Advanced Review

'Form is easy, meaning is hard' revisited: (re) characterizing the strengths and weaknesses of language in children with autism spectrum disorder

Letitia R. Naigles* and Saime Tek

Children with autism spectrum disorder (ASD) demonstrate impairments in social interaction and communication, and in repetitive/stereotypical behaviors. The degree to which children with ASD also manifest impairments in structural language—such as lexicon and grammar—is currently quite controversial. We reframe this controversy in terms of Naigles' (Naigles, *Cognition* 2002, 86: 157–199) 'form is easy, meaning is hard' thesis, and propose that the social difficulties of children with ASD will lead the meaning-related components of their language to be relatively more impaired than the form-related components. Our review of the extant literature supports this proposal, with studies (1) reporting that children with ASD demonstrate significant challenges in the areas of pragmatics and lexical/semantic organization and (2) highlighting their good performance on grammatical assessments ranging from wh-questions to reflexive pronouns. Studies on children with ASD who might have a co-morbid grammatical impairment are discussed in light of the absence of relevant lexical-semantic data from the same children. Most importantly, we present direct comparisons of assessments of lexical/semantic organization and grammatical knowledge from the same children from our laboratory, all of which find more children at a given age demonstrating grammatical knowledge than semantic organization. We conclude with a call for additional research in which in-depth grammatical knowledge and detailed semantic organization are assessed in the same children.

How to cite this article:
WIREs Cogn Sci 2017, 8:e1438. doi: 10.1002/wcs.1438

INTRODUCTION

Autism spectrum disorder (ASD) refers to a group of neuro-developmental disorders marked by impairments in social communication and interaction and repetitive/stereotypical behavior.[1] According to this definition, impairments in *social/pragmatic* aspects of language, such as comprehension and use of gestures and initiating or maintaining reciprocal conversations with people, are one of the defining characteristics of ASD. Although many children with ASD also present with delays and/or deficits in formal aspects of language,[2–4] impairments in these areas are not usually considered necessary for a diagnosis, and for this reason, there is a tendency among researchers to attribute structural language difficulties in ASD solely to impairments in social behavior.[5] In contrast, a new wave of recent research investigating the acquisition of lexical semantics and grammar

*Correspondence to: Letitia.naigles@uconn.edu
University of Connecticut, Storrs, CT, USA

Conflict of interest: The authors have declared no conflicts of interest for this article.

in children with ASD has revealed a number of findings that are inconsistent with this view.[6] For example, the tendency of children with ASD to reverse personal pronouns—producing 'I' when the context calls for 'you' and vice versa—has primarily been attributed to these children's lack of interest in and/or sophistication with reciprocal relationships with others[7]; however, we and our colleagues have recently demonstrated that the children's language level, as indexed by their vocabulary size, plays an independent and stronger role in predicting pronoun reversals than their social perspective-taking, as indexed by their initiations of joint attention.[8]

Delineating the nature and origins of impairments in language acquisition in ASD is important for clinical reasons because impairments in language use are one of the earliest symptoms that parents of young children with ASD notice, and because language functioning early in life strongly correlates with long-term outcomes.[7,9] In addition, from a more research-based perspective, characterizing the strengths and weaknesses of the language of children with ASD, *because* their most overt impairments are in the domain of social interaction, can shed light on the degree to which different aspects of language rely on the meanings and intentions that social interaction affords. In this article, we explore the proposal that some components of language, such as pragmatics and lexical/semantic organization, are disproportionately impaired in children with ASD, whereas other components of language, such as grammar, are relatively spared; thus, this is an extension of the 'form is easy, meaning is hard' thesis put forth by Naigles.[10]

FORM IS EASY, MEANING IS HARD

Naigles first proposed the 'form is easy, meaning is hard' thesis in 2002, to resolve some seemingly paradoxical findings in the language development literature of typically developing (TD) children. The paradoxical findings were that infants demonstrated robust abilities to abstract both specific and general patterns of varying complexity from auditory (both linguistic and language-like) stimuli whereas toddlers demonstrated weak or non-existent evidence of general or complex patterns in actual language use. The 'form is easy, meaning is hard' thesis contributed to the resolution of this paradox by pointing out that the infant studies involved statistical learning of artificial grammars or auditory-only comparisons of language-specific attested versus unattested structures (i.e., they targeted linguistic forms only) whereas the toddler studies involved fairly complex integrations of linguistic meaning—such as pinpointing the intended reference event—with linguistic structure. As such, the infant studies highlighted how easily preverbal and barely verbal TD infants can analyze auditory stimuli and extract both item-specific and abstract patterns (e.g., segmenting word boundaries from a stream of speech[11]) whereas the toddler studies shed light on the challenges that language learners face in analyzing and integrating their social and physical surroundings to determine just which meanings are intended by their co-conversationalists and instantiated by the words and structures of their specific language (e.g., using morphological markers with a limited number of verbs rather than extending them across the entire class of verbs[12–14]). Thus, Naigles[10] argued that children's acquisition of linguistic meanings—including especially verb meanings and meaning-dependent structures such as the occurrence of verbs in different types of constructions—is more difficult than their discovery of formal aspects of grammar, such as basic word order, identification and arrangement of nominal and verbal morphology, and dependencies among aspects of morphosyntax.[15,16] Naigles[10] did not discuss children's acquisition of pragmatics per se; however, learning how to engage in discourse also clearly requires meaning discernment.[17,18] This is because language users must integrate the external situation with the thoughts and intentions of their co-conversationalists to know, for example, what the 'real' topic of a conversation is, which aspects of a narrative are inside versus outside common ground, and how the context indicates when 'he kicked the bucket' refers to an irate toddler versus an expired film legend.[19]

Children with ASD provide an interesting expansion of the 'form is easy, meaning is hard' thesis, because their marked social impairments often manifest in the face of cognitive resilience.[7,20,21] To the extent that meaning discernment requires social interaction and the integration of social, physical, etc. stimuli to proceed efficiently, then children with ASD should be particularly impaired in the semantic and pragmatic areas of language development. However, to the extent that the discovery and abstraction of grammatical forms can occur prior to complete establishment of their meanings (i.e., doing what TD infants do), then children with ASD should not demonstrate as severe delays of grammatical development as they do of semantic and pragmatic development. Tager-Flusberg[22,23] has in the past made a similar claim (but see also Refs 21, 24, and 25). In what follows, we survey the current literature, with particular emphasis on recent findings from our lab, on pragmatic, lexical semantic, and grammatical

development (in that order) in children with ASD, and highlight how they are consistent with the 'form is easy, meaning is hard' thesis. In this article, we will argue that when the appropriate comparisons are made, deriving meaning in a language context is shown to be disproportionately impaired in ASD, as is reflected in deficiencies in pragmatics and lexical semantics, whereas form or syntactic knowledge is shown to be either intact or proportional to other areas of functioning.

