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Word structure and word processing in developmental disorders

Abstract: Developmental disorders offer a rare view into properties of language that might go unnoticed in typically developing individuals. Quite often such cases are used to demonstrate dissociations between language and the rest of cognition. Yet, detailed recent research suggests that the picture is more complex and nuanced. For instance, in high-functioning autism, we find a dissociation between vocabulary skills and the acquisition and processing of figurative expressions, suggesting that bigger-size lexical units (such as non-transparent idioms or conventional metaphors) are probably stored and processed differently than word-size items. Other populations, such as children with language impairment, have problems with units of a smaller size, namely morphemes, and how they are used to indicate relations of agreement in grammar. Children suffering from dyslexia experience problems in cracking the orthographic code and how it maps onto the sound structure of oral language. Finally, some children will only experience problems in understanding text and what individual words in a given text mean, but not in decoding itself. This chapter provides an overview of developmental deficits that affect language, with a focus on how lexical items are acquired, stored and processed in atypical populations.

Keywords: word knowledge, word learning, language impairment, Williams syndrome, autism, reading deficits, poor comprehenders

1 Introduction

On the view of the mental lexicon reflected in the current volume, word knowledge is best conceived as an interface between multiple levels of representation. Lexical items are multiple linking rules between phonology (the sound segment),

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grammar information (features that indicate how the word can be used in larger linguistic contexts, e.g. phrases and sentences), and semantics (the meaning associated with the sound segment) (Jackendoff 2002). For languages with an orthographic tradition, the form part of the word also includes the word's orthography (Levelt 1989). When words are acquired in infancy, children form stable associations between sound and meaning, which are necessary for the word to become part of the speaker's lexical inventory. Word learning has been shown to depend on multiple instances of exposure to the word, in varied contexts. Perfetti and Hart (2002) and Perfetti (2007) suggest that multiple encounters with the word ensure the creation of a common core (lexical) representation, which is a nexus of phonological, orthographic and semantic information. Fast and efficient retrieval of a word relies exactly on the quality of all the features which form part of the word representation. Furthermore, recent longitudinal research suggests that individual word mastery (comprehension and production) is characterized by specific spatio-temporal signatures, and does not rely solely on the word's frequency in the infant's environment (Roy et al. 2015).

Word knowledge develops early in infancy and successful comprehension and production of words is an important milestone in early language acquisition. A crucial step along the path of acquiring words is the infant's ability to associate a phonological form with its referent. Word learning depends on a number of mechanisms, such as mutual exclusivity, which is the ability of the child to map a novel label, rather than an already known one, to a new referent. The syntactic context of a new word has also been suggested to contribute to establishing its meaning (a mechanism known as "syntactic bootstrapping"). Other factors of crucial importance in word learning are speech perception and speech processing (Swingley and Aslin 2007). In fact, Swingley and Aslin suggest that speech processing can impose limitations on early word learning. They show that lexical competition (inhibitory interaction among words in speech comprehension) can prevent children from using their full phonological sensitivity in learning new words. However, other research highlights that semantic and syntactic information can attenuate the inhibitory effect of phonological similarity (Dautriche, Swingley and Christophe 2015).

An important individual factor in word learning is phonological memory and the ability to store and retrieve information about (new) words. Mani and Plunkett (2010) provided evidence of the relevance of phonological similarity for word access (retrieval) as early as 18 months. In that study infants saw images of objects (*cat*) followed by an image of an object, whose label had the same onset as the previously shown object (*cup*) alongside an unrelated distractor image. Infants displayed significantly stronger preference (proportion of looks) for the phonologically related item (*cup*) when they heard the word,

compared to the unrelated object. This and other studies reflect the nature of the infant lexicon and provide evidence of priming from early on in the developing lexicon (Mani and Plunkett 2010).

Two important steps characterize new word learning. The first step is consolidation, which obtains initially from encountering the word to storing it in long term memory. The second, equally important stage is the word's integration in the already existing lexicon, whereby it becomes part of a network of lexical representations. These processes have been documented in both adult (Dumay and Gaskell 2007; Gaskell and Dumay 2003) and child (Henderson et al. 2014) word learning research. In these studies integration was tested based on the strength and time course of phonological competition. Phonological competition is one of the best documented processes which tap lexical knowledge and the nature of the mental lexicon. Adult proficient speakers of a language, upon hearing a word (e.g., *candle*) have been shown to activate phonological neighbors in parallel to the word they are hearing (words with the same onset, e.g., *candy*). Phonological competition is very fast (typically in the first 200 ms.) and is characterized by fast decay (Tanenhaus, Spivey-Knowlton, Eberhard and Sedivy 1995). Lexical competition of this type has been shown to last longer for children, and, unlike adults, children are more likely to yield to phonological competition by selecting a non-target referent (Huang and Snedeker 2011).

Typically, word knowledge is assessed on the basis of vocabulary size (breadth) and vocabulary depth (associations with other words in the lexicon; semantic networks). Both measures reflect a child's lexical skills and competence. It is important to observe that the causal link between vocabulary status and some of the mechanisms that underlie word learning is bi-directional. Thus, while early word learning relies on memory capacity, vocabulary knowledge itself contributes to phonological and short-term memory later in development.

