Published in final edited form as:

Lang Acquis. 2020 ; 27(4): 410–433. doi:10.1080/10489223.2020.1769626.

Children with ASD use joint attention and linguistic skill in pronoun development

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Research on typical children's early lexical development has provided compelling evidence for the influence of both social-pragmatic and linguistic cues (Clark, 2015; Graham et al., 2015), and is beginning to create an integrative framework to explain how these various sources of knowledge converge and diverge in different contexts and across development to guide word learning (Graham et al., 2015; Hoff & Naigles, 2002; Hollich et al., 2000). Researchers of language learning in special populations have also recently called for investigations of the concurrent and predictive relations between linguistic and nonlinguistic development for these children (Abbeduto, McDuffie, Thurman, & Kover, 2016). We take up this task in the current study and extend the investigation of the combined roles of linguistic and social-pragmatic cues to the acquisition of personal pronouns in both typically developing (TD) children and children with autism spectrum disorder (ASD).

Personal pronouns pose a particularly challenging problem for young language learners. Unlike object nouns, the referents of personal pronouns change depending on the role of the speaker in a conversation, and more than one person can be referred to by the same pronoun even within the same conversation (e.g. multiple instances of *her* in a group of girls). An English-exposed child must learn to identify a pronoun's person (*I* vs. *you*), case (*me* vs. *my*), and number (*me* vs. *us*) to correctly use the pronoun system (Charney, 1980; Chiat, 1982). Learning pronoun words and being able to shift perspective to understand their changing referents obviously requires social-cognitive knowledge; moreover, research has explored how specifically linguistic knowledge is necessary as well (Oshima-Takane, Takane, & Shultz, 1999; Rispoli, 2005; Markova & Smolík, 2014). The current study breaks new ground by assessing the relative contribution of *both* factors, via comparison of the developmental trajectories of personal pronoun production in TD children and children with ASD because these groups differ, by definition, in their social-cognitive abilities and often in their language onsets and trajectories as well (Naigles et al., 2016; Tek et al., 2014). Moreover, whereas previous work with toddlers and preschoolers has focused on correct pronoun usage in one-time lab assessments or parental surveys (e.g., Rispoli, 2005; Naigles et al., 2016; Campbell, Brooks, & Tomasello, 2000; Markova & Smolík, 2014), we assessed pronoun production across time in an ecologically-valid home setting, and used two predictors of interest: a social-cognitive factor (joint attention) and a linguistic factor (a name bias). Because the impersonal pronoun *it* differs from personal pronouns in both its social and linguistic constraints, we have chosen to focus solely on personal pronouns.

Social-cognitive factors in pronoun acquisition

Communication partners must be able to understand what a given pronoun refers to for successful communication to take place. Therefore, one aspect of early pronoun acquisition involves learning when it is customary and preferred to replace nouns and names with pronouns, even when either would be grammatically correct. (We focus here on pronouns as lexical items more than as grammatical constructs; therefore, later aspects of their acquisition, such as their relations to binding principles (e.g., Perovic, Modyanova, & Wexler, 2013) are beyond the scope of this paper.) According to Gundel, Hedberg, and Zacharski (1993), adults' pronoun use depends on their understanding of each other's mental states to determine the "givenness" or availability of referents. Under this account, speakers use perspective-taking skills to determine what is "given" in a context, and then use pronouns to substitute for those referents. However, the precise role of social and perspective-taking skills on TD children's emerging pronoun use has yet to be fully determined. For example, Oshima-Takane and colleagues (1988; Oshima-Takane, Goodz, & Derevensky, 1996) have reported from both observational and experimental studies that overheard speech input (i.e., addressed to others) is critical for children's correct pronoun production; however, the degree to which overheard speech promotes perspective-taking, itself, is unclear. It is possible, for example, that the functionality of overheard speech lies more in its presentation of varied pronouns (e.g., Smiley et al., 2011) than its enabling of shifts in perspective. Markova and Smolík (2014) have linked parent report of first- and second-person pronoun usage in Czech-speaking 2-year-olds to the children's usage of mental state language (i.e., sensory, emotional, desire, and cognition terms), but again, the relation of mental state language to perspective-taking is indirect, and also involves linguistic factors.

More direct measures of children's perspective-taking have involved their propensity to engage in *joint attention* (JA), which occurs when a person shares focus with another person with regards to an object. Mundy and colleagues (Mundy, Sullivan, & Mastergeorge, 2009; Mundy, Gwaltney, & Henderson, 2010) elegantly describe JA as spontaneous sharing of enjoyment that allows children to gain information about their world. There are multiple ways that children engage in shared attention: they can respond to someone's bid for attention by following a verbal or physical cue, or they can initiate by drawing a conversation partner's attention using their own voice or gestures. In the current study, we were most interested in children's tendency and ability to respond to attentional bids from others. In a study of object label learning with five-year-old children with ASD, Parish-Morris et al. (2007) found cues regarding perceptual attention to be more crucial than cues regarding social intention. We are interested in examining social intention (i.e. response to JA) here because personal pronouns may be more dependent on such intention than object labels. Response to joint attention (RJA) requires children to deliberately shift their attention from their own focus to that of another (Mundy, Gwaltney, & Henderson, 2010). Lewis and Ramsey (2004) directly compared visual self-recognition and personal pronoun use, finding that children who showed self-recognition (in this case, visual recognition in a mirror) used more personal pronouns. By responding to attentional bids, children demonstrate social understanding of reference to an object and an understanding of another's intentions.

Bottema-Beutel's (2016) thorough review and analysis of JA and language in ASD also demonstrated the importance of RJA: she found support for RJA as a stronger predictor (i.e., higher effect sizes) than other forms of JA for relationships between shared attention and language in this population.

Direct assessments of JA have not consistently yielded positive effects on pronoun usage, though: Campbell and colleagues (2000) elicited sizeable numbers of pronouns from 2-year-olds regardless of whether the addressees were in JA with the child and whether the object had been mentioned previously. Similarly, Naigles et al. (2016) found that TD toddlers' propensity to reverse pronouns – use *I* for *you* and vice versa – was not related to their JA behavior. What has been missing from the 'direct assessment of perspective taking' literature, though, are investigations of the onset and developmental trajectory of the whole range of pronoun use in naturalistic contexts (as in Oshima-Takane, et al. 1996). That is, Naigles et al. (2016) may not have observed significant relations between JA and pronoun usage because their measure, pronoun reversal, was extremely rare (1–2% of pronouns in TD children) in their corpus. Furthermore, it is possible that the toddler participants in Campbell et al.'s (2000) study did not understand the experimental situation, which involved multiple experimenters, objects, and their changes of location. In the current study, we provide such an investigation, using a longitudinal dataset in which TD children's pronoun usage and JA behaviors have been independently coded and tracked across a two-year span.

Linguistic factors in pronoun acquisition

Pronoun acquisition is also clearly a *linguistic* phenomenon, as children need to learn the multiple forms of I/me/my/mine, you/your/yours, he/she/his/her/him/her/his/hers, we/us/our/ours, and they/them/their/theirs. Most developmental research has only considered singular first- and second-person pronoun forms, but even these are nontrivial in terms of number as well as the complexity of the grammatical paradigm (i.e., gender and case; Rispoli, 2005). Indeed, previous research has found that children's linguistic abilities predict their pronoun usage: Evans and Demuth (2012) and Dale and Crain-Thorensen (1993) reported precocious pronoun production in toddlers who were early talkers overall, and Markova and Smolík (2014) found that parent report of two-year-olds' command of Czech grammar was uniquely and positively related to the children's pronoun usage. Moreover, Oshima-Takane and colleagues (1999) used feed-forward neural networks to demonstrate that a learning system must have an encoding of the words "I" and "you" *as well as* an understanding of role shifts in a conversation in order to correctly use first- and second-person pronouns.

