolalia out of total utterances was inversely related to language level: children with low language had near 100-percent use of echolalia, and percentage of echolalia in total utterances decreased as language level increased and more creative language was produced.

These findings indicate a developmental sequence in terms of echolalia and language development. When children with autism begin to speak, they produce very few utterances, but they are almost exclusively echolalic. As language improves, echolalia increases along with creative language, so the frequency of echolalia increases as the percentage of echolalia out of total utterances decreases. As language continues to develop, frequency and percentage of echolalia both drop as echolalic utterances are replaced with creative utterances.

Roberts (1989) related language development to echolalia in terms of mitigation, or change to echolalic utterances. Mitigated echolalia is an utterance that exhibits echoing of the model utterance and creative change to that utterance. For example, a child might be asked "What do you want?" and respond with "What do you want a cookie," an utterance with both echoic and creative parts. In Roberts's study, ten children with autism were tested for their receptive language capabilities, and found to exhibit a broad range of competencies and age-levels. After using language-sampling techniques to elicit expressive language, utterances that were "recognizable imitation occurring within two utterances of the model" (Roberts, 1989, p. 276) were analyzed as immediate echolalia. Roberts found an inverse relationship between receptive language level and percentage of utterances that were echolalic. Her subjects' echolalia made up a decreasing proportion of their utterances as language ability increased, similar to McEvoy and Loveland's findings.

Interestingly, Roberts also found a direct relationship between receptive language level and percentage of echolalia that was mitigated echolalia; as language level increased, a higher percentage of echolalic statements had modifications made to them. This manipulation on the part of the child indicates a more complete understanding of meaning and syntax in the echoed statement. "Echolalia seems to be a transitional stage connected with poor comprehension; increasing linguistic competence… is reflected in the child's ability to manipulate the echolalic response and produce utterances that are syntactically and semantically modified" (Roberts, 1989, p. 278).

In 1983, Prizant suggested that echolalia in children with autism was not a symptom of an underlying deficit as much as a manifestation of a specific type of underlying cognitive processing. This drew together previous research on echolalia as a communicatively and developmentally significant act. Specifically, Prizant offered that echolalia is part of a larger pattern of development in children on the autism spectrum known as gestalt learning. Gestalt learning as a theory was introduced in 1912 by German psychologists, and centers around the concept that a person’s mind actively divides experiences into meaningful “chunks” which are more complex than the individual elements of experience (Hergenhahn & Olson, 2005).

As Prizant (1983) describes, the majority of children fall along a continuum between analytic learning and gestalt learning of language. Analytic language learning involves first understanding and producing individual segments of language (ex.: “Cookie!”). As more individual words are understood in terms or meaning and grammatical function, these individual parts are combined to form increasingly complex semantic relationships (ex.: “Wanna cookie!” precedes “Can I have a cookie?”). Gestalt language learning involves producing a longer sentence or phrase (ex.: “Good morning. How are you today?”) without understanding the semantic relationships of the individual elements of the phrase (ex.: the child does not use “good” to describe other things, or understand what time of day “morning” is). Most typically developing children use both gestalt and analytical learning styles as they learn language.

According to Prizant (1983), children with autism are very limited in their ability to use an analytic style of learning. The transition from gestalt processing to analytic processing for children with autism is hugely difficult, and this difficulty explains the developmental trends in frequency, percentage, and mitigation of echolalia previously mentioned. When a child with autism first begins to communicate verbally, a gestalt understanding of heard language means that echolalia will form the majority of initial utterances, and that it will be unmitigated, as the processing necessary to manipulate language has not yet developed. As language development progresses, echolalia becomes mitigated, indicating that children have begun to acquire the ability to think analytically and break down and manipulate the large segments of language. As the ability to process language analytically improves, the percentage of utterances that are echolalic decreases, and echolalia is replaced almost entirely by creative language.

A child's "location" on the spectrum between analytic and gestalt processing impacts not only language, but other aspects of cognition including memory (Naus and Halasz, 1979) and the vocalizations of typically developing infants (Dore, 1974). Since gestalt learning in children with autism is both a linguistic and a cognitive phenomenon, it would be reasonable to expect to see some of the processes that result in echolalia in verbal children affecting vocalizations in preverbal children.

At the 2007 American Speech-Language and Hearing Association (ASHA) conference, Schoen, Paul, Chawarska, Klin, and Volkmar presented on their research into the vocalizations of toddlers on the autistic spectrum. These researchers compared the non-speech vocalizations made by toddlers diagnosed with autistic spectrum disorders (ASD) to those made by age- and gender-matched typically-developing peers. The team used acoustic analysis to quantitatively enumerate the differences in these vocalizations that had been qualitatively described in previous studies. Their results showed similar mean syllable length across groups, but that the ASD toddlers produced a significantly higher number of vocalizations that were longer than .5 seconds. They also found that toddlers with ASD produced a significantly higher number of vocalizations with complex pitch contours. That is, the vocalization pitch contours did not fall into any of the types of simple pitch contours, including falling pitch, rising pitch, rise-fall and fall-rise, employed by the researchers; they reflected more complex patterns than the classification system used.