Given this complexity and multiplicity of factors that impact on word learning and processing, as well as the environmental influences on word acquisition, an important question is how words are acquired and processed in developmental deficits. What aspects of word knowledge are compromised and what challenges do impaired individuals experience in understanding and using words? Responding to these questions could also shed light on the nature of word learning, its relation to the acquisition and development of other dimensions of language, and the dichotomy between language and other cognitive processes.

2 Developmental disorders

Developmental disorders are a variety of conditions characterized by impairment of specific aspects of cognitive functioning, including language. Evidence from current research suggests that they are biologically conditioned. However, their etiology remains largely undetermined, and many genes have been implicated in causing disruption of the structures that support language learning and use. The most common and well-studied language-related deficits include language impairment (LI), reading and writing difficulties (dyslexia), and autism spectrum disorder (ASD). Each of these deficits is characterized by a (unique) phenotype representing the cluster of features and impairments at the cognitive level which define the condition. A serious problem with most deficits, however, is the great amount of commonly observed co-morbid overlap of the impairments in the phenotype between conditions. Autism, for example, frequently appears together with language impairment, and language impairment and dyslexia are also frequently co-morbid.

2.1 Language Impairment

Language impairment (LI), currently also labelled developmental language disorder (DLD), is a developmental disorder that selectively compromises language competencies and skills in affected children. Depending on cut-off points, the deficit is estimated to affect the language development of around 7% of children (van der Lely 2005; Norbury et al. 2016). Children with LI cannot keep up with age peers in their language development and manifest problems in core domains of grammar (syntax and morphology), phonology, as well as oral language comprehension and the lexicon (Rice 2007; Leonard 1998). The accepted definitions of language impairment rest on both exclusionary and inclusionary criteria. The main inclusionary criterion is the observed systematic underperformance in core domains of language relative to age expectations. Among exclusionary criteria, the most important ones are the absence of any obvious language-independent cause for the condition, such as hearing loss or intellectual disability (or overall delayed development). Like many other developmental deficits, LI is characterized by heterogeneity, leading to disagreement concerning whether a core deficit can be identified and how to define the phenotype (Bishop 2004; Leonard 1998; Marshall and van der Lely 2007; van der Lely 2003). Attempts have been made to suggest sub-groups including children with similar profiles of language strengths and weaknesses. At the same time, it is possible to assume that these are just variable manifestations of the same language deficit (Bishop 1997; see Marshall

and van der Lely 2007 for a discussion). Studies using MRI and brain morphometry seem to support the idea of a common core language problem. They have shown that core areas of perisylvian language networks, such as the pars triangularis (adjacent to classical Broca's area) of the left inferior frontal gyrus, are smaller in children with language impairment compared to age-matched controls, and the normal leftward asymmetry in the same networks (left larger than right) is reversed: these structural abnormalities were predictive of language disability in the atypical sample (Gauger et al. 1997).

The majority of children with LI could be included in a group often labelled Grammatical-LI – G(S)LI – which is characterized by specific problems in the domain of morphology and grammar (formal aspects of words and word structure), and to a lesser extent in the domain of the lexicon (lexical knowledge and meaning), with vocabulary knowledge considered a relative strength (e.g., Spaulding, Hosmer and Schechtman 2013). Problems that are widely reported in the research literature include omissions of tense forms of regular verbs in obligatory contexts and frequent substitutions of inflected forms with either bare/root forms (e.g. infinitives), where the language allows a bare form to be used (e.g., English) or other inflected default forms, when it does not (e.g., Italian; Penke 2008). Interestingly, a dissociation can be observed between clear problems in the domain of inflectional morphology contra relatively intact use of derivational morphology and spared lexical knowledge. Furthermore, less problems have been reported for irregular verbs in English (van der Lely and Ullman 2001). This may suggest that for such children the deficit manifests itself in problems with word structure, and the way it encodes grammar information, but not with lexical meaning. However, these findings have not been replicated for other languages with irregular verbal paradigms, such as German, Dutch, Italian and Spanish (Kornilov et al. 2012).

Despite the robust findings of primarily verb inflection problems in English-speaking environments, research on LI in other languages suggests that the manifestation of the deficit is subject to variation, much in the same way as the systematic grammar variation across languages. Thus, Spanish-speaking children with LI, when compared to age-matched peers and younger children matched on Mean Length of Utterance (MLU), demonstrate problems specific to Spanish grammar, namely related to the relatively richer paradigm of nouns, such as adjective agreement inflections, as well as limitations in the use of direct object clitics, which are typical of Spanish syntax and are characterized by dedicated placement in the structure of the sentence (Bedore and Leonard 2001). Also the errors made by Spanish children with LI primarily consist of substitutions of the required form by a neighboring form in the same paradigm and one which shares most grammatical features with the target form, except for one (e.g., target tense and number, but wrong person). Similar problems in noun-related

morphology and object clitics have been reported for LI in French and Greek (Bedore and Leonard 2001). It has also been shown that the size of the inflectional paradigm affects the rate of substitution errors, and richer paradigms with more forms lead to higher substitution rates (Dromi et al. 1999).

