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It takes all kinds (of information) to learn a language: Investigating the language comprehension of typical children and children with autism

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Abstract

What factors influence children's understanding of language, in both typical and atypical development? In this article, I summarize findings from the Longitudinal Study of Early Language (LSEL), which has been following the talk, understanding, and interactions of typically developing (TD) children and children with Autism Spectrum Disorder (ASD). The LSEL has found group similarities in syntactic understanding and word learning strategies, but also within-group variability that correlates with other aspects of the children's behavior. In particular, early linguistic knowledge and social abilities are both shown to play independent roles in later talk and understanding. Thus, theoretical perspectives that highlight social vs. linguistic underpinnings to language development should be viewed as complementary rather than competing.

Keywords

Language learning; variability; autism; children

Children's speech develops, from babbling to speaking one word at a time, to combining words into longer utterances with more grammatical elements, conveying a plethora of meanings. Children's speech understanding also develops, from distinguishing sounds to associating words with objects, to recognizing grammatical elements and sentence orders and comprehending more complex discourse (Hoff, 2013). Viewed with one lens (e.g., compared with non-human animals), human children's language development looks universal and uniform (Valian, 2015). However, other lenses reveal rampant variability: Children learning one language may demonstrate earlier/speedier acquisition of specific grammatical constructions compared to those learning another language (e.g., Kline & Demuth, 2010). Children with neurodevelopmental disorders such as Williams Syndrome or Autism Spectrum Disorder (ASD) develop language at different rates than those with typical development (TD) (Zukowski, 2016). And *within* languages and/or etiologies, some children produce more words and/or understand words and sentences more quickly, than others (Fernald, Perfors & Marchman, 2006; Fernald & Marchman, 2012).

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Such variability can illuminate the underlying causes and/or processes of child language acquisition. For example, specific relationships that have been found between variability in the ways caregivers talk and variability in their children's language outcomes have revealed both simple and complex ways that children *use* their linguistic input (Huttenlocher et al., 2002; Hoff & Naigles, 2002; Cartmill et al., 2013). Kidd, Donnelly, and Christiansen (2018) recently argued that such variability (aka 'individual differences') in children's language proficiency, and their cognitive and social abilities, also has the potential to shed new light on longstanding theoretical debates about the factors that promote and/or enable language development. One such debate contrasts social vs. specifically linguistic perspectives: A brief sketch of the first perspective is that language learning is largely based on children's developing social abilities, which they use to discover the intentions of adult speakers with whom they are interacting. The meanings of words are initially acquired, for example, by children realizing that adults are probably looking at the objects they are talking about. The structures of sentences are later acquired by combining words into general sequential patterns (Tomasello, 2015). In contrast, the second perspective launches children into language acquisition with some linguistic knowledge already in place, which is then elaborated and extended via caregiver linguistic input. For example, children might know initially that sentences in languages can be ordered in terms of their subjects (S), verbs (V), and objects (O), and English learners would discern from their input that English sentence order is SVO (The girl tickles the boy) rather than SOV (The girl the boy tickles). Within this perspective, word learning and syntactic development proceed in tandem, with social and linguistic abilities operating independently (Valian, 2015).

The Longitudinal Study of Early Language (LSEL; Naigles & Fein, 2017) has addressed this debate via three unique components: (a) the contributions of variability in children's early social and linguistic abilities have been compared across a 2.5 year span of intensive language assessments, (b) the children include both those with TD and those with ASD, and (c) children's language has been assessed primarily via their comprehension, using the Intermodal Preferential Looking paradigm (IPL).

Children with ASD uniformly demonstrate marked challenges in social interaction, as well as excessive restricted and repetitive behaviors, starting early in development (APA, 2015). For example, children with ASD are less likely to follow a caregiver's point or gaze, and they engage in episodes of joint attention, which occur when child and adult focus on the same object(s) while also referencing each other, much less frequently than TD children (Mundy, 2016). Furthermore, the ultimate language attainment of children with ASD varies widely within the population; in particular, some children with ASD achieve age-appropriate levels of words and syntax, others barely talk at all, and still others populate the entire range in between (Kjelgaard & Tager-Flusberg, 2001). Such uniform social impairments coupled with varied language outcomes motivated our investigations of the joint roles of linguistic and social factors in TD and ASD language acquisition.

