Title: Receptive and Expressive Syntax Development in Youth with Down Syndrome and Fragile X Syndrome

Authors: Sarah Nelson Potter & Leonard Abbeduto – UC Davis MIND Institute

Introduction: Down syndrome (DS) and fragile X syndrome (FXS) are the leading known genetic causes of intellectual disability (ID). Individuals with DS or FXS also present with significant impairments in multiple domains of language. Several previous studies have shown that individuals with FXS outperform those with DS on measures of both receptive and expressive language (e.g. del Hoyo Soriano, Thurman, & Abbeduto, 2018; Price, Roberts, Vandergrift, & Martin, 2007), with comprehension skills being less impaired than production skills in both populations (Finestack, Sterling, & Abbeduto, 2013). Syntax, in particular, is thought to be more impaired in DS than would be expected based upon level of ID (Martin, Losh, Estigarribia, Sideris, & Roberts, 2013) or level of expressive vocabulary skill (Abbeduto et al., 2003; Laws & Bishop, 2003). However, few studies have examined longitudinal trajectories of language in DS and FXS and thus, the emergence of their language phenotypes is poorly understood. In the current study, we examined the age-related trajectories of receptive syntax (RS) and expressive syntax (ES) in older school-aged children and adolescents with DS and FXS, as well as in younger typically developing (TD) children. A greater understanding of the ways in which language skills develop over time in these populations, as well as what factors may contribute to these skills, will allow for the development of more effective interventions.

Method: We employed multilevel growth modeling to examine the longitudinal trajectory of RS and ES across four annual assessments in adolescents with DS (*N* = 30, *M* age (time 1) = 12.75 years, range = 10-15) and FXS (*N* = 36, *M* age (time 1) = 12.85 years, range = 10-16), and younger TD children (*N* = 56, *M* age (time 1) = 5.74 years, range = 3-8). Females with FXS were excluded from analyses. Total number of blocks passed on the Test for Reception of Grammar, 2^{nd} Edition (TROG-2) provided the dependent measure of RS and raw scores from the Comprehensive Assessment of Spoken Language-Syntax Construction subtest (CASL-SC) provided the dependent measure of ES. Age was centered at the first assessment, such that each participant's age at the Time 1 visit was zero. Covariates included mean-centered growth scores from the Leiter-R and a mean-centered metric of maternal education level. Initially, models were specified separately for each group to examine trajectories of RS and ES, and then diagnostic group was entered into a model as a predictor along with the covariates (i.e., Leiter-R growth scores and maternal education) to examine differences in RS and ES between the diagnostic groups.

Results: At the initial visit, individuals with DS and FXS had significantly lower RS scores (DS: *M* = 2.40, SD = 1.63; FXS: *M* = 3.86, SD = 3.24) compared to TD youth (*M* = 10.61, SD = 5.51). The RS scores of individuals with DS and FXS did not differ from each other at this visit. In contrast, individuals with DS had significantly lower ES scores compared to both individuals with FXS and TD youth at the initial visit (*M* = 6.31, SD = 6.39). Individuals with FXS also had significantly lower ES scores (*M* = 12.82, SD = 9.46) compared to the TD youth (*M* = 22.79, SD = 9.56). For youth with DS and FXS, neither RS nor ES increased significantly with age across the annual assessments (**DS**—RS: $\beta = 0.10$, SE = 0.13, $p = 0.45$; ES: $\beta = 0.13$, SE = 0.22, $p = 0.53$; **FXS**—RS: $\beta = 0.22$, SE = 0.14, $p = 0.12$; ES: $\beta = 0.30$, SE = 0.34, $p = 0.37$). However, unsurprisingly, both RS and ES increased linearly with age for the TD youth (RS: $\beta = 1.93$, SE = 0.17, $p < 0.001$; EV: $\beta = 4.89$, SE = 0.23, $p < 0.001$). Upon specifying a model with diagnostic group as a predictor along with the covariates, we found that the age-related trajectories for the individuals with DS and FXS were not significantly different from each other for RS or ES, but they were significantly different from the trajectories of the TD youth. In addition, Leiter-R growth scores predicted both RS and ES raw scores at the first assessment (RS: $\beta = 0.18$, SE = 0.01, $p < .001$; ES: $\beta = 0.23$, SE = 0.03, $p < .001$), whereas maternal education did not contribute to RS or ES scores (RS: $\beta = 0.25$, SE = 0.26, $p = 0.35$; ES: $\beta = 0.81$, SE = 0.76, $p = 0.29$).

Discussion: Surprisingly, these results showed that neither individuals with DS nor those with FXS demonstrate growth in RS or ES during adolescence. Furthermore, although individuals with FXS had more advanced ES skills compared to those with DS, which is consistent with past research (Martin et al., 2013), these groups did not differ in their RS skills. Moreover, the younger TD children of a similar nonverbal developmental level outperformed individuals with DS and FXS in both language measures and demonstrated significant growth in these measures over time. Chapman, Hesketh, and Kistler (2002) found that comprehension slope changed from positive to negative from middle childhood through late adolescence in a sample of youth with DS by including age at study start to predict growth. Therefore, future studies should examine whether there is a plateau in syntactic development during adolescence in DS and FXS by including a wider age range of participants at study start, more carefully accounting for the age of the participants in the statistical models, and through the use of other measures of syntax. Furthermore, although nonverbal IQ contributed to RS and ES, maternal education was not found to be predictive of language skills. These results suggest that future studies should also investigate additional cognitive and environmental factors that may contribute to language development in these populations.

References:

- Abbeduto, L., Murphy, M. M., Cawthon, S. W., Richmond, E. K., Weissman, M. D., Karadottir, S., & O'Brien, A. (2003). Receptive language skills of adolescents and young adults with Down or fragile X syndrome. *American Journal on Mental Retardation*, *108*(3), 149-160.
- Chapman, R. S., Hesketh, L. J., & Kistler, D. J. (2002). Predicting longitudinal change in language production and comprehension in individuals with Down syndrome. *Journal of Speech, Language, and Hearing Research*, *45*(5), 902-915.
- del Hoyo Soriano, L., Thurman, A. J., & Abbeduto, L. (2018). Specificity: a phenotypic comparison of communication-relevant domains between youth with Down syndrome and fragile X syndrome. *Frontiers in Genetics*, *9*, 424.
- Finestack, L. H., Sterling, A. M., & Abbeduto, L. (2013). Discriminating Down syndrome and fragile X syndrome based on language ability. *Journal of Child Language*, *40*(1), 244-265.
- Laws, G., & Bishop, D. V. (2003). A comparison of language abilities in adolescents with Down syndrome and children with specific language impairment. *Journal of Speech, Language, and Hearing Research*.
- Martin, G. E., Losh, M., Estigarribia, B., Sideris, J., & Roberts, J. (2013). Longitudinal profiles of expressive vocabulary, syntax and pragmatic language in boys with fragile X syndrome or Down syndrome. *International Journal of Language & Communication Disorders*, *48*(4), 432-443.
- Price, J., Roberts, J., Vandergrift, N., & Martin, G. (2007). Language comprehension in boys with fragile X syndrome and boys with Down syndrome. *Journal of Intellectual Disability Research*, *51*(4), 318-326.