Development of ToM in Autistic Youth: The Potential Impact of Language

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INTRODUCTION

- **Theory of Mind (ToM):** The ability to attribute mental states (eg. ”happy,” ”confused”) to oneself and others.[1]
- Typically developing children (TD) develop ToM by age 4 or 5[2] .
  - Children w/ Autism Spectrum Disorder (ASD) continue to underperform on ToM Tasks through middle childhood and adolescence, compared to TD peers[2].
- The **role of language** in ToM ability remains unclear.
  - School-aged TD children’s language levels were not found to impact their ToM ability[3]; however, a relationship has been reported between ToM and complex syntax[4].
- **Caregiver language shown to have impact on ToM**
  - Mother-child conversations including more cognitive 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[6] to confirm ASD diagnosis.
  - CELF-5[7] to assess language functioning.
- **Participants were prompted to produce personal narratives:**
  - “Can you tell me about a time when you were proud of yourself?”
  - “Has there ever been a time you’ve been jabbed or poked by something?”
  - “Has there ever been a time that you lost or misplace something?”
  - “Have you ever gone to a game or sporting event?”
- **Participants and a caregiver then played the Aliens Categorization Game[8] 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[9].
- Re-recruited as teenagers and young adults, now more widely ranging in language ability (Table 1).
- **Table 1.**

	ASD (n=13)	TD (n=19)	*T*	*p*
Chronological Age (in years)	16.46 (3.57)	15.37 (3.18)	0.908	0.371
ADOS Restrictive Repetitive Behaviors (RRB)	1.38 (1.94)	0.26 (0.65)	2.010	0.064
ADOS Communication and Social Interaction Total (SOC)	11.54 (7.90)	2.16 (2.75)	4.118	<0.001
CELF (Raw)	158.31 (54.27)	205.1 (25.18)	-2.906	0.011
Theory of Mind Score (Total)	9.46 (3.43)	12.37 (0.83)	-2.996	0.010

Coding and Transcribing

- All participant/caregiver recordings (narrative and Aliens game) transcribed in Datavyu[10]; utterances segmented on the basis of 1-second pauses
- Transcriptions then analyzed in CLAN[11] for:
  - Mean length of utterance (MLU) and total number of utterances
  - Total number (types and tokens) 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*

LIWC Categories Used	Definition[12]
Emotion Tone	Degree of positive/negative tone. (e.g. *Love, nice, sweet, hurt, ugly, nasty*)
Analytical thinking	Metric of logic, formal, hierarchal thinking patterns [articles + prepositions – pronouns - auxiliary verbs - adverb - conjunctions - negations]
Cognitive processing	Words related to thinking (e.g., *but, not, if, know, cause, ought*)
Authenticity	Perceived honesty, genuineness

Method: Theory of Mind Day 1 Tasks[13]

- Seven first-order false belief (FB) tasks
  - First-order FB: The ability to hold false beliefs about events[2,14].

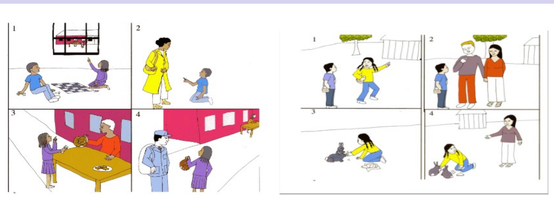
Figure 1. *ToM Day 1 Tasks*

Note. Each task investigated different subscales of first-order FB (e.g., 1. Diverse Desires).Scoring: # correct (7 trials).

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 belief[2,14].

Figure 2. *ToM Day 2 Tasks*



Note. Scoring: # correct (3 questions per task;, total of 6 trials).

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) 1 point for correctly referencing the mental states of relevant characters (e.g. “because that’s what he told Lucy and he didn’t see her see him get it from the cookie jar”)
  - b) 0.5 point for referencing the mental state of only one character (e.g., “because he lied to Lucy and said it was in the cupboard”)
  - c) 0 points for providing irrelevant (e.g., “he wants to tell the truth to his mom”) or “don’t know” responses.

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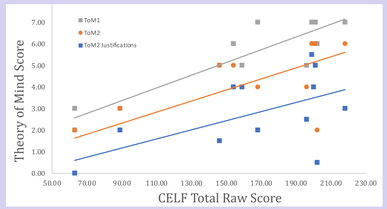
RESULTS

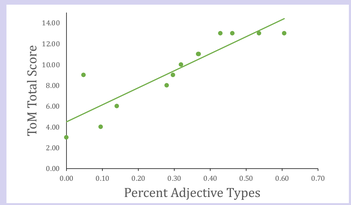
Relationships Unique to Autistic Youth

CELF-5 Scores Positively Correlated With ToM Scores



Note. CELF scores positively correlated with ToM Day 1 scores (r = 0.912, p <.001), ToM Day 2 scores (r = .736, p = 0.004), and ToM Day 2 Justification scores (r = .628, p = 0.022).

Adjective Types in the Narratives Positively Correlated with Combined ToM Scores

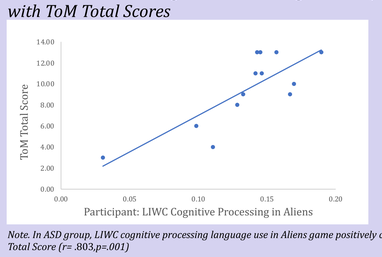


Note. % adjective types and tokens were calculated by dividing the total number of adjective types and tokens, respectively, by the total number of utterances (for narratives only). Combined ToM scores were calculated by summing ToM Day 1 and ToM Day 2 scores. In the ASD group, combined ToM scores positively correlated with % adjective types (r = .896, p <.001) and tokens (r = .899, p <.001).

The relationship between % adjective types and ToM2 scores (r = 0.721, p =.019) and ToM total score (r =.697, p =.025) remained significant when CELF scores were co-varied

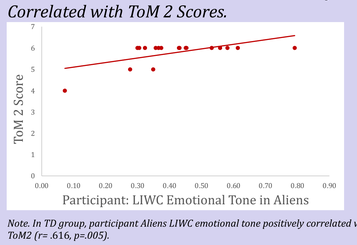
Relationships from the Aliens Game: TD and ASD Youth

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



Note. In ASD group, LIWC cognitive processing language use in Aliens game positively correlated with ToM Total Score (r= .803,p=.001)

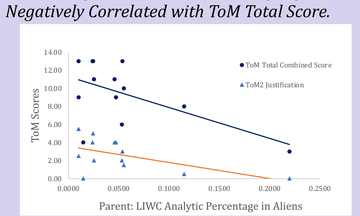
TD: *Percent LIWC Emotional Tone Positively Correlated with ToM 2 Scores.*



Note. In TD group, participant Aliens LIWC emotional tone positively correlated with ToM2 (r= .616, p=.005).

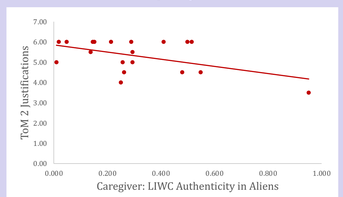
Relationships with Caregivers in both TD and ASD Groups

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



Note. In ASD Group, LIWC analytic language use (in percent) in parent Aliens transcript negatively correlated with ToM total score (r= -.570, p= .042) and ToM2 justification scores (r= -.556, p= .049).

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



Note. In TD group, LIWC authenticity language use (in percent) in parent Aliens negatively correlated with ToM 2 justification scores (r=-.500, p= 0.029).

- 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.