



HAL
open science

Does the development of syntax comprehension show a premature asymptote among persons with Down syndrome? A cross-sectional analysis.

Bruno Facon, David Magis

► To cite this version:

Bruno Facon, David Magis. Does the development of syntax comprehension show a premature asymptote among persons with Down syndrome? A cross-sectional analysis.. *American Journal on Intellectual and Developmental Disabilities*, 2019, *American Journal on Intellectual and Developmental Disabilities*, 124, pp.131-144. 10.1352/1944-7558-124.2.131 . hal-02509041

HAL Id: hal-02509041

<https://hal.univ-lille.fr/hal-02509041v1>

Submitted on 16 Mar 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

**Does the Development of Syntax Comprehension Show
a Premature Asymptote Among Persons With Down Syndrome?
a Cross-Sectional Analysis**

Bruno Facon and David Magis

<1>Abstract

Uncertainty persists regarding the post-childhood trajectory of syntactic acquisition of persons with Down syndrome (DS). In some studies, asymptote is reached in the early teens, whereas others find syntax continuing to develop at least into early adulthood. This study addressed the issue using a cross-sectional approach. Receptive syntax and vocabulary were tested in 62 children, adolescents and young adults with DS matched on chronological age and cognitive level with 62 participants with intellectual disability (ID) of undifferentiated etiology. On both tests there were significant effects of chronological age and diagnosis, but the chronological age \times diagnosis interactions were nonsignificant. We concluded that comprehension of vocabulary *and* syntax does not asymptote prematurely in individuals with DS relative to those with other forms of ID.

Key Words: *intellectual disability; Down syndrome; syntax comprehension; receptive vocabulary; developmental trajectory; critical period; premature asymptote*

DEVELOPMENT OF SYNTAX COMPREHENSION

Persons with Down syndrome (DS) are known to have significant weaknesses with language acquisition. Although the sequences and patterns of their language development are generally comparable to those observed in the typical child (e.g., Berglund, Eriksson, & Johanson, 2001; Facon & Magis, 2016; Facon, Magis, & Courbois, 2012; Facon, Nuchadee, & Bollengier, 2012; Hart, 1996; Loveall, Channell, Philipps, Abbeduto, & Conners, 2016; Poliřenská & Kapalková, 2014; Scarborough, Rescorla, Tager-Flusberg, Fowler, & Sudhalter, 1991; Tager-Flusberg, Calkins, Nolin, & Baumberger, 1990), numerous studies have shown that language development in DS is particularly slow and plateaus at a very low level in adulthood (e.g., Berglund et al., 2001; Fowler, 1988; Fowler, Gelman, & Gleitman, 1994). The morphosyntactic component of their language development is particularly affected, whether in comprehension or expression. Indeed, at virtually every stage of development, their grammatical abilities fall well below their nonlinguistic abilities. In fact, this is probably the most pronounced language weakness of individuals with DS (Abbeduto, Warren, & Conners, 2007; Martin, Klusek, Estigarribia, & Roberts, 2009; Roberts, Price, & Malkin, 2007; Ypsilanti & Grouios, 2008).

Uncertainty persists regarding the evolution of syntactic acquisition beyond childhood. We know that, ultimately, language development of persons with DS does not reach typical adult levels (Rondal & Edwards, 1997). However, it is still unclear as to *when* it reaches its asymptote.

DEVELOPMENT OF SYNTAX COMPREHENSION

Do language learning in general and syntax acquisition in particular continue during or even beyond early adulthood? Do they asymptote early in adolescence? If the latter, no progress would occur beyond 12-14 years. These questions originate from the critical period hypothesis widely popularized by Lenneberg (1967), who stated that language learning stagnates at puberty because of maturational constraints linked to changes in neuroplasticity. Beyond adolescence, the acquisitions would be far more difficult, especially in the morphosyntactic component of language. Although he has no solid empirical underpinnings relating to children and adolescents with DS, his prediction about them is clear and definite:

In virtually all [...] cases, language development comes to a complete standstill in the early teens, so that these individuals are arrested in primitive stages of language development that are perpetuated for the rest of their lives. Training and motivation are of little help (Lenneberg, 1969, p. 640).

On the basis of a literature review, Rondal and Comblain (1996, 2002, see also Rondal, 2010) concluded that there are arguments in favor of a critical period ending at age 12-14 years for the phonological and morphosyntactic components of language development of persons with DS. The semantic and pragmatic components would be less affected and, therefore, could lead to slow but real progress, potentially up to 30-40 years of age. However, a closer look at individual studies

DEVELOPMENT OF SYNTAX COMPREHENSION

often reveals conflicting results, such as in the following examples. In Fowler's (1988) longitudinal study (see also Fowler et al., 1994), the mean length of utterance and the index of productive syntax were computed on utterances of 10 children with DS from 4 to 13 years of age who were visited every 6 months for 4 to 7 years. Results showed syntactic development leveling off as early as 8 years of age, as though syntactic abilities of persons with DS had plateaued at a level corresponding to that of 3- to 4-year-old typically developing children.

In another longitudinal study, Chapman, Hesketh, and Kistler (2002, see also Chapman, Seung, Schwartz, & Kay-Raining Bird, 1998) examined the development of receptive and productive syntax of 31 participants with DS 5 to 20 years old at the start of the study. Their syntactic level was evaluated four times over a 6-year period using the Test of Auditory Comprehension of Language-Revised (TACL-R, Carrow-Woolfolk, 1985), and the mean length of spontaneous utterances was obtained in 12-minute narrative tasks. Results showed a steady increase with chronological age in the average length of verbal productions suggesting an increase of syntactic abilities even *beyond* adolescence. In contrast, a decline of syntax comprehension was observed between adolescence and adulthood and only a shallower increase between 12 to 18 years. However, this result is not confirmed by Laws and Gunn (2004), who

DEVELOPMENT OF SYNTAX COMPREHENSION

noted a significant increase of scores on the Test for Reception of Grammar (TROG, Bishop, 1983) between 11 to 16 years among their participants with DS.

Cross-sectional comparisons between children, adolescents, and adults with DS conducted by Rondal and Comblain (1996) gave still different results. Receptive skills were measured using two standardized tests, one of vocabulary, the other of morphosyntax (personal pronouns, definite and indefinite articles, verbal inflexions, coordinate clauses, subordinate clauses, relative clauses, negative and passive sentences). The authors assessed productive language skills using a standardized test of productive vocabulary and the mean length of utterance obtained from free play or conversational speech. To summarize, results indicated stable performance for nearly all receptive and productive measures between adolescence and adulthood. Between childhood and adolescence, the results were more complex. The differences were nonsignificant (indicating a lack of progress) for the level of productive vocabulary and the comprehension of personal pronouns, articles, verbal inflections, subordinate clauses, and passive sentences. However, progress was observed for mean length of utterance, receptive vocabulary, and comprehension of coordinate clauses, relative clauses, and negative sentences.

These conflicting results could reflect methodological differences among the studies. For example, mean length of utterance was computed in a narrative context by Chapman et al.

DEVELOPMENT OF SYNTAX COMPREHENSION

(2002), while it was estimated in a conversational setting in the Fowler (1988) and Fowler et al. (1994) studies. And it turns out that the narrative context promotes utterances of greater complexity (Abbeduto et al., 2007). Similarly, receptive syntax was evaluated with different tests in the Laws and Gunn (2004) and Chapman et al. (2002) studies. Other methodological factors are probably also involved, as in Rondal and Comblain's (1996) study in which cognitive level was not very well controlled and the samples were very small (11 to 16 participants per age group). Finally, no control groups of persons with intellectual disability (ID) without DS have been included in these studies. Consequently, no conclusions can be drawn regarding possible developmental specificities among persons with DS.

