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Title Sensory profiles in school-age children with Developmental Language Disorder

Short title Sensory, DLD

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Abstract

There has been limited research on identifying and understanding co-occurring challenges associated with Developmental Language Disorder (DLD). This is an exploratory study to examine the sensory profile of school-age children with DLD, and to investigate possible relationships between sensory profiles and language skills. Chart information was extracted for 28 children (*Mean* = 6 years 11 months) who attended a language specialist school in Australia. The children's sensory profile was compared with normed data, and associations between sensory and language skills were investigated. Probable or definite difference to sensory stimuli was reported on 60% of the children. There was no correlation between sensory responses and language skills. Identifying and understanding the relationship of co-occurring features associated with DLD aids in future development of interventions to better support children with DLD.

Sensory profiles in school-age children with Developmental Language Disorder

Developmental Language Disorder (DLD), formerly known as Language Disorder (American Psychiatric Association [APA], 2013), and Specific Language Impairment (see Bishop, Snowling, Thompson, Greenhalgh, & Catalise consortium 2017, for a discussion), affects approximately 4-8% of children (Norbury et al., 2016; Tomblin et al., 1997; Weindrich, Jennen-Steinmetz, Laucht, Esser, & Schmidt, 2000). Children with DLD have functional language impairments that have no obvious cause (Bishop, Snowling, Thompson, Greenhalgh, & Catalise consortium, 2016). Diagnosis of DLD is associated with challenges in educational attainment, mental health, and employment (Law, Rush, Schoon, & Parsons, 2009; Snowling, Adams, Bishop, & Stothard, 2001). While the impact on communication has been widely acknowledged in diagnostic criteria (e.g. American Psychiatric Association, 2013), secondary challenges have received comparatively less investigation. Understanding secondary challenges is important for understanding and identifying ways to best support children with DLD which may impact on outcomes, goals for interventions, and design and delivery of appropriate interventions and supports. Thus, the aim of this research was to explore sensory responses within children with DLD.

A child's sensory profile generally refers to their behavioural responses to sensory information (taste, smell, auditory, visual, touch, balance and movement) across daily activities (Little, Dean, Tomchek, & Dunn, 2016). Atypical sensory modulation profiles may include hypo- (under responsiveness), and hyper-responsiveness (over responsiveness) to sensory input, and sensory seeking behaviours with differing profiles occurring across and within sensory modalities (Baranek, Fabian, Poe, Stone, & Watson, 2006). Although atypical sensory responses have been reported in the typically developing children these behaviours appear to be more common in children with developmental disabilities (Little et al., 2016). In particular, high rates of atypical sensory responses have been reported in children with autism

spectrum disorder (ASD), and attention deficit/hyperactivity disorder (ADHD) (Engel-Yeger & Ziv-On, 2011; Mimouni-Bloch et al., 2018; Simpson, Adams, Alston-Knox, Heussler, & Keen, 2019). These differing sensory response behaviours have been associated with child functioning and learning outcomes (Dunn, Little, Dean, Robertson, & Evans, 2016).

Identifying if children display atypical sensory responses is important for providing appropriate supports for children with developmental disabilities. Previous research has identified sensory differences have been negatively associated with academic outcomes, activities of daily living, play and leisure behaviours, social interaction, motor performance, activity competence, sleep behaviours, and anxiety (review Dunn et al., 2016). Watson et al., (2011) reported an association between atypical sensory responses and poorer language skills in children (*Mean* 48.1 months) with developmental disabilities. Although this group included children with DLD, they were not identified as a separate group making it problematic in generalising to this population. Little is known about the sensory profile of children with DLD, with only one study identified investigating this area (van der Linde et al., 2013).

van der Linde et al. (2013) used the caregiver-completed Sensory Profile (Dunn, 1999) to investigate the sensory profile of 22 children (5-11 years) with DLD. Significant differences on all measures in children with DLD were found when compared with the normed population. In particular, over 80% of children demonstrated difficulties in modulating their response to sensory input which affected their emotional responses to the situation. This suggests, children with DLD may demonstrate differing responses to sensory stimuli. This provides important preliminary information and highlights the importance of assessing the sensory profile of children with DLD. However, the diagnosis of primary speech and language disorder was based on speech and language therapist report and special education needs report status, and the severity of the children's language impairment was not verified using standardised tools. Further research is clearly needed to replicate these findings

in a group of children whose DLD diagnosis was confirmed through a norm-referenced language assessment.