However, as with the social factor of perspective-taking, current research does not yet pinpoint which linguistic abilities are critical for pronoun acquisition. For example, the early talkers in Evans and Demuth (2012) and Dale and Crain-Thorensen (1993) were advanced in both lexical and grammatical development, while Markova and Smolík (2014) and Oshima-Takane et al. (1999) have highlighted specific roles for grammatical and lexical growth, respectively. In the current study, because we are targeting early pronoun development and examining the emergence of first-, second-, *and* third-person pronouns, we primarily focus on the *lexical* contributions to children's pronoun development. Specifically, because personal pronouns replace proper nouns (Mommy) and some count nouns (the girl), we

conjecture that their emergence may be related to children's propensity to acquire and use proper names. As theorized by Oshima-Takane, young children use their prior knowledge of proper names—their own and others'—in determining the content of personal pronouns used by others, in at least two ways. First, proper names require children to trace their own and others' identity over time, facilitating the realization that 'Taylor now' is the same as 'Taylor yesterday' and 'Taylor this morning.' This connection is similar to, and postulated to enable, that required by personal pronouns; i.e., that 'I now' could be the same as 'you this morning.' Second, proper names are usually interspersed with personal pronouns in children's input (e.g., *Taylor, would you push the ball over here? And I told Daddy that he should pick up ice cream on the way home*). This mixture of proper names and pronouns has been shown in both computer modelling and observational studies to facilitate personal pronoun acquisition (Oshima-Takane et al., 1999; Smiley et al. 2011). Finally, of course, it is also likely that children who are proficient at word learning overall may also be better at learning and using personal pronouns.

Generative linguistic theorists have also provided proposals concerning pronoun acquisition; for example, Kerstens (1993; see also Ackema & Neeleman, 2019) has proposed that the features associated with the three pronoun persons are organized such that 1st person includes (+utterance/+speaker (or *proximal*)), 3rd person includes (-utterance/-speaker (or *distal*)), and 2nd person features overlap with each of 1st and 3rd person (i.e., +utterance/-speaker (*distal*)). In terms of acquisition, these proposals predict that 1st person and 3rd person pronouns would not pattern together developmentally, because they do not share features, while 2nd person pronouns could pattern with 1st person because of shared +utterance features, or with 3rd person because of -speaker/*distal* features. Including all three person pronouns in our investigation allows us to shed light on the relative primacy of these features in acquisition.

Examining pronoun production longitudinally in naturalistic settings is a powerful way to get us closer to a full picture of the contributions of social-cognitive and linguistic knowledge. Previous generations of researchers have examined the presence, frequency, and onset of all three persons in pronoun use (e.g., Goodenough, 1938; Brown, 1973; Cruttenden, 1977), reporting that pronoun production in English-speaking TD children starts around 18 to 24 months of age with 1st person pronoun emergence, followed by 3rd and 2nd person pronouns; however, most of these earlier studies included few children and/or observations. Moreover, while 1st person pronouns were consistent in their primacy, the ordering of 2nd and 3rd person pronouns varied across studies. A more recent examination including 12 TD children learning English (Girouard, Ricard & Gouin-DeCarie, 1997) replicated the developmental primacy of 1st person pronouns but found no differences in age of acquisition for 2nd vs. 3rd person pronouns. We renew this inclusion of all three persons in our study, as we are interested in not only how children talk about themselves and their immediate conversational partner, but also how they refer to others using third person pronouns.

Autism spectrum disorders and pronoun development

While investigating children's speech in a longitudinal naturalistic paradigm allows us to track pronoun emergence in all three persons, this does not easily afford opportunities to manipulate children's social or lexical knowledge. However, including children who present with a wider range of social and lexical abilities allows us to shine a stronger light on these influences. By definition, children with ASD demonstrate dramatically different social-cognitive development than TD children. Furthermore, at least four distinct patterns of language growth have been reported, including children who are minimally verbal throughout childhood, children who show near-typical language throughout childhood, children who are verbal but language impaired throughout childhood, and children who are minimally verbal when diagnosed but whose language reaches near-typical levels by adolescence (Anderson et al., 2007; Pickles, Anderson & Lord, 2014; Naigles & Chin, 2015). Following the paradigm pioneered by Gleitman and her colleagues (Landau et al., 2000), we propose to illuminate the role of social-cognitive and lexical knowledge in pronoun acquisition by investigating children with clear social-cognitive impairments; namely, those with ASD.

ASD is a neurodevelopmental disorder characterized by a wide range of deficits in social communication and interaction, and by restricted, repetitive behavior patterns (APA, 2013). The diagnosis of ASD is based partly on social interaction being markedly different from typical interactions, and one of the hallmarks of that difference is an impairment in the incidence and nature of JA. Thus, Mundy et al. (2010) characterize ASD as specifically creating disturbances in the processing of the concepts of 'self' and 'other,' and this characterization concurs with descriptions of ASD that emphasize difficulties with theory of mind (Frith and Happé, 1999) and "intersubjectivity" (García-Pérez, Lee, & Hobson, 2007). Based on Gundel et al. (1993), Oshima-Takane et al. (1999), and Loveland (1984), we should expect delayed development and particular difficulties with the production of pronouns by children with ASD. Two aspects of the literature on pronoun development in ASD bear this out: First, pronoun reversals (using *you* for *I* and *I* for *you*) have consistently been shown to be more frequent in the speech of children with ASD compared with their language-matched TD peers (Kanner, 1946; Loveland & Landry, 1986; Tager-Flusberg, Paul, & Lord, 2005; McGregor, Nunez, Cebula, & Gomez, 2008; Luyster & Lord, 2009; Evans & Demuth, 2012; Naigles et al., 2016), although their pervasiveness in actual speech has been recently questioned (i.e., Naigles et al. 2016 found that only 7–10% of personal pronouns were reversed by children with ASD, and this low level of reversals has been replicated by Barokova & Tager-Flusberg, 2019).

Second, some research has suggested that perspective-taking in various forms is related to pronoun usage: Naigles et al. (2016) reported that English-speaking preschoolers with ASD who engaged in more JA episodes at study onset were less likely to produce reversed pronouns, and Meir and Novogrodsky (2019) found that 3rd person pronoun usage by school age Hebrew-speaking children with ASD was predicted by their performance on perspective-taking tasks involving theory of mind. Interestingly, though, Mazzaggio and Shield (2020) found no significant relationships between theory of mind performance and 1st or 2nd person pronoun production in school age Italian speakers with ASD. These mixed

findings further support the need to examine all three person pronouns, in naturalistic situations, to clarify the role of social-cognitive factors.

Finally, the literature on pronoun development in ASD also implicates lexical influences in terms of both overall production and correct production (i.e., lack of reversals). In experimental tasks in a number of spoken languages, children with ASD tend to use more nouns and proper names rather than pronouns, in pronoun-appropriate contexts, compared to TD children (Jordan, 1989; Lee, Hobson, & Chiat, 1994; Mazzaggio & Shield, 2020; Terzi et al., 2019). This has held even when the pronouns were shorter than the nouns and proper names, and thus were less phonologically taxing to produce. Shield, Meier, and Tager-Flusberg (2015) reported similar findings for deaf children with ASD who used American Sign Language (ASL), in both a naturalistic language sample as well as a direct elicitation task (i.e., asking the children to identify themselves in a photograph); specifically, the children were more likely to fingerspell proper names than use the points that manifest pronouns in ASL. For these children, the common and especially proper nouns they had acquired seemed to ‘interfere’ with pronoun usage. Naigles et al. (2016) found that children with ASD with larger vocabularies produced *fewer* pronoun reversals; that is, vocabulary size was a significant *negative* predictor of pronoun errors. Thus, children with ASD are more likely to use nouns and names than pronouns, and a larger vocabulary relates to better use of those pronouns. In the current study, we narrow in on the relation between linguistic ability and pronoun production by assessing children’s novel name-learning abilities in a preferential-looking task (Swensen et al., 2007), and examine how these contribute to their growth in pronoun usage in a naturalistic setting.