Overall, it is therefore not yet possible to draw a clear picture of the developmental trajectory of syntactic skills of persons with DS nor, in particular, to specify the period when they reach their asymptote. The present work addressed this issue using a cross-sectional developmental approach focused on the development of receptive language about which, as noted above, conflicting results persist. Beyond a better knowledge of language development of persons with DS, the objective was to help to stir a debate whose educational implications are important. Indeed, if one takes for granted Lenneberg's (1969) position and some of the above-mentioned studies' results, there are no strong reasons either to continue language education beyond childhood or to maintain, among the parents, the hope of a possible growth of language abilities.

DEVELOPMENT OF SYNTAX COMPREHENSION

However, if progress is observed during adolescence or even in early adulthood, this pessimistic view will no longer be tenable.

<1>Present Study

A test of receptive syntax and one of receptive vocabulary were administered to children, adolescents and young adults with DS who were matched on chronological age and on a measure of nonverbal cognitive development with participants with ID of undifferentiated etiology. Syntax and vocabulary test scores were regressed on chronological age and the slopes of regression lines of the two groups were compared. If a premature asymptote occurs for participants with DS, their regression lines should exhibit an inflection point earlier than those observed for participants with undifferentiated etiology. However, it is also possible that the slope of their regression lines is zero. In either case, one might well conclude that participants with DS *specifically* present a premature arrest of language development. Conversely, if the relationship between chronological age and syntax or vocabulary comprehension is similar for the two groups, the hypothesis of a *specific* developmental trajectory of language acquisition of persons with DS would be seriously questioned.

The comparison of participants with DS vs. undifferentiated etiology while holding ID constant will allow separation of the effect of trisomy 21 from that of ID on chronological age-related changes of test scores. Indeed, with only one group of participants with DS, both ID

DEVELOPMENT OF SYNTAX COMPREHENSION

and specific genetic etiology could be invoked to explain the results (see, Dykens, Hodapp, & Finucane, 2000; Fidler, Daunhauer, Will, Gerlach-McDonald, & Schworer, 2016; Yoder & Warren, 2004). However, contrary to a very widespread usage in the ID field, no control-group of typically developing participants was formed. Indeed, although this practice is essential in most cases, the objective of the present study was to examine the relationship between chronological age and receptive language of children, adolescents, and young adults with ID. Thus, the addition of a group of typically developing participants matched both on chronological age *and* a measure of nonverbal cognitive development with our participants with ID was technically unfeasible given the target age ranges of the tests used, the mean chronological age (nearly 15 years) and the mean nonverbal intelligence level (approximately 5 years) of participants with DS and undifferentiated etiology included in the study (see below).

Contrary to several above-mentioned studies exclusively focused on syntax, a measure of lexical development was also included to check whether the issue of premature asymptote concerned only the syntactic component of language development. According to the conclusions of the literature review by Rondal and Comblain (1996, 2002), no inflection point should be observed for the lexical development of either group.

<1>Method

DEVELOPMENT OF SYNTAX COMPREHENSION

<2>Participants

There were two groups of participants diagnosed as having ID who, according to their age, were enrolled in special education schools for youngsters with mild to severe ID by the Commission Départementale d'Education Spéciale (Departmental Committee for Special Education) or the Commission des Droits et de l'Autonomie des Personnes Handicapées (Committee on the Rights and Autonomy of Persons with Disabilities). All were from French-speaking families. The first group included 62 children, adolescents, and young adults (25 males and 37 females) diagnosed as having DS (trisomy 21) matched on chronological age and nonverbal cognitive level with a group of 62 participants with undifferentiated etiology (36 males and 26 females). This group was composed of persons with ID of unknown origin and of persons with ID of various causes (e.g., genetic syndromes [except DS], fetal alcohol syndrome, pre or perinatal brain injuries, infectious disease, and epilepsy).

The younger participants (up to the age of 14) attended specialized schools called Instituts Médico-Pédagogiques, which offer a curriculum aimed to promote the development of personal independence, socialization, communication, physical skills and, if appropriate, school subjects. The older participants attended specialized schools called Instituts Médico-Professionnels or

DEVELOPMENT OF SYNTAX COMPREHENSION

Section d'Initiation et de Première Formation Professionnelle. These schools aimed to reinforce previous achievements while providing basic vocational training.

Participants were tested as part of a larger study on language development of persons with ID supported by the French National Research Agency and approved by the Ethics Committee of the Cognitive and Affective Sciences Laboratory (SCALab, University of Lille).

<2>Instruments

<3>**Test for reception of grammar.** The French version of the Test for Reception of Grammar (F-TROG, Lecocq, 1996) was individually administered with no time limits by master's students in developmental psychology or by contract psychologists trained in psychometrics. Testing sessions were conducted individually in quiet rooms situated near participants' classrooms or workshops. The F-TROG comprises 92 items intended to assess syntax comprehension among children aged 4 to 12 years. For each item, the participant must select from among 4 drawings presented on a single page the one corresponding to a sentence spoken by the examiner. Like the English versions (Bishop, 1983, 2003), the F-TROG evaluates comprehension of various linguistic constructions (e.g., negative sentences, simple sentences with prepositions, reversible active sentences, simple sentences with singular or plural articles, reversible passive sentences, and embedded sentences). A recent study using the F-TROG with typically developing participants and those with undifferentiated etiology or DS yielded Cronbach's alphas = .792, .804 and

DEVELOPMENT OF SYNTAX COMPREHENSION

.809, respectively. It also showed that the rank order of item difficulty was remarkably similar for participants with and without ID (Facon & Magis, 2016). All participants received all 92 items.

<3>Raven's Colored Progressive Matrices. The 36 items of Raven's Colored Progressive Matrices (RAVEN, Raven, Court, & Raven, 1998) were administered to all participants to obtain an estimate of their nonverbal cognitive level. This test was chosen because of its simplicity and speed of administration and scoring, its reliability, and the great similarity of item response profiles to which it gives rise for participants with and without ID (Facon, Magis, Nuchadee, & DeBoeck, 2011; Facon & Nuchadee, 2010; Van Herwegen, Farran, & Annaz, 2011).

<3>Echelle de Vocabulaire en Images Peabody. The Echelle de Vocabulaire en Images Peabody (EVIP, Form B, Dunn, Thériault-Whalen, & Dunn, 1993 — the French version of the PPVT) was used to assess the participants' receptive lexical knowledge. For each item of the EVIP, the participant must select from among four pictures presented on a single page the one corresponding to a word spoken by the examiner. The test covers the age range 2½ to 18 years. It comprises 170 items belonging to different categories such as nouns, verbs or adjectives, root and inflected words, concrete vs. verbally defined words, or basic, superordinate, or subordinate nouns. Given the average developmental level of our participants (approximately 5 years), only the first 140 items were actually used, and those 140 were given to all participants. This test was used in a recent study conducted with participants with and without ID. Cronbach's alphas approached .90,

DEVELOPMENT OF SYNTAX COMPREHENSION

and the rank order difficulty of items was very similar across the two types of participants (Facon, Nuchadee, & Bollengier, 2012).

