**Symposium Title**: Language, Literacy, and Their Relations with Executive Function in Individuals with Down Syndrome

**Chair**: Susan J. Loveall[[1]](#footnote-1)

**Discussant**: Nancy Raitano Lee[[2]](#footnote-2)

**Overview**: Spoken and written language are two important ways in which individuals communicate with and learn about the world around them. However, individuals with Down syndrome are known to have unique patterns of strengths and difficulties in language and literacy across the lifespan (Abbeduto et al., 2007). Understanding these patterns, as well as individual differences and underlying predictors of success, can help identify important targets for intervention at different points in development. In typical development, executive function skills are one of those underlying predictors, known to contribute to language and literacy development (Nouwens et al., 2021). Despite a well-documented and unique executive function profile of relative strengths (e.g., organization of materials) and difficulties (e.g., working memory) in individuals with Down syndrome (Tungate & Conners, 2021), the relation between executive function and language and literacy has not been well-documented in this population. Thus, the focus of this symposium is to bring together recent research on the language and literacy skills of individuals with Down syndrome across different developmental periods and discuss if and how executive functions intersect with these abilities.

**References**

Abbeduto, L., Warren, S. F., & Conners, F. A. (2007). Language development in Down syndrome: From the prelinguistic period to the acquisition of literacy. *Mental Retardation and Developmental Disabilities Research Reviews*, *13*(3), 247-261.

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**Paper 1 of 4**

**Paper Title**: Language Heterogeneity and Executive Function Links in Children with Down Syndrome

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**Introduction**: Over the past several decades, research on the Down syndrome (DS) language profile has identified relatively stronger pragmatic (i.e., social) language skills than structural (i.e., non-social) language skills (for a review, see Abbeduto et al., 2007). Despite the rich knowledge base on the DS language profile when the group is considered as a whole, far less is known about heterogeneity (i.e., individual differences) in language skills among individuals with DS and the sources of this heterogeneity. Thus, the current research sought to characterize heterogeneity in language skills among children with DS using the Children’s Communication Checklist-2 (CCC-2), a caregiver-report measure assessing real-world structural and pragmatic language functioning. In particular, we sought to (a) contrast structural and pragmatic language skills among participants with DS when the group is considered as a whole and when these skills were considered at an individual level; (b) characterize the degree of heterogeneity observed in structural and pragmatic language skills in children with DS relative to typically developing peers; and (c) examine a possible source of heterogeneity in language functioning among children with DS, specifically executive function skills.

**Method**: Participants were 68 children with DS with phrase speech at a minimum (MAGE = 11.03 years [4.5-16.92], SDAGE = 3.31, PctFEMALE = 54.4%, PctWHITE = 79.4%) and 56 with typical development (TD) (MAGE = 10.0 years [4.1-16.9], SDAGE = 4.2, PctFEMALE = 46.4%, PctWHITE = 83.9%) selected to be of a similar chronological age. Caregivers completed the Children’s Communication Checklist-2 (CCC-2; Bishop, 2003). To reduce the number of analyses, structural and pragmatic language composites were created by averaging scaled scores on the CCC-2 Speech, Syntax, Semantics and Coherence scales, and the Initiation, Scripted Language, Context, and Non-verbal communication scales, respectively. To examine the cognitive correlates of language skills, performance from a subset of participants (n=21) who had completed tasks of cognitive flexibility (NIH Toolbox Dimensional Change Card Sort Test; DCCS; Weintraub et al., 2013), inhibitory control (NIH Toolbox Flanker Inhibitory Control and Attention Test; Flanker; Weintraub et al., 2013), and verbal short-term/working memory (WISC-V Digit Span Forward; DSF; Wechsler, 2014) was also examined in relation to the CCC-2.