PRAGMATICS YIELDS CONSISTENT CHALLENGES

Impairments in various aspects of pragmatic skills in individuals with ASD have been well documented in the literature. For example, use and comprehension of body language, understanding humorous material and figurative language, and initiating social interactions with others have been generally accepted to be consistently impaired in children with ASD.[26–33] Moreover, problems in discourse such as the use of repetitive phrases or inappropriate comments as well as neologisms and idiosyncratic utterances, are not uncommon.[28,33] Difficulties with story-telling in children with ASD include producing impoverished narratives, such as using bizarre or inappropriate utterances, neglecting to mention central themes, and misinterpreting story events.[28] During conversations, individuals with ASD frequently have difficulty turn-taking, following topics, responding adequately to questions or providing clarifications for topics that are unclear to a conversational partner.[26,34,35]

Deficits in pragmatic aspects of language usually persist throughout the life span, and are equally observed among high-functioning children with this disorder. For example, high-functioning individuals with ASD with average to above-average cognitive and linguistic skills demonstrate difficulty comprehending humorous materials such as picking funny endings for cartoons and jokes compared to their age-matched typical peers.[36] Similarly, high-functioning adults with autism or Asperger syndrome who show milder symptoms compared to classic autism use fewer referential expressions and form sentences that are not linked in a temporal order while narrating a story.[37] Even optimal outcome children (those who had been previously diagnosed with an ASD, but are currently completely integrated in typical classrooms after receiving intensive behavioral therapy) display pragmatic deficits when narrating a story, including difficulties with naming story characters, communicating fewer descriptions that are central to the narrative, producing ambiguous pronominal referents, and using idiosyncratic language.[38,39]

In sum, pragmatics involves discerning meaning in a specific context. A successful conversation with a social partner is not possible if one is not able to decode the intended meanings of words and utterances or, conversely, to produce utterances that are meaningful from a listener's perspective. Difficulties in many aspects of pragmatics have been consistently shown to be impaired since the earliest reports on ASD, and persist throughout the lifespan even among higher functioning individuals with this disorder whose syntactic knowledge (linguistic form) is similar to that of TD individuals but who, nevertheless, have difficulties applying that knowledge in a meaningful context.

VOCABULARY GROWTH IS EASY, BUILDING LEXICAL/SEMANTIC ORGANIZATION IS HARD

Unlike the universally reported deficits in (most; see Ref 40 for some caveats) pragmatic skills, the typicality of lexical and semantic development in ASD has been a matter of debate. Early reports of lexical use among children with ASD suggested mostly intact skills; for example, in their seminal work on language skills in children with ASD, Tager-Flusberg et al.[41] showed similar developmental profiles in lexical diversity (as measured by different word roots) and distribution of vocabulary among the main form classes including nouns, verbs, and modifiers in children with ASD and children with Down syndrome. Similarly, Fein et al.[42] reported that the vocabularies of children with ASD increase steadily with age, and are composed primarily of nouns, as has been found with TD children. Weismer et al.[43] reported similar findings comparing 30-month-old children with ASD and 25-month-old late talkers without ASD who were matched on productive vocabulary. The authors showed that the two groups did not differ from each other on the semantic categories of words in their vocabularies, including psychological state terms.

More recently, using a parent checklist assessing the vocabularies of large samples of young children with ASD, Charman et al.[44] (see also Ref 45) showed that, although the participants were largely delayed in word production, their developmental path was similar to what has been reported in TD children: children's overall comprehension of words was ahead of their production, and the composition of word categories and word forms was similar to

that of TD children. Rescorla and Sayfer[46] reported similar findings on a different parent checklist of vocabulary composition with preschool-aged children with ASD who were matched to TD children on vocabulary size. The ASD group in this study did not differ from TD children in the semantic category distributions of their lexicon, with both groups showing a higher percentage of nouns than verbs in their productive vocabulary.

In addition to standardized assessments and parent checklists, experimental studies on vocabulary use and understanding have also shown similarities between children with ASD and TD children. Using the intermodal preferential looking paradigm (IPL[47,48]) to study language acquisition in toddlers with ASD, Swensen et al.[49] found that the ASD group did not differ from language-matched TD children in their use of the noun bias, which assessed whether the children would map a novel word onto an object as opposed to an action. McDuffie et al.[50] demonstrated that preschool-aged children with ASD increased their attention to novel objects in the presence of words, albeit not as consistently as language-matched TD children. Moreover, Luyster and Lord[51] showed that, similar to language-matched TD children, toddlers with ASD could use social information by following an experimenter's focus of attention to learn new object labels (see also Refs 20, 52, and 53).