In summary, DLD is a common neurodevelopmental disorder characterised by unexplained impairments in functional language. It is associated with poor long-term outcomes, thus understanding factors that may impact on outcomes is valuable for informing future interventions and supports for individuals living with DLD. To date, limited research has investigated potential secondary challenges in sensory processing that may be associated with the primary impairment in language. Sensory differences are commonly reported in other neurodevelopmental conditions and whether this generalises to children with DLD is as yet unknown. The aim of this study is to investigate the sensory profile of children with DLD using a norm-referenced tool, the short sensory profile (McIntosh, Miller, & Shyu, 1999). The following questions were asked:

- 1) How do school-age children with DLD perform on the Short Sensory Profile (SSP)?
- 2) Are there correlations between children's performance on the SSP and their language skills.

Method

Participants

This study used a chart review to identify a sample of children from a language specialist school in Australia. This school provides curriculum instruction based on the Australian Curriculum to children who have an identified DLD through assessment by a multidisciplinary team of speech pathologists, occupational therapists and psychologist. Programs are individualised to support each child. Children with DLD at the school perform below two standard deviations on a standardised language assessment and have a non-verbal IQ greater than 70 on a standardised cognitive assessment. The language difficulties cannot

be accounted for by other conditions (e.g. hearing loss, physical impairment) (see Ziegenfusz et al., 2018). Two research assistants reviewed the physical records of the students. The details of family demographics and assessment data were extracted and de-identified. The data were placed in SPSS then cross checked by the third author for reliability. Ethical approval for this study was obtained from <removed for blind review> University's Research Ethics committee and the school's research committee.

Initial review identified 55 children with language and sensory measures. Inclusion criteria were having a verified diagnosis of DLD (the education system in <removed for blind review> uses the terminology of Speech-Language Impairment for funding purposes). Children were excluded if their language skills were not significantly delayed, which was operationally defined as two standard deviations below the mean based on their core language score measured on Clinical Evaluation of Language Fundamentals 4 (CELF-4; Semel, Wiig, & Secord, 2006). To reduce the potential of confounding effects, children were excluded if they had a co-occurring diagnosis including ASD and/or intellectual impairment. From the sample of 35, children were further excluded if there was a time difference of more than two years between administrations of the standardised measures. The final sample consisted of 28 children aged between 5 years 1 month and 10 years 1 month ($M = 6;11$, $SD = 1;2$), of which 9 were female and 19 were male. Children had been enrolled at the school between two and seven years ($M = 3$ years 4 months, $SD = 1$ year 8 months). English was predominantly (89%) the first language spoken in the home. Children spoke English as their first language and appropriate steps were taken in language assessments to account for their exposure to other languages. The majority of parents (mothers 93%, fathers 82%) had post-school qualifications.

Measures

Short Sensory Profile (SSP; McIntosh et al., 1999). The SSP is a parent-report measure of children's (3-10 years) response to sensory experiences within their daily context. The 38-items address seven sensory domains. Tactile Sensitivity has seven items (e.g. "expresses distress when grooming"), Taste/Smell Sensitivity has four items (e.g. "will only eat certain tastes"), Movement Sensitivity has three items (e.g. "becomes anxious or distressed when feet leave the ground"), Underresponsive/Seeks Sensation has seven items (e.g. "enjoys strange noise/seek to make noise for noise's sake"), Auditory Filtering has six items (e.g. "can't work with background noise"), Low Energy/Weak has six items (e.g. "poor endurance/tires easily") and Visual/Auditory Sensitivity has five items (e.g. "covers eyes or squints to protect eyes from light"). Scoring is on a Likert scale of 1 = always and 5 = never with lower scores indicating probable or definite difference, while higher scores indicating within typical range. Comparison to normative data provide scores for each domain and for overall sensory profile. Internal consistency of overall and subdomain sections of the profile has been reported as ranging between $r = .70-.90$ along with acceptable discriminative validity (95% in differentiating children with and without sensory impairments; McIntosh et al., 1999).