**Results**: First, to characterize language profiles, average scores on the CCC-2 structural and pragmatic language composites were examined using a 2 (group) x 2 (CCC-2 composite) mixed model ANOVA. Results revealed a significant interaction between group and composite (F[1,122]=55.55, *p*<.001), such that children with DS demonstrated a pragmatic language advantage relative to structural language skills (t[67]=10.40, *p*<.001), whereas no significant difference between composites was observed in the TD group (t[55]=1.64, *p*>.1). Moreover, Levene’s tests for equality of variance revealed more variance in raw scores in the DS than the TD group (F values ranging from 7.55 to 13.82, all *p*s<.001). Evaluation of within group variance among participants with DS indicated that despite group level evidence for a pragmatic language advantage, heterogeneity within the DS group existed. Specifically, 72.1% of children with DS showed a pragmatic language advantage (operationalized as an average composite score at least 0.5 SD greater on the pragmatic than structural composite), 25% had similar scores on structural and pragmatic composites (i.e., within 0.5 SD on the composites), and 2.9% exhibited a structural language advantage (i.e., structural language composite that was at least 0.5 SD greater than the pragmatic composite). Among children with DS, significant heterogeneity in composite scores was noted, with scaled scores ranging from as low as the instrument floor (48.5% of participants for structural; 20.6% for pragmatic) to within the average range (11.8% of participants for structural; 28% for pragmatic). Finally, partial correlations controlling for non-verbal IQ were executed for participants with available data to examine associations between language skills and executive functioning challenges. A composite score across executive functioning measures was highly correlated with both the CCC-2 Structural (*r*=0.521, *p*<.0.05) and CCC-2 Pragmatic composites (*r*=0.545, *p*<0.05).

**Discussion**: Consistent with the existing literature, participants with DS demonstrated a significant pragmatic language advantage on the CCC-2 – that is, on average, children with DS received higher scores on the CCC-2 Pragmatic than Structural composite. However, heterogeneity among children in the DS group was evidenced. Although 72% of the sample demonstrated stronger pragmatic than structural language skills, a substantial minority did not fit this profile. Moreover, when compared to TD peers, greater variance in both structural and pragmatic language skills was observed in the DS group. A qualitative examination of Structural and Pragmatic language composite scores revealed significant heterogeneity, with scores ranging from the floor of the instrument to within the average range. Finally, executive functioning was associated with both structural and pragmatic language skills in those with DS, highlighting potential links between cognitive and language outcomes. These findings underscore the need to consider individual variability in language skills and associations with other cognitive skills, including executive function, when designing communication interventions for children with DS.

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**Paper 2 of 4**

**Paper Title**: Reading Comprehension Skills of Students with Down Syndrome: Testing an Extended Model of the Simple View of Reading

**Authors**: Susan J. Loveall1,Frances A. Conners[[6]](#footnote-6), Xin Dang[[7]](#footnote-7)

**Introduction**: Despite reading comprehension being the ultimate goal of reading instruction, this skill has not been well-studied in individuals with Down syndrome (DS). This includes the extent to which the cognitive-linguistic profile common to individuals with DS may impact their reading comprehension outcomes. The Simple View of Reading (Gough & Tunmer, 1986) is a well-supported model of reading comprehension in typical development; this model proposes that reading comprehension is predicted by word identification (i.e., identifying printed words) and listening comprehension (i.e., understanding the meaning behind them). The aim of this study was to determine the key components of reading comprehension in individuals with DS. We hypothesized that 1) the original Simple View model would be supported in a sample school-age readers with DS, and that 2) an extended Simple View model, adding cognitive processing subskills (executive function subskills of verbal working memory and attentional control, plus processing speed), would show improved model fit, with these subskills contributing uniquely to reading comprehension outcomes.