These researchers found that the non-word vocalizations of toddlers with ASD were more likely to be more than .5 seconds long and more likely to have complex pitch contours than the non-word vocalizations made by typically-developing peers. While this study was not designed to look for intonation echoes, these findings could indicate that toddlers with ASD produce some vocalizations that echo the intonation patterns of adult utterances, since these utterances would tend to be longer than .5 seconds and have more complex pitch contours.

Previous studies offer a broad range of possible communicative functions for both immediate and delayed echolalia, phenomena that previously had been considered aberrant language which should be suppressed. Studies of echolalia and language development show developmental functions for echolalia in verbal children with autism. A theory of language development and cognition in children with autism explains the developmental patterns seen in other studies and suggests that echoing of words is indicative of an underlying cognitive process that affects memory and nonverbal vocalizations. A study of differences between toddlers with autism spectrum disorders and their typically-developing peers shows that vocalizations from ASD toddlers are more likely to be longer and to have complex pitch contours. Since the utterances of adults tend to be longer and have more complex pitch contours, these results could be expounded upon to indicate that young children with autism might be echoing adult intonation patterns before they can speak. Furthermore, since echolalia in verbal children has been shown to serve functional and developmental purposes, finding tonal echoes in children with autism who do not speak may shed light on language development or communicative intent in these children.

IV. Hypothesis

The average pitch and pitch range of the vocalizations produced by a nonverbal child on the autistic spectrum will be more varied when the child's communication partner is using an animated voice (many changes in pitch), and less varied when the communication partner is using a monotone voice (few changes in pitch).

V. Methodology

Participant Recruitment

Participants were recruited from the clientele in the Roy Eblen Speech and Hearing Clinic (RESHC), University of Northern Iowa campus, Cedar Falls, Iowa. To protect client and family privacy, an initial request was sent out to all clinical supervisors in the RESHC, all of whom are licensed speech-language pathologists or audiologists. Clinical supervisors were asked if any client they supervised fit study inclusion criteria.

The inclusion criteria for subjects in this study were:

1) Must have diagnosis of a disorder on the autistic spectrum by a speech-language pathologist, psychiatrist, physician, or similarly qualified professional OR display the following characteristics from the DSM-IV, (APA, 1994), as determined by a speech-language pathologist, psychiatrist, physician, or similarly qualified professional:

    a. At least two of: marked impairment in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction; failure to develop peer relationships appropriate to developmental level; a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people; lack of social or emotional reciprocity

    b. Lack of varied, spontaneous make-believe play or social imitative play appropriate to developmental level

    c. Restricted repetitive and stereotyped patterns of behavior, interests, and activities

2) Must display delayed language development.

3) Must not be currently producing more than five identified words. These words must not be the primary mode of communication.

4) Must be currently producing vocalizations in some form during interactional situations.

5) Must be under seven (7;0) years of age. This makes the child more likely to still exhibit developing communication (Prizant & Duchan, 1981).

6) Must have no untreated sensory disruption (e.g, unaided hearing loss, uncorrected visual impairment, et cetera).

7) Must be in good general health at time of data collection.

If a supervisor responded affirmatively, a consent form was given to the supervisor to supply to the guardian of the client. No information about potential participants or their families was provided to the author of this study until a parent or guardian agreed to be in the study.

Once a study subject was recruited, his current clinician was contacted and asked to participate in the study. Informed consent was obtained from the mother of the study subject, and from the speech-language clinician.

Study Participants

The subject of this case study is one three-year, two-month-old male, “John,” a therapy client at the Roy Eblen Speech and Hearing Clinic. According to study criteria, a qualified speech-language pathologist determined that he displays characteristics of autism as outlined in the DSM IV.

At the start of the study, the Kent Infant Developmental (KID) Scale and the MacArthur Communicative Development Inventory (MCDI) were administered. Both of these measures are parental-report forms, designed to produce a standardized picture of communicative and overall development. These tests are designed primarily for use with children younger than John, but his language level was appropriate for measurement by these tests. While subtests for self-help and motor development on the KID Scale were not appropriate for John, since he is capable of running around freely, John's language, cognitive, and social subscores on the KID Scale were analyzed. These scores were near the median scores for infants of nine, eleven, and eight months, respectively. These scores indicate that John's language, cognition, and social interaction show significant impairment for his age.