The IPL paradigm is well-suited to reveal variable language comprehension in very young children with poor social and/or attentional skills: Children sit in front of side-by-side visual displays (Figure 1) and hear a single linguistic stimulus which matched only one of the two displays. The children's eye movements are recorded and later coded off-line. Baseline trials whose audio is non-directing (e.g., "Look") are also included, and the core assumption is that children who understand the linguistic stimulus better will look more quickly and/or for longer periods of time at the matching display during test trials compared with baseline trials (Fernald, et al., 2006; Golinkoff, Ma, Song, & Hirsh-Pasek 2013).

In the present article, we first present the LSEL participants, the IPL tasks, and the findings for the TD and ASD children as distinct groups (Naigles & Fein, 2017). Then we present our investigations concerning the extent to which children's variability in IPL performance was predicted by—and/or a predictor of—their linguistic and social abilities. Finally, we discuss theoretical conclusions, cautions, and future directions.

LSEL Participants and IPL Findings by Group

The LSEL includes children with ASD or TD (total N = 42 and 45, respectively), assessed every four months for 4–6 at-home visits spanning 1.5–2.5 years. The children's ASD diagnostic status was confirmed at the first visit, when the TD children averaged 20 months and the children with ASD averaged 33.5 months, and reconfirmed at visit 5, two years later. By design, the two groups were at similar stages of language development at visit 1; children in both groups had small vocabularies and were just beginning to produce words in combinations.

The video and audio stimuli for the six tasks are presented in Table 1; see Naigles and Fein (2017) for more details about these and the group findings reported below. At each visit, we also recorded 30-minute caregiver-child semi-structured play sessions, from which we coded the children's and caregivers' speech for word frequency and diversity, mean length of utterance (MLU), wh-questions, and pronouns. We also coded the sessions for episodes of joint attention (JA), when both child and caregiver were looking at the same object(s) and referencing each other. Thus, the LSEL dataset comprises plentiful data from each participant at each of 6 visits, including measures for speed and strength of language understanding for each of three IPL tasks (see Table 1), measures of children's productions of words and syntactic constructions, and measures of the number, duration, and initiator (child vs. caregiver) of JA episodes. The LSEL also collected measures from standardized tests of cognitive, language, and/or social functioning, at all six visits. While not a focus here, measures of caregiver speech have also been coded and analyzed.

During tasks assessing understanding syntactic constructions, children with ASD and TD children demonstrated overall similar successes. They showed comprehension of Subject-Verb-Object (SVO) sentence order, distinguishing 'the girl pushed the boy' from 'the boy pushed the girl'. TD children and children with ASD demonstrated understanding of both subject- and object- wh-questions ('what hit the flower?' and 'what did the apple hit?' respectively). When grammatical aspect was tested, the children with ASD successfully connected ongoing activities to verbs with the '-ing' suffix ('Washing the dolly') and completed actions to verbs in the past tense ('Washed the dolly'). Note that the ASD group's difficulties in social functioning did not prevent them from acquiring these three core syntactic constructions; as such, these findings support the 'early linguistic knowledge' theoretical perspective.

During tasks assessing word learning strategies, both TD children and children with ASD showed a noun/naming bias: They mapped unfamiliar words (‘toopen’) onto new objects/puppets rather than new actions, partially explaining the prevalence of nouns over verbs in early speech. Moreover, both groups were able to exploit (or ‘bootstrap’) their knowledge of syntax to learn new verbs (aka ‘syntactic bootstrapping’); children were taught unfamiliar verbs in SVO sentence frames (‘the duck is gorping the bunny’) and mapped these onto causative (duck making bunny bend over) rather than noncausative (duck and bunny move independently) actions (Naigles et al., 2011; Shulman & Guberman, 2007). More recently, researchers have contributed positive findings for additional word learning strategies; for example, Venker (2019) taught novel words to children with ASD or TD in an eyetracking paradigm that assessed cross-situational word learning. Both consistent and inconsistent object and label pairings were presented across trials, and both groups eventually distinguished the consistent pairings from the inconsistent ones.