**Method**: Sixty-two school aged individuals with DS (age *M* = 14.2 years, *SD* = 2.6, *range* = 9-18 years; 30 females; IQ *M* = 46.8, *SD* = 14.3) completed a series of standardized reading, language, and IQ assessments. Reading comprehension was assessed via the reading comprehension subtests on the Woodcock Reading Mastery Test, 3rd edition (WRMT-III) and the Kaufman Test of Educational Achievement, 3rd edition (KTEA-3). Word identification was assessed via the WRMT-lll basic skills cluster, and listening comprehension was assessed via the Oral and Written Language Scales, 2nd edition (OWLS-ll). Working memory, inhibition/attentional control, and processing speed were assessed via the NIH Toolbox; a second measure of working memory was collected via the memory for digits subtest of the Comprehensive Test of Phonological Processing, 2nd edition (CTOPP-2). Growth scores from the WRMT-lll and KTEA-3 (i.e., raw scores weighted for item difficulty), raw scores from the OWLS-ll and NIH Toolbox, and developmental/growth scores from the CTOPP-2 were used in analyses. Structural equation modeling was used to test the original Simple View and Extended models, and a Chi-square difference test was used to compare the fit of the two models. The models included two measured variables for reading comprehension, one measured variable each for word identification and listening comprehension, and four measured variables for cognitive processing. Maximum likelihood of SEM was used to account for missing data.

**Results**: Analysis revealed that the original Simple View model was supported, with good model fit (Comparative Fix Index, CFI: 1.00; Tucker-Lewis Index, TLI: 1.03; Standardized Root Mean Square Residual, SRMR: .002) and both word identification and listening comprehension contributing to reading comprehension outcomes (*p*’s < .05). The Extended Model was also supported, with good model fit (CFI: .97; TLI = .95; SRMR: .06). In the Extended Model, both word identification and cognitive processing were significant predictors of reading comprehension (*p*’s < .05), but listening comprehension was no longer individually significant (*p* = .19). There was a significant difference between the two models, with the Extended Model showing better fit, *p* = .02.

**Discussion**: Both the Original Simple View and the Extended Model were supported in individuals with DS, suggesting word identification, listening comprehension, and cognitive processing skills, including some executive function subskills, are all important to their reading comprehension outcomes. When compared, the Extended Model had a better fit. Listening comprehension and cognitive processing were strongly correlated (*r* = .78) and may measure overlapping constructs. When both are included in the same model, cognitive processing is the stronger predictor of reading comprehension. Our results suggest that educators, speech-language pathologists, parents, and others who work to help individuals with DS learn to read should provide training in each of these domains. Future research should examine if/how the contribution of each of these skills changes across development and test the efficacy of different intervention strategies.

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**Paper 3 of 4**

**Paper Title**: Effects of Parent-delivered Early Language Intervention on Language, Literacy, and Executive Function in Children with Down Syndrome: Outcomes from a Feasibility Randomized Controlled Trial

**Authors**: Kelly Burgoyne[[8]](#footnote-8), Kirstie Hartwell8, Rebecca Baxter[[9]](#footnote-9), Emma Pagnamenta9, Vesna Stojanovik9

**Introduction:** Finding ways to support language development from an early age is critical for children with Down syndrome. Early childhood is characterised by rapid brain growth and heightened neuroplasticity (Brown & Jernigen, 2012), making this a particularly fruitful time for learning. Further, some of the language and memory difficulties seen in Down syndrome are not present in the early years but emerge downstream and could potentially be ameliorated through early intervention (Roberts & Richmond, 2015). However, very little evidence-based support for early language development is currently available (e.g. O’Toole et al., 2018). PACT-DS is a novel, parent-delivered early language intervention programme which has been developed in collaboration with parents of young children with Down syndrome: This paper reports data from a feasibility randomized controlled trial of the programme.

**Method:** Thirty children with Down syndrome aged 3-6 years were randomly allocated to intervention (PACT-DS oral language programme) and control groups. Parents in the PACT-DS group were trained to deliver the programme in daily 20-minute sessions over 30 weeks. Children were assessed before intervention (t1), after 30-weeks of intervention (t2) and after a delay of 4 months (t3) on a battery of assessments measuring language, early literacy, and executive function skills.

**Results:** Given the nature of the feasibility trial, outcomes are assessed using descriptive analysis, focusing on confidence interval estimation and effect sizes rather than formal hypothesis testing. Data at t2 indicate relatively larger gains for the intervention group on a range of language outcomes at immediate post-test, with effect sizes ranging from -.41 to .54. No effects were observed on a measure of executive function at t2 (effect size -.50). T3 data collection is underway (and will be completed end of October 2024) and will be presented to explore longer-term effects of intervention, and effects on early literacy.