<2>Statistical analyses

Separate hierarchical regression analyses were performed on EVIP and F-TROG to estimate the contributions of chronological age, diagnostic status (undifferentiated etiology vs. DS) and the chronological age \times status interaction. Chronological age was entered first in the regression equations. The status variable, coded 0 and 1 for participants with undifferentiated etiology and those with DS, respectively, was then entered followed by the interaction term (chronological age \times status). A main effect of diagnostic status would indicate an overall performance difference between the two groups for the age-span considered. On the other hand, a significant interaction would indicate a between-groups difference in slope and, thus, a difference in rate of syntax or vocabulary comprehension development. Since the purpose of the study was to examine the absolute differences in developmental trajectories of the two groups of participants, data analyses were conducted using only raw scores.

In a multiple regression analysis, the first preliminary step is to ensure that the relationship between the dependent and independent variables is linear. This verification was essential in the present context given the possibility of a premature asymptote and, thus, of a curvilinear relationship between chronological age and F-TROG and/or chronological age and EVIP.

DEVELOPMENT OF SYNTAX COMPREHENSION

It was done by comparing adjusted squared multiple correlation coefficients ($R^2_{adj.}$) obtained using linear and quadratic equations (Cohen, Cohen, West, & Aiken, 2003).

<2>Results

Descriptive statistics for chronological age, RAVEN, EVIP and F-TROG are given in Table 1.

Because of the matching procedure, the group mean differences for chronological age and

RAVEN of the two groups were nonsignificant ($t_{2-tailed} = 0.189$, $df = 122$, $p = .851$ for

chronological age; $t_{2-tailed} = -0.060$, $df = 122$, $p = .952$ for RAVEN), as were the Levene tests for

homogeneity of variance ($F_{(1,122)} = 0.689$, $p = .408$ for CA, $F_{(1,122)} = 0.002$, $p = .968$ for RAVEN).

The correlation between chronological age and Raven was also nonsignificant for both groups ($r =$

.069, $p = .592$ and $r = .178$, $p = .166$ for participants with undifferentiated etiology and DS,

respectively). Consequently, if between-group differences in developmental trajectories were

observed for receptive syntax and/or vocabulary, the distributions of nonverbal

intelligence scores and chronological ages of each group could not be invoked as potentially

confounding factors (Facon, Magis, & Belmont, 2011).

Comparisons between $R^2_{adj.}$ coefficients obtained using linear and quadratic equations

showed that for neither EVIP nor F-TROG did the quadratic term significantly improve

predictability over that obtained using the linear term alone. In fact, $R^2_{adj.}$ coefficients were lower

if anything in the quadratic than in the linear models ($R^2_{adj. linear} = .179$ and $R^2_{adj. quadratic} = .169$ for

DEVELOPMENT OF SYNTAX COMPREHENSION

EVIP; $R^2_{adj. linear} = .053$ and $R^2_{adj. quadratic} = .041$ for F-TROG). Analyses of the residuals revealed an EVIP outlier (standardized residual > 3). The EVIP regression analyses were therefore rerun while excluding the outlier, but the differential of $R^2_{adj.}$ coefficients between the two models was of the same order as previously ($R^2_{adj. linear} = .195$ and $R^2_{adj. quadratic} = .193$).

The same comparisons were conducted for the group of participants with undifferentiated etiology and gave similar results ($R^2_{adj. linear} = .167$ and $R^2_{adj. quadratic} = .154$ for EVIP; $R^2_{adj. linear} = .020$ and $R^2_{adj. quadratic} = .019$ for F-TROG). Therefore, subsequent statistical analyses were conducted within a linear framework.

The main results of the regression analyses of EVIP and F-TROG are presented in Table 2, and the corresponding bivariate plots in Figure 1. In the figure, raw scores were standardized to z scores based on the combined group's mean and standard deviation (SD) to facilitate the visual analysis of performances of each group of participants on the two tests. Analyses of the residuals revealed an EVIP outlier (standardized residual > 3). Consequently, the EVIP analysis was rerun while excluding this observation. Although no notable change in the model parameters was observed in this second analysis, we chose to exclude this outlier from all subsequent analyses of EVIP.

<INSERT TABLE 1 HERE>

<INSERT TABLE 2 HERE>

DEVELOPMENT OF SYNTAX COMPREHENSION

Results in Table 2 indicate that chronological age was significantly related to both vocabulary and syntax comprehension with a larger effect for vocabulary ($R^2 = .155$) than for syntax ($R^2 = .038$). Diagnostic status also had a significant effect on both dependent variables. The increase of R^2 was .12 for vocabulary and .198 for syntax. For both measures, participants with undifferentiated etiology performed better than those with DS as is clear in the two bivariate distributions displayed in Figure 1.

For vocabulary, as for syntax, the introduction of the interaction term in the regression equation did not significantly increase the variance accounted for. Indeed, the increase of R^2 is only .002 for vocabulary and .0002 for the syntax. Thus, the strength of the relationship between chronological age and lexical or syntactic knowledge is the same for the two groups, as is well illustrated by the parallelism of the regression lines (Figure 1).

As can be seen in Table 2 and Figure 1, the strength of the relationship between chronological age and vocabulary appears greater than that for chronological age and syntax. To statistically test this difference, we compared the correlation coefficient between chronological age and vocabulary ($r = .393, N = 123, p < .001$) with that between chronological age and syntax ($r = .177, N = 123, p < .001$). Given the strong correlation between the scores on the two tests ($r = .741, N = 123, p < .001$), we used the Steiger (1980) test for comparing dependent correlations implemented in the *cocor* R package (Diedenhofen &

DEVELOPMENT OF SYNTAX COMPREHENSION

Musch, 2015). The comparison showed a significant difference between the two correlations ($z = 3.470, N = 123, p = .0005$). Consequently, one may conclude that the relationship between chronological age and test scores is indeed greater for vocabulary than for syntax. Note that this result cannot be attributed to the correlation between chronological age and group status since the latter is practically zero ($r_{pb} = -.008, N = 123, p = .958$) given the matching of groups on chronological age. We then compared the point-biserial correlation between group status and test scores on vocabulary ($r_{pb} = -.350, N = 123, p < .001$) and syntax ($r_{pb} = -.442, N = 123, p < .001$). This time, however, the Steiger (1980) test returned a nonsignificant result ($z = 1.546, N = 123, p = .122$).

<INSERT FIGURE 1 HERE>

<2>Discussion

The aim of this study was to compare the developmental trajectories of vocabulary and syntax comprehension of participants with DS or undifferentiated etiology in order to know whether a premature asymptote arises for participants with DS. Although the chronological effect size was small for syntax and moderate for vocabulary (4% and 15% of the explained variance, respectively), results showed a linear increase of test scores between childhood and adulthood for participants with undifferentiated etiology and those with DS. Moreover, the absence of an interaction between chronological age and diagnostic status indicated that the

DEVELOPMENT OF SYNTAX COMPREHENSION

rate of receptive language development was similar for the two groups. The results also showed that the relationship between chronological age and test scores was significantly stronger for vocabulary than for syntax and that participants with undifferentiated etiology performed better than participants with DS, whatever the test. However, the two groups' performance differential on the two tests was not statistically significant.

The nonsignificant chronological age \times diagnostic status interaction as well as the lack of a significant quadratic component in the relationship between chronological age and test scores challenge the idea of a premature asymptote of language development of people with DS, and of their syntactic acquisition in particular. This contradicts Lenneberg's (1967) and Fowler's (1988) positions on this crucial aspect of language learning and calls into question Lenneberg's (1969) pessimistic predictions about the relevance of language interventions for people with DS beyond the early teens. Our results also contradict those of Chapman et al. (2002) which showed that syntax comprehension decreases during late adolescence among participants with DS. This discrepancy may be due to difference between study designs (cross-sectional in our study, longitudinal in that of Chapman et al. [2002]). The type of test used in the two studies is perhaps also involved. Chapman et al. (2002) relied on the TACL-R (Carrow-Woolfolk, 1985) while we used the F-TROG. Thus, it is possible that the difference in outcomes resulted at least in part from differences in the measures' contents or their psychometric properties. It must be noted, in this

DEVELOPMENT OF SYNTAX COMPREHENSION

regard, that our results have now been nicely confirmed by a new cross-sectional study of German participants with DS that shows improvements in their TROG scores between childhood and late adolescence (Witecy & Penke, 2017).