On the MCDI, John's mother reported no expressive vocabulary and a receptive vocabulary expected for an infant of nine months. John's scores for communicative gestures are slightly higher, with scores near the mean scores of children ranging from one year to fourteen months of age. Based on his MCDI scores, John's language functioning can be very roughly compared to that of an eleven-month-old. This is not to say that John behaves like an infant or is comparable to an infant, but that his apparent levels of language understanding and production are those that are seen in typically-developing children at around eleven months of age.

John is a favorite around the RESHC, and almost all who meet him find him to be a wonderful little boy. He is described by clinicians as "loveable" and "cute." While in therapy, he works hard for his clinicians and especially enjoys singing, blowing bubbles, and playing with a marble ramp.

John's communication partners in this study were Sarah, the author of this study, and "Adam," John's speech clinician. Adam is a first year graduate student in speech-language pathology at the University of Northern Iowa. He has been working with John twice per week for approximately thirteen weeks.

Procedure

John was video- and audio-recorded for four roughly 30-minute sessions, three in the company of Adam and one in the company of Sarah. Because of the nature of the therapy John was receiving at the RESHC, Adam, Sarah, and John’s mother decided that it was appropriate to record therapy sessions between John and Adam for use in this study. Therapy sessions with Adam were generally directed play sessions with an emphasis on having John make requests of his communication partner. The session with Sarah was an unstructured play session using materials in which John had shown previous interest and enjoyment in therapy.

The original intent of the study was to record John for eight sessions. However, due to inclement weather and other circumstances, only four sessions could be recorded in the time allotted. During two of these sessions, John’s communication partner spoke in a monotone voice. He or she made as few variations in pitch and intonation as possible without varying other aspects of his or her interaction with John. During the other two sessions, John’s communication partner spoke in an animated voice. He or she made as many and as large variations in pitch and intonation as possible without varying other aspects of his or her interaction with John. The order of these conditions was originally randomized via coin-flipping; however, when fewer sessions were available, the last two session conditions were chosen to balance out the number of animated and monotone sessions during the remaining sessions.

VI. Analysis of Data

Sessions were recorded using a Marantz Professional Solid State PMD660 digital recorder. Sessions were videotaped using the closed-circuit camera system in the Roy Eblen Speech and Hearing Clinic and a VCR in a locked professor's office. After recording, audio data was input to the Audacity sound manipulation program in the RESHC voice science laboratory. With this program, each session was filtered with Audacity's noise reduction function, using a reduction level of 24 decibels (dB), frequency smoothing at 150 hertz (Hz), and attack and decay times set at 0.15 seconds. This reduced ambient noise caused by a fan in the therapy room.

After filtering in Audacity, each session was input to the TF-32 voice analysis software. The majority of John's vocalizations were analyzed and raw data was extracted by the TF-32 program for the average pitch, minimum pitch, maximum pitch, and length of each vocalization.

These raw measurements were then converted into meaningful units of measure. Average pitch, in hertz, was calculated for uninterrupted data by the TF-32 program. Vocalizations that were disrupted by noise required slightly different analysis, as described later. Pitch variance was calculated for each vocalization by taking the absolute value of each average pitch subtracted from the median pitch for each session. Pitch range, in hertz, was calculated by subtracting minimum pitch from maximum pitch for each vocalization. The length, in seconds, was found by computer measurement of the time between visible start and finish of the waveform. Pitch range / length was computed by dividing the number for pitch range by the number for vocalization length.

Some vocalizations were not analyzed for various reasons. Vocalizations shorter than .3 seconds were not analyzed, since these were deemed too short to reflect any intonation pattern. Vocalizations that were primarily laughter or made in times of distress were not analyzed.

Laughter was presumed to be under an insufficient level of voluntary control to show meaningful pitch traces. Several studies (Prizant & Duchan, 1981; Prizant & Rydell, 1984) show that echolalic utterances made in moments of distress exhibit different intonation patterns than the model utterance, so for the purposes of this study it was presumed that sounds of distress would not echo intonation patterns.

In several instances, John’s vocalizations were whispered and thus did not produce a pitch trace. Occasionally, a vocalization was too overshadowed by ambient noise to yield a usable pitch trace (see figure 1).