There exist multiple accounts of what is causing the disorder. While some accounts view the deficit as primarily morphosyntactic in nature (Clahsen 1989; Clahsen et al. 1997; Gopnik 1999), other accounts attribute the morphology (inflection) deficit to a phonological problem seen in the inability to represent adequately the inflection which is in a weak phonological position at the end of the word. It will appear then that the problem is not a difficulty in suffixation/inflection as such, but rather in the phonological context of the suffix, which places the acquisition and use of that morpheme at risk (Joanisse and Seidenberg 1998, 2003; McClelland and Patterson 2002). A related account links the observed problems to perception and processing problems, which eventually compromise morphosyntax (Joanisse 2004; Leonard 1998). These accounts seem consistent with studies demonstrating a selective auditory perceptual deficit in children with language impairment for brief, but not for long tones in some (non-linguistic) sound contexts (Wright et al. 1997), and with neuroscience research showing smaller volumes or no leftward asymmetry in the planum temporal, adjacent to or comprising the primary auditory cortex, in language-impaired children (Gauger et al. 1997). Other approaches explain the grammar deficit as immaturity of the feature system (e.g. the marking of finiteness) and view the condition as a disruption in the language growth of children with LI (Rice 2007; Rice et al. 1995). Marshall and van der Lely (2007) offer an alternative account motivated by the complexity of language structure. In their computational grammatical complexity (CGC) hypothesis, they attribute the specific deficits found in children with LI to a deficit in representing language complexity at the three levels most relevant for grammar: phonology, morphology, and syntax. While processing accounts face the problem that perceptual deficits are not commonly found in LI children (Bishop et al. 1999; van der Lely et al. 2004), a valid argument in support of such an approach is the robust evidence of a phonological memory and a phonological processing deficit in LI children, also reflected in poor performance on non-word repetition (Bishop et al. 1996; Coady and Evans 2008; Conti-Ramsden 2003; Conti-Ramsden et al. 2001; Conti-Ramsden and Hesketh 2003; Dollaghan and Campbell 1998; Ellis Weismer et al. 2000; Gray 2003).

What is apparent in most approaches, however, is the awareness that morphology (word structure) and syntax are intimately linked to, and interface richly with, phonology, the latter mediating language form at the level of sound. Languages express form and meaning distinctions by means of phonology, and inflection paradigms reflect similarity in phonological form. Thus, word roots which

pattern together tend to inflect similarly by belonging to the same inflection class (paradigm). Sensitivity to this similarity rests on the intersection between phonology and morphology. Supportive evidence of the importance of the phonology/morphology interface comes from a study by Marshall and van der Lely (2007), where they found that consonantal clusters that arise by adding an inflectional suffix/ending were the most likely environment to prevent the production of regular past tenses in English for LI children in a past-tense elicitation task. Furthermore, morphological distinctions encode features of importance for sentence structure (syntax), such as tense, person and number. Thus, compromised sensitivity to any of these interfaces or representations may lead to the core deficits observed in grammar in children with LI.

An interesting finding concerning how words are retrieved in this population is an observed difference between LI children who show a consistent frequency effect for both regular and irregular verbs alike, and control typically developing children who only show this effect for irregular verbs, as would be expected (van der Lely and Ullman 2001). This suggests that in LI, regularly inflected items are stored in the mental lexicon very much like irregular forms. Thus, it may be the case that children with language impairment attempt to retrieve regular forms from the lexicon rather than compute them online. The absence of such a dissociation between regular and irregular morphology, which has been shown in typical populations, has interesting consequences for Pinker's (1998) dual processing hypothesis. The main assumption in this approach is that the default mechanism first attempts to retrieve the (irregular) form from the lexicon, only then to proceed to apply the grammar rule, if no such form can be retrieved. It is then puzzling why language impaired children are not successful in producing the correct regular form, if they tend to store it along with irregular forms.

It deserves notice that some studies also report semantic problems in LI children. A broad range of semantic difficulties have been reported, ranging from problems with the acquisition of novel words, to the storage and organization of already acquired words, to lexical access/retrieval (Brackenbury and Pye 2005). Regrettably, most studies are confined to assessing receptive and expressive vocabulary size, but not so much accompanying semantic difficulties. A study by Gray (2004) documents that existing lexical knowledge, as measured by the Peabody Vocabulary Test (PPVT-III), and fast-mapping ability can identify poor word-learners among a group of LI children, and that problems were specifically related to word production in that group. A study based on a large sample ($N=519$) evaluated longitudinal vocabulary growth in affected and non-affected children (Rice and Hoffman 2015). Children with LI showed lower levels of vocabulary at all assessment time points, and the gap between them and their age peers never closed with time. This study, however, documents that individual variation in both

groups was explained by non-verbal IQ and maternal education level. In addition, in both groups, vocabulary acquisition slowed down around age 12 years, suggesting that children with LI follow an otherwise similar developmental trajectory, despite the receptive vocabulary deficit. Research using ERPs has found that children with language impairment show reduced N400 amplitudes (Sabisch et al. 2006), consistent with weaker lexical representations in this population (for a review, see Friederici 2006). There is also recent evidence that the very process of word acquisition may be compromised. Collisson et al. (2015) found that pre-school children with language impairment were on average significantly worse than typical children on visual paired-associate learning and that the language-impaired children did not demonstrate the expected shape bias in object label learning. Furthermore, individual variation in language outcomes was significantly predicted by visual paired-associate learning skills, but not by other non-verbal or verbal measures, in both the language-impaired children and their age-matched controls.