The notion of a critical period must be relativized in view of data collected in the years since its first formulation by Penfield and Roberts (1959) and its subsequent elaboration by Lenneberg (1967). Indeed, it is now accepted that the age span of optimal language acquisition is far more extended than previously supposed and that the expected sharp drop-off in performance beyond the "critical" window of learning is more the exception than the rule (Hakuta, Bialystok, & Wiley, 2003). Thus, one does better to speak of an "optimal" or "sensitive" period rather than a "critical" period (Morgan, 2014; Newport, 2006; Werker & Tees, 2005). A distinction must also be made between the phonological and syntactic aspects of language development on the one hand, and its semantic and pragmatic aspects on the other. Indeed, the notion of an optimal period seems far more relevant for the phonological and syntactic components of language development than it is for the two other components (Kuhl, 2010; Rondal, 2010; Stevens & Neville, 2009). The present results are in line with these changes of perspective on the notion of a critical period. On the one hand, continuous progress between childhood and adulthood is observed for both vocabulary and syntax for both groups of participants. This supports the idea of a relatively extended window for

DEVELOPMENT OF SYNTAX COMPREHENSION

language development and a lack of sharp drop-off in language learning rates, even with regard to syntax. On the other hand, the results corroborate the distinction made between syntactic and semantic-lexical aspects of language development by showing, for the two groups of participants, a less pronounced relationship between age and syntax than between age and vocabulary. As a matter of fact, these differences of developmental trajectories are consistent with the notion of different processes underlying these two aspects of language.

The lower performances of participants with DS on both vocabulary and syntax confirm previous work showing that language development is a recognized weakness among persons with DS, especially its syntactical component (e.g., Abbeduto et al., 2007; Chapman & Kay-Raining Bird, 2012; Roberts et al., 2007). What causes this weakness? Although research is still needed to establish with certainty the causal relationships, it is probably the result of multiple difficulties such as sleep disorders (Edgin, Clark, Massand, & Karmiloff-Smith, 2015), auditory impairment (Chapman, 2006), incomplete automatization of speech-related processes (Silverman, 2007) and weaknesses in attention (Borella, Carretti, & Lanfranchi, 2013; Brown et al., 2003), verbal short-term/working memory (e.g., Chapman & Hekseth, 2001; Chapman & Kay Raining Bird, 2012; Jarrold & Brock, 2012; Lee, Maiman, & Godfrey, 2016) or explicit verbal long-term memory (Vicari, 2012; Vicari, Costanzo, & Menghini, 2016). These weaknesses, especially those

DEVELOPMENT OF SYNTAX COMPREHENSION

related to memory, are also observed in other groups of persons with ID (Lee et al., 2016).

However, they are particularly pronounced among those with DS (Conners, Moore, Loveall, & Merrill, 2011; Nichols et al., 2004) and, consequently, possibly explain why their performance in syntax and vocabulary are lower than those of participants with undifferentiated etiology (see, McDuffie, Thurman, Channell, & Abbeduto, 2017). This interpretation is reinforced by the greater effect of clinical status on syntax than on vocabulary. Although not statistically significant ($p = .122$), this small differential effect is possibly related to the fact that syntax comprehension is strongly constrained by cognitive abilities such as verbal short-term/working memory (Chapman et al., 2002; Laws & Bishop, 2004; Laws & Gunn, 2004; Miolo, Chapman, & Sindberg, 2005; Montgomery, Gillam, & Evans, 2015; Montgomery, Magimairaj, & Finney, 2010). Indeed, children with poor verbal short-term/working memory skills encounter difficulties in understanding complex and even simple sentences, which impedes the learning of syntactic structures. This necessarily results in lower performance on receptive syntax tests.

The present study, as well as that of Witecy and Penke (2017), focused only on receptive tests. As such, they cannot be considered as definitive. Studies using expressive language tests are needed to determine whether or not persons with DS have a premature asymptote of their productive language. Indeed, the literature on this question is still very much up in the air because of the use of the studies' disparate measures of expressive language (see, Abbeduto et al., 2007).

DEVELOPMENT OF SYNTAX COMPREHENSION

A second limitation of this study, especially from the standpoint of generalization, was that it concerned only participants with undifferentiated etiology or DS. Thus, it would make sense to follow up by conducting comparable analyses with other etiological groups (e.g., Williams or Fragile X [FX] syndromes) in order to determine whether or not the present results hold regardless of the origin of ID. In this respect, some researchers have reported a decrease in IQ over time in children with FX syndrome (e.g., Dykens et al., 1989), a result related to the negatively accelerating annual growth of their intellectual skills during childhood (Hall, Burns, Lightbody, & Reiss, 2008). Thus, it would be interesting to know whether the same phenomenon is observed for their language competencies. However, given the strong similarities of the language comprehension profiles of participants with FX and DS (Oakes, Kover, & Abbeduto, 2013), it is possible that, just like their peers with DS, those with FX do not have a premature asymptote.

The lack of solid data on family background of participants is another limitation. Since family SES, parental education or educational attitudes and practices of parents are related to language development among typically developing children (Hart & Risley, 1995; Hoff, 2006; Huttenlocher, Vasilyeva, Waterfall, Vevea, & Hedges, 2007; Huttenlocher, Waterfall, Vasilyeva, Vevea, & Hedges, 2010; Vasilyeva, Waterfall, & Huttenlocher, 2008) and those with ID (Price,

DEVELOPMENT OF SYNTAX COMPREHENSION

Roberts, Vandergrift, & Martin, 2007; Warren, Brady, Sterling, Fleming, & Marquis, 2010), parental education, SES, and educational practices should certainly be included as covariates in future studies on the developmental trajectories of language components of persons with ID.

The cross-sectional analyses of the present study open them to several well-known potential limitations. However, all cross-sectional data are not necessarily corrupted by the potential biases attributed to such designs, and the longitudinal approach itself is not without potential flaws (Shadish, Cook, & Campbell, 2002). Moreover, given the matching procedure, the fact that chronological age, clinical status and cognitive level of participants were not correlated with one another increases the internal validity of the study. In fact, as suggested by Hertzog (1996), one of the best ways to study development is to begin with comparisons of extreme-age-groups, continue with full cross-sectional studies and, then extend the analyses with longitudinal or, better, cross-sequential designs (see also Thomas et al., 2009). Thus, the next stage of this study would involve a longitudinal or cross-sequential approach that would test and extend the present findings. Beyond its methodological interest, the use of the longitudinal or cross-sequential approaches would make it possible to identify inter-individual differences of developmental trajectories among participants from the same etiologic group and thus to determine the exogenous (e.g., SES) or endogenous (e.g., cognitive abilities) variables that cause them.

