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REVIEW

Atypical vocabulary acquisition in autism: where is it coming from?

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Abstract Word-learning development is extremely varied among children with autism, with some showing a peak of abilities in vocabulary and others little or no comprehension or expression of isolated words. Typical word learning mechanisms, such as the application of mutual exclusivity, cross-situational mapping, the whole-object principle, and the noun-naming bias also share this heterogeneity: some mechanisms appear to develop in a typical fashion and others depend on the individuals' language level. The reason for which word-learning processes could be atypical in autism is still the object of debate. Atypical attentional biases or early social interaction could both play a role in early word acquisition. But it is also unclear whether differences in vocabulary acquisition simply reflect the impact of co-morbid language impairment or there is a degree of specificity in autism. Finally, I propose that a more dimensional view in the study of word learning could be useful to move the field forward.

Keywords Autism · Word learning · Mutual exclusivity · Cross-situational mapping

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Vocabulary delay in autism

Autism is a disorder characterized by limitations in social interaction, and communication and restrictions in activities and behavior (American Psychiatric Association, 2013). These defining symptoms may coexist with important limitations in language skills, which range from total absence of verbal communication to limitations solely in purely pragmatic abilities, such as the use and comprehension of figurative language (Kalandadze et al., 2018; Morsanyi & Stamenković, 2021; Morsanyi et al., 2020; Vulchanova et al., 2015). There has been considerable debate over the nature of language disorders in autism, mostly related to whether individuals with autism spectrum disorder (ASD) and language impairment show a purely comorbid profile or their language limitations are of a different nature (Tomblin, 2011), with many comparisons focusing on phonological processing or grammatical structures (Huang & Finestack, 2020). Most studies have approached these issues by comparing children with ASD to typically developing (TD) controls matched on different measures, such as chronological or language age. This approach has generally left more open questions than answers. In this review I shall provide an overview of these issues, and argue that we need to approach them with a more dimensional perspective. The recognition of variability within autism has brought with it a view that emphasizes individual differences based on a

number of continuous dimensions, rather than the membership of the particular diagnostic category of ASD. This way of looking at variability could also prove useful in understanding word learning in autism.

Within language development, I shall focus on vocabulary acquisition. It is not only relevant per se, but lexical development is often used in research as an indicator of the level of language acquired (Sukenik & Tuller, 2021). However, it has been argued that vocabulary acquisition is a *peak* of linguistic profiles in autism. Others have proposed that vocabulary acquisition is impaired in autism. Surprisingly, considering the broad use of vocabulary measures in autism research and its importance in adaptive communication, the number of studies specifically addressing the issue is limited. The review by Sukenink and Tuller found only 32 empirical studies in the last 20 years, a small proportion of the total devoted to language in ASD. Of these, approximately half reported impairments in lexical processing, which is indicative of the great variability in the results. However, two successive meta-analyses seem to confirm that, in general, people with autism show delayed vocabulary with respect to their peers (Belteki et al., 2022; Kwok et al., 2015). Belteki et al. found that both children at-risk and with a diagnosis of ASD had poorer vocabulary as measured with parental scales than typically developing peers, and that this difference increased with age.

It has also been suggested that there are qualitative differences between ASD and typically developing children. Not only are autistic children slower to respond to vocabulary tasks, but they can also make semantic errors of a different nature. Although expressive vocabulary has also been indicated to be larger than receptive, this does not appear to be a universal marker in autism (Kwok et al., 2015). Additionally, it could be that the levels of vocabulary relate to language ability and are just a reflection of general language development. It does not appear to be the case (Sukenik & Tuller, 2021). Whereas measures of general language ability provide a very broad scope of abilities (from *profoundly impaired* to *low average,* in Kwok et al.´s meta-analysis), vocabulary scores seem to have a greater range (*profoundly impaired* to *high average)*. When global measures were used, their results showed that autistic participants' language levels were from 3.17 to 0.07 standard deviations below the means of control groups for receptive language (and from 3.06 to 0.22 for expressive). However, when vocabulary was used as a proxy, scores would range from − 3.06 to 0.91 and − 3.06 to 0.91 standard deviations with respect to typically developing groups, respectively. This would indicate globally an over-estimation of language ability when vocabulary is used for autistic participants. This meta-analysis, however, does not allow us to conclude whether or not vocabulary and general language skills effectively correlate, or if vocabulary could be an isolated peak skill.

In any case, as with many other areas of development in autism, heterogeneity is the norm. However, where this variability comes from is of crucial importance. It is relevant to understand how and under which parameters communication and language are developing in autism. But also, which are the mechanisms producing this variability. Understanding them should open the road to tailoring interventions to this heterogeneity and targeting therapy appropriately.