Intriguingly, the LSEL groups diverged in their performance on the shape bias. Across visits, TD children consistently extended a newly-taught label to objects of the same shape, rather than the same color, as the original, and only showed this ‘shape bias’ when the objects were labelled. In contrast, the children with ASD showed no preferences in extending new labels to objects of either color or shape, nor did they show different looking patterns during ‘label’ vs. ‘no-label’ trials (Potrzeba, Fein, & Naigles, 2015). The multi-task format of the LSEL allowed us to highlight the unique challenge of the shape bias: The same children with ASD who successfully demonstrated a noun/naming bias, did syntactic bootstrapping, and/or understood wh-questions and grammatical aspect, did not demonstrate a shape bias. Such specific difficulty with the shape bias in preschoolers with ASD may be an early indicator of challenges this group faces in semantic organization and category formation (Naigles & Tek, 2017), and discovering the underlying bases for the ASD group’s difficulty with the shape bias continues to be an LSEL priority (see below).

What did the IPL tasks reveal about individual differences?

Recent studies using IPL have reported variability in both children’s speed and strength of matching the linguistic and visual stimuli (Fernald et al., 2006; Song, Demuth & Morgan, 2018; Goodwin, Fein, & Naigles, 2012). Children in the LSEL varied in whether they were stronger/faster or weaker/slower comprehenders of any of the three grammatical constructions, and/or more vs. less consistent users of the three word learning strategies. Some variability in participant performance is randomly generated, of course, but we next investigated the extent to which the IPL variability we observed corresponded to variability in other tasks and/or domains.

Did IPL variability relate to general language variability?

Across the LSEL (Naigles & Fein, 2017), children’s spoken vocabulary, as measured by caregiver checklists and/or the number of word types produced in spontaneous speech, correlated significantly and positively with their concurrent strength of comprehension with five of the six IPL tasks: wh-questions, syntactic bootstrapping, noun/naming bias, shape bias, and aspect. The children’s scores on experimenter-administered standardized language tests also correlated significantly and positively with their concurrent strength of comprehension of the shape bias and aspect. It is possible that these relationships merely indicate that children who are more developmentally advanced overall perform at higher levels in IPL tasks; however, two strands of evidence make this 'advanced-in-everything' explanation unlikely. First, within the LSEL, significant correlations between *non*verbal cognition scores and IPL measures were observed much less frequently. Second, several recent eyetracking studies including children with ASD have consistently reported significant concurrent relationships between children's looking behavior and their standardized language assessments, whereas their looking behavior and standardized *non*verbal IQ scores were not found to be correlated (Bavin & Baker, 2017; Ellis Weismer et al., 2016; Venker, 2019).

Longitudinal relationships between general language and IPL behaviors were observed in the LSEL as well. For example, children with ASD with larger vocabularies at the early visits demonstrated a stronger shape bias at later visits, and those with stronger shape bias performance at early visits had larger vocabularies at later visits (Potrzeba, et al., 2015). Interestingly, these shape-bias-vocabulary relationships seemed to be general rather than specific: Whereas some researchers have found connections between TD children's specifically *shape-oriented* vocabularies and their shape bias consistency (Perry & Samuelson, 2011), we found no such significant relationships in either our TD or ASD groups (Potrzeba et al., 2015; Abdel-Aziz, Kover, Wagner & Naigles, 2018).

Because of these strong relationships between IPL measures and standardized/general language, we always controlled for the latter in our statistical models comparing children's IPL measures and their social or specific linguistic performance, to ensure that any observed relationships were not reducible to the core IPL-general language connections.

Did IPL variability relate to other child abilities/factors?