Design of current study

Children (both TD and with ASD) use pronouns frequently and often correctly. We propose that children bring both lexical and social knowledge to bear when they do this; however, the relative influence of these different components across development has never been assessed. Using a longitudinal design and multilevel modeling, we compared pronoun production in children with ASD and TD, to each other and to themselves, over the course of two years.

Naigles and colleagues have explored a number of connections between language, attention, and cognitive measures in the larger sample of children of ASD from which our subsample is drawn. They found that early language and early JA were predictive of pronoun reversals (which were infrequent; Naigles et al., 2016). Tek et al. (2014) found two distinct profiles of language growth, including vocabulary and question complexity. The children overall do not consistently use a shape bias for object labelling (Tek et al., 2008), but a subset who engaged in longer periods of JA at study onset showed a stronger shape bias 1.5 years later (Abdel-Aziz et al., 2018). Nonetheless, this work still leaves us with questions about the relations between attention, linguistic ability, and pronoun production.

We hypothesized that children with ASD would produce fewer pronouns than TD children overall (Naigles et al., 2016), but first-person pronouns would emerge earlier and be produced more frequently than second- and third-person pronouns across groups

(Cruttenden, 1977; Shield et al., 2015; Barokova & Tager-Flusberg, 2019). Reductions in pronoun production were hypothesized to be related to difficulties in perspective-taking, which was indexed by the amount of time children spent in JA with their parent (Roos et al., 2008). Moreover, given that Bottema-Beutel's (2016) meta-analysis found stronger effects of RJA on overall language development in ASD samples compared with TD, we expected a similar asymmetry in our dataset. Pronoun production was also hypothesized to be related to children's naming bias, with the hypothesis that children with a more consistent naming bias (i.e., stronger tendency to assign names to puppets; Waxman et al., 2013) might have higher pronoun production (Oshima-Takane, 1999). That is, if children are adept at labeling puppets with names they may be also be more likely to have learned, and so use, personal pronouns.

In addition to using RJA and naming bias as predictors in our model, we included pronoun type and word tokens. Given work by Goodenough (1938), Cruttenden (1977), and Girouard et al. (1997), we expected children to produce 1st, 2nd, and 3rd person pronouns at different rates, so using pronoun type as a variable allowed us to see how person itself affected acquisition, and was affected by diagnosis, RJA, and naming bias. For example, perspective shifting is clearly implicated in shifting between 1st and 2nd person pronouns, but perspective may also be important in replacing a noun with a 3rd person pronoun in a way that is comprehensible to the conversation partner. Repeatedly using a noun or proper name is pragmatically awkward and using a pronoun without a clear referent (which involves knowing what is "clear" to the conversation partner) is incorrect. Therefore, 3rd -person pronouns might use similar social cognitive abilities as 1st and 2nd person pronouns.

Word tokens were included to control for overall talkativeness in the children, as well as (indirectly) general language level. We assumed that children who talked more would produce more pronouns as a function of their quantity of verbal output. Including word tokens as a control variable allowed us to look at the production of pronouns as a function of ASD and social and linguistic abilities, to see if the predictive relations would hold over and above general talkativeness or language level.

In sum, we had four guiding hypotheses for our study: (1) Children with ASD would exhibit slower development of pronoun production than TD children. (2) Children with higher levels of JA would produce more pronouns, with the ASD group showing a stronger influence. (3) Children with a stronger naming bias would use more pronouns because learning proper names facilitates personal pronoun acquisition. (4) Finally, pronoun development would vary by person, with 1st person emerging earliest; however, we predicted that the different persons would manifest similar relations to social-cognitive and lexical knowledge.

Method

Participants

Eighteen TD children and 15 children with ASD were included in this study; they were visited every four months at home over the course of two years, for a total of six visits (V1–V6). Children were recruited through mailing lists, autism service providers, and word of mouth. The children were mostly boys; ASD is more prevalent in males and our TD group

was selected to match the ASD group in composition based on children's biological sex. Both groups' demographics were representative of the populations in Connecticut, Massachusetts, New York, Rhode Island, and New Jersey from which they were recruited. The children with ASD had been diagnosed based on the DSM IV by a clinician within six months of the first visit, and diagnosis was confirmed through administration of the Autism Diagnostic Observation Schedule (Lord et al., 2000) and the Childhood Autism Rating Scale (Schopler, Reichler, & Renner, 1988) by a research-reliable administrator.

The children in this study were part of a larger longitudinal sample (Naigles & Fein, 2017), in which the TD children were recruited at chronologically younger ages, with the goal of the two groups being similar in expressive language at the first visit. For the current study, the sole inclusionary criterion from the larger sample was that each child produced at least one pronoun by the sixth visit; this criterion eliminated some of the lower-verbal children with ASD who were in the larger sample (e.g., in Tek et al., 2014). Table 1 displays demographic and diagnostic information for all participants; as the Table shows, neither MLU nor vocabulary size (measured by the MacArthur Communicative Development Inventory; Fenson et al., 1994) differed significantly between groups, nor did Mullen Receptive Language raw scores. There were, of course, significant group differences in their diagnostic and adaptive behavior scores due to the characteristics of children diagnosed with ASD. The diagnostic groups also differed on Mullen Visual Reception and Expressive Language raw scores, but notice that on this latter measure the ASD group's mean is higher than that of the TD group; this is because the ASD group is chronologically older and includes only children who produced at least one pronoun. Figure 1 displays violin plots of the Mullen raw scores, showing a great deal of overlap between groups. Whereas some studies examining language in children with ASD divide their sample in those who are language-normal vs. language-delayed (Norbury, 2017; Perovic 2017 from book), such a division was not possible in our sample because language delay is not reliably diagnosed in children under four years of age; moreover, the violin plots highlight the unimodal rather than bimodal nature of the distributions in both groups.

Procedure

Two to four experimenters visited each child at home and administered a series of standardized tests. The battery of tests differed slightly between visits depending on age-appropriateness and time constraints. After the tests, children watched a series of videos that assessed language comprehension using Intermodal Preferential Looking (IPL; Hirsh-Pasek & Golinkoff, 1996; Piotroski & Naigles, 2011; Naigles & Tovar, 2012), which is a simple paradigm that has little social demand, so is well-suited to children with typical or atypical development.

After watching the videos, the child and a parent (a mother in all cases except two) were videotaped while playing together for 30 minutes. Fifteen minutes were spent in free play, with the parent instructed to play with their child as they normally would. The other half incorporated a series of 12 play-based activities based on the Screening Tool for Autism in Two-year-olds (STAT; Stone, Coonrod, & Ousley, 2000), which was designed to encourage interaction, language, and JA using a specific bag of toys provided by the experimenters.

Parents were prompted to engage in the activities (e.g., engaging with a certain toy) by an experimenter, who quietly handed notecards with activity descriptions to the parent. Parents complied with instructions. One video camera with built-in microphone was set on a tripod and operated by an experimenter who focused the camera on the play area (generally the family's living room) and who remained quiet throughout the session.

Diagnostic Measures

The Autism Diagnostic Observation Schedule (ADOS).—The ADOS (Lord et al., 2000) is a diagnostic tool for ASD. A trained research assistant engaged the children in a series of activities that were designed to identify deficits in social and communicative behaviors.

Mullen Scales of Early Learning.—The Mullen (Mullen, 1994) provided scores for Expressive Language and Receptive Language and nonverbal cognitive (Visual Reception) abilities through a series of activities administered by a trained research assistant. We also used the Visual Reception scale as a measure of non-verbal intelligence to compare diagnostic groups (see Fig. 1 and Table 1).