Word-learning mechanisms in autism

Oral word learning requires pairing a phonological representation with a meaning, which can range from an action to a category of objects or a specific exemplar (in the case of proper nouns, for example). Most research has centred on concrete noun learning (see Horvath et al., 2018; Vigliocco et al., 2018, for exceptions). The meaning-to-form pairing is far from straightforward. It entails referent selection (which is the object to which the word can be applied to?), retention (which was that word that referred to this object that I had learned?), and generalization (can I use that word for this new object?) (Gleitman, 1990).

Referent selection

Infants realize that new names refer to new objects, since every class of objects has a different name. This one-to-one principle and *the mutual exclusivity* related to it allow children to learn the novel terms in environments with competing referents (Markmann & Watchel, 1988): when a new object is introduced together with a known object, for example, the novel term will be applied to the unknown referent (since there is already a name for the known one).

The ability to apply mutual exclusivity to word learning appears to relate to variability in language development found in autism. Mathée-Scott et al. (2021), for example, included children from 24 to 36 months of age, matched to typically developing toddlers on visual reception raw scores on the Mullen scales, but with poorer receptive language abilities and nonverbal IQ. They found poorer performance on a mutual exclusivity task, even after accounting for age and comprehension of familiar words. However, when receptive language ability was factored into their statistical model, there were no longer significant group effects. There *were* differences between a lower and higher language ability subgroups of the autism group however.

But often words are not learnt in one trial and situation. Statistical learning allows children to acquire the meaning of a word across different situations even when correspondence to referents is ambiguous. As opposed to experiments testing for mutual exclusivity, these situations do not allow for an immediate identification of the referent. Controlling for appearance of referents and labels across different trials, children can eventually establish reliable object-word pairings. This kind of statistical learning has been proposed as a powerful mechanism for word learning. Hartley et al. (2020) found that there were no differences between TD and autistic children matched on receptive vocabulary, although the latter were slower in identifying the correct referents. Venker (2019) had found similar results with children of these ages also matched on receptive vocabulary.

This lack of differences is not surprising considering that children with ASD do not appear to show limitations in statistical learning as such. A meta-analysis (Obeid et al., 2016) across a variety of statistical learning tasks (Serial Reaction Time, Alternating Serial Reaction Time, Contextual Cueing, Artificial Grammar Learning, Observational Learning, and Probabilistic Classification Learning) did not find indication of difficulties in these kinds of tasks in autistic participants (Hedge's $g = -0.11$, $p = 0.30$), in line with a previous systematic review by Foti et al.2015). Task modality did not affect effect sizes, which would indicate that no specific task of statistical learning differs from the others in ASD, $Q(1) = 1.25$, $p = 0.26$, nor in DLD, $Q(1) = 1.36$, $p = 0.24$.

But when Hartley et al. (2020) explored variability across their autistic participants, they found that cross-situational mapping was related to receptive vocabulary, although not non-verbal IQ. So, even though at a group level statistical learning does not seem to be a major marker of word reading development in autism, it could play a role in explaining developmental variability. Conversely, it could also be the case that pre-existing vocabulary facilitates the acquisition of new words in cross-situational mapping experiments.

Generalization

Once a word has been paired to a specific object, it needs to be applied to other objects of the same category. The *whole-object principle* allows children to apply a word to a similar object to that initially named, and not to one of its parts (Markman, 1990). Nouns are in this sense the default meaning for words, as opposed to verbs: children will apply a novel word to other similar characters in an oral narrative (with puppets, for example), but not to similar actions performed by other characters. Children also tend to use shape as an important characteristic for applying meaning to new objects, rather than other less relevant dimensions. At 24 months children can infer that the relationship relies on shape, but not other features (Landau et al., 1988).

Children with autism do not appear to show this preference for shape in most studies (Hartley et al., 2019). Children at preschool age with a relatively broad vocabulary base (100 +) do not use this principle when extending the meaning of novel words to other objects. This is the case even when they are matched on receptive vocabulary and nonverbal IQ (Hartley & Allen, 2014). This contrasts with an apparently clear noun-naming bias. Naigles et al. (2021), for example, using the intermodal preferential looking paradigm, found that both young children with autism and typically developing peers applied a novel word to similar puppets previously paired with the word, but not to a similar action performed by another puppet.

Some questions

Atypical social communication or attentional bias?