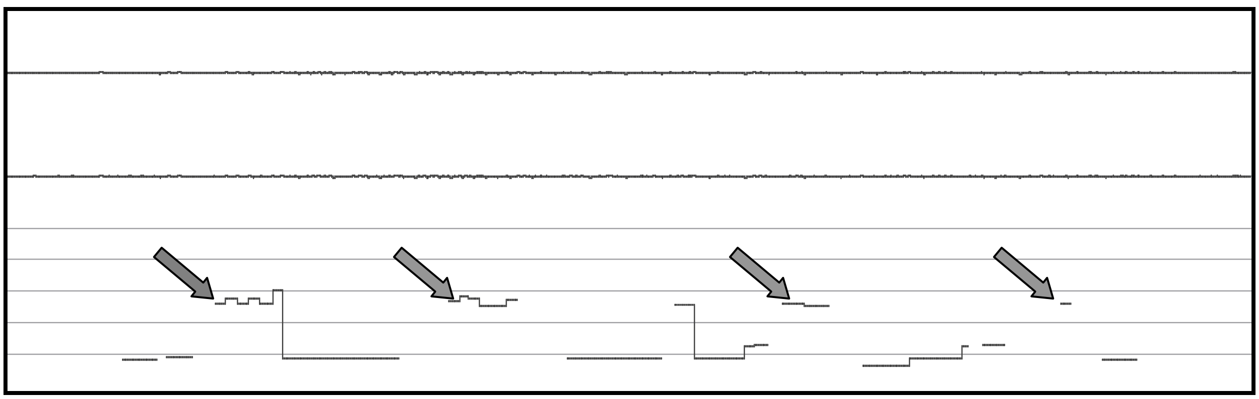

Figure 1: Waveform above and pitch trace below. There is not sufficient pitch trace (arrows) to undergo useful analysis.

Occasionally, a usable pitch trace was disrupted by ambient noise even after filtering with Audacity. For example, the vertical lines seen in the computer screen capture (figure 2) were not made by John’s voice and would skew calculations of average pitch as well as minimum and maximum pitch. In these instances, minimum and maximum values were derived excluding those vertical lines, which frequently went far above and below the pitches John actually produced. For the same reason, average pitch was calculated for each uninterrupted segment of pitch trace and then averaged together across the vocalization.

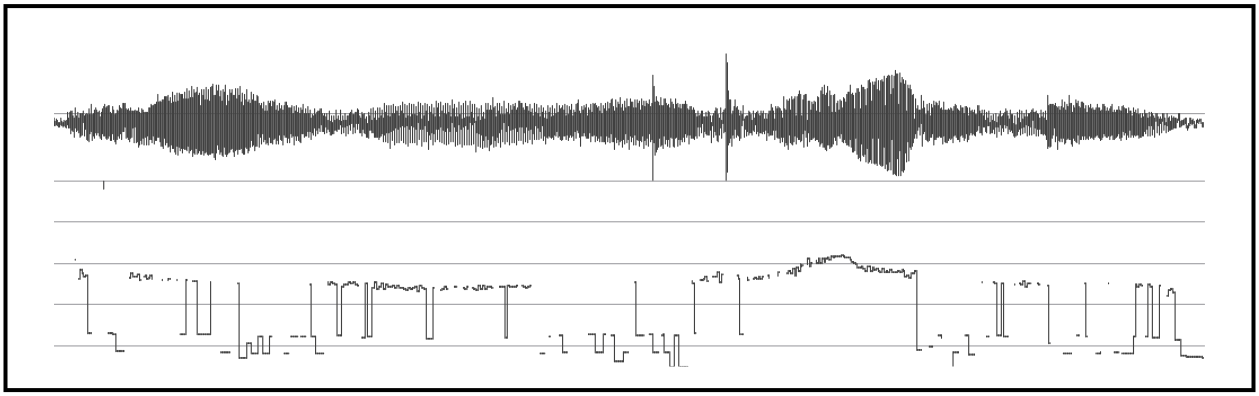

Figure 2: Waveform above and pitch trace below. The undulating pitch trace is interrupted by sudden vertical lines.

Outliers were removed based on the average pitch data. An average pitch that was more than 150 hertz higher or lower than the next-highest or next-lowest pitch in each session was removed and not analyzed. This removed one data point from the Animated condition and one data point from the Monotone condition, and resulted in a total of 59 analyzed vocalizations in the monotone condition and 53 analyzed vocalizations in the animated condition.

VII. Results

Initially, a T-test was performed on data gathered during John's session with Adam speaking in a monotone and John's sessions with Sarah speaking in a monotone. No significant differences were found between John's vocalizations for the different communication partners, so the two sessions were collapsed into one for the Monotone condition. Both sessions with John's communication partner speaking in an animated tone were with Adam, so these two sessions comprised the Animated condition and needed no preliminary analysis.

A mixed analysis of variance (ANOVA) with one between-subject variable of Condition and one within-subject variable of Session was implemented to analyze the following variables of: Average pitch, pitch variance, pitch range, length, and pitch range / length. The means and standard deviations for these measures are displayed in Table 1.

Table 1: Mean and standard deviation values for variables across conditions and sessions.