Lexical processing in language impairment is a relatively new topic in research on this population. Dollaghan (1998) has shown that children with LI need more acoustic information to identify spoken words compared to age-matched peers. In an ERP study Kornilov et al. (2015) document reduced negativity amplitudes (N400) in a group of LI children for phonological competitor words of visually presented targets, as well as for words that were not semantically or phonologically related to the pictured object. There was also a depressed phonological mapping negativity in an early time window, indicative of a deficit in phonological processing or early lexical access. The authors interpret this evidence as support for a multi-dimensional view of the deficit, and explain the pattern of performance in light of a neuroplasticity account of neurodevelopmental disorders, whose deviant response patterns can be explained as the result of impaired language development, which, in turn, alters the brain circuits that support language growth and use (Bishop 2013).

Indeed, children with LI have been shown to experience problems in the very process of word learning. They seem to have difficulties in word consolidation (Kan and Windsor 2010). Furthermore, their vocabularies appear to be characterized by greater instability and increased lexical uncertainty, most likely as a result of increased competition effects and fast lexical decay of the target word (McMurray, Samuelson, Lee and Tomblin 2010; McMurray, Munson and Tomblin 2014). For a recent comprehensive review of lexical learning and processing in developmental language impairment, see Nation (2014).

From the concise review above it becomes evident that children with LI manifest problems in both the acquisition of word structure and detecting and using word structure in grammar (e.g., applying inflectional rules). In accounting for

the insight into language structure and its biological basis offered by grammatical impairment, van der Lely and Pinker (2014) suggest that a distinction can be made between “extended” and “basic” morphology/phonology/syntax. On this distinction, children with LI demonstrate relatively spared abilities in the basic domains, e.g., perception of individual sounds, storage of morphemes (roots) and lexical items, but display compromised skills in the “extended” domains, which require the online computation of complex forms. However, emerging evidence suggests also deficits in the storage and organization of lexical knowledge (e.g., semantic skills), and in the access and retrieval of words (Nation, 2014). Such problems, are also more prevalent in a group labelled “poor comprehenders”, which will be addressed below.

2.2 Williams Syndrome

Williams Syndrome (WS) is a rare developmental disorder characterized by relatively spared language abilities and compromised spatial cognition and motor skills (Bartke and Siegmüller 2004; Lukács 2005). Traditionally, WS has been seen as diametrically opposed to language impairment when comparing their contrasting cognitive and language profiles. Thus, together LI and WS are often used to argue for a double dissociation between language and the rest of cognition. Detailed studies, however, suggest that aspects of language may also be affected in WS. Of interest for the current chapter is the attested strength in domains of vocabulary knowledge where individuals with WS show superior performance compared to controls (Bellugi et al. 1990). Studies that have documented this strength have used semantic fluency tasks (e.g. subjects are asked to provide as many examples as they can of a given semantic category, such as animals). The interesting observation is that children with WS displayed atypical responses in those first studies. Subsequent research has failed to show any group differences between participants with WS and typical controls concerning response typicality or frequency (Jarrold et al. 2000; Levy and Bechar 2003; Scott et al. 1995).

Individuals with WS have also been shown to process homonyms/homographs atypically. In a task that involved pairing a homonymous word with one of its possible readings, children with WS failed to associate the word with its more frequent sense (Rossen et al. 1996). However, these results are open to interpretation and are possibly related to the nature of the task.

One study documents increased semantic priming, as judged from increased late positivity in WS participants in response to auditorily presented stimuli, only in the sentence-final condition where words were congruent with

the preceding sentence. For the anomalous words condition, however, responses in the WS group were comparable to those of controls (Neville, Mills and Bellugi 1994). These results are, however, challenged by a later study, which shows normal semantic priming effects in WS (Tyler et al. 1997).

Thus, the picture that emerges concerning semantic skills in Williams Syndrome is controversial. On the one hand, specific strengths in vocabulary knowledge have been reported, while on the other, there is recent evidence that vocabulary acquisition in that population is not typical, and, quite likely, children with WS rely on different mechanisms compared to typical children (Brock 2007). One conclusion is that, with development, the advantage at receptive vocabulary skills is apparently enhanced, and this is what has probably given rise to the original reports of an unusual vocabulary strength.

2.3 Autism

Autism is a neurodevelopmental disorder characterized by deficits in social reciprocity and communication and by repetitive and restricted patterns of behavior (Lord et al. 2000; DSM-5). Autism spectrum disorder offers vast heterogeneity, not in the least regarding the language profiles of individuals on the spectrum, ranging from highly verbal on the higher end, to non-verbal on the lower end (Rapin et al. 2009; Kjelgaard and Tager-Flusberg 2001). For this reason, and due to the similarity with the profile that defines language impairment, recent accounts consider the co-occurrence of language problems with autistic symptomatology as an instance of co-morbidity with language impairment (the ASD + LI group) (Kjelgaard and Tager-Flusberg 2001).