**Discussion:** Findings from the feasibility trial indicate that the parent-delivered early language teaching programme may improve children’s language skills. There is no evidence of effects on executive functioning immediately following intervention. The project advances our understanding of ways to enable parents of young children with DS to support their child’s language development at home and has implications for theory and practice which will be discussed.

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**Paper 4 of 4**

**Paper Title**: Supporting Continued Reading Development in Young Adults with Down Syndrome: Functional Reading Activities to Motivate and Engage

**Authors**: Alison Prahl[[10]](#footnote-10),Kaitlynn Fraze10, Anupama Kannan10, Rodney Sturdivant10

**Introduction**: For young adults with Down syndrome (DS), reading proficiency is an important life skill that contributes to improved quality of life and becoming an active member in society (e.g., Copeland et al., 2016). The current study aimed to evaluate an intervention designed to improve functional reading skills for young adults with intellectual and developmental disabilities (IDD), including those with DS, as they transition from compulsory education to adult life and, hopefully, greater independence.

**Method**: A pilot randomized controlled trial was conducted with 44 young adults (18-26 years of age) with IDD, 14 of whom had a primary diagnosis of DS (20-26 years of age). Participants were randomly assigned to the Functional Reading Activities to Motivate and Empower (FRAME) intervention (*n* =23) or a “business as usual” control group *(n* = 21)*.* The young adults in the treatment group were taught reading comprehension strategies which are known to be effective for struggling readers. The strategies were explicitly taught to be implemented before, during, and after reading across 24 sessions that were conducted virtually using Zoom Version 6.2.3. The strategies were chosen based on empirical evidence on the behavioral phenotype of commonly occurring IDDs (Lemons et al., 2015) and included strategies to address executive functioning challenges. Examples include the use of a graphic organizer to support working memory and organization, using strategies at multiple timepoints to promote planning and prioritizing, and self-monitoring strategies. The primary outcome measure was participant use of the reading comprehension strategies. Additional secondary, distal outcome measures included: (a) multiple choice comprehension questions, (b) written responses to a text message and email, (c) summarization, and (d) verbal responses to functional text samples. Social validity data was collected through interviews immediately following the treatment period.

**Results**: Results from the overall study indicate improvement in the primary outcome—use of reading comprehension strategies and multiple choice comprehension question secondary outcome. Young adults with IDD in the treatment group made statistically significant more gains in use of reading comprehension strategies (*d* = 1.09, *p* = .002) and multiple-choice comprehension questions (*d* = 0.79, *p* = .038) as compared with the control group. The differences in gains in participants’ written responses to a text message and email (*d* = -.065, *p* = .600), spoken summaries (*d* = .46, *p* = .200), and spoken responses to functional texts (*d* = -.42, *p* = .400) between the treatment and control groups were not statistically significant. These nonsignificant results are likely due to the small sample. When evaluating potential covariates that may explain which participants responded positively to the intervention, though not a statistically significant (*p* = .07), the mean score for the primary outcome was much higher in the DS group compared to the autism and other study groups (see Figure below).



Figure 1: Box plots of Intervention Group RC score differences (Post-Pre) by Diagnosis

**Discussion**: Improving functional reading skills throughout the lifespan is critical as it provides a sense of accomplishment and enhances vocational and independent living opportunities for individuals with IDD (Copeland and Keefe, 2016). This study demonstrates the feasibility and social validity of FRAME as well as provides preliminary evidence that the intervention is associated with improved use of reading comprehension strategies that maintains over time for young adults with IDD and may be particularly beneficial for adults with DS. The importance of understanding the differences in learning based on the phenotypic characteristics of DS are discussed. Services typically end during this period; however, it is essential that evidence-based literacy supports are available as this is a skill that continues to develop throughout the lifespan and has the potential to transform an individuals’ transition to adulthood and independence.

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