DEVELOPMENT OF SYNTAX COMPREHENSION

The main implications of the present study are twofold. First, the absence of a premature asymptote for participants with DS is important and encouraging from an educational point of view insofar as it justifies the continuation beyond childhood of interventions focused on language learning. Second, the present results indicate that all aspects of language development of persons with DS are not necessarily specific. In fact, our data show that even if participants with DS have lower performances than those with undifferentiated etiology, the developmental trajectories of the two groups are highly similar with respect to vocabulary and syntax comprehension. This finding is in line with studies showing that many aspects of language development of persons with ID in different etiological groups are similar to what is observed among typically developing children (e.g., Berglund et al., 2001; Facon & Magis, 2016; Facon et al., 2012; Hart, 1996; Laws & Gunn, 2004; Loveall, et al., 2016; Polišenská, Kapalková, & Novotková, 2018; Reilly, Losh, Bellugi, & Wulfeck, 2004; Rondal, 2007; Scarborough et al., 1991; Tager-Flusberg et al., 1990). Indeed, these studies suggest

... that language development in individuals with ID, including those with DS, proceeds, in major ways, as it does in TD [typically developing] individuals. Similar sequences of steps are documented until final plateaus are reached. Development in individuals with ID is slower and remains in many respects incomplete. There are no clear indications, however, that the basic mechanisms involved in each domain of language development radically differ (Rondal, 2007, p. 64).

DEVELOPMENT OF SYNTAX COMPREHENSION

From this standpoint, the widespread idea of a well-defined language phenotype associated with each syndrome should be tempered by the well-documented inter-syndromic overlaps, and the wide within-syndrome variations (Abbeduto, McDuffie, Thurman, & Kover, 2016; Rondal, 2010).

In conclusion, the present findings do not indicate a premature asymptote of language comprehension in people with DS in general, nor of their syntactic acquisition in particular. Although this result is encouraging from the viewpoint of language intervention, further studies are needed to verify whether this finding holds for other clinical groups and other tests, particularly of expressive language.

<1>References

- Abbeduto, L., McDuffie, A., Thurman, A. J., & Kover, S. T. (2016). Language development in individuals with intellectual and developmental disabilities: From phenotypes to treatments. *International Review of Research in Developmental Disabilities*, *50*, 71-118. doi:10.1016/bs.irrdd.2016.05.006
- 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*, 247-261. doi:10.1002/mrdd.20158

DEVELOPMENT OF SYNTAX COMPREHENSION

- Berglund, E., Eriksson, M., & Johansson, I. (2001). Parental reports of spoken language skills in children with Down syndrome. *Journal of Speech, Language, and Hearing Research, 44*, 179-191. doi:10.1044/1092-4388(2001/016)
- Bishop, D. V. M. (1983). *T. R. O. G. Test for Reception Of Grammar*. Manchester, UK: Chapel Press.
- Bishop, D. V. M. (2003). *The Test for Reception of Grammar, Version 2 (TROG-2)*. London, UK: Psychological Corporation.
- Borella, E., Carretti, B., Lanfranchi, S. (2013). Inhibitory mechanisms in Down syndrome: Is there a specific or general deficit? *Research in Developmental Disability, 34*, 65-71. doi:10.1016/j.ridd.2012.07.017
- Brown, J., Johnson, M. H., Paterson, S., Gilmore, R., Longhi, E., & Karmiloff-Smith, A. (2003). Spatial representation and attention in toddlers with Williams syndrome and Down syndrome. *Neuropsychologia, 41*, 1037-1046. doi:10.1016/S0028-3932(02)00299-3
- Carrow-Woolfolk, E. (1985). *Test for Auditory Comprehension of Language—Revised (TACL-R)*. Allen, TX: DLM Teaching Resources.
- Chapman, R. S. (2006). Language learning in Down syndrome: The speech and language profile compared to adolescents with cognitive impairment of unknown origin. *Down Syndrome Research and Practice, 10*, 61-66. doi:10.3104/reports.306
- Chapman, R. S., & Hesketh, L. J. (2001). Language, cognition, and short-term memory in individuals with Down syndrome. *Down Syndrome Research and Practice, 7*, 1-7. doi:10.3104/reviews.108

DEVELOPMENT OF SYNTAX COMPREHENSION

- Chapman, R. S., Hesketh, L. J., & Kistler, D. J. (2002). Predicting longitudinal change in language production and comprehension in individuals with Down syndrome: Hierarchical linear modeling. *Journal of Speech, Language, and Hearing Research, 45*, 902-915. doi:10.1044/1092-4388(2002/073)
- Chapman, R. S., & Kay-Raining Bird, E. (2012). Language development in childhood, adolescence, and young adulthood in persons with Down syndrome. In J. A. Burack, R. M. Hodapp, G. Iarocci, & E. Zigler (Eds.), *The Oxford handbook of intellectual disability and development* (2nd ed., pp. 167-183). New York, NY: Oxford University Press.
- Chapman, R. S., Seung, H. K., Schwartz, S. E., & Kay-Raining Bird, E. (1998). Language skills of children and adolescents with Down syndrome: II. Production deficits. *Journal of Speech, Language, and Hearing Research, 41*, 861-873. doi:10.1044/jslhr.4104.861
- Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mahwah, NJ: Laurence Erlbaum Associates.
- Connors, F. A., Moore, M. S., Loveall, S. J., & Merrill, E. C. (2011). Memory profiles of Down, Williams, and Fragile X syndromes: Implications for reading development. *Journal of Behavioral Pediatrics, 32*, 405-417. doi:10.1097/DBP.0b013e3182168f95
- Diedenhofen, B., & Musch, J. (2015). cocor: A comprehensive solution for the statistical comparison of correlations. *PLoS ONE, 10*(4): e0121945. doi:10.1371/journal.pone.0121945
- Dunn, L. M., Thériault-Whalen, C. M., & Dunn, L. M. (1993). *Echelle de Vocabulaire en Images Peabody. Adaptation française du Peabody Picture Vocabulary Test-Revised*. Richmond Hill, ON: Psycan.

DEVELOPMENT OF SYNTAX COMPREHENSION

- Dykens, E. M., Hodapp, R. M., & Finucane, B. (2000). *Genetics and mental retardation syndromes: A new look at behavior and interventions*. Baltimore, MD: Paul H Brookes Publishing Company.
- Dykens, E. M., Hodapp, R. M., Ort, S., Finucane, B., Shapiro, L. R., & Leckman, J. F. (1989). The trajectory of cognitive development in males with fragile X syndrome. *Journal of The American Academy of Child & Adolescent Psychiatry*, 28, 422-426. doi:10.1097/00004583-198905000-00020
- Edgin, J. O., Clark, C. A., Massand, E., & Karmiloff-Smith, A. (2015). Building an adaptive brain across development: Targets for neurorehabilitation must begin in infancy. *Frontiers in Behavioral Neuroscience*, 9: 232. doi:10.3389/fnbeh.2015.00232
- Facon, B., & Magis, D. (2016). An item analysis of the French version of the Test for Reception of Grammar among children and adolescents with Down syndrome or intellectual disability of undifferentiated etiology. *Journal of Speech, Language, and Hearing Research*, 59, 1190-1197. doi:10.1044/2016_JSLHR-L-15-0179
- Facon, B., Magis, D., & Belmont, J. M. (2011). Beyond matching on the mean in developmental disabilities research. *Research in Developmental Disabilities*, 32, 2134-2147. doi:10.1016/j.ridd.2011.07.029
- Facon, B., Magis, D., & Courbois, Y. (2012). On the difficulty of relational concepts among participants with Down syndrome. *Research in Developmental Disabilities*, 33, 60-68. doi:10.1016/j.ridd.2011.08.014
- Facon, B., Magis, D., Nuchadee, M.-L., & De Boeck, P. (2011). Do Raven's Colored Progressive Matrices function in the same way in typical and clinical populations? Insights from the intellectual disability field. *Intelligence*, 39, 281-291. doi:10.1016/j.intell.2011.04.002