Condition	**Average Pitch**		**Pitch Variance**		**Pitch Range**		**Length (seconds)**		**Range/ Length**		**Session**
	M	SD	M	SD	M	SD	M	SD	M	SD	
Animated	331.8	59.8	47.6	37.5	123.3	78.1	1.1	0.8	152.4	122.1	**Session 1**
	370.8	72.7	50.5	51.3	96.6	80.9	1.1	1.1	132.0	143.8	**Session 2**
Monotone	316.3	63.2	53.0	33.5	113.5	96.5	1.2	0.9	136.8	179.1	**Session 1**
	327.6	52.9	36.15	40.9	90.8	66.3	1.3	1.0	92.7	59.7	**Session 2**

A main effect of Condition was observed [F(1,112)=4.38, p=.04]. Planned post hoc analysis of pairwise comparisons using Tukey's method indicated a significant difference between Condition 1 (Animated) and Condition 2 (Monotone) for average pitch. No other statistically significant conditions or effects were observed.

VIII. Discussion and Implications

Quantitative Findings

The observed main effect of Condition caused by a significant difference in average pitch is not directly indicative of echoing. Condition effects caused by significant differences in pitch variance, pitch range, or pitch range over length would be directly indicative of echoing, assuming that numbers for these metrics were larger during the Animated than in the Monotone condition. These, however, were not observed.

At this time, the reasons behind the observed Condition effect are unknown. However, there are many possible explanations of why the average pitch of John's utterances was significantly lower during the Monotone condition. Firstly, it is possible that during the

Monotone condition the adult's communication style changed in dimensions other than pitch, such as utterance frequency, loudness, or content, and John was responding to this. A second way to interpret these results is that John's vocalizations were echoic, and the average pitch of the adult speaker was lower during the Monotone condition. Since adult utterances were not analyzed in this study, this is not possible to determine at this time. However, adult utterances were recorded, and future study could directly compare John's vocalizations with a clinician's utterances to possibly better determine the relationship between average pitch and adult communication within the Monotone condition.

One interesting possibility that could account for the significantly lower average pitch during the Monotone condition is that an unexamined variable during that condition actually caused John to exhibit more intonation echoes, and a lower average pitch reflects more vocalizations that follow an adult's intonation contour as opposed to high-pitched, "squeal"-type vocalizations to which John was prone when excited. Furthermore, it is conceivable that John's vocalizations are primarily examples of delayed tonal echoing – theoretically similar to delayed echolalia – and do not echo the intonation patterns of utterances immediately previous but instead may be echoing utterances heard hours or days before. Because of the ambiguous nature of tonal echoes, this is also impossible to rule out or confirm at this time.

Non-significant effects of Condition on pitch range divided by vocalization length [$F(1,112)=1.76$, $p=.19$] offer some quantitative indication of pitch echoing. Pitch range divided by length is worthy of particular note because this metric would indicate that increased pitch range across a vocalization is not simply due to longer vocalizations with more opportunity for pitch change. While these trends suggest that vocalizations produced during the Animated condition had a wider variation in pitch, the standard deviations were ultimately too large and the effect of Session too great to yield any significant effects of Condition.

Interesting to note is a non-significant Session effect on pitch range [$F(1,112)=3.25$, $p=.07$]. It is not known why John's pitch range would show variation according to Session, since three of four sessions were held in the same room, at the same time of day, and with the same clinician. Again, many possible explanations exist: different activities or even the slight change in location (one therapy room to another, similar one) may have unsettled John enough so that he produced more vocalizations with wide pitch ranges. Another possibility to consider is that his responses may have been perseverative and linked to activity before these sessions. In future studies, more data collection sessions would help remedy this problem by averaging out conditions outside of the session to isolate variables within the session.

Qualitative and Anecdotal Findings

While quantitative analysis does not offer statistically significant evidence of intonation echoing, qualitative evidence of echoing may be indicated by some of John's vocalizations. Unfortunately, the metrics used by the study did not detect the elements of speech that might be echoic for John. The discussion following relates to other aspects of speech that, to the researcher, seemed to be echoic. The evidence is qualitative, and mostly anecdotal in nature.

One metric that was not measured and may have offered evidence of echoing was vowel formants. Frequently, John would produce a vocalization which, while it did not seem to echo prosodic patterns of the previous utterance, sounded to the listener like rough echoes of phrases spoken by the clinician. Upon careful listening and analysis, it appeared that his was generally due to similar vowel shapes used by the clinician and John. An analysis of vowel formants might yield evidence that vowels are being echoed while intonation pattern is not. One example of this is represented in Figure 3. In this sample, John produces a vocalization after Adam produces "Ready, set" as the two drop a marble down the marble ramp. Adam produces "Go" immediately afterward. John's vocalization sounds like "go," and the captured vowel formant data show that a similar vowels were produced by John and Adam.