Vineland Adaptive Behavior Scales.—The Vineland (Sparrow, Balla, & Cicchetti, 1984) is a semi-structured interview conducted with a caregiver (usually the mother) that scores children's communication skills, daily living activities, socialization abilities, and motor skills. The socialization subscale of the Vineland was used to compare diagnostic groups; the parent answered questions about whether the child showed preferences and affection for certain people, demonstrated a desire to please others, imitated complex actions, or used emotion words.

Childhood Autism Rating Scales (CARS).—The CARS (Schopler, Reichler, & Renner, 1988) is a parent checklist tool that screens for skills and behaviors that are indicative of ASD.

The MacArthur Communicative Development Inventory (CDI: words and gestures, infant form).—The CDI (Fenson et al., 1994) is an assessment of vocabulary size. At V1, parents were provided with a list of common words that occur in children's early vocabularies and checked off the words their child produced.

Dependent measure: Pronouns produced

Children's speech during the 30-minute play session was transcribed and analyzed in the lab, using CLAN software (MacWhinney, 2000), which yielded counts of each type of pronoun. Undergraduate research assistants were trained in word-level transcription using the CHAT and CLAN manuals (MacWhinney, 2000), and two of them transcribed each interaction. They were blind to diagnostic category and specific hypotheses of the study, although diagnosis could often be inferred based on behaviors in the videos. Any discrepancies between the two coders were resolved via discussion between the transcribers and the last author. We used algorithms built into the CLAN program to output counts of specific words and word types.

Pronoun production was defined as a count of the total number of personal pronouns (*I, me, you, he, she, him, her, we, us*) in uncontracted (e.g., *I will*) or contracted (e.g., *I'll*) forms, but only those deemed by a trained coder to have an unambiguous referent were used in this study. This measure included all pronouns that were produced by the children, including the few reversed pronouns, to obtain a full picture of the times a child tried or tried and succeeded in referring to themselves or to another person (across all 6 visits, mean pronouns reversed were 4% for the ASD group and 2% for the TD group, with the highest being 7% for the ASD group at V1; such a low proportion of reversed pronouns has recently been corroborated by Barokova & Tager-Flusberg, 2019).

Predictor variables: Response to joint attention and name bias

Response to joint attention (RJA) duration.—Coders were trained to recognize JA following instructions based on Roos et al. (2008). Episodes of a child responding to JA were coded when the parent used a verbal directive to gain the child's focus (including verbal, pointing, or showing behaviors) in a situation where the child was initially showing different focus, and where the parent showed intention to change the child's focus. Examples include calling the child's name, asking questions (e.g., "Wanna play with the baby?"), comments (e.g., "This is a nice car!"), or using imperatives (e.g., "Put the blocks together!"). A change in eye gaze was one behavior that could indicate a shift of attention, but given that the camera was trained on the play session from only one angle, at times the body position or hand movements were used to indicate the direction of attention. The same coders also marked episodes in which children initiated JA, but given our hypotheses we did not use those data in the current study. The coder marked the beginning and end of each episode using ELAN (a software program designed to record language-specific behaviors from video) to watch the video frame-by-frame. The sessions were coded as part of a dissertation (Tek 2010; see also Naigles et al. 2016); after the primary coding, 11% of the sessions were re-coded by two highly trained undergraduate research assistants. Disagreements were resolved through explicit discussion with Tek and the last author. We calculated inter-rater reliability using a one-way, consistency, single measures intra-class correlation (Hallgren, 2012) and found excellent consistency, $ICC = 0.85$.

Name bias (NB) looking time.—At V1, we tested all children's preference for interpreting novel words as puppet names rather than action labels using IPL (Tek et al., 2008; Naigles & Tovar, 2012). Video stimuli were edited into a series of clips with accompanying audio using novel words conforming to English phonology. For a detailed layout of one of the videos, see Table 2. For example, in video clips 1–3 in Table 2 a child saw a possum puppet making a digging motion while the audio played "Here's *toopen!*", "See, *toopen!*", and "Look, *toopen!*" Side-by-side clips (video clips 4–5) then showed the same puppet in a different action (swaying side-to-side) and a different puppet (a beetle) engaging in the digging action while the child heard "They are different now!" and "Where's *toopen?*" Videos were projected onto a screen via a projector and the audio was emitted from a speaker centered below the screen. Lights centered between the videos attracted the children's attention between trials. The children sat approximately three feet in front of the screen either on a small chair or on a parent's lap. Some children needed to sit in the parent's lap to ensure cooperation; however, parents were instructed not to direct the child in

any way (and none overtly did). Children's faces were filmed while they watched the videos. This film was subsequently digitized into a format where the children's eye movements were coded frame by frame (Naigles & Tovar, 2012). Because this film was silent, the coders were blind to the experimental condition. To assess inter-rater reliability, 10% of the videos were coded by a second coder; the correlation between coders was $r=.97$.

NB video trials were six seconds long, preceded by a three second inter-trial-interval when only the red centering light was visible. All audios were presented in child-directed speech. The first three trials introduced the novel puppet (e.g., a possum), the novel action (e.g., nose digging) and the novel word (e.g., *toopen*); these were the teaching trials. The novel words for this study all ended in "en" to provide a morphological shape that is appropriate to both names (e.g., *Aidan*) and verbs (e.g., *jumpin'*; see Golinkoff et al., 2013; Naigles et al., 2011; Swensen et al., 2007; Tek et al., 2008 for more discussion). In addition, the presentation of the novel word without a determiner makes a proper noun interpretation more felicitous than a common noun interpretation. The control trial presented two new visual stimuli; one showed the old puppet performing a new novel action while the other showed a new unfamiliar puppet performing the old action. Lacking a directing audio, this trial revealed the relative salience of the two stimuli. The test trial presented the same visual stimuli as the control trial, but was accompanied by the test audio, "Where's *toopen*?" This tested whether the child attached the novel word to the original puppet or the original action. We considered the scene with the original puppet performing the new action to be the matching (naming-biased) scene. A total of six novel words were introduced and then tested.

We calculated the percent of time that each child spent looking at the puppet matching screen and the action matching screen, and found the difference between those two. This gave us a number that represents the child's preference for name interpretations, with increasingly positive numbers showing a stronger name interpretation and increasingly negative numbers showing a stronger action interpretation. As described in more detail in Tek et al. (2008), children with both groups generally showed a Name Bias (with no group differences), but there was considerable variability in both groups (see also Table 3).

Covariate: Word output

Word token count.—The number of *total* words a child produced during the 30-minute play sessions at each visit was calculated using CLAN and is referred to here as Word tokens. We used tokens in these analyses because we were interested in the number of pronouns children used *over and above their specific talkativeness during the 30-minute sample*.

Analysis Method: Growth Curve Analysis

Children's change in pronoun production was modeled using several variables as predictors. Growth curve analysis (GCA) is a type of regression that suits this dataset because it treats a time variable ("visit" in this dataset) in a sequential manner, allowing for analyses of *change over time* (Singer & Willett, 2003; R Core Team, 2013; R Studio, 2012; Bates, Maechler, & Bolker, 2012); it also allows for time-varying predictors, like our RJA variable, so that we can assess the effect of the change in the predictor on the change in the dependent variable.