The common finding among the studies summarized above is that the onset of lexical development might be delayed in children with ASD, but overall lexical growth, and especially the early noun lexicon, seem to be similar to TD children and so are relative strengths in children with ASD. However, studies investigating the acquisition of specific word classes have revealed atypical patterns of lexical use, and provide some indications of increasing difficulties with meaning discernment. For instance, mental-state terms such as *think*, *know*, and *imagine,* and words referring to emotions are underrepresented in children with ASD.[54–57] Moreover, high-functioning individuals with ASD have difficulty labeling emotions depicted in video vignettes or understanding or providing definitions for different emotions such as *happy*, *sad*, and *disappointed* compared to typical controls.[56] Finally, a longitudinal study carried out in our lab collected the speech of children with ASD interacting with their parents, at 4-month intervals for six visits. The children with ASD as a group were matched at visit 1 on overall language level (Mullen Expressive and Receptive Language raw scores[58]) with a group of TD children who were also followed, and noun use across visits did not differ by group.[4] However, when Tek et al.[4] divided the ASD group via a median split, two distinct patterns of verb growth were observed. The high-verbal children with ASD increased in their verb production across visits, at similar rates to the TD children; in contrast, the low-verbal children with ASD showed a significantly slower rate of growth in overall verb use. Even more interestingly, when the children's verbs were categorized by semantic category, the low-verbal children were found to produce disproportionately more general-all-purpose (GAP) verbs (GAP verbs such as *make*, *do*, and *go*) than the high-verbal children with ASD or the TD children (who did not differ[59]). All of these effects can be traced to difficulties in socially based meaning discernment: children who find it difficult to read the mental states and emotions of others will likewise find it difficult to learn the words that refer to these, and lower-functioning children who experience even greater difficulties in navigating the cognitive and social worlds may over-rely on words that are essentially 'bleached' of specific lexical content.

Another area of observed impaired functioning in ASD in the lexical/semantic domain is lexical organization, particularly the conceptual understanding that guides information about meanings of words (e.g., lexical knowledge) and relationships between objects (e.g., typical/atypical members of a lexical category, hierarchical organization of categories at the superordinate, basic, and subordinate levels). For example, as part of the same longitudinal study in our lab, Tek et al.[60] investigated the shape bias among toddlers with ASD and TD controls matched on expressive language over a 1 year period. The shape bias is a word learning mechanism that helps children extend novel words onto new instances of objects matching in shape while ignoring other visual similarities such as color, texture, and size.[61] In our first investigation of the shape bias with children with ASD, we conducted both 'real object' and IPL tests.[60] In the 'real object' test,[61] we showed the children three-dimensional objects, labeled them, held up three-dimensional color- and shape matches, and asked the children to point to which object was also called that label. In the IPL task, we created videos of the same objects (moving slowly back and forth) and also presented these first in 'no-name' trials and then with the target objects labeled. The TD children in Tek et al.[60] behaved as expected: they pointed to the shape-matched object more in the 'name' than 'no-name' trials first at 28 months of age, and demonstrated the same pattern via eye gaze at 24 months of age (i.e., one visit earlier). In contrast, the children with ASD demonstrated no label-driven shape

preferences with either task throughout the first four visits.[60]

In a recent follow-up, we doubled the size of the samples (now, 30+ children in each group) and reported similar findings. With the larger sample, TD children showed a shape preference when hearing the novel word at 20 months (i.e., at visit 1), but the children with ASD, as a group, still did not look reliably longer at the shape match than color match (nor at the color match over the shape match) during the 'name' trials relative to the 'no-name' trials, even through visit 6.[62] Many of the children knew more than 100 object labels by parental report; moreover, because they frequently looked at the shape match during the 'no-name' trials, they did seem to notice the shape similarity between the target and test objects. What they did not do, in contrast to the TD children, was highlight this shape similarity during the 'name' trials; that is, they did not preferentially extend the novel word to objects of the same shape. In sum, while the children with ASD were similar to the TD children in acquiring a sizable lexicon, they did not seem to organize their words around the same conceptual units (e.g., shape similarity). Therefore, these findings highlight how lexical use and lexical organization might be dissociated in ASD. In a similar vein, Perkins et al.[63] suggested that using words appropriately in a context does not necessarily reflect conceptual understanding in individuals with ASD (e.g., asking 'what does *silence* mean?' after using the word appropriately in a sentence). One reason for this dissociation between lexical use and knowledge may be that individuals with ASD have been noted for their strength in rote-learning while showing a difficulty for flexible use of language.[63]

Difficulties in lexical/conceptual organization have been demonstrated even among higher functioning individuals with ASD, which may be taken as evidence that these difficulties may not be explained by below-average IQ or impaired overall language skills. In a word fluency task, high-functioning children with ASD provided fewer prototypic exemplars than did the language-impaired children or language-matched TD children.[64] In a similar study, compared to age- and IQ-matched TD individuals, high-functioning children and adolescents with ASD responded more slowly to somewhat typical and atypical exemplars of a category than the typical exemplars.[65] A recent replication of this study with our participants revealed additional subtle deficits in the ASD group, such that they responded inaccurately to 'somewhat typical' exemplars especially when these were preceded by 'atypical' exemplars; seeing these latter items seemed to have disrupted the children's category organization, at least in the moment. Interestingly, whereas an index of category structure for the TD children was strongly correlated with their overall language levels, the same category structure index for the ASD group only correlated with nonverbal IQ.[66] Categorical induction, which prompts the extension of properties associated with one instance of a category (e.g., that a rabbit eats grass) to other instances with the same label, and which has been shown to be operational in TD children as young as 2 years of age,[67] also seems impaired in children and adolescents with ASD.[68,69]

These studies suggest that while initial lexical development might be a strength in children with ASD, assessments of more detailed lexical-semantic content and organization reveal noticeable impairments. It is possible, of course, that single-word learning is the 'only' language-related strength in children with ASD, and that in-depth scrutiny of grammatical development and usage will reveal equally substantive impairments; we turn to this area of language next.

DEVELOPMENT OF SYNTAX AND MORPHOLOGY SEEMS EASY

Grammatical development and processing in children with ASD have come under increasing scrutiny in recent years, and a large number of studies indicate substantial resilience in this area of language, especially when children's mental ages are factored in.[7,22,41,70] For example, Tager-Flusberg et al.'s[41] classic longitudinal study found that children with ASD were similar to mental-age-matched children with Down syndrome in their increases in mean length of utterance (MLU), which is an overall measure of syntactic development. In a cross-sectional study, Waterhouse and Fein[70] found that the order of acquisition of Brown's 14 morphemes in children with ASD was similar to the order of acquisition in TD children (see Ref 71 for a recent replication). More recently, Tek et al.[4] conducted individual growth curve analyses on a variety of morpho-syntactic measures (e.g., Brown's 14 morphemes, wh-questions) and sentence complexity (e.g., MLU) using our longitudinal dataset of children's spontaneous speech. The TD group and the high-verbal children with ASD showed increases over time in their frequency of use of all grammatical measures; moreover, the trajectories of these two groups were equivalent once differences in intercept were controlled (see also Ref 72 for similar results with the larger sample).

