Speech Atypicalities & Expressive Prosody in Autism: Empirical Evidence, Theories & Early Identification

Mary V. Andrianopoulos, Ph.D.
Department of Communication Disorders
University of Massachusetts – Amherst

MA ACT Early Summit
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Today’s Objectives

1. Introduction to “Speech Atypicalities”, Motor Speech Impairment and Expressive Prosody;

2. Empirical evidence regarding atypical Speech, Prosody and Motor Speech in children with ASD;

3. Past and current research at UMass Amherst regarding the acoustic-perceptual, motoric and prosodic features of ASD;
Today’s Objectives

4. Theoretical constructs that support the underlying mechanisms regarding the Speech Atypicalities and Expressive Prosody in ASD;

5. The Need for Early Identification and Early Intervention of Atypical Speech and Motor Impairment in children with Neurodevelopmental Disabilities and ASD;

6. Early Identification using the **LAMS**
   - Language-Neutral Assessment of Motor Speech (Velleman, Andrianopoulos, Rupela, 2013)
Hans Asperger (1906-1980)

Studied 4, then 34 individuals
Ages 5-35 years

Primary Features:

- “Communication - abnormal content” (tangential and verbose)
- “Stereotypical speech”
- “Grammar acquired at later age”
- “Lack of ability to understand and use the rules governing social behavior”
- “Poor comprehension of jokes, other’s facial expression, non-verbal gestures”
- “Become intensely interested in 1 or 2 subjects”
- “Report facts, good rote memory, but little grasp of meaning”
Hans Asperger (1906-1980)

- Primary Features (continued)
  - “Delayed walking”
  - “Gestures are limited, or else large and clumsy”
  - “Vocal intonation monotonous, droning, exaggerated”
  - “Gross motor movements are clumsy and ill-coordinated”
  - “Posture and gait appear odd”
  - “Most, or 90% of the 34 cases are poor at games involving motor skills”
Historical Background of Autism

1943 Kanner: (child psychiatrist - 1894-1981)

- Studied 11 children
  “who were similar to each other but whose pattern of difficulties were quite different from children diagnosed other conditions”
- Gender: 8 boys; 3 girls
- Primary features
  - “Social withdrawal; Aloneness; Stereotypical behaviors”
  - “Deafness” suspected in 2 (18%)
  - “Several were somewhat clumsy in gait and gross motor performances”
- Kanner coined term “early infantile autism”
- “autism” taken from Greek word “autos” (self)
What Do We Know About Language, Speech, Motor Abilities, Prosody and ASD?

Review of the Literature
Communication Abilities and ASD

- **Difficulty with communication and social interaction** is a hallmark feature of ASD (Center for Disease Control, 2014a)

- **Language abilities** are one area that is very variable across the spectrum:
  - skills ranging from **non-existent** to rather **sophisticated**;
  - severity ranges from **very impaired** to **above average**.
Communication Abilities and ASD

- Yet, some distinct features of ASD speech and language **may be present across the entire spectrum**:
  - abnormal prosody; vocal / motoric differences
  - structural language deficits
  - problems with narrative coherence

(Boucher, 2012; Eigsti, Bennetto, & Dadlani, 2007; Kjelgaard & Tager-Flusberg, 2001; McCabe, Hillier & Shapiro, 2013; Nadig & Shaw, 2012)
Language and ASD

▪ Most children with ASD begin to speak later than their TD peers, and develop language skills at a slower rate (Tager-Flusberg et al., 2005)

▪ Structurally simpler, less coherent narratives than typically developing peers (Diehl et al., 2006; McCabe et al., 2013)

▪ Children with HFA have a strong vocabulary, but have trouble using the words they know in social contexts, especially words relating to mental state (Tager-Flusberg et al., 2005)
Speech Differences and ASD

- Approximately 30% - 50% of children with ASD do not develop functional communication or remain non-verbal or "minimally verbal" past the age of 5 years (Prizant, 1996; Gernsbacher, Sauer, Geye, Schweiger, Hill, Godsmith, 2008; Chenausky, Norton, Tager-Flusberg, & Schlaug, 2013; Tager-Flusberg and Kasari, 2013; Thurm, Manwaring, Swineford, & Farmer, 2014; Tager-Flusberg, 2014; Shire, Goods, Shih, Distefano, Kaiser, Wright, Mathy, Land, & Kasari, 2015; American Speech Language Hearing Association, 2015; Brignelli, Song, Zhu, Suo, & Lu, 2016)