GCA involves creating an equation that includes an intercept added to a series of predictors multiplied by coefficients. We used guidelines suggested by Babyak (2004) and Finlay (2014) who suggested at least 10 data points per predictor variable; with six visits for each of 33 children total, we were able to include our variables of interest without overloading the model. A key benefit of GCA for longitudinal data is the inclusion of two levels of equations: Level-1 for within-child variation, and Level-2 for between-child variation. Conceptually this differs greatly from ordinary least squares regression, which finds an average best-fit line; GCA fits a line for each individual participant on its way to creating the best-fit model. Due to the multi-level aspect of GCA, we can say that we are finding the best-fit growth parameters for our outcome measures while accounting for individual variation in intercept and slope. We then added our variables of interest and used -2LL and chi-squared tests to judge which model was the best fit for our data (Singer & Willet, 2003; Rowe, et al. 2012).

At Level-1 (within-child variation), we found the best fit to be a quadratic model of Visit, meaning that it contains Visit and Visit-squared, with additional main effects of our key variables of interest, RJA and NB, as well as our control variable (word tokens, labelled “Words” in the equation). For child i at time j the equation is:

$$Y_{ij} = \pi_{0i} + \pi_{1i}(Visit_{ij}) + \pi_{2i}(Visit_{ij})^2 + \pi_{3i}(RJA_{ij}) + \pi_{4i}(NB_i) + \pi_{5i}(Words_{ij}) + \varepsilon_{ij}$$

Where Y_{ij} is child i 's pronoun production at visit j , π_{0i} is child i 's pronoun production at V1, and π_{1i} is child i 's velocity at V1, π_{2i} is child i 's acceleration at V1. The coefficients π_{3i} , π_{4i} , and π_{5i} were calculated by adding variables into the model and assessing model fit. The variable NB only has a subscript i because it is not time-varying; each child had one value of NB measured at V1. The residual ε_{ij} is the error term: the portion of pronoun production not predicted by the variables of interest. At Level-2 the coefficients were calculated by entering our variables into the equation to find the best fit for the actual data one at a time, to check for significantly improving model fit and avoid overfitting (Babyak, 2004; Finlay, 2014). Our final model can be represented with the following equations, each corresponding to one of the coefficients in the Level-1 equation:

$$\pi_{0i} = \gamma_{00} + \gamma_{01}(Diagnosis_i) + \gamma_{02}(ProType_i) + \gamma_{03}(Diagnosis_i \times ProType_i) + \zeta_{0i}$$

$$\pi_{1i} = \gamma_{10} + \gamma_{11}(Diagnosis_i) + \gamma_{12}(ProType_i) + \gamma_{13}(Diagnosis_i \times ProType_i) + \zeta_{1i}$$

$$\pi_{2i} = \gamma_{20} + \gamma_{21}(Diagnosis_i) + \gamma_{22}(ProType_i) + \gamma_{23}(Diagnosis_i \times ProType_i) + \zeta_{2i}$$

$$\pi_{3i} = \gamma_{30} + \gamma_{31}(Diagnosis_i) + \gamma_{32}(ProType_i) + \gamma_{33}(Diagnosis_i \times ProType_i) + \zeta_{3i}$$

$$\pi_{4i} = \gamma_{40} + \gamma_{41}(\text{ProType}_i) + \zeta_{4i}$$

$$\pi_{5i} = \gamma_{50} + \zeta_{5i}$$

Diagnosis (ASD or TD), ProType (first, second, or third person pronoun), and the interaction between the two were important to the intercept, the Visit variable, the Visit-squared variable, and the RJA coefficients (π_0 through π_3). Therefore, they are all included in the equations that make up the estimates for those coefficients. ProType was the only variable crucial to the NB coefficient, and Word tokens was used as a control and therefore not put into an interaction with any of the other variables. It is possible for the variables to be part of an equation that explains the variance in pronoun production, but for the individual variable to be non-significant within that equation, so Table 4 displays the coefficients of our final model and shows whether each one was significant.

Results

Our main goal in this study was to create an equation to model children's pronoun production using the variables of interest. Table 3 displays the means and distributions for our key variables, and Table 4 displays the coefficient estimates, standard errors, and significance levels for the final best-fit model that included all of our important predictors. To develop the model for this study, we first represented the trajectory of all pronouns produced based on time (measured by Visit) and then added main effects and interactions based on hypotheses about the outcome variable. For this study, those next steps included adding pronoun type, word tokens, diagnostic group, RJA duration, and NB looking time.

Our final model incorporates all of our predictors of interest. By interpreting the significant coefficients, we can get a picture of the relations between pronoun production and our predictors. In the first section of Table 4 there are significant main effects of linear and quadratic coefficients for the TD group; that is, the overall shape of the change in pronoun production over time is an increase with a tapering off at the end of our study period. In the next section of the table, we see a lower intercept for 2nd person pronouns (all the person effects are in relation to 1st person pronouns) and a steeper increase, while 3rd person pronouns also have a lower intercept than 1st person, with a steeper positive slope and less of a tapering effect (negative coefficient on the quadratic effect).

The ASD group intercept is higher than the TD group (coefficients were calculated relative to the TD group) with a less steep increase (negative coefficient for the Visit interaction) and a stronger tapering effect. The intercept, slope, and quadratic effect were not significantly different from the TD group for 2nd person pronouns, but for 3rd person pronouns the intercept was lower, the slope was steeper, and the tapering effect was shallower.

RJA duration did not have a significant effect on pronouns in the TD group. In contrast, RJA duration for the ASD group has a negative coefficient for the 1st person pronouns and positive for 2nd and 3rd; that is, RJA has a negative influence on 1st person pronouns for the

ASD group, but a positive influence on 2nd and 3rd person pronouns. The next section in the table shows that, naming bias does not have a significant effect on 1st person pronouns (non-significant coefficient), but that it does have a positive effect on 2nd - and 3rd person pronouns. This means that children who had a greater naming preference also produced higher numbers of 2nd and 3rd person pronouns. There is no interaction between name bias and diagnosis group, meaning that the effects of name bias are the same for children with ASD and TD children. The lack of interaction between name bias and visit means that the effects of name bias do not affect the rate of change over time. Moreover, the word tokens variable accounts for overall production of all words; more talkative children produce more word tokens and the significant coefficient on word tokens means that those children who produced more tokens produced more pronouns. By including this in the model we know that the relations between RJA and NB and pronouns hold over and above child talkativeness.

Figure 2 is a plot of our final model. It shows the predicted growth of pronouns over time based on the equation that includes our predictor variables. We used mean values for RJA, word tokens, and name bias when creating this figure. Figure 3 shows depictions of modeled data for each pronoun type. We calculated a low (1st quartile) and high (3rd quartile) value for RJA for each diagnosis group, then inserted that value into the equation for RJA to see how the pronoun trajectories were affected. Because the significant effect of NB was on the values overall, rather than on the trajectory, a similar figure with high and low NB would simply shift the entire second- and third-person lines up (for higher NB values) or down (for lower NB values).

To test whether expressive language ability was more influential than ASD diagnosis for pronoun production, we created a model that included raw Mullen expressive language score and excluded the binary diagnosis variable. If that model had been a better fit of our data, it would mean that a child's expressive language drives their pronoun production more than their diagnostic category. However, we found the Mullen score model to have a worse model fit, based on Akaike Information Criterion (AIC; Akaike, 1974). We also created models to assess the possible importance of three other measures of children's language. In place of word tokens in our model, we swapped in MLU, CDI score, or Mullen expressive language raw score. Each of these had a significant effect; however, none had a better model fit, as measured by AIC values, than the model that included word tokens. Therefore, we maintained our use of word tokens as our control variable.

The model reported in Table 4 in this section treated 1st person pronouns as the default and compared 2nd and 3rd to this default; and differences between 1st and 2nd person trajectories, and between 1st and 3rd person trajectories, were observed. We re-ran the model using 2nd person pronouns as the default, to check for differences in trajectory or intercept between 2nd and 3rd person pronoun production; however, no significant effects of visit or intercept emerged for 3rd person pronouns when 2nd person pronouns were the default.