Clinical Evaluation of Language Fundamentals – Fourth Edition (CELF-4; Semel et al., 2006). This assessment is a norm-referenced measure conducted with individuals 5.0-21.11 years to diagnose and determine the nature of DLD. The subtests evaluate strengths and weaknesses in a range of language areas including semantics, morphology, syntax, pragmatics and classroom language skills, which yield composite scores. The core language, receptive language, and expressive language standard scores ($M = 100$, $SD = 15$) are used in this study. The CELF-4 demonstrates strong psychometric properties in the Australian standardisation, including test-retest reliability ($.77-.94$), internal consistency ($.70-.92$), and inter-scorer reliability ($.99-1.0$) (Semel et al., 2006).

Procedure

The CELF-4 was administered by certified practising speech pathologists and the SSP was completed by parents or caregivers and scored by registered occupational therapists. Both groups of professionals were employed by the language specialist school. The data were collected routinely at enrolment or as outcome measures.

Results

Data Screening

The data for the 28 retained participants were screened for missing data and for meeting assumptions of parametric analysis. There was < 1% missing data which appeared to be missing completely at random (Little's MCAR test chi-squared = 108.00, $df = 128$, $p = .90$, *ns*). Data was consequently deleted listwise from each analysis as is acceptable under these conditions (Tabachnick & Fidell, 2007). Data were observed to meet other assumptions for parametric statistics with no major violations of skew or kurtosis or outliers detected (all using $z = 3.29$). Data analysis was run with z scores for the SSP to determine if this impacted on outcomes. There was no difference between z scores and raw scores, therefore, raw scores were used for ease of interpretation.

Sensory Response Scores

The response of participants on each sensory domain and their overall total sensory response score on the short sensory profile is displayed in Table 1. This includes the mean, standard deviation and group range of scores for participants' performance as well as the normed typical range (McIntosh et al., 1999). The overall mean score was lower than the typical range indicating overall more sensory differences. The mean domain scores for tactile sensitivity, underresponsive/seeking sensation, auditory filtering, and low energy/weak were below the typical range suggesting overall more sensory differences in these domains. Mean scores were in the typical range for the taste/smell sensitivity, movement sensitivity,

visual/auditory sensitivity domains. Standard deviation and range scores indicated some children were outside the typical range on all the domain areas.

[Table 1 goes about here]

Further investigation was conducted to explore the individual differences. Following the example used by Lane, Young, Baker, and Angley (2010) example Figure 1 shows the percentage of children showing responses within the typical, probable difference (1 SD or more from the normative data) and definite difference (2SD or more from the normative data) on the short sensory profile domains and total sensory scores.

[Figure 1 goes about here]

When compared with normative data, at least half the participants demonstrated typical performance on the domains tactile sensitivity (50%), taste/smell sensitivity (60.7%), movement sensitivity (67.9%) and visual/auditory sensitivity (64.3%). Less than 22 % of the participants showed definite differences on these domains. Over half the participants showed differences on underresponsive/seeking sensation (57.1%), auditory filtering (75%) and low energy/weak (62.5%) with definite differences highest on the auditory filtering (60.7%) and low energy/weak (53.1%) domains. On the total score population split there was a similar distribution within typical difference (39.3%) and definite difference (42.9%).

Language

The mean score on all measures was more than 2 SDs below the typical range (i.e. standard scores < 70). Scores were reported on CELF-4 core language standard score ($M = 49.71$, $SD = 8.69$, range = 40 - 66); CELF-4 receptive language standard score CELF-4 ($M = 58.43$, $SD = 10.69$, range = 45-77); expressive language standard score ($M = 51.85$, $SD = 11.60$, range = 11- 68).

Correlations

The relationship between sensory and language behaviours was investigated using Pearson's r . There was no significant correlation between SSP total raw scores and language scores measured using CELF-4 core language standard score $r = -.84, n = 28, p = .67$, CELF-4 receptive language standard score $r = -.29, n = 28, p = .13$, and CELF-4 expressive language standard score $r = -.19, n = 28, p = .34$.