Individuals in the high-functioning autism (HFA) group, which includes persons with Asperger's syndrome, are characterized by largely intact structural language, including adequate grammar and vocabulary size. Another current label for this part of the spectrum is highly verbal individuals with autism. Even though no problems have been reported in core grammar domains (morphology and syntax) in that group, subtle dissociations within these domains have been observed. Thus, a study of Finnish adolescents with Asperger's syndrome documents a significant difference from controls on the comprehension of instructions (Saalasti et al. 2008). This is surprising in view of the otherwise intact syntax competence in such participants (e.g. knowledge of imperatives). However, a possible explanation for this result may be the communicative value of instructions as requests for action and a possible failure by participants to read the intentions of the speaker.

Some studies attest a specific strength in highly verbal participants with autism in the domain of morphology. These strengths manifest specifically in aspects of word form and in the ability to detect grammar patterns and the regularity in inflectional paradigms (Smith and Tsimpli 1995; Vulchanova et al. 2012a, 2012b; Walenski et al. 2014). This strength is further corroborated by a talent for learning the grammars of second languages found even in individuals on the lower end of the spectrum (Smith and Tsimpli 1995). The specific advantage in regular morphology evident in the HFA profile applies to the detection and production in required context of regular and sub-regular tense forms, as well as plural forms of nouns. Vulchanova et al. (2012b) document a significantly superior performance by a highly verbal adolescent with autism in comparison with a group of age-matched controls, particularly for sub-regular past tense forms of verbs. These findings are consistent with the results in Walenski et al. (2014), where a group of highly verbal participants with autism displayed smaller latencies on producing regular verb forms in English compared to similarly aged controls. The authors explain faster responses by the ASD participants in terms of a deficit in inhibition. This is couched within the dual processing hypothesis (Pinker 1998) and the procedural deficit hypothesis (Ullman 2004; Mostofsky et al. 2000), where the first step in producing the correct form involves an attempt to retrieve a stored form, as applicable to irregular verbs. If retrieval of this form fails (e.g., if no such form has been stored), then a regular form can be computed online. Thus, it seems that individuals with HFA are too fast to proceed to the second stage by-passing the retrieval stage, or rather, failing to inhibit direct generation of a regular form. This tendency is further explained in terms of a deficit in frontal/basal ganglia circuits that underlie grammar (for converging evidence on the role of basal ganglia anomalies in autism, see Sears et al. 1999; Qiu et al. 2010; Estes et al. 2011). An alternative explanatory account, however, is offered by the weak central coherence hypothesis (Frith and Happe 1994; Happe and Frith 2006), where the local processing bias in autism can confer a strength at pattern detection of the type necessary for regular and, possibly, sub-regular, grammar inflection (Vulchanova et al. 2012b).

Given the social and communication impairment in autism, an interesting question is whether it affects the way such children learn words. Vocabulary size and word knowledge have been systematically found to be a strength in autism. Furthermore, children with autism typically do not manifest problems in word learning and can use mutual exclusivity as a mechanism in word-learning similarly to typically developing children (Rescorla and Safyer, 2013; Marchena et al. 2011; Eigsti et al. 2007). Still, an interesting difference in word learning has been observed between children with autism and typically developing children. On the assumption that word learning involves the successful

association between phonological pattern and meaning mediated by social cues provided by the context, Norbury et al. (2010) tested how these aspects of words affect the process of novel word learning in verbal children with autism compared to typical controls. While the typical children were more attentive to the social cues in the context, the children with autism were more sensitive to the formal (phonological) aspects of words, suggesting a deviant pattern of word learning. They were also less successful than the controls in vocabulary consolidation reflected in acquisition of both phonological and semantic information four weeks after the learning session. These results suggest a specific advantage in the formal aspects of words (phonological pattern), as well as in perceptual processes (e.g., imagery) associated with semantic decisions (Gaffrey et al. 2007), and a deficit in semantics (word meaning). As such they are consistent with the advantage at acquiring and using regular and sub-regular inflectional morphology and a sensitivity to the formal patterns of language. They are also consistent with findings in research of poor multisensory temporal integration in autism, reflected in the way information from multiple modality sources (e.g., auditory and visual perception) is integrated, which may affect the way sound patterns and meaning are associated in word-learning (Stevenson et al. 2014). Previous research has also established superior orthographic processing in autism regardless of language status, with a significant overlap between the group of precocious readers (hyperlexia) and autism traits (Nation 1999). This provides further support for the advantage at formal aspects of words contra word semantics, and a dissociation between these two in the autistic profile. Such dissociations in clinical populations have inspired the independent lexical access model proposed by Caramazza (1997).