- Sound odd, awkward, or "bizarre" (Filipe et al., 2014; Grossman et al., 2013; Grossman & Tager-Flusberg, 2012; Nadig & Shaw, 2012)

- Differences in acoustic features (Filipe et al., 2014; Grossman et al., 2013; Nadig & Shaw, 2012)

- Differences in laryngeal quality (Sheinkopf et al., 2000)
Speech Differences and ASD

- **Problems with motor imitation**
  (Peppe, S., McCann, J., & Gibbon, F., 2007)

- **Groping & difficulty with non-speech oral motor movements**
  (Adams, L., 1998)

- **Increased repetitions & revisions; atypical patterns of fluency**
  (Shriberg, L., Paul, R., Black, L., Santen, J., 2011; Turner, 1999)

- **Some demonstrate difficulties oral motor skills.**
  (Belmonte, M.K., Saxena-Chandhok, T., Cherian, R., Muneer, R., George L., Karanth, P., 2013)
Speech Differences and ASD

- **Monotonous speech; atypical prosody**
  (Nadig & Shaw, 2012; Nakai et al., 2013)

- **Different stress patterns, high fundamental frequency, and other voice disorders such as poor volume control**
  (Tager-Flusberg et al., 2005; Shriberg et al., 2001)
General Motor Impairment and ASD

- Motor impairments and general motor deficits in individuals with ASD are a widely noted (i.e., hypotonia, motor apraxia, gross motor delays) (Belmonte, Allen, Beckel-Mitchener, Boulanger, Carper & Webb, 2004; Diamond, 2000; Hardan, Kilpatrick, Keshavan, & Minshew, 2003; Muller, Kleinhans, Kemmotsu, Pierce, & Courchesne, 2003; Muller, Pierce, Ambrose, & Allen, 2004; Prizant, Wetherby, & Rubin, 2003; Ming, Brimacombe, & Wagner, 2007)

- Individuals with ASD are described as being “clumsy” and “uncoordinated”. (Ghaziuddin, Butler, & Tsai, 1994; (Allen, Müller, & Courchesne, 2004; Ghaziuddin, Butler, Tsai & Ghaziuddin, 1994; Green, Baird, Barnett, Henderson, Huber & Henderson, 2002; Thede & Coolidge, 2007)
Published Empirical findings are inconsistent...

To support differences among children with ASD with respect to:

- Linguistic Abilities
- General Motor
- Motor Speech / Articulation
- Vocal Differences
- Prosody (Receptive vs. Expressive)
Definitions

Clinical Implications
What is a Motor Speech Impairment?

**MSDs are disorders of speech resulting from:**

- “**Neurologic**” involvement

**MSDs affect:**

- Neuromuscular execution of speech (**Dysarthria**)  
- Motor programming + planning (**Apraxia**)  
- Sensory innervation to speech mechanism
What is a Dysarthria?

- **Due to CNS and/or PNS involvement:**

- Dysarthria is categorized by:
  - associated clinical symptomatology of speech and;
  - location of breakdown within the CNS and/or PNS

- Dysarthria affects Neuromuscular Execution, Control
  - *changes in speed, strength, range, timing, coordination, accuracy*

- In children, dysarthria is referred to as CD
Central and Peripheral Nervous Systems

[Diagram of the brain and nervous system networks]
Speech Characteristics of Childhood Dysarthria (CD)

- Consistent distortions;
- Fast, slow or irregular speech rate;
- Incoordination of speech processes;
  - respiration, phonation, articulation, and nasal resonance;
- Short bursts of speech; and
- Differences in pitch, volume/loudness, resonation, prosody,
  - and/or vocal quality (dysphonia)
What is Childhood Apraxia of Speech (CAS)?