Grammatical rule use, too, has been attested similarly in preschool-aged children with ASD and language-matched TD children, with both groups appropriately adding plural markers to novel (nonsense) nouns, past tense markers to novel verbs, and mapping novel verbs in transitive frames onto causative rather than noncausative actions.[71,73] Additional findings from our longitudinal dataset indicate that preschoolers with ASD understand wh-questions (e.g., when they see an apple hit a flower followed by the apple and flower presented side by side, they look longer at the flower after hearing 'What did the apple hit?' compared with a baseline trial) once their overall language level reaches that of the younger TD children who show reliable comprehension.[74–76] Moreover, they demonstrate some understanding of the aspectual '-ing/-ed' distinction, looking longer at ongoing activities when they hear verbs ending in '-ing,' and longer at completed actions when they hear the same verbs with the past/-ed suffix.[77,78]

Similar reports of good grammatical performance have been found for school-aged children with ASD. Bavin and Baker[79] and Norbury[53] describe a series of 'visual world' eyetracking studies demonstrating that children with ASD process sentences incrementally similarly to TD children; for example, when they hear (1) *The girl will cut the cake with the knife* versus (2) *The girl will cut the cake with the candles*, both groups look at the knife when they first hear 'cut' in both sentences, but then shift their eye gaze to the cake with candles by the end of sentence (2). Using a similar paradigm. Diehl et al.[80] found that teenagers with ASD were able to efficiently use prosodic cues to constrain their interpretation of sentences like 'Put the apple on the towel in the box.' High-functioning children with ASD also understand the structural restrictions of reflexive pronouns in English (i.e., appropriately distinguishing *Bart washed him* from *Bart washed himself*[81]) and French (i.e., appropriately producing *Elle se lave* when shown pictures of a girl washing herself, and *Elle le lave* when shown pictures of the girl washing another[82]). Finally (and allowing us to circle back to the original 'form is easy' studies), statistical learning of both artificial grammars and novel speech streams have been assessed in school-aged children with ASD, and have yielded similarly positive effects as their TD controls[83,84] (see Ref 85 for a recent meta-analysis of statistical learning in ASD).

It is important to acknowledge, though, that a number of studies seem to contradict our claim of generally good (or even intact) grammatical usage and development in children with ASD. For example, both Tek et al.[4] and Park et al.[71] observed subgroups of children with ASD whose grammatical development was far slower than, and whose usage of grammatical morphemes was far less frequent than, the TD controls (see also Ref 86). However, these lower-verbal children performed at levels across-the-board that were lower than those of their age-mates, displaying cognitive as well as language impairments, and it is likely that their lower grammatical performance is attributable to general intellectual disability. Eigsti et al.'s[3] contrary findings raise a different issue; they compared 3–6-year-old children with ASD to TD children and children with general developmental delay (DD), who were both matched to the ASD group on nonverbal IQ. Children's spontaneous speech during free play was analyzed, and Index of Productive Syntax (IPSyn) scores, which measure grammatical complexity on verb phrases, noun phrases, question and negations, and sentence structure, were calculated. Eigsti et al.[3] found that children with ASD produced fewer syntactically complex utterances than both TD children and children with DD, particularly on the 'verb phrases' and 'question and negations' scales. However, Eigsti et al.[3] also noted that the children with ASD talked less frequently about the kinds of situations that might elicit, for example, past tenses and questions, and thus it is possible that the dearth of these grammatical constructions is more attributable to the paucity of appropriate contexts than to actual grammatical impairments. These studies highlight the importance of considering how samples of atypically developing children are matched (or not) to samples of TD children (see also Refs 87 and 88), as well as the importance of ensuring that the relevant contexts are included—even prompted—when assessing language samples of spontaneous and/or elicited speech.[89]

Thus far, then, the findings we have reviewed are consistent with the 'form is easy, meaning is hard' hypothesis. However, a third set of studies demonstrating grammatical impairments in children with ASD warrants a closer look. These include studies using standardized assessments and/or psycholinguistic tasks in which a set of school-aged children with ASD, who have nonverbal IQ scores within the normal range of their TD age-mates, perform quite poorly on grammatical tasks. For example, children with this profile show considerable difficulty in producing past tense markers and clitic pronouns in the appropriate contexts,[82,90] they do not reliably distinguish the personal pronouns 'him' and 'himself,'[81] they show reduced sensitivity to biasing conditions during eye-tracking tasks[91] and they make substantial numbers of errors when repeating complex sentences.[92] For these children with ASD, grammatical

forms do not seem 'easy,' and so they present a potential counter-example to our thesis. What we argue in the next section, though, is that few extant studies of children with ASD actually include the relevant comparisons between language form and language meaning.

DIRECT COMPARISONS OF FORM AND MEANING IN CHILDREN WITH ASD

Putting aside this latter group of grammatically impaired children with ASD for the moment, the previous literature review did seem to support our thesis that children with ASD experience or manifest greater difficulties with lexical organization (e.g., the shape bias and category structure) than with grammatical organization (e.g., rule use, trajectories of morpheme use, and understanding of numerous grammatical constructions). However, it must be acknowledged that none of these studies have actually tested this hypothesis directly. That is, the evidence for our claim presented thus far has been based on cross-study comparisons, which include different children assessed using different tasks. Most importantly, the studies that tested children's detailed lexical organization included only general grammatical assessments (e.g., standardized tests such as the Clinical Evaluation of Language Fundamentals (CELF)) and the studies that tested children's detailed grammatical organization included only general lexical assessments (e.g., the Peabody Picture Vocabulary Test (PPVT)). Given that these general standardized assessments were not designed to provide in-depth information about children's specific grammatical or lexical representations, they really cannot be used to test our hypothesis; thus, these studies do not include detailed assessments of both grammar and lexical semantics. We suggest, then, that just because children with ASD who manifest clear grammatical impairments show PPVT scores within the normal range does not mean that their lexical representations or category structures are truly intact (for a similar argument for children with specific language impairment see Ref 93). And to be fair, just because the children with ASD with impaired lexical category structures[66,69] showed grammatical standardized test scores within the normal range (i.e., demonstrating better form than meaning) does not necessarily mean that their actual grammatical knowledge is indeed fully intact (see Ref 94 for more discussion). What are needed are studies in which the same children have been assessed for both their in-depth lexical/meaning-related knowledge and their in-depth grammatical/form-related knowledge. From our longitudinal project, we can provide some of these comparisons; as we summarize below, all of the comparisons point to more impaired lexical organization than grammatical knowledge.