The advantage at formal aspects of words, however, can also have adverse effects on word learning. A study by Henderson, Powell, Gaskell and Norbury (2014) aimed to establish whether individual differences in vocabulary knowledge in ASD might be explained by problems in the consolidation, and especially the integration of newly learned words with already existing vocabulary. The group with autism demonstrated similar success at novel spoken word recognition and identification 24 hours after training, suggesting adequate initial consolidation. However, the participants with autism only showed immediate phonological competition for the novel words, but unlike the typical participants, did not display competition effects 24 hours after training. These results suggest problems in the process of word learning, especially regarding subsequent lexical integration. Also, the presence of immediate phonological competition may be potentially problematic for the storage of lexical items. This is reminiscent of the findings from typically developing, albeit much younger, children (Swingley and Alsin, 2007).

Knowledge of highly idiosyncratic and specialized vocabulary has been reported in autism (Volden and Lord, 1991; Rouhizadeh et al., 2014). Often discrepancies are found between receptive and expressive measures, with receptive competence and comprehension being more affected (Lord and Paul 1997). However, such findings are contradictory, with some studies showing no such discrepancy (Kjelgaard and Tager-Flusberg 2001). Still, the latter study documents great heterogeneity in performance on a comprehensive battery of language tests (receptive vocabulary – PPVT, expressive vocabulary – EVT, receptive and expressive grammar – CELF), thus establishing three sub-groups of children: those with no language impairment, a borderline group and a group with language impairment.

Despite the overall vocabulary strength, a commonly observed phenomenon is a deficit in interpreting word meaning, especially in context (Frith and Snowling 1983; Happé 1997). These findings are based on studies of ambiguity due to the existence of homographs in language. Thus, younger children with autism showed a tendency to read the frequent pronunciations of homograph words regardless of context. In a similar way, Joliffe and Baron-Cohen (1999) found a deficit in the integration of sentence information for the purpose of identifying the correct reading of the homograph. However, other studies have shown that competence at making use of context depends on language status, and children with higher verbal age can perform at the level of controls (Snowling and Frith 1986). Success in that group may also depend on the exact position of the homograph in the sentence. Lopez and Leekam (2003) found that even though children with ASD performed worse than controls, they were more successful with homographs occurring later in the sentence (middle or end), suggesting sensitivity to context also in that group. A study by Brock et al. (2008) showed that participants with autism display a tendency similar to controls to use predictions based on the meaning of the lexical verb, as reflected in an increase in looks to a picture matching the object of the verb. At the same time both groups were less likely to be distracted by a phonological competitor of the object word. This tendency, however, was mediated by language status in the autism group. In that study, context was restricted to the level of the sentence, with a focus on the information encoded in the lexical verb and the ability to use that information to successfully orient to the possible object.

The notion of context has been questioned itself. It appears that highly verbal individuals with autism are capable of employing minimal local context, e.g. the phrase or even the sentence (Vulchanova et al. 2012a, 2012b). It seems that it is not the size of the processing domain which is problematic, but rather the number of operations that are needed to arrive at the correct interpretation. Quite likely, the problems reside in integrating grammar and semantic

information, which is distributed and expressed at different loci in the sentence, such as inflections marking tense, aspect, or syntactic function (subject, object), thus taxing the processing system.

Against the problems with word meaning, an often observed strength in the ASD population is a tendency for superior word decoding. Children with autism frequently constitute the greater part of the group of early precocious readers, a condition also known as hyperlexia (Nation 1999; Nation et al. 2006).

The advantage in decoding the formal aspects of words, such as orthography for example, is also evident in studies that address the extent to which highly verbal children with autism can monitor their own reading process. A study by Micai, Vulchanova and Saldana (2019) documents that ASD children perform equally well on detecting spelling errors in a text when explicitly instructed to do so, but fail to detect semantic errors, despite explicit instruction. The same study revealed an atypical gaze pattern in performing the error detection task in comparison to age-, IQ- and comprehension-matched controls.

A consistent problem reported in autism is difficulties with the comprehension of figurative language. Research in this domain documents subtle dissociations between the ability to understand literal expressions and the comprehension of non-literal (figurative) language. For instance, high-functioning individuals with autism with intact structural language skills often fail to understand the meaning of jokes, irony, and idiomatic language (Chahboun et al. 2016a, 2016b; Gold and Faust 2010; Vulchanova et al. 2012a, 2012b; Vulchanova et al. 2015).

Such dissociations between structural language skills and extended uses of language (e.g., figurative language) raise interesting questions concerning theories of the nature and processing of idiomatic expressions. Some theories assume that idioms (which are one instance of figurative language) need to be stored (Bobrow and Bell 1973; Swinney and Cutler 1979). Other accounts highlight idiom decomposability and suggest that idiom interpretation depends on identifying the individual constituents, because most idioms are decomposable (Hamblin and Gibbs 1999). Thus, the idea is that compositional (literal) interpretation proceeds up until a point when a key word is encountered, which provides an indication (the key) of the figurative nature of the expression (Titone and Connine 1999). It is thus suggested that processing and understanding idioms cannot be reduced to lexical access or lexical retrieval only (Cacciari and Tabossi 1988; Gibbs 1992; Vega-Moreno 2001). This type of approach, also known as the configuration hypothesis, assumes that idioms are represented in a distributed way and are processed as complex decomposable expressions. Thus, the processing of figurative language will be similar to the processing of literal (semantically compositional) language (cf. Vulchanova, Milburn et al.