• CAS is motor planning – programming problem that affects:
  ▪ Voluntary use of speech for communication purposes

• CAS is characterized by difficulties with:
  ▪ Sequencing articulatory movements; phonemes, and syllables;
  ▪ Trial and error groping behaviours; and
  ▪ Unusual and inconsistent substitution error patterns for both consonants and vowels

(Rvachew, Hodge, & Ohberg, 2005; ASHA, 2007)
CAS Localization

- The exact location of breakdown of CAS is indeterminate;
- Research supports a breakdown the cortical networks in the language dominant hemisphere;
- CAS is typically congenital
- Speech never develops appropriately, but due to a programming/planning problem.
Why is Early Identification of a MSD important?

Motor speech disorders:

- negative consequences for literacy, educational achievement, relationships and employment (Lewis et al., 2004; Carrigg et al., 2016)
- occur with or without diagnosed neurodevelopmental conditions (ASD, Down syndrome, Williams syndrome, 7q11.23 duplication syndrome ...)
- not completely predictable based on other diagnoses.
What is Prosody?

Prosody refers to aspects of speech that convey meaning
- **What** is said (lexical content)
- **How** it’s said (prosody)

**Prosodic Features of Speech**

- Pitch
- Stress
- Pauses
- Loudness
- Tempo
Prosodic Development: Perception

- ERP data indicate that “…aspects of the human voice & prosody are processed early in life” (Grossman et al., 2010)

- “Studies show that newborns (2 days old) can discriminate between different prosodies and speech sounds shortly after birth” (Perani et al., 2011)

- Head-turn listening procedures & sucking habituation studies show that infants prefer speech that is similar to the phrasing patterns in native language (Speer and Ito, 2009)
"R Hemisphere plays a predominant role in processing emotional prosody”
(Wildgruber et al., 2002; as cited in Grossman et al., 2010)

"An adult-like left hemispheric specialization for segmental information and an adult-like right hemispheric preference for suprasegmental information has been demonstrated in 4-y-old children using NIRS
(Wartenberger et al., 2007; as cited in Perani, 2011)
Prosodic Development: Production

• Lack of consistent evidence regarding developmental milestones of expressive prosody;

• “Unclear how early infants’ vocalizations are influenced by the adult prosodic system” (DePaolis et al., 2008)

- Most studies suggest that as the infant nears the end of the second year of life, the prosody of vocal productions become increasingly adult-like, coinciding with the increase in word production (Vihman, Macken, Millar, Simmons, & Millar, 1985; cited in Depaolis et al., 2008).
Underlying Mechanisms of Atypical Speech and Prosody

Differences reported among children with ASD, but what are the underlying mechanisms?

- Linguistic Abilities and Development
- Receptive vs. Expressive Prosody Abilities
- Motor Speech / Articulation
- Vocal Differences
- Other Mechanisms or a combination there of:

Published Empirical findings are inconsistent...
Research at UMass Amherst
In a series of studies, our research teams have investigated the presence and type of motor, acoustic-perceptual and prosodic differences and/or impairments in children with ASD compared to TD and other cohorts.

Our research supports that children with ASD do exhibit underlying motoric, phonatory (voice-related) and prosodic differences that affect speech. We have identified the tasks the tease out the most salient and confirmatory signs and symptoms of Motor Speech Impairment.
1. What **features** distinguish the speech of individuals with ASD compared to typically developing peers?