Recall that one of the earliest and most striking indicators of impaired lexical category structure is the absence of a shape bias in preschool-aged children with ASD (see also Ref 95). We tested over 30 children with ASD with the shape bias IPL video at all six visits, when the children were between 2.5 and 4.5 years of age[60,62]; even by the last visit, only about one-third of the children preferentially extended the novel label to objects of the same shape. We also tested the same children on their comprehension of subject- and object-wh-questions (e.g., 'What hit the flower?' vs 'What did the apple hit?'), and, on this grammatical task, by the last visit about two-thirds of the children looked longer at the matching image relative to baseline.[74,76] Crucially, of the children who demonstrated wh-question comprehension only about one-third also showed the shape bias. That is, within the same set of children, more demonstrated sophisticated grammatical knowledge than an age-appropriate word learning bias.

We observed this same pattern when these children with ASD were also compared on their shape bias and grammatical aspect performance (e.g., distinguishing the verb suffixes 'ing' vs 'ed'). For grammatical aspect, three-quarters of the children demonstrated successful mapping of verbs onto ongoing activities when they ended in 'ing' but onto completed actions when they ended in 'ed.'[78] However, only 38% of the children who demonstrated an understanding of grammatical aspect also showed the shape bias. Furthermore, demonstrating that the challenge with the shape bias was not simply in processing a novel word, we compared the children with ASD who had abstracted the SVO construction (i.e., used syntax to learn about novel verbs[73]) with those who showed a shape bias at the same visit: Whereas 93% of those with a shape bias also used syntax to learn about a novel verb (i.e., syntactic bootstrapping: 12 of 13 children), only 62% of those who did syntactic bootstrapping also showed a shape bias (13 of 21 children).

Two more within-group comparisons further emphasize the form-meaning disconnect in this sample of children with ASD. First, we coded the children's play sessions for their joint attention abilities, calculating both number and duration of episodes that began via their own initiations which were responded to by their mothers (initiation of joint

attention: IJA) and that began via their mothers' initiations that they themselves responded to (response to joint attention: RJA). Overall, and not surprisingly, the number and duration of both RJA and IJA episodes were lower in the children with ASD than the TD children. However, what was surprising and novel was that when we matched the two groups of children on MLU—thus removing the low-verbal and lower-functioning children—this subset of children with ASD still engaged in fewer and shorter episodes of joint attention.[8] That is, if the TD children are taken as a baseline, then these children with ASD showed more advanced grammatical development than social/communicative development. The children's gestures were also coded and categorized by function (e.g., adding meaning to speech, disambiguating speech, reinforcing speech, emphasizing speech, or being produced without speech; see Ref 96), and children with ASD produced fewer gestures than TD children who were matched on MLU.[31,97] Thus, this analysis provides another example that children with ASD seem farther along in grammatical development than in social/communication development.

CONCLUSION

We believe that the above within-subjects comparisons of detailed aspects of linguistic form and linguistic meaning support a re-characterization of language development in children with ASD such that learning form is relatively easier than learning meaning. However, we should not stop here; thus far, these comparisons are unique to one sample of 30+ children with ASD, and to the preschool period of language development. Our group has reported findings of category structure and categorical induction impairments in school age and adolescent children with ASD,[66,69] but we have not yet analyzed the more detailed grammatical assessments that the children were also administered; this comparison is needed. Moreover, we call for researchers who study children's grammatical knowledge in detail, to also include an in-depth assessment of their lexical semantics/category structure, and researchers who study children's lexical semantics/category structure to also test their participants on specific aspects of their grammatical knowledge. In other words, we have learned that standardized tests are only the first step in assessing the language of children with ASD; detailed psycholinguistic tasks provide a much clearer picture of their strengths and challenges. However, we will only be able to fully understand their relative strengths and weaknesses with language when more comprehensive assessments are conducted.[39,98]

In sum, the disconnects between language form (e.g., grammar) and language meaning (both context-dependent and context-independent) that we have reviewed in this paper, both across studies and within a single sample, are intriguing because their directionality suggests that at least some components of grammatical form can develop more quickly than—and possibly somewhat independently of—some components of lexical meaning. As such, they expand Naigles'[1] original 'form is easy, meaning is hard' thesis to the population of language learners who are children with ASD.

REFERENCES

1. Association AP. *Diagnostic and Statistical Manual of Mental Disorders (DSM-5®)*. Washington, DC: American Psychiatric Publication; 2013, 1679 pp.
2. Boucher J. Research review: structural language in autistic spectrum disorder – characteristics and causes. *J Child Psychol Psychiatry* 2012, 53:219–233.
3. Eigsti I-M, Bennetto L, Dadlani MB. Beyond pragmatics: morphosyntactic development in autism. *J Autism Dev Disord* 2007, 37:1007–1023.
4. Tek S, Mesite L, Fein D, Naigles L. Longitudinal analyses of expressive language development reveal two distinct language profiles among young children with autism spectrum disorders. *J Autism Dev Disord* 2014, 44:75–89.
5. Eigsti I-M, de Marchena AB, Schuh JM, Kelley E. Language acquisition in autism spectrum disorders: a developmental review. *Res Autism Spectr Disord* 2011, 5:681–691.
6. Naigles LR, ed. *Innovative Investigations of Language in Autism Spectrum Disorder*. Language and the Human Lifespan Series, vol. xv. Berlin: Walter de Gruyter GmbH; 2017, 255 pp.
7. Tager-Flusberg H, Paul R, Lord C, Volkmar F, Paul R, Klin, A. Language and communication in autism. *Handbook of autism and pervasive developmental disorders* 2005, 1:335–364.
8. Naigles LR, Cheng M, Xu Rattanasone N, Tek S, Khetrapal N, Fein D, Demuth K. "You're telling me!" The prevalence and predictors of pronoun reversals in

children with autism spectrum disorders and typical development. *Res Autism Spectr Disord* 2016, 27:11–20.