DEVELOPMENT OF SYNTAX COMPREHENSION

- Facon, B., & Nuchadee, M.-L. (2010). An item analysis of Raven's Colored Progressive Matrices among participants with Down syndrome. *Research in Developmental Disabilities, 31*, 243-249. doi:10.1016/j.ridd.2009.09.011
- Facon, B., Nuchadee, M.-L., & Bollengier, T. (2012). A qualitative analysis of general receptive vocabulary of adolescents with Down syndrome. *American Journal on Intellectual and Developmental Disabilities, 117*, 243-259. doi:10.1352/1944-7558-117.3.243
- Fidler, D. J., Daunhauer, L. A., Will, E., Gerlach-McDonald, B., & Schworer, E. (2016). The central role of etiology in science and practice in intellectual disability. *International Review of Research in Developmental Disabilities, 50*, 1-36. doi:10.1016/bs.irrdd.2016.05.005
- Fowler, A. E. (1988). Determinants of rate of language growth in children with DS. In L. Nadel (Ed.), *The psychobiology of Down syndrome* (pp. 217-245). Cambridge, MA: The MIT Press.
- Fowler, A. E., Gelman, R., & Gleitman, L. R. (1994). The course of language learning in children with Down syndrome. In H. Tager-Flusberg (Ed.), *Constraints on language acquisition: Studies of atypical children* (pp. 91-140). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Hakuta, K., Bialystok, E., & Wiley, E. (2003). Critical evidence: A test of the critical-period hypothesis for second-language acquisition. *Psychological Science, 14*, 31-38. doi:10.1111/1467-9280.01415
- Hall, S. S., Burns, D. D., Lightbody, A. A., & Reiss, A. L. (2008). Longitudinal changes in intellectual development in children with fragile X syndrome. *Journal of Abnormal Child Psychology, 36*, 927-939. doi:10.1007/s10802-008-9223-y
- Hart, B. (1996). The initial growth of expressive vocabulary among children with Down syndrome. *Journal of Early Intervention, 20*, 211-221. doi:10.1177/105381519602000305

DEVELOPMENT OF SYNTAX COMPREHENSION

Hart, B. M., & Risley, T. R. (1995). *Meaningful differences in the everyday experiences of young American children*. Baltimore, MD: Paul H. Brookes Publishing Company.

Hertzog, C. (1996). Research design in studies of aging and cognition. In J. E. Birren, K. W. Schaie, R. P. Abeles, M. Gatz, & T. M. Salthouse (Eds.), *Handbook of the psychology of aging* (pp. 24-37). San Diego, CA: Academic Press.

Hoff, E. (2006). How social contexts support and shape language development. *Developmental Review, 26*, 55-88. doi:10.1016/j.dr.2005.11.002

Huttenlocher, J., Vasilyeva, M., Waterfall, H. R., Vevea, J. L., & Hedges, L. V. (2007). The varieties of speech to young children. *Developmental Psychology, 43*, 1062-1083. doi:10.1037/0012-1649.43.5.1062

Huttenlocher, J., Waterfall, H. R., Vasilyeva, M., Vevea, J. L., & Hedges, L. V. (2010). Sources of variability in children's language growth. *Cognitive Psychology, 61*, 343-365. doi:10.1016/j.cogpsych.2010.08.002

Jarrold, C., & Brock, J. (2012). Short-term memory and working memory in mental retardation. In J. A. Burack, R. M. Hodapp, G. Iarocci, & E. Zigler (Eds.), *The Oxford handbook of intellectual disability and development* (2nd ed., pp. 109-124). New York, NY: Oxford University Press.

Kuhl, P. K. (2010). Brain mechanisms in early language acquisition. *Neuron, 67*, 713-727. doi:10.1016/j.neuron.2010.08.038

Laws, G., & Bishop, D. M. (2004). Verbal deficits in Down's syndrome and specific language impairment: A comparison. *International Journal of Language & Communication Disorders, 39*, 423-451. doi:10.1080/13682820410001681207

DEVELOPMENT OF SYNTAX COMPREHENSION

- Laws, G., & Gunn, D. (2004). Phonological memory as a predictor of language comprehension in Down syndrome: A five-year follow-up study. *Journal of Child Psychology and Psychiatry*, 45, 326–337. doi.org/10.1111/j.1469-7610.2004.00224.x
- Lecocq, P. (1996). *L'ECOSSE: une épreuve de compréhension syntaxico-sémantique*. Villeneuve d'Ascq, FR: Presses Universitaires du Septentrion.
- Lee, N. R., Maiman, M., & Godfrey, M. (2016). What can neuropsychology teach us about intellectual disability?: Searching for commonalities in the memory and executive function profiles associated with Down, Williams, and Fragile X syndromes. *International Review of Research in Developmental Disabilities*, 51, 1-40. doi.org/10.1016/bs.irrdd.2016.07.002
- Lenneberg, E. H. (1967). *Biological foundations of language*. New York, NY: John Wiley & Sons, Inc.
- Lenneberg, E. H. (1969). On explaining language. *Science*, 164, 635-643.
- Loveall, S. J., Channell, M. M., Phillips, B. A., Abbeduto, L., & Conners, F. A. (2016). Receptive vocabulary analysis in Down syndrome. *Research in Developmental Disabilities*, 55, 161-172. doi.org/10.1016/j.ridd.2016.03.018
- Martin, G. E., Klusek, J., Estigarribia, B., & Roberts, J. E. (2009). Language characteristics of individuals with Down syndrome. *Topics in Language Disorders*, 29, 112-132. doi:10.1097/TLD.0b013e3181a71fe1

DEVELOPMENT OF SYNTAX COMPREHENSION

- McDuffie, A., Thurman, A. J., Channell, M. M., & Abbeduto, L. (2017). Language disorders in children with intellectual disability of genetic origin. In R. G. Schwartz (Ed.), *Handbook of child language disorders: (2nd ed., pp. 52-81)*. New York, NY: Taylor and Francis. doi:10.4324/9781315283531
- Miolo, G., Chapman, R. S., & Sindberg, H. A. (2005). Sentence comprehension in adolescents with Down syndrome and typically developing children: Role of sentence voice, visual context, and auditory-verbal short-term memory. *Journal of Speech, Language, and Hearing Research, 48*, 172-188. doi:10.1044/1092-4388(2005/013)
- Montgomery, J. W., Gillam, R. B., & Evans, J. L. (2015). Information processing in children with specific language impairment. In R. H. Bahr & E. R. Silliman (Eds.), *Routledge handbook of communication disorders* (pp. 183-192). New York, NY: Routledge/Taylor & Francis Group.
- Montgomery, J. W., Magimairaj, B. M., & Finney, M. C. (2010). Working memory and specific language impairment: An update on the relation and perspectives on assessment and treatment. *American Journal of Speech-Language Pathology, 19*, 78-94. doi:10.1044/1058-0360(2009/09-0028)
- Morgan, G. (2014). Critical period in language development. In P. Brookes & V. Kempe (Eds), *The encyclopedia of language development* (pp. 115-118). Thousand Oaks, CA: Sage Press.
- Newport, E. L. (2006). Language development, critical period in. In L. Nadel (Ed.), *Encyclopedia of cognitive science* (pp. 737-740). New York, NY: John Wiley & Sons, Inc. doi: 10.1002/0470018860