Discussion

In this study, we examined the contributions of social and linguistic factors to the production of pronouns in children with ASD and TD children over time. Previous work has emphasized contributions of *either* social (Clark, 2015) *or* linguistic (Graham, et al., 2015) abilities on language development, and entire theories have been built on the idea that either social *or* linguistic competence is the driving force in linguistic development (e.g., Tomasello, 2015; Valian, 2015, respectively). However, children's abilities in both areas are changing and influencing one another throughout childhood and the current work demonstrates that we can measure the implications of both at the same time. Our findings were fourfold:

First, pronoun production increased over time for both groups for all pronoun types; however, TD children produced more pronouns than children with ASD. Moreover, 1st person pronouns were produced more frequently than 2nd and 3rd, and production of these latter two pronoun types increased more quickly over time than first-person. These effects held even after controlling for the child's total number of word tokens, meaning that even if a child was particularly talkative, his or her sheer amount of language did not drive the difference in the number of pronouns when compared to other children. Our third finding was that RJA duration exerted significant and positive effects on ASD but not TD pronoun production, with 1st person use being lessened by increased JA and 2nd and 3rd person use being enhanced. Finally, children's strength of name bias also exerted independent and positive effects on pronoun production; these held for both diagnostic groups and also varied by pronoun type. In what follows, we discuss these findings with respect to our four hypotheses.

Our first hypothesis, that children with ASD would produce fewer pronouns overall than TD children, was supported for all three pronoun types (see Figures 2 and 3). With respect to developmental trajectory, children with ASD increased production of 1st person pronouns more slowly than TD children, but increased their production of 3rd person pronouns more quickly initially, with a stronger tapering effect (i.e., quadratic shape) at the end of our study period. No differences by group were observed for increases in 2nd person pronoun usage. These findings corroborate those of previous researchers (Shield et al., 2015; Mazzaggio & Shield, 2020; Meir & Novogrodsky, 2019; Terzi et al., 2019) on the general paucity of pronoun usage in individuals with ASD, with our study being the first to demonstrate this paucity in children as young as preschoolers, and in naturalistic situations. Additionally, and also of relevance to our fourth hypothesis, ours the first demonstration of a difference in the trajectory of pronoun use distinguished by person (i.e., pronoun type). The fact that the model using 2nd person pronouns as the default showed no difference between 2nd and 3rd person intercepts or trajectories replicates the patterns found by Girouard et al. (1997) regarding the primacy of 1st person pronouns, and the similarity of 2nd and 3rd person pronouns, during development. The differences between 1st person and 2nd person trajectories are consistent with the predictions of Kerstens (1993) and Ackema and Neeleman (2019), supporting the relevance of the +/-speaker (or proximal/distal) feature for children's acquisition of pronouns. Moreover, the similarity of the 2nd and 3rd person pronoun developmental trajectories suggests that during acquisition, learning to refer to

addressees and *others* is a similar task; we will return to this point when we consider the effects of RJA and the naming bias.

The fact that different types of pronouns show different trajectories by group adds nuance to the descriptions of language in ASD such as those presented by Tek et al. (2014) and Boucher (2012). These trajectories present an interesting pattern where the rate of 1st person pronoun increase over time is less for the ASD group than the TD group while the rate of 2nd person pronoun usage is parallel for the two groups. The slower increase in the ASD group might be attributable to the fact that children with ASD are often taught (especially when they are minimally verbal) to produce rote sentences using “I” (e.g., “I want cookie, please”). Especially at the early stages, then, they may produce a number of “I” pronouns without really understanding the self-referential nature of this pronoun; the slower increase in “I” production may thus reflect their growth in their self-understanding. The different trajectories of 3rd person pronoun usage by group should be pursued further, especially with respect to specific contexts of use. In our dyadic play sessions, pretend play with the provided doll was most likely to afford consistent 3rd person usage (“She wants to eat more”), and the lower-frequency 3rd person usage by children with ASD compared to the TD group might be attributable to their attested lack of interest in pretend play (Jarrold, 2003). Interestingly, though, the steeper increase in 3rd person pronoun usage in the ASD group could reflect the continued presence of the doll, across visits, in drawing the children with ASD’s attention away from their usual pre-occupations. Thus, while some children with ASD may have high language abilities overall, there could be very specific areas of impairment and difference relevant to different pronoun types. Those differences could be important to understanding pronominal reference to self and others, which seem to involve multiple components in both TD children and those with ASD (e.g., Frith & Happé, 1999; Weschler, 2010).

It is important to emphasize that the finding that children with ASD produce fewer pronouns than children with TD over time is not based on quantity of speech produced by the children, because we used the word tokens variable to control for talkativeness. We hypothesized this difference based on the idea that lower JA might be related to lower pronoun production. We used it to set the stage for our further questions in the following hypotheses: what are the relations between our social and linguistic measures and this diminished pronoun production?

Our second hypothesis, that children with longer durations of RJA, especially those with ASD, would produce more pronouns, was supported. The ASD group demonstrated a positive effect of RJA on pronouns; none was demonstrated in the TD group. Moreover, the ASD group showed a complex pattern of results, in that RJA duration was not related to all aspects of pronoun production. Instead, those children with ASD with longer JA episodes produced fewer 1st person pronouns but more 2nd and 3rd person pronouns. We expected JA to be a supportive factor for pronoun use because it should increase a child’s ability to shift perspectives and roles, and our data support this idea for talking about *others* (i.e., using second- and third-person pronouns). That is, children with ASD who spent more time in JA were evidently able to shift their perspective to refer to other people using pronouns and did so more frequently. However, the opposite was true for first-person pronouns (see Fig. 3).

The more time children spent in response to JA, the less they referred to themselves with pronouns. Toddlers and young children are notoriously egocentric and the early and frequent production of first-person pronouns suggests that the children in both diagnostic groups are more likely to talk about themselves than others. But our data show that they talk about themselves *less*, and others *more*, the more time they spend in RJ, suggesting that the sharing of attention is related to less self-centered talk and more pronominal reference to others.

Similar findings that pronominal references to self and others do not pattern together were also reported by Markova and Smolík (2014), who found a stronger relation between social-cognitive knowledge (measured by mental state language), and referring to *others* versus *oneself* (measured by pronoun and verb conjugation), in TD children learning Czech. In addition, Wechsler (2010) argued from a linguistic perspective for the importance of theory of mind in second person reference in particular, because the production of first-person reference can depend solely on the child's own self-image, while second-person reference requires a more complex understanding of another's role in relation to oneself. Our data also suggest that pronominal reference to others in the second person is fundamentally different from referring to oneself, based on the findings that RJ contributed differently to the two forms of pronominal reference. Our findings extend Markova and Smolík's work and Wechsler's theorizing to demonstrate that second- and third-person reference are related to RJ, and replicate Meir and Novogrodsky's (2019) finding that 3rd person reference relates to theory of mind.

The lack of influence of RJ on pronouns in the TD group may be explained by the overall level of RJ in the two groups. As expected based on diagnostic criteria, the TD children engaged in more RJ than the ASD group. Perhaps there is a minimum level of RJ required to gain pronoun abilities, and all TD children reached that level early (see also Evans & Demuth, 2012). This idea is supported by Bottema-Beutel (2016), who found larger effect sizes in the relations between language and JA in samples of children with ASD versus TD children. Others have also demonstrated that the strongest relations between JA and language outcomes are observed in samples of children with ASD who have lower verbal and JA skills (Abdel-Aziz, et al., 2018; Charman et al., 2003; McDuffie, et al., 2005). In addition, very young TD children (i.e., 18 months of age and younger) have more robust effects of JA on language outcomes than older TD children (Salley & Dixon, 2007; Farrant & Zubrick, 2011). Bottema-Beutel suggests, and we agree, that there may be a threshold level of JA needed for language growth that TD children generally meet early on, and above that threshold there is a weaker relation between attention and language.