Discussion

This is the first study, to the authors' knowledge, that used the SSP to explore the sensory profile of children with DLD, and to investigate if there was an association between the child's sensory profile and language skills (core language, expressive skills and receptive skills) using standardised measures. The charts from 28 children with a verified diagnosis of DLD were reviewed. Based on the overall sensory profile, 60% of the participants in the current study experienced probable or definite differences in response to sensory stimuli. There was variability across the seven domain areas with the highest probable or definite differences reported on auditory filtering (75%), low energy/weak (62.5%) and underresponsive/seeks sensation (57.1%). In contrast, the majority of children with DLD performed within typical range on the four sensitivity-related scales supporting the findings of van der Linde et al. (2013). There was no significant association between sensory responses and language skills.

The high percentage of children in this study demonstrating differences with auditory filtering is not surprising given children with DLD have been reported to demonstrate similar profiles to children who show auditory processing challenges (Iverson & Braddock, 2011). This is further supported by the reported association between auditory processing and poor communication performance (review deWit et al., 2016). There were, however, 25% of children who demonstrated typical responses to auditory filtering, indicating this is not universal in children with DLD. It is also not specific to DLD, as differences in responses to

auditory filtering have also been reported in children with differential diagnoses including children with ASD (Ashburner, Ziviani, & Rodger, 2008; Lane et al., 2010) and children with ADHD (Mimouni-Bloch et al., 2018). This would suggest that atypical responses to auditory filtering may be present and common in children with neurodevelopmental disorders, rather than being specific to a diagnostic condition.

More than sixty percent of the participants (62.5%) reported atypical responses on the low energy or weak domain. This domain relates to poor endurance and poor muscle strength. There was a higher percentage of children with difficulties in this area compared to the 50% reported by van der Linde et al. (2013). These differences may be due to cultural and environmental influences on caregiver perceptions of their child's responses. For example, Caron, Schaaf, Benevides and Gal (2012) identified significant differences in reporting with caregivers from the United States identifying higher rates of atypical responses than Israeli caregivers.

The third domain where differences were reported was underresponsive/sensory seeking (57.1%). This response was similar, although slightly more elevated than sensory seeking rates for DLD reported by Van der Linde et al (50%). While there has been little research in DLD, atypical under responsiveness and sensory seeking behaviours have been associated with low language and communication scores in children with ASD and children with developmental delay (Patten, Ausderau, Watson, & Baranek, 2013; Tomchek, Little, & Dunn, 2015; Watson et al., 2011). In particular, hyporesponsive and sensory seeking behaviours were more evident in children with ASD who were nonverbal (Patten et al., 2013) and greater differences in sensory seeking behaviours have been associated with poor receptive language skills (Tomchek et al., 2015). As proposed by Watson et al. (2011) under responsiveness and sensory seeking behaviours may be more related to developmental

abilities than to specific diagnostic conditions, with these sensory behaviours impacting on learning opportunities as these children may miss or not register relevant/significant input.

The children, despite all fitting the DLD classification, demonstrated a heterogeneity in sensory profiles ranging from within typical range to definite sensory differences. There was no reported association between total sensory behaviours and language skills based on the CELF-4. This heterogeneity of sensory profiles appears to be consistent with reported findings from sensory subtype studies in children with ASD, other developmental conditions and typically developing children (DeBoth & Reynolds, 2017; Little et al., 2016) where differing subtypes within groups have been identified. This appears to be separate to the diagnostic criteria. For example, Simpson et al. (2019) found autism severity was not associated with sensory behaviours. This suggests while sensory subtypes may be more pronounced in certain neurodevelopmental conditions, they are not universal within these conditions. This has important implications for interventionists as sensory subgroups may occur across the population rather than specific to conditions and a focus on the subgroups and impacts of sensory behaviours may better inform intervention practices.