Significant relationships have been observed between IPL tasks in the LSEL. Specifically, children with ASD who showed faster understanding of SVO order at early visits showed stronger syntactic bootstrapping eight months later (Naigles, et al., 2011). Furthermore, both TD children and children with ASD who showed stronger understanding of SVO at early visits displayed stronger wh-question comprehension about a year later (Jyotishi, Fein & Naigles, 2017). Thus, it appears that knowledge of SVO with familiar verbs was extended to learning new verbs, and understanding statements in SVO order was related to understanding questions in OVS order ('what did the apple hit?'). Both of these effects indicate that later syntactic acquisitions are outgrowths of, or dependent on, early syntactic knowledge. Given that these relationships hold even when children's levels of general language and/or vocabulary size are accounted for, these findings are supportive of the theoretical perspective that children command at least some aspects of syntactic knowledge starting early in development (Valian, 2015).

Additionally, children's social abilities were found to contribute, independently, to their IPL performance. For example, children with ASD or TD who were rated by parents as more advanced socially subsequently showed stronger wh-question comprehension (Jyotishi, et al., 2017). This relationship could indicate that a disposition to engage with others, and curiosity about one's surroundings, help promote children's acquisition of wh-question structures and functions (Eigsti, Dadlani & Bennetto, 2006). Moreover, while levels of socially-relevant JA (both number and duration of episodes) were lower in the children with ASD compared with the TD children, variability in JA behavior was related to variability in several aspects of language. In particular, children with ASD who engaged in longer episodes of JA with their caregivers showed subsequently stronger performance in the shape bias task (Abdel-Aziz, et al., 2018). Interestingly, we have found that personal pronoun development was also linked to JA episodes, in that children who engaged in longer JA episodes showed steeper increases in 2nd and 3rd person pronoun usage ('you', 'she', 'they') across visits (Kelty-Stephen, Fein & Naigles, 2020), and fewer pronoun reversals (using 'you' for 'I'; Naigles et al., 2016). Pronouns and the shape bias are both more abstract lexical acquisitions, involving more than 'just' mapping a word to a referent, so how might JA contribute?

For the shape bias, children need to make a higher-order generalization, that many words distinguish objects based on their shapes (Colunga & Smith, 2008), and JA interactions may enable children to efficiently take in relevant information—from the scene and/or from their input—about such generalizations (Mundy, 2016; Abdel-Aziz et al., 2018). The extent to which the relevant abilities indexed by JA are purely social vs. also attentional is currently a matter of debate: With recent eyetracking studies documenting successful but slower familiar word comprehension in children with ASD compared with TD children (Bavin & Baker, 2017; Ellis Weismer et al., 2016), researchers have linked such slow performance and the aforementioned lower JA levels as indicators of misalignment between auditory and visual information in the world, which might lead to ASD word learning challenges (Venker, Bean & Kover, 2018). However, as several word learning processes (described above) seem to be operational in children with ASD, such misalignments cannot capture the whole story.

For personal pronouns, children need to recognize that these words refer to people from specific interactive perspectives (speaker, addressee), and the interactions within JA episodes could be well-suited to help children practice switching perspectives while engaged with objects of interest. However, as with the acquisition of wh-questions, LSEL data demonstrate that social/interactive abilities are not the only important components for pronoun acquisition: A stronger IPL noun/naming bias at the early visits was independently predictive of steeper increases in 2nd and 3rd person pronoun usage across visits (Kelty-Stephen et al., 2020). The noun/naming bias task indexes the ability to efficiently *name* multiple animate characters as individuals, and evidently this naming-individuation process also contributes to pronoun development (see Figure 2).

Conclusions and Future Directions

The Longitudinal Study of Early Language has demonstrated that IPL captures considerable early success in language understanding and word learning strategies in both children with ASD and TD. Moreover, the IPL variability we have observed seems systematic, in that it relates to other aspects of variability in the children's development. These documented independent contributions of early social and linguistic knowledge to later linguistic understanding support Kidd et al.'s (2018) hypothesis that individual differences investigations can illuminate how language is acquired. Given that both social abilities and early linguistic information have been shown to play significant roles in the LSEL children's language learning, these theoretical perspectives can more helpfully be viewed as complementary rather than competing.