The relationship between greater time spent in response to JA, more reference to others, and less to oneself makes an interesting contribution to our understanding of ASD. Theorists have long considered egocentrism to be a key feature of autism (Kanner, 1946) and are currently seeking insight into the relation between perspective-taking, social cognition, and language use (e.g., Conson, Mazzarella, et al 2015; Shield, Pyers, Martin, & Tager-Flusberg, 2015; Mazzaggio & Shield, 2020). These findings further buttress the need for JA intervention in the social development of children with ASD (Murza, Schwartz, Hahs-Vaughn, Nye, 2016). However, the child must be cognitively able to move past the formulaic

“I want x” to benefit from instruction in talking about other people. Instruction in initiating and especially responding to JA bids should be able to help the child learn how to refer to others who are both inside and outside the actual conversation.

Our third hypothesis, that children with a stronger name bias would use more pronouns, was also supported. That is, having a strong name bias increased the number of second- and third-person pronouns children used and had no effect on first-person pronouns, and this held for children in both diagnostic groups. The fact that this variable was collected at a single time point means that the effects are similar to an intercept effect: Children who are more likely to assign a new name to a puppet are also more likely to refer to others using pronouns on the whole. These findings are consistent with Oshima-Takane’s (1999) theory that pronoun acquisition depends at least partly on children’s ability to learn proper names, on the idea that such names provide children with their first clues that specific people’s identities endure over time and space. Moreover, both Oshima-Takane (1999) and Smiley et al. (2011) have demonstrated that pronoun production is enhanced when proper nouns and pronouns are combined in TD children’s input; the children in the latter study, for example, were faster to produce pronouns if they heard their mother use both “me” and “Mommy” in reference to herself. A positive effect of naming might seem to be at odds with the results of Shield et al. (2015), who found that deaf children with ASD used proper names in sign language when pronouns were more appropriate, as if names and pronouns competed for usage. However, it is possible that the children with ASD in Shield et al. (2015) were at an earlier stage of language development, when the more frequent use of proper names generally occurs. A longitudinal study is needed to see if these deaf children with ASD begin to use pronouns as their language levels increase.

An additional reason why the children in our study might have manifested a positive relationship between a naming bias and 2nd and 3rd person pronoun production is that children who are advanced in one aspect of language are generally more likely to be advanced in other aspects as well. It is also important to point out, though, that the effect of the naming bias held even when overall talkativeness was controlled; thus, general language level cannot be the sole explanation. When we substituted other measures of expressive language (Mullen expressive language score, CDI score, and MLU) as control variables, they each had a significant effect (without creating as good a model fit as the word tokens variable), but none completely eliminated the effect of the naming bias; thus, the naming bias gives provides unique information about how the children’s linguistic tendencies contribute to their pronoun use. In sum, our study is the first to demonstrate that an increase in likelihood to use a name bias is related to an increase in 2nd and 3rd person pronoun production during a key developmental time period, and the first to use an experimental and objective measure to assess children’s name learning and interpretation. Other studies have used the CDI, the PPVT, or spontaneous speech samples, all of which are critical to our understanding of children’s developing language but all of which involve some social context that is less viable when children are not socially motivated or engaged in following instructions, as is frequently the case in ASD.

Our final hypothesis was that pronoun development would vary by person in timing but would have similar relations to social-cognitive and linguistic knowledge. We found partial

support for this hypothesis. As discussed earlier, children produced 1st person pronouns most frequently early on, and increased the use of those pronouns quickly, while 2nd and 3rd person pronouns patterned together in their intercept and trajectories, supporting previous work demonstrating earliest acquisition of 1st person pronoun reference (e.g., Girouard et al., 1997). Moreover, children with ASD who spent more time in RJA used more 2nd and 3rd -person pronouns, and children regardless of diagnosis who had higher name bias scores also used more 2nd and 3rd person pronouns. Neither naming puppets nor engagement in RJA facilitated 1st person pronoun usage, but indeed, 1st person pronouns did not appear to need much facilitation. In contrast, using pronouns to refer to other people, whether in the 2nd or 3rd person, is related to a tendency to name puppets and to follow another's perspective. Labelling other people with pronouns seems more similar, cognitively, to using names than labelling oneself with pronouns. Our discovery of the similar patterning of 2nd and 3rd -person pronouns together, as opposed to 1st person pronouns, being influenced independently by both a social-cognitive skill and a linguistic ability, further emphasizes the difference between pronominal reference to self and others (Kerstens, 1993; Ackema & Neeleman, 2018, 2019).

In sum, we found that children with ASD are uniquely impacted by JA in terms of their production of pronouns, and that TD children and children with ASD who are better at naming puppets are also more prolific users of pronouns that refer to others. We found that referring to oneself is different from referring to others, pointing to important differences within the use of pronouns. Our study is a naturalistic, observational one involving parent interactions. This strengthened our conclusions because we know that children were using language in a relatively uninhibited, quotidian manner. We need not be concerned with limitations due to explicit instructions. However, we were limited in the kinds of situations we could present that might encourage pronoun use. A 30-minute play session in a single room of one's house may not allow for the range of situations that elicit pronouns, particularly third-person pronouns, as the child was playing with just one other person. The toys provided included animals and a baby doll, which presumably encourage reference to others, but the presence of more people could strengthen that. Future research could use experimental paradigms, and/or expand the contexts, to more specifically target third-person reference.

Our focus on very early language production meant that we had little information about how significant the language delays or challenges were of any given child in the ASD group. Future research may look towards implementing treatment that supports pronoun production in a specific effort to ease communication about self and others. Experimental work that elicits pronouns from children across the spectrum could give a fuller picture of how treatment might progress, but given our findings, researchers should be aware that there are different predictors that are important when referring to oneself and others. Further work could also use the pronoun "it" as a control to look at the importance of pronouns relating to social development versus learning about reference in general and could count proper names to account for additional reference to others. Skarabela and Ota (2016) found that typically-developing children develop comprehension of the pragmatics of "it" during the second year of life, and it would be important to explore the relationship between that development and social and linguistic variables. Lee, Hobson, and Chiat (1994) found atypical use of proper

names in children with ASD; thus, analyzing proper name use might lead to further insights about other-reference in ASD.

Another element not included in the current study is an examination of parental pronoun production. Parental linguistic input can have different effects on the language of children with ASD versus TD (e.g., Goodwin, Fein, & Naigles, 2015) and parental pronoun input changes as children get older (Oshima-Takane & Derat, 1996), which points to the importance of elucidating the role of parental pronoun input. He, Luyster, Hong, and Arunachalam (2018) have explored maternal use of pronouns with children at risk for ASD and discovered that mothers of children at high-risk were more likely to use their infants' name rather than a pronoun when making a bid for attention. Somewhat contrariwise, though, Barokova and Tager-Flusberg (2019) found only restricted effects of parental input on their children with ASD's pronoun usage. Further work in this area is an important next step.

A number of questions could also be addressed with a larger sample of children. Children's talkativeness may influence pronouns in a way that is not captured when using the word tokens measure as a control, but our sample size and the number of predictors necessary to answer our hypotheses meant that we could not include interactions between word tokens and other variables. For example, splitting up the children further (for instance, a median split of the ASD group on some measure of linguistic competence). created underpowered models that would not converge to give reliable coefficients (Singer & Willett, 2003). Larger sample sizes in future work could address this limitation.

This work demonstrates the importance of combining measures of linguistic and social ability when examining language development. By collecting naturalistic language and interactions over two years as well as early linguistic task data, we modeled pronoun production in children with ASD and TD as a function of time, diagnosis, pronoun type (first-, second-, and third-person), JA duration, *and* strength of name bias. Integrating multiple predictors in a longitudinal study allowed us to create a powerful model demonstrating nuance in the differences in pronoun acquisition within and across groups.