2. What underlying mechanisms and processes contribute to these speech atypicalities observed children with ASD?
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<thead>
<tr>
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<tbody>
<tr>
<td><strong>ASD, N=40</strong></td>
<td><strong>CAS vs. TD, N=16</strong></td>
<td><strong>ASD vs. CAS vs. TD; N=30</strong></td>
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<tr>
<td>Age: 2;0-22</td>
<td>Age: 5-8;11</td>
<td>Age: 4-6;11</td>
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<tr>
<td><strong>Acoustic</strong></td>
<td><strong>Acoustic</strong></td>
<td><strong>Acoustic</strong></td>
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<tr>
<td>High pitch</td>
<td>Lower pitch vowel [i].</td>
<td>Higher formant values, vowel [i]</td>
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<tr>
<td>Breathy, rough, Strained</td>
<td>Motor Speech</td>
<td>Decreased pitch vowel [i].</td>
</tr>
<tr>
<td>Monotone, Flat Prosody</td>
<td>Decrease rate</td>
<td>Decreased maximum phonation time</td>
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<tr>
<td>Speech</td>
<td>Increase duration phrases sentences</td>
<td>Slower rate of speech uniform</td>
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<tr>
<td>Poor Speech Intelligibility</td>
<td>Variable and/or inconsistent performance</td>
<td>lengthening across phrases, pause</td>
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<tr>
<td>Distorted consonants</td>
<td>phrase sentence repetitions.</td>
<td>length and vowel length</td>
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<tr>
<td>Omission of phonemes</td>
<td>Decreased MPT</td>
<td>Difficulty in producing 2 or more</td>
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<td>Poor -Increase complexity</td>
<td>Slow rate AMRs SMR</td>
<td>repetitions of syllables in AMR &amp; SMR</td>
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<td>Motor Speech</td>
<td></td>
<td>tasks.</td>
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<tr>
<td>Non-verbal Struggle</td>
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<td>Variable and/or inconsistent</td>
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<td>AMRs / Sequencing issues</td>
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<td>performance across tasks.</td>
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<td>Neuromuscular</td>
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<td>Brisk reflexes</td>
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<td>Clumsiness</td>
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<td>Muscular Weakness</td>
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<td>Drooling, Eating issues</td>
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School of Public Health and Health Sciences: Department of Communication Disorders
<table>
<thead>
<tr>
<th>Study</th>
<th>Group Comparison</th>
<th>Sample Size</th>
<th>Age Range</th>
<th>Acoustic Features</th>
<th>Motor Speech Features</th>
<th>Prosody Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pecora, Andrianopoulos, Velleman, 2007</strong></td>
<td>ASD vs. TD; <strong>N=10</strong></td>
<td><strong>Age: 4-9;11</strong></td>
<td></td>
<td>Pitch variation “<strong>monopitch</strong>” “<strong>monoloudness</strong>”</td>
<td>Shorter MPT</td>
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<td><strong>Acoustic</strong></td>
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<td><strong>Motor Speech</strong></td>
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<td><strong>Longer duration, longer pauses</strong></td>
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<td><strong>Variable and/or inconsistent performance across tasks.</strong></td>
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<td><strong>Falcon, Andrianopoulos, Velleman, 2011</strong></td>
<td>ASD vs. TD; <strong>N=15</strong></td>
<td><strong>Age: 5;11-11;3</strong></td>
<td></td>
<td><strong>Significantly greater variability of pitch</strong> children with ASD during both [a] and [i]</td>
<td><strong>Greater variability</strong> during spontaneous speech, narrative</td>
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<td></td>
<td><strong>Acoustic</strong></td>
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<td><strong>Motor Speech</strong></td>
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<td><strong>Respiratory vigilance</strong></td>
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<td><strong>Boucher, Andrianopoulos, Velleman, 2013</strong></td>
<td>ASD vs. CAS vs. TD, <strong>N=30</strong></td>
<td><strong>Age: 8;4-12;7</strong></td>
<td></td>
<td><strong>Lower formant values.</strong> <strong>Lower pitch values</strong></td>
<td><strong>Generally lower MPT of the fricative [f], prolongations,</strong></td>
<td><strong>Atypical production of prosody</strong></td>
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<td></td>
<td><strong>Acoustic</strong></td>
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<td><strong>Prosody</strong></td>
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<td><strong>Motor Speech</strong></td>
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<td></td>
<td><strong>Significantly decreased MPT</strong></td>
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<td><strong>Slower rate of speech, increased utterance, pause, and vowel durations.</strong></td>
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<td><strong>Reduced number of syllable repetitions</strong> in AMR and SMR</td>
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<td><strong>Variable and/or inconsistent.</strong></td>
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UMass Amherst Expressive Prosody Investigation
Expressive Prosodic Profile N=8 ASD Age 4 -10 yrs

<table>
<thead>
<tr>
<th>Perceptual</th>
<th>Acoustic</th>
<th>PEPS-C (Peppe et al, 2011)</th>
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</thead>
<tbody>
<tr>
<td>high pitch</td>
<td>high F0</td>
<td>impaired contrastive stress</td>
</tr>
<tr>
<td>extended utterance duration</td>
<td>high max F</td>
<td>impaired expressive affect</td>
</tr>
<tr>
<td>wide intensity range</td>
<td>decreased MPT</td>
<td>poor imitation of complex tone and pitch</td>
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<tr>
<td>“odd/awkward”</td>
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</tbody>
</table>
Perceptual Characteristics of Spontaneous Speech in High Functioning Autism: Are We Discriminating Listeners?