Important caveats involve the relatively small size of this sample and the reliance on standard regression techniques for some (but not all) of the analyses. Both of these point to the need for more highly-powered replications as well as carefully designed intervention studies. Studies with larger samples could also reveal how the TD and ASD distributions overlap (or not) with respect to each IPL task, further illuminating the degree to which the groups are qualitatively and/or quantitatively different.

Future directions for IPL studies might involve casting both narrower and wider nets of analysis, such as more micro-analyses of eyegaze during teaching trials, as well as investigations of longer-term developmental pathways through childhood and adolescence (e.g., Tecoulesco, Fein & Naigles, in press). Broadening the samples to include children learning languages other than English is also crucially needed (e.g., Zhou, Ma & Zhan, 2020). Nets such as these could yield additional areas of variability that will contribute to solving the puzzle of language acquisition in both typically and atypically developing children.

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Recommended reading

1. Naigles L & Fein D (2017) Looking through their eyes: Tracking early language comprehension in ASD. In Naigles L (Ed.) Innovative Investigations of Language in Autism (pp. 49–70). NY: APA Books/Walter deGruyter.A comprehensive overview of the IPL methodology and findings of the LSEL
2. Naigles LR & Chin I (2015) Language development in children with autism. In Bavin E & Naigles L (Eds.) Handbook of Child Language, 2nd edition. Cambridge: CUP.A comprehensive and accessible overview of what is known about language in children with ASD.
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Figure 1:
The IPL setup in a family's home.

