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Computer Assisted Feedback Strategies for Social Language Training in Autism: A Neurobehavioral Model

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Abstract

Psychologists and other clinical professionals struggle with the problem of understanding and modifying non-congruent conversational styles of individuals with Autism Spectrum Disorders (ASD). More recent studies have attempted to identify relevant acoustical parameters of speech, including volume, pitch, rhythm and lengths of utterances, in an attempt to better explain errors in social communication and interaction. While a complex set of biological, behavioral and developmental factors lead to disruptions in social and communication abilities there is both theoretical and empirical support for focused intervention. In our lab we have utilized a software platform called speechmatch that provides children and adults with ASD real time feedback about their success in matching critical acoustic parameters that contribute to effective social interaction. A neuro-behavioral rehabilitation model focuses on early chain intervention, operant/reward-based shaping of sound matching, and neuroplasticity.

Keywords: Autism; Language training; Neurobehavioral model

Introduction

Linguistic studies and speechmatch

The ability to match other's speech patterns is present from early on in post-natal development. From the earliest months, babies placed near each other not only babble but babble in turn. Linguistic analyses of babbling suggest that not only are babies engaging in turn-taking but also communicating based on matching of various parameters of speech [1]. This is an early sign of language being shaped or reinforced by another person, consistent with Skinner's notion of a reinforcing verbal community [2] as well as Chomsky's ideas of internal language abilities that are ready to be elicited [3]. In addition to hearing problems and socio-economic variables, challenges to these opportunities for social exchange include a variety of neurological problems affecting various brain regions. Regardless of the specific etiology, the critical point is that babies deprived of these early exchanges may fall out of developmental sequence, which in turn can blunt social conversational skill development and possibly the development of relevant neural pathways.

Intervention based on visual feedback of speech may be especially helpful for remediating the marked difficulties in inferring meaning from non-content aspects of speech and in vocal congruence in ASD, given that high level visual processing abilities is generally intact in the disorder [4]. Our recent pilot studies suggest that a software program that uses an iPad to provide immediate visual feedback regarding speech matching may be helpful [5]. This "Speechmatch" program provides immediate feedback to subjects regarding their ability to match sound waves that reflect pitch, rhythm, volume and overall match. Specifically, subjects are asked to match pre-recorded phrases that reflect several emotional domains that have been studied extensively and which are viewed as distinct domains, including happy, sad, unpleasant surprise, and pleasant surprise. The universality of these domains includes cross-cultural responses to emotion in faces and voice. Connections between these observations of visual, aural, and emotional systems in ASD are of great interest and require further exploration.

A recent study in our lab involved 5 adolescents (ages 12-18) with diagnosed ASD each of whom received ten 100-minute training sessions (5 phrases for 20 minutes each) in which each phrase represented different emotions including happy, sad, pleasant surprise, unpleasant surprise and neutral. Autism diagnoses were confirmed by the Childhood Autism Rating Scale (CARS) [6] administered by a psychologist and consent was obtained from parents and assent from all participants. Subjects were accompanied by a research assistant who timed each study segment and provided instructions regarding use of the software program. There was minimal variation in the time taken to complete 10 training sessions ranging from 4-6 weeks. Pre-post t-test showed significant improvement in percentage match of pitch and rhythm (Figures 1 and 2). No changes in volume across the 10 training sessions were attributed to a ceiling effect reflected in the high volume matching scores produced from the very first training session onward.

In addition to improvements in percentage match of two of the three acoustical parameters, improvements were also reported in blind ratings of behavioral tests for generalizability. College students working as research assistants were trained in ratings using a consensus model in which they listened to pre and post recordings, provided initial ratings which were discussed at lab meetings in which consensus was developed utilizing explicit rating criteria. For the study an average of all ratings were used in the final analysis. Specifically, ratings of pre and post recordings of "free conversations" between experimenter and subject showed significant improvements in matching ($p<0.05$) and content ($p<0.01$) but no significant changes in turn-taking, volume, or length of talking. The changes in content were of note since content was not targeted in this study. A plausible explanation is that improvements in non-content (acoustical) aspects of speech lead to improvements in the content aspects of speech (the words and topics choosen).

Potential neural pathways

While some have speculated about the neurological pathways and brain connectivity associated with prosody deficits in ASD [7], this remains a neglected area of study in terms of brain imaging. Several

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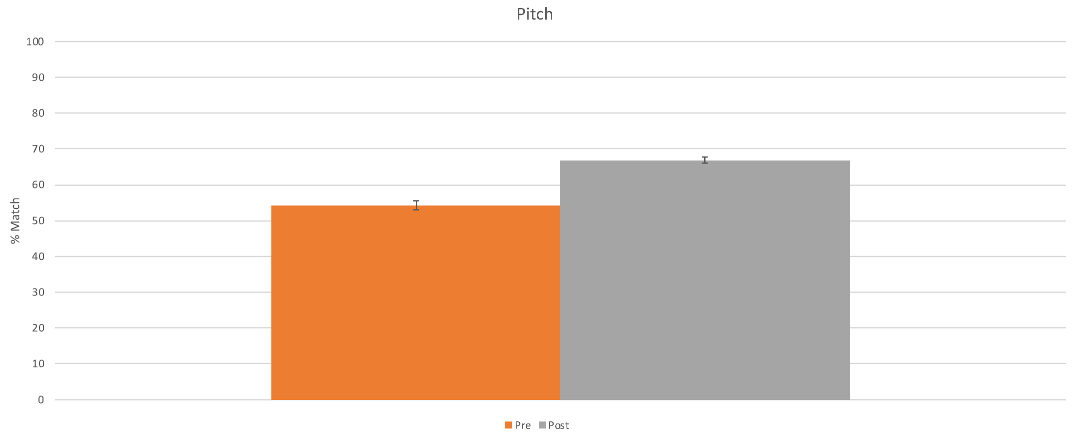