Mary V. Andrianopoulos, Ph.D.
Carlene McGuigan, MS candidate
Rachel Warshaw, B.A.
University of Massachusetts – Amherst, MA

Elena Zaretsky, Ph.D.
Clark University – Worcester, MA
Research Questions

1. Are there distinct **speech** and **language differences** as perceived by human listeners that distinguish children with autism as sounding “different” compared to their age- and gender-matched neurotypically developing (TD) peers?

2. Do **experienced** and **non-experienced judges** rate the narratives of children with **ASD** differently than they rate the narratives of **TD peers**?
<table>
<thead>
<tr>
<th>Age</th>
<th>Clinical Group</th>
<th>Control Group</th>
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<tbody>
<tr>
<td>8</td>
<td>9</td>
<td>5</td>
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<td>3</td>
<td>8</td>
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<tr>
<td>10</td>
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<td>6</td>
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<tr>
<td>11</td>
<td>4</td>
<td>5</td>
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<tr>
<td>Gender</td>
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<tr>
<td>Male</td>
<td>22</td>
<td>21</td>
</tr>
<tr>
<td>Female</td>
<td>2</td>
<td>3</td>
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<tr>
<td>Comorbid Diagnosis</td>
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<tr>
<td>ADHD</td>
<td>11</td>
<td>2</td>
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<tr>
<td>Anxiety</td>
<td>2</td>
<td>2</td>
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<tr>
<td>Depression</td>
<td>2</td>
<td>0</td>
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<tr>
<td>Mood Disorder</td>
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<td>0</td>
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<tr>
<td>Apraxia</td>
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<td>0</td>
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<tr>
<td>Oppositional Defiant Disorder</td>
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<td>0</td>
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<tr>
<td>Obsessive Compulsive Disorder</td>
<td>1</td>
<td>0</td>
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</table>
### Descriptive Statistics for the Peabody Picture Vocabulary Test (PPVT-IV)

<table>
<thead>
<tr>
<th></th>
<th>Clinical Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peabody Picture Vocabulary Test (PPVT-IV)</td>
<td>103.33 (18.17)</td>
<td>117.38 (12.43)</td>
</tr>
</tbody>
</table>

### Mean Performance by Group on each Emotion Attribution Measure (S.D.)

<table>
<thead>
<tr>
<th>Assessment of Children’s Emotion Skills</th>
<th>Clinical Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facial Expressions</td>
<td>23.33 (2.10)</td>
<td>22.71 (2.27)</td>
</tr>
<tr>
<td>Behaviors</td>
<td>10.21 (2.34)</td>
<td>11.17 (1.76)</td>
</tr>
<tr>
<td>Situations</td>
<td>12.50 (2.13)</td>
<td>12.92 (1.41)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The Levels of Emotional Awareness Scale for Children</th>
<th>Clinical Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emotional Awareness</td>
<td>29.71 (8.05)</td>
<td>33.00 (4.13)</td>
</tr>
<tr>
<td>Emotional Accuracy</td>
<td>9.00 (2.10)</td>
<td>10.13 (1.51)</td>
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<tr>
<th>Edmonton Narrative Norms Instrument</th>
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<tbody>
<tr>
<td>Emotion Frequency Count</td>
<td>3.21 (2.43)</td>
<td>2.63 (1.91)</td>
</tr>
</tbody>
</table>
**Methodology: Human Listeners**

Two (2) cohorts of 20 SLP and 20 non-SLP full-time graduate students were recruited across the university campus to participate as “listeners”.

