INTRODUCTION

- Theory of Mind (ToM): The ability to attribute mental states (e.g., "happy," "confused") to oneself and others.1
  - Typically developing children (TD) develop ToM by age 4 or 5.2
  - Children with Autism Spectrum Disorder (ASD) continue to underperform on ToM tasks through middle childhood and adolescence, compared to TD peers.1
- The role of language in ToM ability remains unclear.
  - School-aged TD children's language levels were not found to impact their ToM ability; however, a relationship has been reported between ToM and complex syntax.1
- Caregiver language shown to have impact on ToM
  - Mother-child conversations including more complex clarifications lead to higher false belief scores in TD children.5
  - Children with ASD performed better on perspective-taking and false belief tasks when mothers used more emotion clarification expressions.5

OUR QUESTIONS:
- Might TD and autistic teens' language predict their ToM ability?
- Can language analysis tools (CLAN, LIWC) be used to elucidate the relationship between caregiver/participant language and participant ToM?

METHODS

- Various standardized tests administered (Table 1)
  -ADOS-2 to confirm ASD diagnosis.
  - CELF-5 to assess language functioning.
- Participants were prompted to produce personal narratives:
  - "Can you tell me about a time when you were proud of yourself?" 
  - "Have you ever been a time that you lost or misplaced something?"
  - "Have you ever gone to a game or sporting event?"
- Participants and a caregiver then played the Aliens Categories Game6 together.
  - Joint computer game that elicits a conversation between caregiver and participant about whether "aliens" seen on the screen are friendly or not
  - The game is used to assess participants' ability to share and combine information as well as have a conversation about emotions.

Participant Demographics

- Participants: subset of an ongoing longitudinal study (LSEL): TD and ASD groups were language-matched at 18-24 months old.6
- Re-recruited as teenagers and young adults, now more widely ranging in language ability (Table 1).

Table 1

<table>
<thead>
<tr>
<th></th>
<th>ASD (n=15)</th>
<th>TD (n=14)</th>
<th>T</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronological Age (yr)</td>
<td>16.66</td>
<td>15.37</td>
<td>0.908</td>
<td>0.371</td>
</tr>
<tr>
<td>ADOS Restricted Repetitive Behaviors (RRB)</td>
<td>1.38</td>
<td>1.94</td>
<td>0.26</td>
<td>0.65</td>
</tr>
<tr>
<td>ADOS Communication and Social Interaction Total (SOC)</td>
<td>11.54</td>
<td>(7.90)</td>
<td>2.34</td>
<td>4.118</td>
</tr>
<tr>
<td>CELF (Raw)</td>
<td>118.31</td>
<td>(24.77)</td>
<td>201.1</td>
<td>0.25</td>
</tr>
<tr>
<td>Theory of Mind Score (Total)</td>
<td>9.46</td>
<td>12.37</td>
<td>0.25</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Coding and Transcribing

- All participant/caregiver recordings (narrative and Aliens game) transcribed in Datavyu10;
  - utterances segmented on the basis of 1-second pauses
- Transcripts then analyzed in CLAN10
  - Mean length of utterance (MU) and total number of utterances
  - Total number of tokens (toms) of nouns, verbs, adjectives
- Transcripts analyzed using Linguistic Inquiry and Word Count (LIWC-22)12 to calculate percentages of words in several categories (Table 2)

Table 2: LIWC Categories and Descriptions

<table>
<thead>
<tr>
<th>LIWC Categories Used</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>Emotional Tone</td>
<td>Degree of positivity/negativity</td>
</tr>
<tr>
<td>Analytical Thinking</td>
<td></td>
</tr>
<tr>
<td>Cognitive processing</td>
<td></td>
</tr>
<tr>
<td>Authenticity</td>
<td></td>
</tr>
</tbody>
</table>

Method: Theory of Mind Day 1 Tasks13

- Seven first-order false belief (FB) tasks
  - First-order FB: The ability to hold false beliefs about events13

Figure 1: ToM Day 1 Tasks

Method: Theory of Mind Tasks Day 2 Tasks 13

- Two second-order FB tasks
  - Second-order FB: The ability to hold a false belief about someone else’s belief13

Figure 2: ToM Day 2 Tasks

Method: Day 2 Justification Coding

- During ToM Day 2 Tasks, participants were prompted to explain the reasoning behind their answer (e.g., "why do you think that?").
- Justifications received:
  - (a) point out criteria inferences the mental states of relevant characters (e.g., "because he doesn’t want to lose his girl to the other kid")
  - (b) use criteria and say "it’s wrong for" (e.g., "he doesn’t want to lose his girl to the other kid")
  - (c) ask for justification (e.g., "he wants to tell his teacher to"") or "don’t know"

RESULTS

Relationships Unique to Autistic Youth

Adjective Types in the Narratives Positively Correlated with Combined ToM Scores

The relationship between % adjective types and ToM total scores (r = 0.721, p = 0.019) and ToM total scores (r = 0.697, p = 0.025) remained significant when CELF scores were co-varied.

Relationships from the Aliens Game: TD and ASD Youth

TD: Percent LIWC Emotional Tone Positively Correlated with ToM Total Scores

ASD: Percent LIWC Cognitive Processing Positively Correlated with ToM Total Scores

Relationships with Caregivers in both TD and ASD Groups

ASD: Caregiver LIWC Analytic Language Negatively Correlated with ToM Total Score.

TD: Caregiver LIWC Authenticity Language Negatively Correlated with ToM2 Justification Score

No positive relationships between caregiver CLAN measures and participant ToM Scores

DISCUSSION

- In Autistic youth, both general language (CELF) and specific language (adjectives during narratives) relate to ToM independently.
- LIWC analyses of the narratives didn’t reveal any significant relationships.
- LIWC analyses of the Aliens game suggested ToM relates to cognitive processing language in Autistic youth but to Emotional tone in NT youth.
- Emotion tone may be difficult for ASD youth as ASD youth show decreased emotion regulation and decreased expression of emotion when compared to NT peers.15
- LIWC analyses of caregiver speech during Aliens Game yielded negative relationships with youth ToM measures.
- This study supports the use of LIWC as an additional tool about language use in relation to ToM.