2019 for a theoretical discussion), and no dissociations will be observed in individuals with autism.

Two types of accounts have been put forth to explain the well-attested problems with figurative language comprehension in autism. The first type of approach aims to link the deficit to other traits of the autistic phenotype, e.g., the impaired social interaction or as caused by a deficient theory of mind (Happé 1993, 1995). The other type of approach views the deficit in figurative language as directly arising from language competence and skills. Thus, immature linguistic skills (Gernsbacher and Pripas-Kapit 2012) or impaired semantic abilities (Norbury 2005) can also lead to problems in figurative language. On both latter accounts it is expected that no problems will be evident in the processing of figurative expressions among individuals with autism and with intact language competence, as assumed by the configuration hypothesis and by approaches attributing the figurative language problems in autism to deficient language skills. The evidence from the processing and comprehension of figurative language in highly verbal individuals with autism, however, suggests that language skills may differentially impact on figurative language comprehension at different stages of development in that group. A study by Chahboun et al. (2016a) tested metaphor comprehension in two groups of HF participants with autism, children aged 10–12 and young adults (16–26), compared to IQ- and verbal comprehension-matched controls. The results from the two ASD groups indicated an interesting pattern of differential relationship between language competences and performance speed and accuracy depending on age. While for the older group of participants (young adults with ASD) language skills exerted an influence on speed, for the younger participants (children with ASD), language competences influenced accuracy, suggesting that the experimental design with alternating conditions (auditory vs. visual modality; figurative vs. literal relation between prime and target) was more demanding for the children and required the recruitment of core language skills. This study also documented a deviant developmental trajectory for the ASD group with the young adult individuals with autism performing at the same speed as the child control group. Another finding in research in this domain suggests that more transparent expressions, such as idioms that have a biological basis and are more closely linked to human experience, as well as novel metaphors, are processed more easily. Also processing speed and degree of comprehension appear to decrease in the case of less transparent figurative expressions, where the semantic motivation is lost (Rundblad and Annaz 2010; Vulchanova, et al. 2019).

In sum, the verbal profile of autism is characterized by huge heterogeneity, and this is also reflected in relative strengths and weaknesses regarding word learning and word processing in this population. In word learning, there appear

to be specific problems in the integration of novel words with already existing lexical knowledge in contrast to somewhat heightened sensitivity to formal aspects of words (phonology, morpho-phonology, orthography), and strengths in the initial mapping of novel words to new referents, most likely due to intact associative learning mechanisms (Parish-Morris et al. 2007; Baron-Cohen, Baldwin and Crowson 1997). Problems with semantic aspects of words are also reflected in qualitative differences in the activation of lexical knowledge for the purpose of language understanding. Despite preserved structural language skills and sometimes strengths in grammar, even highly verbal individuals with autism are faced with problems in figurative language comprehension and display a delayed developmental trajectory (Chahboun et al. 2016b).

2.4 Reading deficits (Dyslexia)

Reading deficits manifest themselves as problems specific to the orthographic aspects of words characterized as poor decoding (reading) and/or writing skills. It is commonly assumed that dyslexia is caused by an impairment of a phonological nature, which results in problems in the mapping of visual symbols (letters/orthography) to phonology (sound). Whether the problems reside in impaired phonological representations or limited access to these representations is still open to debate (Ramus et al. 2013). Reading deficits have also been associated with impaired phonological processing, and poor memory span. Like with other developmental disorders, dyslexia has a greater than chance overlap with other disorders, such as LI, ADHD, and dyscalculia (Germanò, Gagliano and Curatolo 2010; Pennington and Bishop 2009).

The cognitive markers of dyslexia/reading difficulty across orthographies appear to be stable. Phonological and phonemic awareness has been identified as a robust indicator of reading skill. However, its influence decreases over time and as the child acquires reading skills. Rapid automatized naming of objects, colors, letters and numbers is the other widely documented competence linked to reading skill, and children with a reading difficulty are typically shown to perform poorly on these tasks. Despite the robust association between rapid automatized naming and reading fluency, its nature is subject to debate. Regardless of the details of perspective, it is logical to assume that rapid automatized naming is a process of accessing the phonological codes associated with words and directly taps the form of words (phonological part of the lexical entry, Levelt 1989). In addition, it taps how automatized the association between the lemma and the morpho-phonological form is. The relevance of the mental lexicon and the strength of associations between form and meaning in words are also highlighted

in models of reading acquisition which describe the process of becoming literate as a process of adding an orthographic lexicon to the already existing oral lexicon (Ziegler et al. 2014). According to the self-teaching hypothesis, each successful decoding encounter with an unfamiliar word provides an opportunity to acquire word-specific orthographic information that is the foundation of skilled word recognition. Thus, phonological decoding acts as a self-teaching mechanism or a 'built-in teacher'.