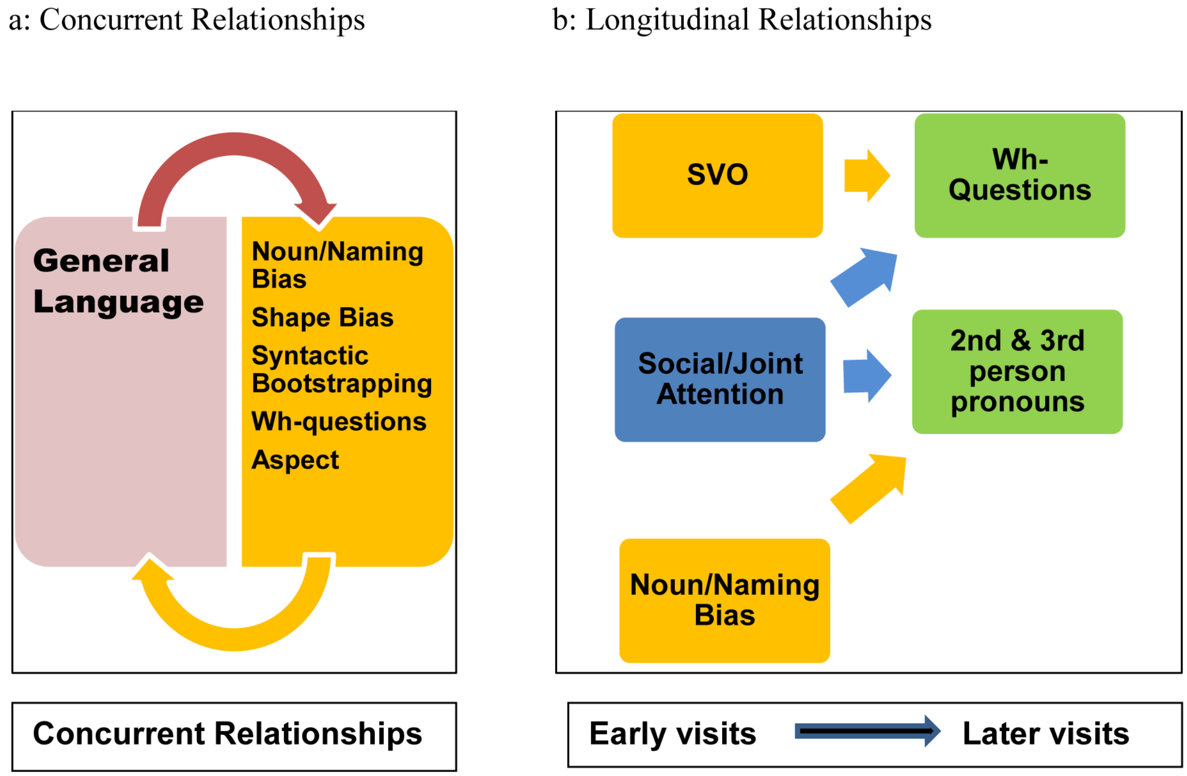
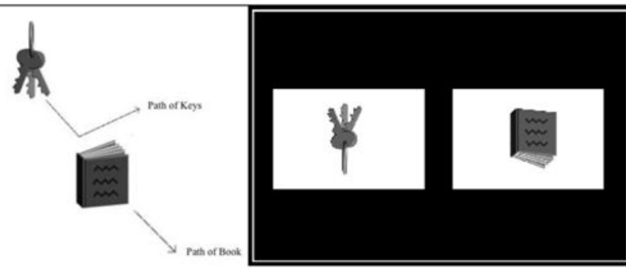
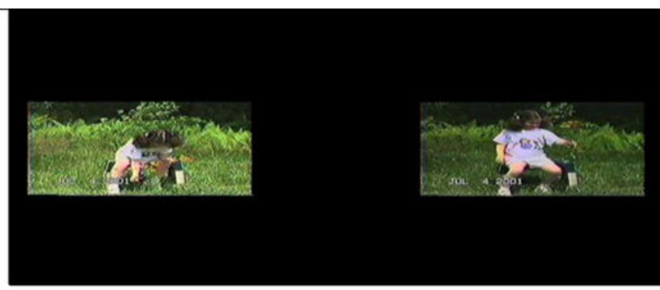
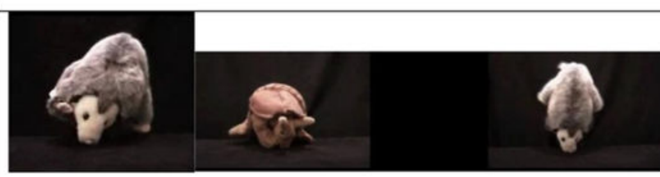
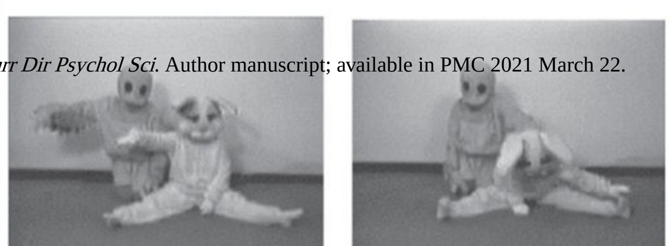


Figure 2:
(a) Pictorial depiction of the observed concurrent relationships between general language measures and IPL tasks. (b) Pictorial depiction of observed longitudinal relationships among specific IPL predictors (orange), social predictors (blue), and IPL and speech outcomes (green), with concurrent relationships controlled.

Table 1:

Visual and linguistic stimuli for the six IPL tasks, including which visits presented

Task/Condition	Visual Stimuli	Linguistic stimuli
SVO Sentence Order (Visits 1 & 2)		Test: *The girl is tickling the boy*
Wh-Questions, Familiarization and Test (Visits 3-6)		Familiarization: *Oh Look!* Tests: *What did the keys hit?* *What hit the book?*
Grammatical Aspect (Visits 5 & 6)		Tests: *She's picking the flowers* *She picked the flowers*
Noun/Naming Bias (Visits 1 & 2)		Teaching: *Look, piffen!* Test: *Where's piffen?*
Syntactic Bootstrapping (Visits 3-4 for ASD, Visits 3-6 for TD)	 	Teaching: *The duck is gorping the bunny* Test: *Where's gorping?*