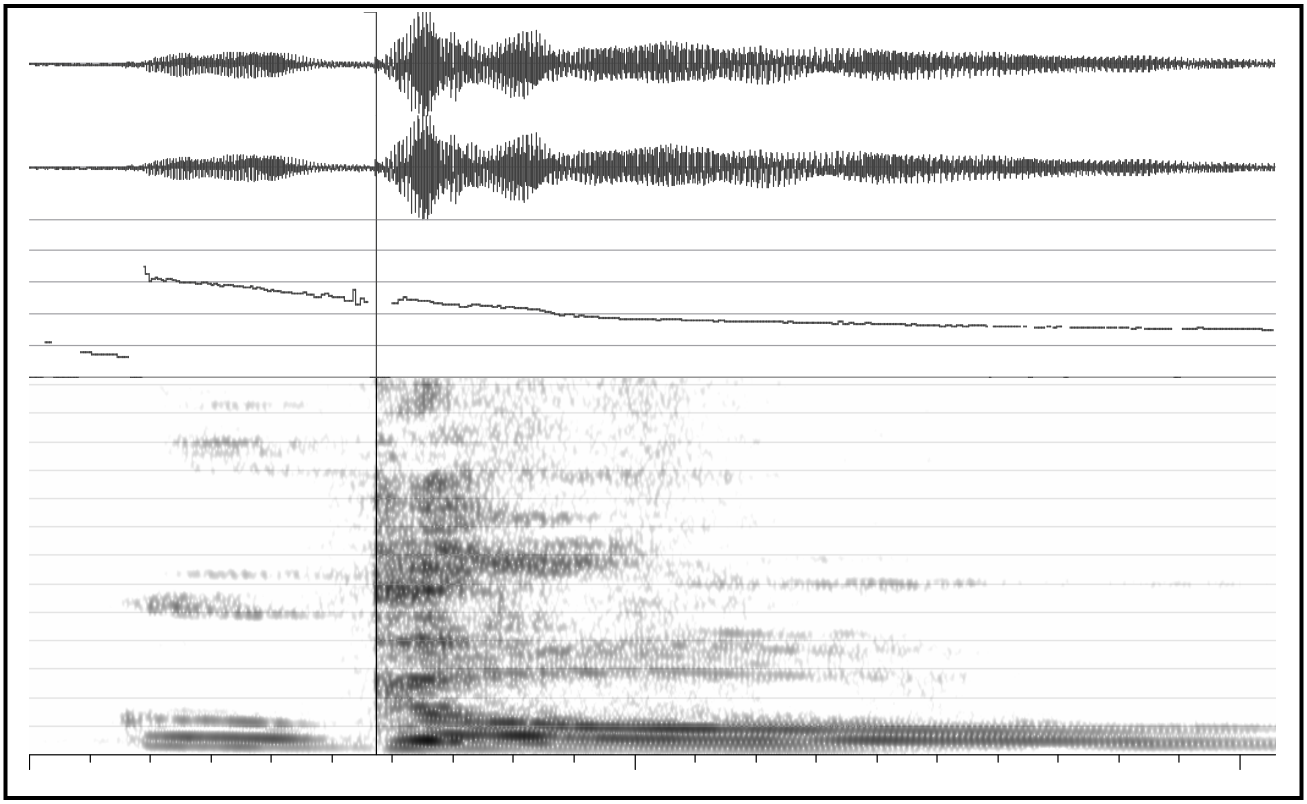

Figure 3: Waveform top, pitch trace center, vowel formants bottom. The cursor line separates John's vocalization (first) from Adam's production of "Go" (second). Similar patterns of darkening show that similar vowel formants were produced.

A second metric of interest is rhythm of vocalizations. The rhythm of vocalizations and pauses that John produced frequently sounded as though they may be echoing the rhythm of a phrase produced by John's communication partner. These patterns, however, could not be read by the computer. One example of this is shown in Figure 4. Almost every time Adam withdrew the bubble wand from the bubble solution and tapped it on the container, he said "Down, tap-tap-

tap-tap." The vocalization John produced in Figure 4 shows a rhythm of on- and offsets that could be similar to "Down, tap-tap-tap-tap."