9. Szatmari P, Bryson S, Duku E, Vaccarella L, Zwaigenbaum L, Bennett T, Boyle, M. Similar developmental trajectories in autism and Asperger syndrome: from early childhood to adolescence. *J Child Psychol Psychiatry* 2009, 50:1459–1467.
10. Naigles LR. Form is easy, meaning is hard: resolving a paradox in early child language. *Cognition* 2002, 86:157–199.
11. Aslin RN, Saffran JR, Newport EL. Statistical learning in linguistic and nonlinguistic domains. In: MacWhinney B, ed. *The Emergence of Language*. Mahwah, NJ: Lawrence Erlbaum Associates Publishers; 1999, 359–380.
12. Gleitman LR, Cassidy K, Nappa R, Papafragou A, Trueswell JC. Hard words. *Lang Learn Dev* 2005, 1:23–64.
13. Hohenstein JM, Naigles LR, Eisenberg AR. Keeping verb acquisition in motion: a comparison of English and Spanish. In: Hall DG, Waxman SR, eds. *Weaving a Lexicon*. Cambridge, MA: MIT Press; 2004, 569–602.
14. Pine JM, Lieven EV, Rowland CF. Comparing different models of the development of the English verb category. *Linguistics* 1998, 36:807–830.
15. Shi R. Functional morphemes and early language acquisition. *Child Dev Perspect* 2014, 8:6–11.
16. Valian V. Innateness and learnability. In: Bavin EL, ed. *Cambridge Handbook of Child Language: [Internet]*. Cambridge: Cambridge University Press; 2009, 15–34. Available at: https://www.cambridge.org/core/books/cambridge-handbook-of-child-language/innateness-and-learnability/4AF4B3F00F5810ACDECC5CAA9307E1FC. (Accessed February 5, 2017).
17. Berman R. Language development and use beyond the sentence. In: Bavin E, Naigles LR, eds. *The Cambridge Handbook of Child Language*, 2nd ed. Cambridge: CUP; 2015, 458–480.
18. Becker Bryant J. Pragmatic development. In: Bavin E, Naigles LR, eds. *The Cambridge Handbook of Child Language*, 2nd ed. Cambridge: CUP; 2015, 438–457.
19. Prutting CA, Kirchner DM. A clinical appraisal of the pragmatic aspects of language. *J Speech Hear Disord* 1987, 52:105–119.
20. McDuffie A, Thurman AJ, Channell MM, Abbeduto L. Learning words in a social world: impairments associated with ASD and fragile X syndrome. In: Naigles L, ed. *Innovative Investigations of Language in Autism Spectrum Disorder*. Language and the Human Lifespan Series. Berlin: Walter de Gruyter GmbH; 2017, 71–87.
21. Joseph RM, Tager-Flusberg H, Lord C. Cognitive profiles and social-communicative functioning in children with autism spectrum disorder. *J Child Psychol Psychiatry* 2002, 43:807–821.
22. Tager-Flusberg H. On the nature of linguistic functioning in early infantile autism. *J Autism Dev Disord* 1981, 11:45–56.
23. Tager-Flusberg H. Brief report: current theory and research on language and communication in autism. *J Autism Dev Disord* 1996, 26:169–172.
24. Kjelgaard MM, Tager-Flusberg H. An investigation of language impairment in autism: implications for genetic subgroups. *Lang Cogn Process* 2001, 16:287–308.
25. Tager-Flusberg H. Defining language phenotypes in autism. *Clin Neurosci Res* 2006, 6:219–224.
26. Capps L, Kehres J, Sigman M. Conversational abilities among children with autism and children with developmental delays. *Autism* 1998, 2:325–344.
27. Landa R. Social language use in Asperger syndrome and high-functioning autism. In: Klin A, Volkmar FR, Sparrow SS, eds. *Asperger Syndrome*. New York, NY: Guilford Press; 2000, 125–155.
28. Loveland KA, McEvoy RE, Tunali B, Kelley ML. Narrative story telling in autism and Down's syndrome. *Br J Dev Psychol* 1990, 8:9–23.
29. Lyons V, Fitzgerald M. Humor in autism and Asperger syndrome. *J Autism Dev Disord* 2004, 34:521–531.
30. Ozonoff S, Miller JN. An exploration of right-hemisphere contributions to the pragmatic impairments of autism. *Brain Lang* 1996, 52:411–434.
31. Özçalışkan Ş, Adamson LB, Dimitrova N. Early deictic but not other gestures predict later vocabulary in both typical development and autism. *Autism Int J Res Pract* 2016, 20:754–763.
32. Tager-Flusberg H, Anderson M. The development of contingent discourse ability in autistic children. *J Child Psychol Psychiatry* 1991, 32:1123–1134.
33. Volden J, Lord C. Neologisms and idiosyncratic language in autistic speakers. *J Autism Dev Disord* 1991, 21:109–130.
34. Hale CM, Tager-Flusberg H. Social communication in children with autism: the relationship between theory of mind and discourse development. *Autism Int J Res Pract* 2005, 9:157–178.
35. Volden J. Conversational repair in speakers with autism spectrum disorder. *Int J Lang Commun Disord* 2004, 39:171–189.
36. Emerich DM, Creaghead NA, Grether SM, Murray D, Grasha C. The comprehension of humorous materials by adolescents with high-functioning autism and Asperger's syndrome. *J Autism Dev Disord* 2003, 33:253–257.
37. Colle L, Baron-Cohen S, Wheelwright S, van der Lely HKJ. Narrative discourse in adults with high-functioning autism or Asperger syndrome. *J Autism Dev Disord* 2008, 38:28–40.