- **Human Judges (Listeners): N=40**
  - **Group 1:** n= 20 SLP Masters Graduate Students
  - **Group 2:** n=20 Non-SLP Graduate Students

- **Participant orientation:**
  - To apply a set of criteria to judge the perceptual and linguistic characteristics of the narratives
Methodology: Assessment Instrument

- Perceptual Rating Instrument Created: 13 Variables
  - 7 Linguistic
    1) story sequencing; 2) topic organization
    3) story details; 4) pronominal references;
    5) causal language; 6) use of elaborations;
    7) ToM language

- 6 Speech/Acoustic variables
  1) articulation; 2) fluency; 3) intonation;
  4) rate; 5) pitch; 6) loudness)
Results: Main Effect Diagnosis (ASD vs. TD)

Statistically significant between group differences were found for four out of thirteen variables

- Variable 1  Sequencing (p=0.008)
- Variable 8  Articulation (p=0.001)
- Variable 9  Fluency (p=.005)
- Variable 12 Rate (p=0.016)

Nonsignificant differences were found for

- Variable 2  Topic organization (p=0.073)
- Variable 11 Pitch (p=0.058)

(For all 6 variables, HFA had lower mean + greater variability)
Atypical Speech and Abnormal Prosody Theories

**Speech attunement framework:** (pragmatic deficits) lack of ability to ‘tune in’ to speech environment and ‘tune up’ speech behaviors.

(Diehl & Paul, 2013; Diehl & Paul, 2012; Shriberg et al., 2011; Schoen, Paul, & Chawarski, 2011*; Lyons, Simmons, & Paul, 2014*)

**Motor deficits:** distorted timing of connected speech, problems of motor imitation, speech-motor control.

(Diehl & Paul, 2012; Peppe et al., 2007; Shriberg et al., 2001; Paul & Binachi, 2008*; Grossman et al., 2013*; Hubbard & Trauner, 2006*)
Atypical Speech and Abnormal Prosody Theories

Deficit in mechanisms that control pitch: auditory processing, phonological representation, motor functioning.

(Bonneh et al., 2010; Diehl & Paul, 2013)

Social reciprocal interaction impairment

(Yasushi, 2014*; consistent with Paul et al., 2005*)
Systematic Review: Abnormal Prosody Theories

Poor language ability, atypical/delayed trajectory for prosodic development, prosody skills may lag in maturity, difficulty interpreting suprasegmental speech features.

(Peppe et al., 2011; Bonneh et al., 2010; Diehl et al., 2009; Shriberg et al., 2001; Diehl & Paul, 2013; Sharda et al., 2010*; Peppe & McCann, 2007*; DePape, 2012*; Nadig & Shaw 2012b*; van Santen et al., 2010*; Peppe et al., 2006*)
Systematic Review: Abnormal Prosody Theories

**Nature of task:** Performance may vary based on structure of task, number of training items/similar trials, language of directions, motivation.

(Diehl & Paul, 2013; Peppe et al., 2007; Sharda et al., 2010*; Peppe & McCann, 2007*; DePape, 2012*; Nadig & Shaw 2012b*; van Santen et al., 2010*; Peppe et al., 2006*)
Language-neutral Assessment of Motor Speech (LAMS)

Shelley L. Velleman, Ph.D.
Mary V. Andriananopulos, Ph.D.
Vani Rupela, Ph.D.
The LAMS: Why a new test?

- The nature, consistency, and developmental progression of speech atypicalities is unclear, need to validate childhood motor and prosodic symptoms;
- Appropriate interventions differ by Speech Sound Disorders, MSD and ASD profiles;
- Early speech profiles can predict outcomes (i.e., ASD severity; Plumb & Wetherby, 2013; Schoen et al., 2011)
- Much more research needed – but need valid, reliable, test, for Early Identification, that is language neutral and not a check-off list!
Results: Perceptual Observations, Output Function

**Prosody**
- “rigid”, “robotic, “patterned”
- “rote”
- “locked into prosodic patterns”
- cannot demonstrate contrastive stress
- “cannot manipulate prosody to express emotions”
Results: Perceptual Observations: Output Form

**Meaningless tone patterns:**
- unable to replicate complex intonation patterns
- “flat” tone

**Pitch:**
- cannot replicate varying pitch

**Silence:**
- atypical, prolonged silences

**Duration:**
- longer duration
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  - Cure Autism Now (CAN, 2005-2007)
  - Organization for Autism Research (OAR, 2010-2012)
References


References


Grossman, R., & Tager-Flusberg, H. (2012). Quality matters! Differences between expressive and receptive non-verbal communication skills in adolescents with ASD. *Author manuscript.*


References


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