DEVELOPMENT OF SYNTAX COMPREHENSION

- Nichols, S., Jones, W., Roman, M. J., Wulfeck, B., Delis, D. C., & Reilly, J. (2004). Mechanisms of verbal memory impairment in four neurodevelopmental disorders. *Brain and Language*, 88, 180-189. doi:10.1016/S0093-934X(03)00097-X
- Oakes, A., Kover, S. T., & Abbeduto, L. (2013). Language comprehension profiles of young adolescents with fragile X syndrome. *American Journal of Speech-Language Pathology / American Speech-Language-Hearing Association*, 22, 615-26. doi.org/10.1044/1058-0360(2013/12-0109)
- Penfield, W., & Roberts, L. (1959). *Speech and brain mechanisms*. Princeton, NJ: Princeton University Press.
- Polišenská, K., & Kapalková, S. (2014). Language profiles in children with Down syndrome and children with language impairment: Implications for early intervention. *Research in Developmental Disabilities*, 35, 373-382. doi:10.1016/j.ridd.2013.11.022
- Polišenská, K., Kapalková, S., & Novotková, M. (2018). Receptive language skills in Slovak-speaking children with intellectual disability: Understanding words, sentences, and stories. *Journal of Speech, Language, and Hearing Research*, 61, 1731-1742. doi: 10.1044/2018_JSLHR-L-17-0029
- 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, 318-326. doi:10.1111/j.1365-2788.2006.00881.x
- Raven, J. C., Court, J. H., & Raven, J. (1998). *Progressive Matrices Couleur / Colored Progressive Matrices*. Paris: Les Editions du Centre de Psychologie Appliquée.

DEVELOPMENT OF SYNTAX COMPREHENSION

- Reilly, J., Losh, M., Bellugi, U., & Wulfeck, B. (2004). "Frog, where are you?" Narratives in children with specific language impairment, early focal brain injury, and Williams syndrome. *Brain and Language*, 88, 229-247. doi:10.1016/S0093-934X(03)00101-9
- Roberts, J. E., Price, J., & Malkin, C. (2007). Language and communication development in Down syndrome. *Mental Retardation and Developmental Disabilities Research Reviews*, 13, 26-35. doi:10.1002/mrdd.20136
- Rondal, J. A. (2007). Language rehabilitation. In J. A. Rondal & A. Rasore-Quartino (Eds.), *Therapies and rehabilitation in Down syndrome* (pp. 63-89). New York, NY: John Wiley & Sons, Inc.
- Rondal, J. A. (2010). Language in Down syndrome: A life-span perspective. In M. A. Barnes (Ed), *Genes, brain and development* (pp. 122-142). Cambridge, UK: Cambridge University Press.
- Rondal, J. A., & Comblain, A. (1996). Language in adults with Down syndrome. *Down Syndrome Research and Practice*, 4, 3-14. doi:10.3104/reviews.58
- Rondal, J. A., & Comblain, A. (2002). Language in ageing persons with Down syndrome. *Down Syndrome Research and Practice*, 8, 1-9. doi:10.3104/reports.122
- Rondal, J. A., & Edwards, S. (1997). *Language in mental retardation*. Philadelphia, PA: Whurr Publishers.
- Scarborough, H. S., Rescorla, L., Tager-Flusberg, H., Fowler, A. E., & Sudhalter, V. (1991). The relation of utterance length to grammatical complexity in normal and language-disordered groups. *Applied Psycholinguistics*, 12, 23-45.
- Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston, MA: Houghton Mifflin.

DEVELOPMENT OF SYNTAX COMPREHENSION

- Silverman, W. (2007). Down syndrome: Cognitive phenotype. *Mental Retardation and Developmental Disabilities Research Reviews*, *13*, 228-236. doi:10.1002/mrdd.20156
- Steiger, J. H. (1980). Tests for comparing elements of a correlation matrix. *Psychological Bulletin*, *87*, 245-251.
- Stevens, C., & Neville, H. (2009). Profiles of development and plasticity in human neurocognition. In M. S. Gazzaniga, E. Bizzi, L. M. Chalupa, S. T. Grafton, T. F. Heatherton, C. Koch, ... B. A. Wandell (Eds.), *The cognitive neurosciences* (4th ed. pp. 165-181). Cambridge, MA: Massachusetts Institute of Technology.
- Tager-Flusberg, H., Calkins, S., Nolin, T., & Baumberger, T. (1990). A longitudinal study of language acquisition in autistic and Down syndrome children. *Journal of Autism and Developmental Disorders*, *20*, 1-21. doi:10.1007/BF02206853
- Thomas, M. S. C., Annaz, D., Ansari, D., Scerif, G., Jarrold, C., & Karmiloff-Smith, A. (2009). Using developmental trajectories to understand developmental disorders. *Journal of Speech, Language, and Hearing Research*, *52*, 336-358. doi:10.1044/1092-4388(2009/07-0144)
- Van Herwegen, J., Farran, E., & Annaz, D. (2011). Item and error analysis on Raven's Colored Progressive Matrices in Williams syndrome. *Research in Developmental Disabilities*, *32*, 93-99. doi:10.1016/j.ridd.2010.09.005
- Vasilyeva, M., Waterfall, H. R., & Huttenlocher, J. (2008). Emergence of syntax: Commonalities and differences across children. *Developmental Science*, *11*, 84-97. doi: 10.1111/j.1467-7687.2007.00656.x
- Vicari, S. (2012). Memory and learning in intellectual disabilities. In J. A. Burack, R. M. Hodapp, G. Iarocci, & E. Zigler (Eds.), *The Oxford handbook of intellectual disability and development* (2nd ed., pp. 97-108). New York, NY: Oxford University Press.

DEVELOPMENT OF SYNTAX COMPREHENSION

Vicari, S., Costanzo, F., & Menghini, D. (2016). Memory and learning in intellectual disability.

International Review of Research in Developmental Disabilities, 50, 1-30.

doi:10.1016/bs.irrdd.2016.05.003

Warren, S. F., Brady, N., Sterling, A., Fleming, K., & Marquis, J. (2010). Maternal responsivity predicts language development in young children with fragile X syndrome. *American*

Journal on Intellectual and Developmental Disabilities, 115, 54-75. doi: 10.1352/1944-

7558-115.1.54

Werker, J. F., & Tees, R. C. (2005). Speech perception as a window for understanding plasticity and commitment in language systems of the brain. *Developmental Psychobiology*, 46, 233-

234. doi:10.1002/dev.20060

Witecy, B., & Penke, M. (2017). Language comprehension in children, adolescents, and adults with Down syndrome. *Research in Developmental Disabilities*, 62, 184-196.

doi.org/10.1016/j.ridd.2017.01.014

Yoder, P. J., & Warren, S. J. (2004). Early predictors of language in children with and without

Down syndrome. *American Journal of Mental Retardation*, 109, 285-300. doi:10.1352/0895-

8017(2004)109<285:EPOLIC>2.0.CO;2

Ypsilanti, A., & Grouios, G. (2008). Linguistic profile of individuals with Down syndrome:

Comparing the linguistic performance of three developmental disorders. *Child*

Neuropsychology, 14, 148-170. doi:10.1080/09297040701632209

Received 6/17/2017, accepted 9/20/2018

DEVELOPMENT OF SYNTAX COMPREHENSION

We are grateful to John M. Belmont for his helpful comments on this manuscript. We also thank the students and psychologists who helped with data collection. We extend our deepest gratitude to the special education facilities and schools that permitted us to conduct this study, and to all the children, adolescents and adults who participated. This work was supported by a grant from the French National Research Agency (Agence Nationale de la Recherche -ANR, LANG & HANDICAPS, Projet no. ANR-09-ENFT-019). David Magis is a Research Associate of the Fonds de la Recherche Scientifique -FNRS- (Belgium). Neither of the authors has any conflicts of interest with any company or other organization regarding the material discussed in this manuscript.