38. Suh J, Eigsti I-M, Naigles L, Barton M, Kelley E, Fein D. Narrative performance of optimal outcome children and adolescents with a history of an autism spectrum disorder (ASD). *J Autism Dev Disord* 2014, 44:1681–1694.
39. Suh J, Eigsti I-M, Canfield A, Irvine C, Kelley E, Naigles LR, Fein D. Language representation and language use in children with optimal outcomes from ASD. In: Naigles L, ed. *Innovative Investigations of Language in Autism Spectrum Disorder*. Language and the Human Lifespan Series. Berlin: Walter de Gruyter GmbH; 2017, 225–243.
40. Naigles LR, Chin I. Language development in children with autism. In: Bavin E, Naigles LR, eds. *Cambridge Handbook of Child Language*, 2nd ed. Cambridge: CUP; 2015, 637–658.
41. Tager-Flusberg H, Calkins S, Nolin T, Baumberger T, Anderson M, Chadwick-Dias A. A longitudinal study of language acquisition in autistic and Down syndrome children. *J Autism Dev Disord* 1990, 20:1–21.
42. Fein D, Dunn M, Allen D, Aram D, Hall N, Morris R, Wilson BC. Language and neuropsychological findings. In: Rapin I, ed. *Preschool Children with Inadequate Communication*. London: MacKeith Press; 1996, 123–154.
43. Weismer SE, Gernsbacher MA, Stronach S, Karasinski C, Eernisse ER, Venker CE, Sindberg H. Lexical and grammatical skills in toddlers on the autism spectrum compared to late talking toddlers. *J Autism Dev Disord* 2011, 41:1065–1075.
44. Charman T, Drew A, Baird C, Baird G. Measuring early language development in preschool children with autism spectrum disorder using the MacArthur Communicative Development Inventory (Infant Form). *J Child Lang* 2003, 30:213–236.
45. Luyster R, Lopez K, Lord C. Characterizing communicative development in children referred for autism spectrum disorders using the MacArthur-Bates Communicative Development Inventory (CDI). *J Child Lang* 2007, 34:623–654.
46. Rescorla L, Sayfer P. Lexical composition in children with autism spectrum disorder (ASD). *J Child Lang* 2013, 40:47–68.
47. Naigles LR, Tovar AT. Portable intermodal preferential looking (IPL): investigating language comprehension in typically developing toddlers and young children with autism. *J Vis Exp* 2012, 70:e4331.
48. Piotroski J, Naigles LR. Intermodal preferential looking. In: Hoff E, ed. *Res Meth Child Lang Pract Guide*. Oxford, UK: Wiley-Blackwell; 2012, 17–28.
49. Swensen LD, Kelley E, Fein D, Naigles LR. Processes of language acquisition in children with autism: evidence from preferential looking. *Child Dev* 2007, 78:542–557.
50. McDuffie AS, Yoder PJ, Stone WL. Labels increase attention to novel objects in children with autism and comprehension-matched children with typical development. *Autism Int J Res Pract* 2006, 10:288–301.
51. Luyster R, Lord C. Word learning in children with autism spectrum disorders. *Dev Psychol* 2009, 45:1774–1786.
52. Hani HB, Gonzalez-Barrero AM, Nadig AS. Children's referential understanding of novel words and parent labeling behaviors: similarities across children with and without autism spectrum disorders. *J Child Lang* 2013, 40:971–1002.
53. Norbury CF. Eye-tracking as a window on language processing in ASD. In: Naigles L, ed. *Innovative Investigations of Language in Autism Spectrum Disorder*. Language and the Human Lifespan Series. Berlin: Walter de Gruyter GmbH; 2017, 13–33.
54. Bang J, Burns J, Nadig A. Brief report: conveying subjective experience in conversation: production of mental state terms and personal narratives in individuals with high functioning autism. *J Autism Dev Disord* 2013, 43:1732–1740.
55. Baron-Cohen S, Ring H, Moriarty J, Schmitz B, Costa D, Ell P. Recognition of mental state terms. Clinical findings in children with autism and a functional neuroimaging study of normal adults. *Br J Psychiatry J Ment Sci* 1994, 165:640–649.
56. Losh M, Capps L. Narrative ability in high-functioning children with autism or Asperger's syndrome. *J Autism Dev Disord* 2003, 33:239–251.
57. Tager-Flusberg H, Sullivan K. Attributing mental states to story characters: a comparison of narratives produced by autistic and mentally retarded individuals. *Appl Psycholinguist* 1995, 16:241–256.
58. Mullen EM. *Mullen Scales of Early Learning Manual*. Circle Pines, MN: American Guidance Service; 1995, 108 pp.
59. Parish-Morris J, Fein D, Naigles LR. Growth in naturalistic verb use differs by verb category in toddlers with ASD. In: *Boston University Conference on Language Development*, Boston, MA, November 2015.
60. Tek S, Jaffery G, Fein D, Naigles LR. Do children with autism spectrum disorders show a shape bias in word learning? *Autism Res* 2008, 1:208–222.
61. Landau B, Smith LB, Jones SS. The importance of shape in early lexical learning. *Cogn Dev* 1988, 3:299–321.
62. Potrzeba ER, Fein D, Naigles L. Investigating the shape bias in typically developing children and children with autism spectrum disorders. *Front Psychol* 2015, 6:446.
63. Perkins MR, Dobbinson S, Boucher J, Bol S, Bloom P. Lexical knowledge and lexical use in autism. *J Autism Dev Disord* 2006, 36:795–805.
64. Dunn M, Gomes H, Sebastian MJ. Prototypicality of responses of autistic, language disordered, and normal children in a word fluency task. *Child Neuropsychol* 1996, 2:99–108.