Which processes support mechanisms such as the application of mutual exclusivity in word learning is

unclear and debated (Mathée-Scott et al., 2021). Some interpretations assume that it is the result of logical problem solving based on the one-to-one principle: if the term for A is already know, term B cannot correspond to object A (Halberda, 2003). But other approaches propose an explanation more closely related to pragmatics. The idea here is that the child uses cues such as eye gaze or gesture, rather than logic, to resolve the mapping issue (Clark, 1990). Whereas specific problems in autism based on a constraint or reasoning-based interpretations of mutual exclusivity might not be expected, this is not the case if we understand eye gaze, gesture, or other pragmatic processing as essential. A similar debate could apply to other word-learning mechanisms. However, a pragmatics-based approach is harder to apply to a lack of shape bias. In this case, an interpretation based on weak central coherence and an attentional bias towards local information processing (Happé & Frith, 2006; Mottron et al., 2006) has been proposed (Hartley & Allen, 2014). Weak central coherence theory posits that individuals with autism tend to focus on detail rather than processing objects and language globally. But there is little developmental research on WCC, and most studies have included relatively older participants. It is therefore still unclear how early this attentional bias is present, what form it would adopt at earlier ages, and how it relates to word learning.

A related perspective is proposed by the *auditory-visual misalignment* theory (Venker et al., 2018). The main proposition of this theory is that word-learning mechanisms are intact in autism, and that therefore it is necessary to look at the input level to determine why many studies find a vocabulary acquisition delay. Word learning requires that the referent and the word form are aligned in time and attentional focus. But this does not only depend on them effectively being present at the same moment: they must be perceived as such by the child. If the child is looking or attending elsewhere, word-referent matching will not develop correctly. Either associations will be imperfect or the link weaker than necessary. If the child tends to look at irrelevant stimuli, a misalignment of referent and word will occur, independently of the social or non-social nature of the stimulus (Tenenbaum et al., 2017). This disruption potentially affects learning repeatedly and in a sustained way across situations. Since children with autism show altered interaction patterns and attentional biases at early ages, in practice alignment may not ocurring. An attention-to-detail bias would be consistent with this model. Both attentional biases and atypical social behaviours could result in this misalignment.

Co-morbid language impairment or specific word-learning patterns?

Another unresolved issue refers to co-morbidity. In many studies, difficulties with word-learning mechanisms appear to be related to level of receptive vocabulary or overall language level (see above). Common to autism and developmental language disorder (DLD) are the poorer results in word-learning tasks compared to typically developing individuals (Kan & Windsor, 2010). A simple interpretation has been to consider that atypical language development in autism is an additive result of language impairment on top of the atypical development found in other domains in ASD. But it could be that vocabulary limitations in autism are (1) of a different nature to DLD or LI (with atypical attentional or social processing?) or (2) the result of an interaction between autism and LI, in a way that both language and atypical social processing are different in the case of autistic children with poor language development.

For example, it appears that statistical learning used in cross-situational word mapping could be affected in developmental language disorder specifically or language impairment more generally. Obeid et al.'s meta-analysis, already mentioned above (2016), showed that individuals with developmental language disorder (DLD) performed more poorly on statistical learning tasks compared to typically developing controls ($g = 0.46$, $p < 0.001$) (recall that autistic participants did not). Similarly, it has been suggested that word learning difficulties in children and adults with DLD are closely related to encoding the word form, with the pairing of form to meaning and retrieval less delayed (Leonard & Deevy, 2020; McGregor et al., 2020, 2022). It is not clear that this would be an issue in autism.

These results would speak to different causal pathways to atypical word learning in autism and language impairment. But it could also be the case that poor language development has a purely additive effect to autism with respect to vocabulary and that word learning mechanisms are not fundamentally altered in autism, once language development is taken

into consideration (Hartley et al., 2019). For example, Vigliocco et al. (2018) have explored abstract word learning in autism. They tested the hypothesis that emotional deficits (in principle, more frequent in autism than in DLD) could impair learning of this type of words. But they found that children with ASD and LI learning concrete and abstract words were indistinguishable from those with LI only. Similarly, children with autism learned concrete and abstract words like the typically developing controls.

A dimensional approach for a broad spectrum?

This takes us to the consideration of whether the predominant approach in the field, comparing distinct categories of children with and without autism with in-between group comparisons is appropriate. Variables related to language development (and vocabulary within it) and to social development (such as joint attention, for example), appear to be important predictors of outcome in autism (Bottema-Beutel, 2016), but also in developmental language disorder (Farrant et al., 2011). Many children with developmental language disorder also share strong limitations in social development (Vissers & Koolen, 2016). Instead of focusing on categorical differences between groups, it might be more interesting to explore the relative impact of cognitive, linguistic, and social development on the different mechanisms of word learning, and their potentially additive or multiplicative impact on vocabulary acquisition. The *case–control paradigm* (Petrolini & Vicente, 2022) operates under the assumption that all the individuals in one of the categories share a series of homogeneous features and that these are clearly different in different diagnostic groups. But, as we have seen, this could be far from true in the case of vocabulary development in autism.

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