Thus, apparently, also in reading, language complexity plays out, and more aspects of lexical items are involved than just, say, phonological information. Research on dyslexia suggests that morphology may be impaired in addition to phonology in this group and that their word recognition problems may also reside at the level of morphological processing (Schiff and Raveh 2006). Emerging evidence contributes to the view that also morphological competence may be relevant to the process of orthographic decoding in reading (see Berthiaume and Daigle 2014 for a review), and that spared morphological awareness can act as a protective factor in children and adults with a reading deficit. A study of morphological awareness in participants with dyslexia, by Law, Wouters and Ghesquière (2015), found a morphological awareness deficit in the dyslexia group. This study also demonstrates that morphological awareness significantly predicts a greater proportion of the variance in reading and spelling skills in the dyslexia group, and furthermore that intact morphological skills contribute to acquiring compensation in adults with dyslexia. In summary, the structure of words at different levels of granularity (individual sounds, syllabic structure, morphological structure) and how this structure is encoded in the word orthography impact on the acquisition of reading skills in typical readers and may present problems for individuals with a reading deficit (Seymour, Aro and Erskine 2003).

2.5 Poor comprehenders

Poor comprehenders (PCs) are children who experience reading comprehension problems in the presence of adequate word decoding (reading) skills. This group has received attention only recently and has often gone undetected, as a result of the widely held view of a strong relationship between decoding ability and reading comprehension. Yet, decoding and reading comprehension have been found to have different independent predictors (e.g. Elwér, Keenan, Olson, Byrne, and Samuelsson 2013), and a recent meta-analysis aimed at determining what factors influence the strength of the relationship between decoding skill and reading comprehension skills in English, suggests that the relationship

between these two abilities is moderated by age and listening comprehension (García and Cain 2014).

Oral (listening) comprehension is supported by both lower-level skills, such as vocabulary knowledge and grammar competence, and verbal memory, as well as higher-level skills, such as inferencing and literal language interpretation. These skills have been found to be reliable predictors of later reading comprehension in typical children (Silva and Cain 2015). Among them, inference skills, grammar and literal comprehension measured prior to school entry independently contribute to reading comprehension in the first year of school (Silva and Cain 2015).

Both vocabulary breadth and vocabulary depth have been shown to predict reading comprehension skills. However, interestingly, word knowledge influences text understanding by predicting higher-level comprehension skills, such as inferencing (Cain and Oakhill 2014). While it would be normal to expect problems primarily on the side of vocabulary knowledge and semantic (conceptual) knowledge in poor comprehenders, other factors that affect oral and reading comprehension ought to be considered as well. Thus, a recent study found that, compared to the typical children, the group of poor comprehenders was characterized by a weakness in morpho-syntax (i.e., finiteness marking of verbs) which could not be explained by overall semantic factors (Adlof and Catts 2015). More recent evidence is suggestive of problems in the domain of grammar. Thus, compared to a group of average comprehenders, the children with poor comprehension demonstrated a weakness in meta-linguistic tasks involving morphology and syntax (Tong, Deacon and Cain 2014). Thus, poor comprehension appears to have an overlap with language impairment in that various aspects of the language system are affected and in that children with poor comprehension exhibit impairment in both semantic, as well as morphological aspects of words. This may explain why this group can be classified as a subset of the category of language impaired children. This is confirmed by findings of impaired phonological (verbal) memory in the group of poor comprehenders, suggestive of concomitant language impairment rather than the direct cause of the comprehension problem (Nation et al. 1999). Also, on the component model of language-related deficits (Ramus et al. 2013), the population with LI only are identified as children with problems in oral language only (i.e., poor comprehenders), while children who, in addition, experience problems with written aspects of language (e.g., word orthography) are characterized by co-morbidity with dyslexia ((S)LI + dyslexia group).

3 Comparing the profiles

An interesting pattern of strengths and weaknesses thus emerges across the profiles of the language-related developmental deficits reviewed here. For instance, the problems experienced by children with language impairment appear to be orthogonal to the weaknesses in the profile of highly verbal individuals with autism. While in LI, the most consistently observed problems apply to online computation operations and constructing morphologically complex forms, in HFA the formal aspects of words (phonology, morpho-phonology) are a relative strength. Regarding semantic skills, deficits in that domain are more frequently reported in HFA, while in LI the picture is more complex, with some evidence of a deficit primarily in vocabulary growth. Interestingly, both children with developmental language deficits and children with autism appear to have problems with the consolidation of novel labels and the integration of new words in the mental lexicon. Also, in both populations, word processing (activation and competition) appear to be deviant, suggesting differences in the structure and operation of the mental lexicon in comparison with typical populations.

Another orthogonal pattern emerges between children with dyslexia and poor comprehenders. While in dyslexia, the problems reside in word decoding as a result of problems in mapping visual symbols (orthography) to sound and, quite likely, problems with the grain (internal) structure of words, in poor comprehenders, the problems are primarily of a semantic and conceptual nature and also relate to aspects of oral language competence, including grammar (morphology). These observed patterns of selective impairments of specific aspects of words and specific mechanisms which support word learning (consolidation, integration) and use (word activation) reflect the complexity of the language system itself and are suggestive of subtle dissociations within the sub-modules of language structure, rather than of dissociations between language and cognition, as previously assumed.

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