Limitations and Future Directions

While this study provides an important and novel contribution to the literature on DLD and secondary challenges, a number of limitations are acknowledged. First, the sample size, while similar to other studies in the area (van der Linde et al., 2013) is relatively small which may have led to Type 2 errors whereby insufficient power may account for the finding of no significant correlations between language scores and sensory processing. Future research with a larger sample that may be collected across a variety of settings to include a more representative sample of individuals with DLD is recommended to ascertain whether these may be linked in this population. Second, total sensory scores were used. While this was chosen due to the small sample size and to reduce family-wise error from multiple

comparisons, it may have masked potential associations between sensory subscores and other factors. Third the assessments were conducted in a clinical setting rather than for research purposes. Thus, measures were selected based on resources and feasibility to minimise burden on children and families thus reducing the breadth of measures available to comprehensively investigate potential associations. There was no detailed information available regarding the children's home language. Future research using a more comprehensive battery of language and sensory evaluations would provide a deeper investigation of potential interrelations. Nevertheless, the present study provides information from clinically-feasible measures that may thus be generalisable and feasible in other real-world settings.

A number of important implications arise from this study. Our findings provide preliminary evidence that the majority of children with DLD demonstrate sensory challenges and highlight the need for assessment beyond the core impairment in communication in this population. Further, our replication of findings from the full sensory profile with the short version is important for clinical practice and indicates time and resources may be saved by using this shorter version, reducing respondent burden. Further, while the short sensory profile has been used to identify sensory subtypes in children with ASD and ADHD (for example Engel-Yeger & Ziv-On, 2011; Lane et al., 2010; Tomchek & Dunn, 2007), this was the first study identified that has used the short sensory profile to identify sensory responses in a group of children with a confirmed diagnosis of DLD. This provides the opportunity for future comparisons between groups to determine similarities and differences across developmental conditions and furthermore to develop intervention supports which may be specific to sensory profiles rather than specific to diagnostic groups.

Atypical sensory response domains identified as most different in this study have also been identified in other groups and the implications of these differences on child performance

have been investigated. The areas identified as most different in this study (atypical responses in auditory filtering, low energy/weak and underresponsive/seeks sensation) have been identified in a subgroup of children with ASD (Lane et al., 2011) and ADHD (Mimouni-Bloch et al., 2018). In children with ASD and ADHD, these atypical responses have been associated with poorer communication and adaptive skills (Engel-Yeger & Ziv-On, 2011; Lane et al., 2010), lower academic performance (Ashburner et al., 2008), and higher maladaptive and emotional and behavioural problems (Baker, Lane, Angle, & Young, 2008, Mangeot et al., 2001). To what extent this may hold true for children with DLD with similar sensory profiles requires future investigation and would provide important information to assist in planning, adjustments to the learning environment and determination if individual strategies are required.

Conclusion

In conclusion, the focus of much research and clinical attention in DLD has been on the core impairment in communication. However, secondary challenges in sensory responses may impact on broader functioning and outcomes. Our study identified children with DLD show a heterogeneity of responses to sensory input with some children demonstrating definite differences in particular sensory domains. Consequently, there is a need to understand the flow-on effects, particularly since research with other clinical disorders, namely ASD and ADHD, indicates differing sensory responses are associated with challenges such as behaviour difficulties and poorer functioning. Future research to understand the broader strengths and needs of this population will assist in developing more targeted supports, assessments, and interventions that meet the unique needs of this population to improve outcomes for their not-so-specific impairments.

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Table 1.

Participants' Performance on Short Sensory Profile

Domain	Mean	SD	range	Typical range
Tactile sensitivity	28.96	5.34	15-35	30-35
Taste/smell sensitivity	15.64	4.32	4-20	15-20
Movement sensitivity	13.07	2.35	7-15	13-15
Underresponsive/seeks sensation	24.25	6.36	14-35	27-35
Auditory filtering	18.89	5.81	11-29	23-30
Low energy/weak	21.25	7.11	8-30	26-30
Visual/auditory sensitivity	19.04	4.48	11-25	19-25
Overall score	141.11	25.55	80-176	155-190

Note. Raw scores are presented. Typical range as reported in the manual (McIntosh et al., 1999).

Figure 1. Percentage of participants showing typical, probable and definite difference on the short sensory profile