Figure 1: Percentage Match Pitch Score Pre to Post of N=5 Adolescents with ASD.

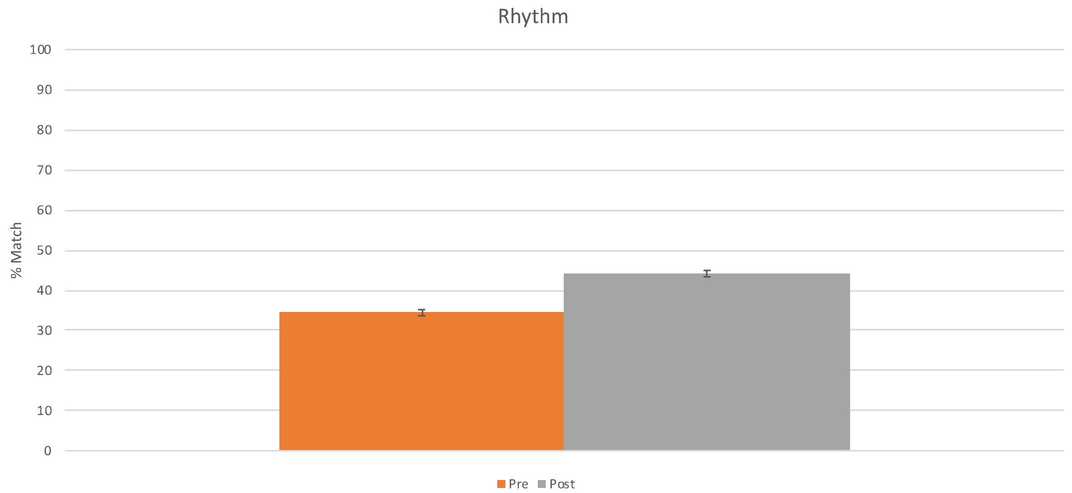

Figure 2: Percentage Match of Rhythm Score Pre v. Post of N=5 Adolescents with ASD.

brain areas have been implicated in language development, particularly in the decoding of emotion in speech. At the hemispheric level, the right hemisphere of the brain has been associated with a specialization for affective speech comprehension but subsequent studies have augmented this perspective by examining patients with left-hemisphere damage who demonstrated intact emotional speech recognition and prosody in speech [8]. Other areas of interest include increased activation in the left amygdala, left insula and hippocampus as well as higher levels of activation in the temporal gyrus in imaging studies of happy vs. angry vs. neutral voices [9].

We have also been interested in "social attention networks" that may hold the key to understanding a person's capacity to orient to and respond to social cues. Several studies have examined aspects of social attention impairments associated with ASD. These studies suggest the impairment is not one of sensory processing of social stimuli, but rather the result of a more specific and integrative impairment in the process of social attention [10]. This network includes the amygdala which has been linked to a number of capacities essential to social communication, including emotional learning and processing faces for information. Biochemical processes are also implicated including levels of oxytocin at critical periods of development [11].

Conclusion

The "speechmatch" training software used in our lab capitalizes on behavioral principles of shaping and neurological concepts of neuroplasticity to improve pragmatic speech. Specifically this tool provides immediate visual feedback of subjects' percentage match of volume, pitch and rhythm after they both hear and see (a soundwave image) and speak a particular phrase (e.g., "My uncle just bought me a puppy"). The program has produced improved acoustic matching in adults and adolescents.

A more complete model for understanding the path of social language delay in ASD acknowledges a fuller pathophysiology that includes both neural and biochemical predispositions that lead to lack of attention to critical non-content aspects of speech. Individuals with Autism simply are not oriented toward the types of social cues that create perceptions of connection, including empathy, warmth, and genuineness, and children with ASD fall out of the social developmental sequence. As a result, the goal becomes putting in place a few critical "pivotal" behaviours that will orient the person toward increased matching of a few speech parameters which in turn leads to more social success.

While there is agreement that individuals with Autism exhibit abnormalities in conversational speech, researchers have not, to date, put forth many ideas regarding successful treatment and intervention. Preliminary data from studies from our lab as well as other related research suggest that computer assisted feedback programs such as "speechmatch" may be a start toward orienting individuals toward more socially effective strategies. A useful analogy may be the use of anti-depressants for social anxiety, where the medication frees the patient to "get out," socialize, and experience the social reinforcement that is available to those who engage with others. Computer assisted speech feedback programs may help individuals with ASD identify important parameters of conversation (e.g., matching volume, rhythm) and experience the benefits of engaging in more pro-social behaviors.

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