65. Gastgeb HZ, Strauss MS, Minshew NJ. Do individuals with autism process categories differently? The effect of typicality and development. *Child Dev* 2006, 77:1717–1729.
66. Ellawadi AB, Fein D, Naigles LR. Category structure and processing in 6-year-old children with autism. *Autism Res* 2016. doi: 10.1002/aur.1652.
67. Gelman SA. *The Essential Child: Origins of Essentialism in Everyday Thought*. Oxford, England, UK: Oxford University Press; 2003, 400 pp.
68. Kelley E, Paul JJ, Fein D, Naigles LR. Residual language deficits in optimal outcome children with a history of autism. *J Autism Dev Disord* 2006, 36:807–828.
69. Naigles LR, Kelley E, Troyb E, Fein D. Residual difficulties with categorical induction in children with a history of autism. *J Autism Dev Disord* 2013, 43:2048–2061.
70. Waterhouse L, Fein D. Language skills in developmentally disabled children. *Brain Lang* 1982, 15:307–333.
71. Park CJ, Yelland GW, Taffe JR, Gray KM. Brief report: the relationship between language skills, adaptive behavior, and emotional and behavior problems in pre-schoolers with autism. *J Autism Dev Disord* 2012, 42:2761–2766.
72. Fusaroli R, Weed E, Fein D, Naigles LR. Language development in context: a longitudinal study of typically-developing children and children with ASD. In: *International Meeting for Autism Research*, Salt Lake City, UT, May 2015.
73. Naigles LR, Kelty E, Jaffery R, Fein D. Abstractness and continuity in the syntactic development of young children with autism. *Autism Res* 2011, 4:422–437.
74. Goodwin A, Fein D, Naigles LR. Comprehension of wh-questions precedes their production in typical development and autism spectrum disorders. *Autism Res* 2012, 5:109–123.
75. Goodwin A, Fein D, Naigles L. The role of maternal input in the development of wh-question comprehension in autism and typical development. *J Child Lang* 2015, 42:32–63.
76. Jyotishi M, Fein D, Naigles LR. Word order understanding guides wh-question comprehension. In: *International Meeting for Autism Research*, Baltimore, MD, May 2016.
77. Wagner L, Swensen LD, Naigles LR. Children's early productivity with verbal morphology. *Cogn Dev* 2009, 24:223–239.
78. Tovar AT, Fein D, Naigles LR. Grammatical aspect is a strength in the language comprehension of young children with autism spectrum disorder. *J Speech Lang Hear Res* 2015, 58:301–310.
79. Bavin EL, Baker EK. Sentence processing in young children with ASD. In: Naigles L, ed. *Innovative Investigations of Language in Autism Spectrum Disorder*. Language and the Human Lifespan Series. Berlin: Walter de Gruyter GmbH; 2017, 35–47.
80. Diehl JJ, Friedberg C, Paul R, Snedeker J. The use of prosody during syntactic processing in children and adolescents with autism spectrum disorders. *Dev Psychopathol* 2015, 27:867–884.
81. Perovic A, Modyanova N, Wexler K. Comparison of grammar in neurodevelopmental disorders: the case of binding in Williams syndrome and autism with and without language impairment. *Lang Acquis* 2013, 20:133–154.
82. Tuller L, Ferré S, Prévost P, Barthez M-A, Malvy J, Bonnet-Brilhault F. The effect of computational complexity on the acquisition of French by children with ASD. In: *Innovative Investigations of Language in Autism Spectrum Disorder*. Berlin: Walter de Gruyter GmbH; 2017, 115–140. (Language and the human lifespan series.).
83. Brown J, Aczel B, Jiménez L, Kaufman SB, Grant KP. Intact implicit learning in autism spectrum conditions. *Q J Exp Psychol* 2010, 63:1789–1812.
84. Mayo J, Eigsti I-M. Brief report: a comparison of statistical learning in school-aged children with high functioning autism and typically developing peers. *J Autism Dev Disord* 2012, 42:2476–2485.
85. Obeid R, Brooks PJ, Powers KL, Gillespie-Lynch K, Lum JAG. Statistical learning in specific language impairment and autism spectrum disorder: a meta-analysis. *Front Psychol* 2016, 7:1245.
86. Bartolucci G, Pierce SJ, Streiner D. Cross-sectional studies of grammatical morphemes in autistic and mentally retarded children. *J Autism Dev Disord* 1980, 10:39–50.
87. Shaked M, Yirmiya N. Matching procedures in autism research: evidence from meta-analytic studies. *J Autism Dev Disord* 2004, 34:35–40.
88. Mervis C. Cross-etiology comparisons of cognitive and language development. In: Rice M, Warren S, eds. *Developmental Language Disorders: From Phenotypes to Etiologies*. Hillsdale, NJ: Erlbaum; 2004, 153–186.
89. Williams D, Botting N, Boucher J. Language in autism and specific language impairment: where are the links? *Psychol Bull* 2008, 134:944–963.
90. Roberts JA, Rice ML, Tager-Flusberg H. Tense marking in children with autism. *Appl Psycholinguist* 2004, 25:429–448.
91. Brock J, Norbury C, Einav S, Nation K. Do individuals with autism process words in context? Evidence from language-mediated eye-movements. *Cognition* 2008, 108:896–904.
92. Riches NG, Loucas T, Baird G, Charman T, Simonoff E. Sentence repetition in adolescents with specific language impairments and autism: an investigation of complex syntax. *Int J Lang Commun Disord* 2010, 45:47–60.

93. McGregor KK, Newman RM, Reilly RM, Capone NC. Semantic representation and naming in children with specific language impairment. *J Speech Lang Hear Res* 2002, 45:998–1014.
94. Eigsti I-M, Schuh JM. Language acquisition in ASD: beyond standardized language measures. In: Naigles L, ed. *Innovative Investigations of Language in Autism Spectrum Disorder*. Language and the Human Lifespan Series. Berlin: Walter de Gruyter GmbH; 2017, 183–200.
95. Collisson BA, Grela B, Spaulding T, Rueckl JG, Magnuson JS. Individual differences in the shape bias in preschool children with specific language impairment and typical language development: theoretical and clinical implications. *Dev Sci* 2015, 18:373–388.
96. Cartmill EA, Ece Demir Ö, Goldin-Meadow S. Studying gesture. In: Hoff E, ed. *Research Methods in Child Language* [Internet]. Oxford, UK: Wiley-Blackwell; 2011, 208–225. Available at: http://onlinelibrary.wiley.com/doi/10.1002/9781444344035.ch14/summary. (Accessed December 13, 2016).
97. Goodwin A, Goldin-Meadow S, Fein D, Naigles LR. The role of gestures in early language development in children with ASD. In: *International Meeting for Autism Research*, Salt Lake City, UT, May 2015.
98. Naigles LR, Fein D. Looking through their eyes: tracking early language comprehension in ASD. In: Naigles L, ed. *Innovative Investigations of Language in Autism Spectrum Disorder*. Language and the Human Lifespan Series. Berlin: Walter de Gruyter GmbH; 2017, 49–69.