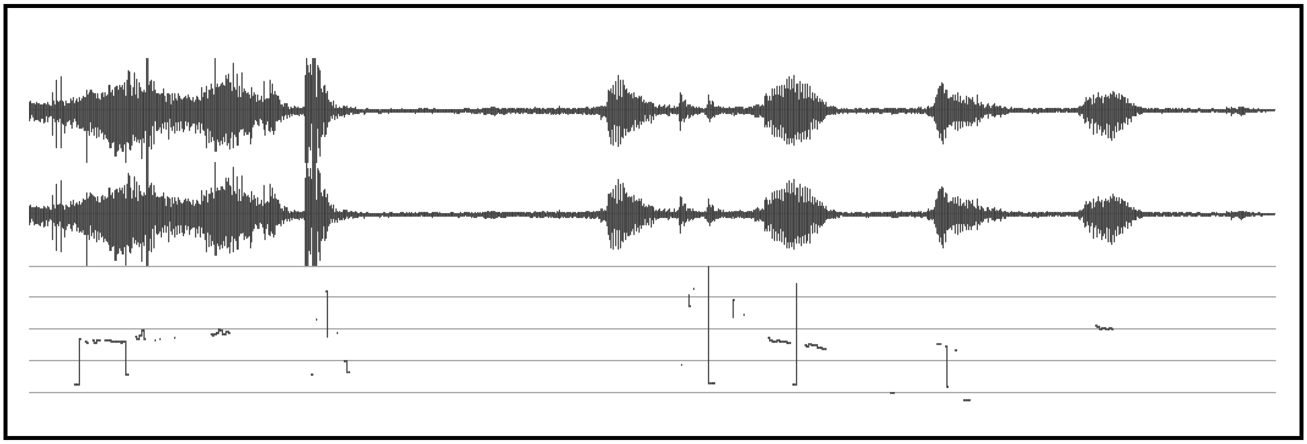

Figure 4: Waveform top, pitch trace bottom. The waveform shows a pattern of vocalizations and pauses not analyzed by this experiment.

Finally, a combination of these two metrics may be useful to future researchers. One particularly interesting segment was heard upon analysis of the recording but was missed in the session due to distractions. The clinician – Sarah – asks "Where did it go?" after a marble falls from the marble ramp. While she looks, John produces what could be an echo of "Where did it go?" In Figure 5, words are added to show the matching pattern of vocalizations and pauses, based on the clinician's speech and John's rough echo. Unfortunately, data on vowel formant was not recorded for this section of the recording.

It is entirely possible that separate analysis of intonation pattern, vowel formant, and rhythm would not yield quantitative indication that this vocalization is echoic. However, some echoic properties are audible on the recording. Also, the curve of the pitch trace in Figure 5 shows overall similarity in the intonation patterns of the two utterances. Some other vocalizations may show similar pitch traces to preceding utterances. Since no other vocalizations had this level of audible similarity to the model utterance, similar one-on-one pitch trace comparisons between utterance and vocalization were not possible.