Acknowledgements:

We would like to thank Saime Tek, Rose Jaffery, Janina Piotroski, and Andrea Tovar for assistance with data collection and coding; Emily Potrzeba and Sabrine Elberkani for assistance with coding pronouns; the undergraduates of the UConn Child Language Lab for transcribing the play sessions and performing reliability coding. We are very grateful to the families and children who participated in this study.

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Figure 1.
Distribution of Mullen Raw Scores for both diagnosis groups on three tests: Visual Reception (non-verbal IQ), Expressive Language, and Receptive Language.

Figure 2.
Estimated pronoun production for both diagnosis groups and all pronoun types based on Table 4.

Figure 3a-c. Pronoun production (tokens) for (a) first-person (b) second-person and (c) third-person for each group of children, using a high and low JA value. In Fig. 3b, the lines for TD high and low JA overlap.

Table 1.

Demographic and diagnostic information at V1. ASD and TD columns contain means and standard deviations; t-value and p-value columns demonstrate significant group differences.

	ASD	TD	t-value	p-value
N	15 (0 female)	18 (2 female)		
Age in months	31.91 (4.53)	20.68 (1.88)	-9.60	<.001**
CDI words	166.93 (108.49)	118.78 (114.35)	-1.23	.23
Mean Length of Utterance	1.75 (.73)	1.4 (.25)	-1.90	.06
ADOS	11.93 (2.60)	0.11 (.32)	-19.15	<.001**
CARS	32.13 (5.65)	15.39 (.76)	-12.47	<.001**
Vineland Social	77.27 (7.86)	100.5 (7.0)	8.98	<.001**
Mullen Raw Scores (unadjusted for age):				
Expressive Language	23.40 (6.82)	19.44 (4.46)	-2.0	.05*
Receptive Language	26.27 (7.81)	25.33 (2.93)	-0.47	.6
Visual Reception	29.93 (4.71)	26.11 (3.23)	-2.75	.01*

Table 2.

Layout of videos for name bias task

	Video 1	Audio	Video 2
1	Possum puppet digs with nose	Here's <i>toopen</i> !	Blank
2	Blank	See, <i>toopen</i> !	Possum puppet digs with nose
3	Possum puppet digs with nose	Look, <i>toopen</i> !	Possum puppet digs with nose
4	Possum puppet sways side to side	They are different now!	Beetle puppet digs with nose
5	Possum puppet sways side to side	Where's <i>toopen</i> ?	Beetle puppet digs with nose

Table 3.

Means, standard deviations, and minimum and maximum for key variables.

Variable	ASD				TD			
	<i>M</i>	<i>SD</i>	<i>Min.</i>	<i>Max.</i>	<i>M</i>	<i>SD</i>	<i>Min.</i>	<i>Max.</i>
Pronouns (counted during 30-minute play session)								
<i>1st person</i>								
Visit 1	9.87	13.62	0	40	2.78	6.46	0	26
Visit 2	19.27	27.71	1	105	11.44	12.13	0	41
Visit 3	24.27	24.59	0	82	27.5	23.37	0	71
Visit 4	20.73	17.98	0	57	35.39	22.09	9	83
Visit 5	20.14	16.22	2	59	41.28	16.79	18	89
Visit 6	30.53	28.61	0	100	39.28	12.96	23	66
<i>2nd person</i>								
Visit 1	2.4	2.82	0	9	.17	.38	0	1
Visit 2	1.73	2.4	0	8	.67	1.08	0	4
Visit 3	4.2	6.05	0	23	5.17	6.01	0	19
Visit 4	6.13	11.13	0	41	7.89	5.8	0	23
Visit 5	8.57	11.41	1	33	13.17	7.97	2	31
Visit 6	9.33	9.60	0	30	17.33	11.34	7	51
<i>3rd person</i>								
Visit 1	.33	1.05	0	4	.28	.57	0	2
Visit 2	2.6	4.03	0	13	2.0	3.40	0	13
Visit 3	6.87	9.97	0	37	5.44	6.17	0	20
Visit 4	8.2	9.78	0	31	13.78	14.52	0	48
Visit 5	8.14	10.52	0	35	17.39	13.36	1	54
Visit 6	5.87	7.16	0	23	14.11	12.21	1	41
Name Bias (percent looking time to same-puppet screen minus same-action screen)								
Visit 1	.03	.15	-.24	.22	.03	.18	-.36	.31
Response to Joint Attention (in seconds, counted during 30-minute play session)								
Visit 1	864.34	360.23	50	1334.50	936.41	365.04	321.37	1499.50
Visit 2	904.18	409.05	0	1537.31	1218.24	231.91	708.67	1509.22
Visit 3	892.48	412.73	271.14	1586.99	1249.15	170.88	965.50	1514.98
Visit 4	946.31	296.89	406.78	1316.94	1207.86	192.18	663.26	1541.10
Visit 5	1006.13	323.85	399.21	1620.28	1066.22	235.80	599.54	1388.77
Visit 6	804.77	233.65	414.77	1222.37	1040.36	203.51	615.11	1365.29
Word tokens (total counted during 30-minute play session)								
Visit 1	221.87	155.94	18	487	125.56	120.29	7	472
Visit 2	354.53	275.43	98	1139	307.89	158.28	95	691
Visit 3	511.8	344.22	47	1265	490.72	227.49	138	868
Visit 4	452.73	213.42	62	788	606.44	265.8	231	1207
Visit 5	545.21	322.29	133	1106	691.83	196.98	299	1131
Visit 6	567.73	312.85	94	1171	680.78	219.74	338	1199

Table 4.

Model coefficients for the final model of the growth curve analysis of pronoun production as the dependent variable.

Predictor	Coefficient (SE)
TD group intercept	0.24 (.39)
Visit (Linear) x TD	1.17 *** (.15)
Visit ² (Quadratic) x TD	-0.15 *** (.02)
TD x 2 nd person pronoun	-2.49 *** (.37)
Visit x TD x 2 nd person	0.40 * (.17)
Visit ² x TD x 2 nd person	-0.007 (.02)
TD x 3 rd person pronoun	-2.16 *** (.33)
Visit x TD x 3 rd person	0.75 *** (.15)
Visit ² x TD x 3 rd person	-0.09 *** (.02)
ASD group intercept	1.52 ** (.57)
Visit x ASD	-0.84 *** (.22)
Visit ² x ASD	0.11 *** (.03)
ASD x 2 nd person	-0.03 (.45)
Visit x ASD x 2 nd person	-0.21 (.22)
Visit ² x ASD x 2 nd person	0.01 (.03)
ASD x 3 rd person	-1.87 *** (.44)
Visit x ASD x 3 rd person	0.58 * (.23)
Visit ² x ASD x 3 rd person	-0.12 ** (.04)
Response to Joint Attention x TD	<0.001 (<.001)
RJA x TD x 2 nd person	<.001 (<.001)
RJA x TD x 3 rd person	<.001 (<.001)
RJA x ASD	-0.0006 ** (<.001)
RJA x ASD x 2 nd person	0.0007 * (<.001)
RJA x ASD x 3 rd person	0.001 *** (<.001)
<i>Variables not interacting with diagnostic group:</i>	
Name bias	-1.16 (.65)
Name bias x 2 nd person	0.52 * (.23)
Name bias x 3 rd person	0.69 ** (.22)
Word tokens	0.001 *** (<.001)
<i>Goodness of fit: -2LL</i>	1966

*
< .05,

**
< .01,

< .001

Note: First-person pronouns were coded as “0.” Therefore, the unmarked effects (i.e. *no* mention of 2nd or 3rd person) are for the 1st person pronouns.

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