Authors:

Bruno Facon, Univ. Lille, CNRS, CHU Lille, UMR 9193 - SCALab - Sciences Cognitives et Sciences Affectives, F-59000 Lille, France ; and **David Magis**, Department of Education, University of Liège, Belgium.

Correspondence concerning this article should be addressed to Bruno Facon, Univ. Lille, CNRS, CHU Lille, UMR 9193 - SCALab - Sciences Cognitives et Sciences Affectives, F-59000 Lille, France (e-mail: bruno.facon@univ-lille.fr).

DEVELOPMENT OF SYNTAX COMPREHENSION

Table 1

Descriptive Statistics for Chronological Age (CA) and Raw Scores on the RAVEN, the EVIP and the F-TROG

	CA (in years)*		RAVEN*		EVIP		F-TROG	
	UND	DS	UND	DS	UND	DS	UND	DS
Mean	14.92	14.80	13.63	13.68	71.66	59.53	57.35	45.27
SD	3.83	3.50	4.44	4.47	19.01	12.11	14.91	8.49
Min	6.69	7.21	3	4	37	24	25	27
Max	20.62	21.85	30	31	129	87	87	67
Skewness	-0.63	0.13	0.73	0.89	0.46	-0.37	-0.11	0.39
Kurtosis	-0.69	-0.60	2.25	2.80	0.20	0.36	-0.72	0.13

Note. *Matching variables. CA = chronological age; RAVEN = Raven Colored Progressive Matrices; EVIP = Echelle de Vocabulaire en Images Peabody; F-TROG = French version of the Test for Reception of Grammar; UND = participants with ID of undifferentiated etiology ($n = 62$); DS = participants with Down syndrome ($n = 62$). The standard errors for skewness and kurtosis are 0.30 and 0.60, respectively.

Table 2

Multiple Regression Analyses of EVIP and F-TROG Scores of Participants With ID of Undifferentiated Etiology or DS

Variables in the equation		EVIP						
		R^2	Overall F	p	b	Partial F	p	
Step 1	CA	.155 [.054, .283]	22.159	< .001	1.733 [1.004, 2.462]	22.159	< .001	
Step 2	CA	.275 [.139, .405]	22.731	< .001	1.721 [1.042, 2.399]	25.239	< .001	
	Status				-11.086 [-16.012, -6.160]	19.851	< .001	
Step 3	CA	.277 [.134, .401]	15.162	< .001	1.892 [0.967, 2.817]	16.396	< .001	
	Status				-11.087 [-16.028, -6.145]	19.737	< .001	
	CA \times Status				-0.373 [-1.738, 0.992]	0.293	.590	
Variables in the equation		F-TROG						
		R^2	Overall F	p	b	Partial F	p	
Step 1	CA	.038 [.000, .128]	4.822	.03	0.722 [0.071, 1.373]	4.822	.03	
Step 2	CA	.236 [.107, .364]	18.717	< .001	0.694 [0.111, 1.277]	5.561	.02	
	Status				-11.994 [-16.231, -7.758]	31.411	< .001	
Step 3	CA	.236 [.101, .359]	12.390	< .001	0.744 [-0.048, 1.537]	3.456	.065	
	Status				-11.995 [-16.249, -7.741]	31.164	< .001	
	CA \times Status				-0.110 [-1.285, 1.065]	0.034	.853	

Note. R^2 = squared multiple correlation coefficient; b = unstandardized regression coefficient; CA = chronological age; Status = respectively 0 and 1 for participants with intellectual disability (ID) of undifferentiated etiology and participants with Down syndrome (DS); EVIP = Echelle de Vocabulaire en Images Peabody; F-TROG = French version of the Test for Reception Of Grammar; $N = 123$ for the EVIP analysis; $N = 124$ for the F-TROG analysis. Numbers between brackets refer to 95% confidence intervals.

DEVELOPMENT OF SYNTAX COMPREHENSION

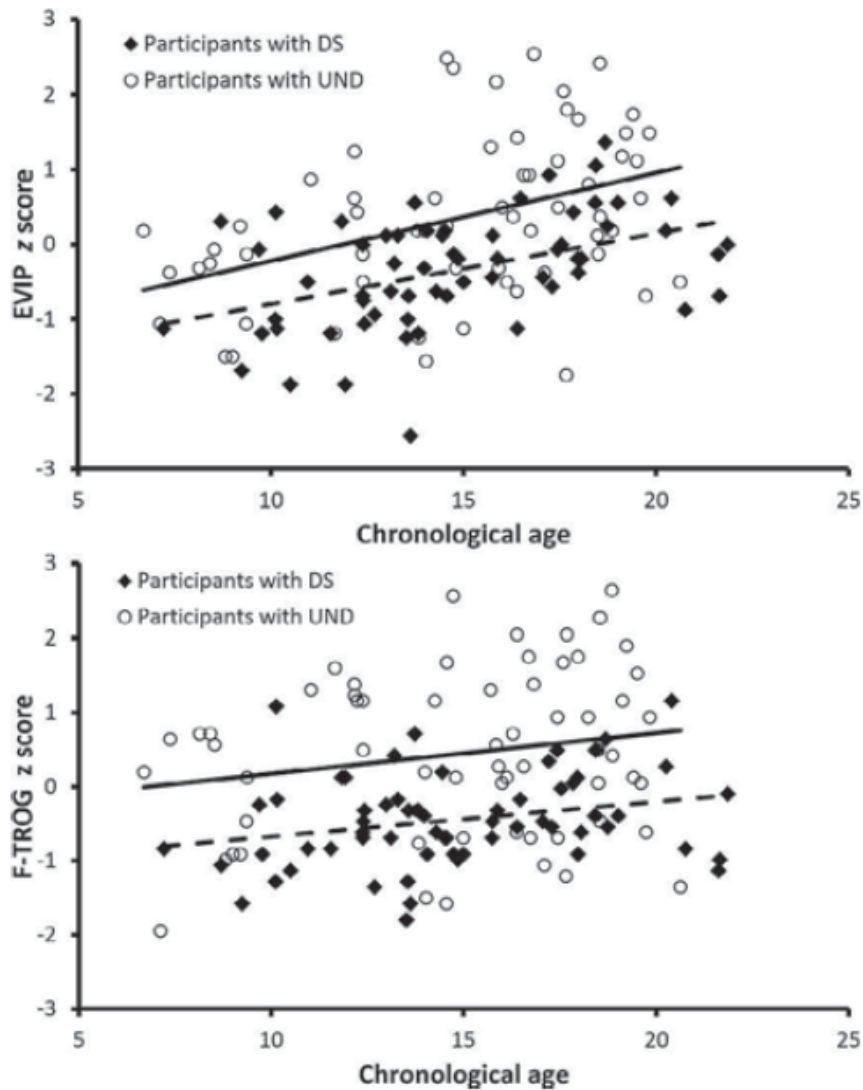


Figure 1. EVIP (top panel) and F-TROG (bottom panel) z scores as a function of chronological age for participants with ID of undifferentiated etiology and those with DS. EVIP = Echelle de Vocabulaire en Images Peabody; F-TROG = French version of the Test for Reception of Grammar; UND = participants with intellectual disability (ID) of undifferentiated etiology ($n = 61$); DS = participants with Down syndrome ($n = 62$). Solid lines correspond to the simple linear regression lines of participants with ID of undifferentiated etiology, dashed lines to the simple linear regression lines of participants with DS.