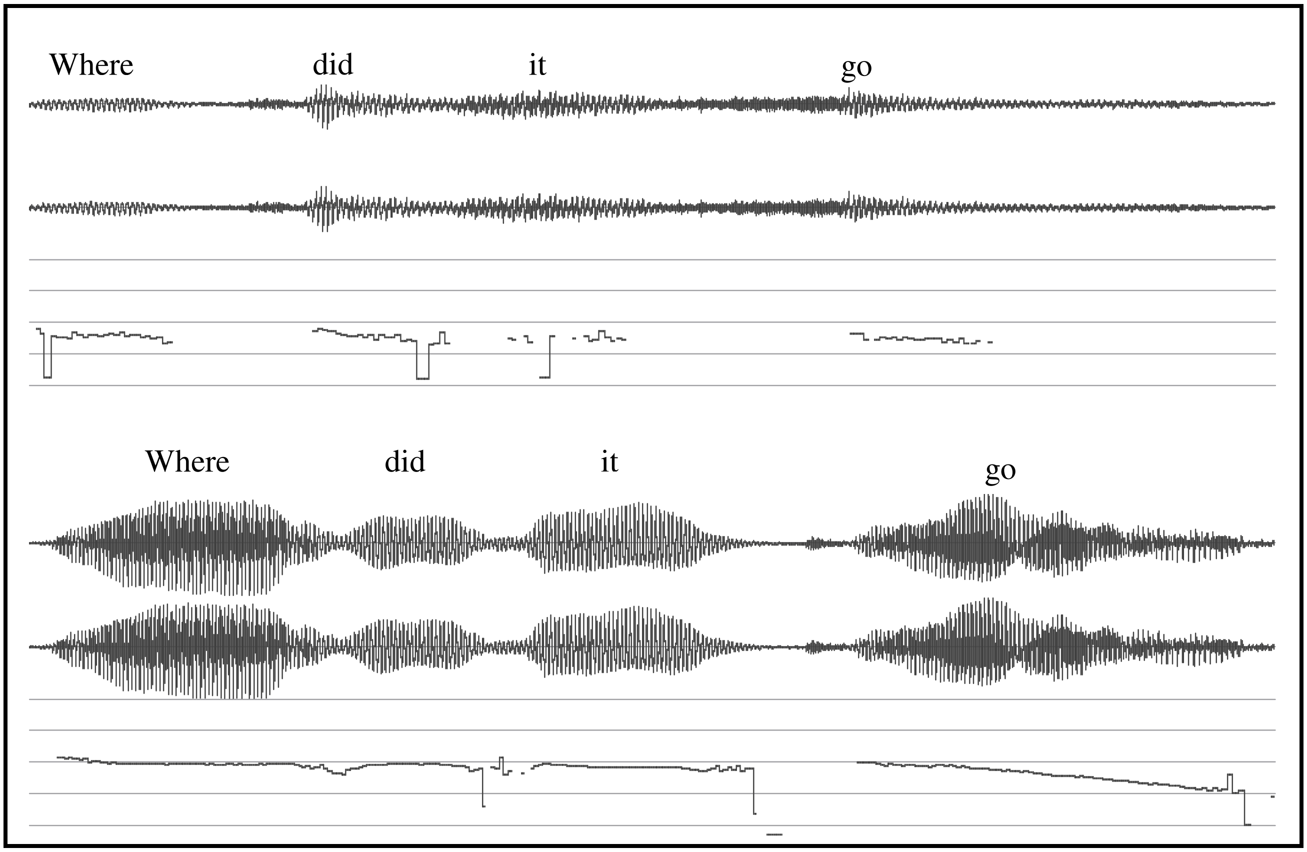

Figure 5: Top image is waveform and pitch trace for the child, bottom image is waveform and pitch trace for the adult.

Future studies in finding ways to analyze vowel formants and the rhythm of vocalizations may be helpful in identifying possible non-speech echoes. A second area of possible research is finding a way to synthesize this information to quantitatively identify echoes that a human researcher might qualitatively identify.

Clinical Implications

Ultimately, this case study presents a situation that cannot be unique: while quantitative evidence of echoing was not gathered, qualitative evidence of echoing may be indicated in a format that was not analyzed by the metrics in this study. While the possibility exists that John's vocalizations were not echoic and the qualitative evidence of echoing exists only in the ears of a researcher, there are many important reasons why these possible echoes cannot be ignored and warrant additional study.

Ample evidence has already been gathered of the communicative and developmental functions of echolalia in autistic children (Prizant & Duchan, 1981; Prizant & Rydell, 1984; McEvoy & Loveland, 1988; Roberts, 1989). Since echolalia is a linguistic expression of gestalt cognitive processes (Prizant, 1983), nonverbal echoes have the potential to hold similar significance. If further studies show evidence of non-speech echoes, be they in pitch contour or other linguistic elements, previous literature indicates that they warrant further study. If non-speech echoes are shown to be a developmental stage or a communicative act, they gain clinical importance in therapeutic interventions for children like John.

Intervention studies in language-learning in echolalic children (Manning & Katz, 1989) show that when echolalic utterances are given functionality by a speech-language pathologist, children become more responsive to their communication partners and produce more functional utterances – both creative and echoic – during these interactions. Treating pre-linguistic echoes with the same functionality may, in turn, increase responsiveness and language skills.

Furthermore, knowledge of pre-linguistic behaviors that may be functional would serve as a guide to clinicians designing therapy for children with autism who are not speaking. Clinicians would respond differently to non-speech echoes that were primarily a developmental stage on the way to spoken language than they would to echoes that had communicative intent behind them, or echoes that were not directly functional. Further study into the possibility of non-speech echoes could also offer a better general understanding of development and possible communication in children with autism who do not speak. This knowledge would also guide clinical decision-making.

Perhaps the most important reason to further examine these qualitative echoes is a very qualitative reason in and of itself. Some children with autism never develop functional spoken language. These children are known to resort to tantrums or physical aggression to make their needs and wants known. Finding a pre- or non-linguistic act that has communicative function and teaching caregivers to react to it as such could greatly reduce frustration – and the external manifestations thereof – for these children. A reduction in violent and disruptive behavior would, in turn, reduce frustration and anxiety for caregivers.

Identifying non-speech echoes as a communicative act in a child who is so severely involved that little other functional communication exists is, frankly, a long shot. However, research into autism is still a very young field. It is most important to leave no proverbial stone unturned to those families with severely involved children. Evidence that a child with autism is communicating in some manner would come as a beacon of hope to the parents and people who love that child.

IX. Conclusion

This case study did not find quantitative evidence of intonation echoing in the subject observed. A main effect of Condition was observed, caused by a significantly lower average pitch during the Monotone condition. While the significance of these findings is currently not clear, this could indicate that John may be reacting in ways we do not understand to changing communication styles on the part of his adult communication partners.

This study did find qualitative evidence suggesting echoing that was not directly measured by the metrics used in analysis. Future researchers would do well to focus on possible echoing of vowel formant and rhythm in vocalizations of other children, as qualitative observations of these indicated an echoic dimension may exist in John's vocalizations.

Earlier research into echoing of words and the cognitive processes underlying echolalia gives weight to the hypothesis that nonverbal echoes may have communicative or developmental significance. In short, nonverbal echoing of intonation patterns or other linguistic features has too much potential therapeutic utility to be ignored, and future researchers would be doing many children and families a disservice by not exploring the qualitative evidence found in this study to its fullest.

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