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Publication Date
2016-08-01

DOI
10.1016/j.ridd.2016.03.018

Peer reviewed

Published in final edited form as:

Res Dev Disabil. 2016 August ; 55: 161–172. doi:10.1016/j.ridd.2016.03.018.

Receptive vocabulary analysis in Down syndrome

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Abstract

The present study is an in-depth examination of receptive vocabulary in individuals with Down syndrome (DS) in comparison to control groups of individuals of similar nonverbal ability with typical development (TD) and non-specific etiology intellectual disability (ID). Verb knowledge was of particular interest, as it is known to be a predictor of later syntactic development. Fifty participants with DS, aged 10–21 years, 29 participants with ID, 10–21 years, and 29 participants with TD, 4–9 years, completed measures of receptive vocabulary (PPVT-4), nonverbal ability (Leiter-R), and phonological memory (Nonword Repetition subtest of the CTOPP). Groups were compared on percentage correct of noun, verb and attribute items on the PPVT-4. Results revealed that on verb items, the participants with ID performed significantly better than both participants with DS and TD, even when overall receptive vocabulary ability and phonological memory were held constant. Groups with DS and TD showed the same pattern of lexical knowledge, performing better on nouns than both verbs and attributes. In contrast, the group with ID performed similarly on nouns and verbs, but worse on attributes.

Keywords

Down syndrome; lexical development; receptive vocabulary; verb knowledge; intellectual disability

Down syndrome (DS) is caused by a triplication of all or part of chromosome 21 (Jacobs, Baikie, Court Brown, & Strong 1959; Lejeune, Gautier, & Turpin, 1959; Pangalos et al., 1994) and is the leading genetic cause of intellectual disability (ID), affecting 1 in every 691

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live births (Parker et al., 2010). Particularly striking in individuals with DS are poor speech and language abilities, with impairments that exceed nonverbal IQ expectations (Abbeduto et al., 2003; Kernan & Sabsay, 1996; Vicari, Caselli, Gagliardi, Tonucci & Volterra, 2002). Not all aspects of language appear equally impaired, however, and, researchers have begun to study the extent and nature of the language profile in DS (for reviews see Abbeduto, Warren & Conners, 2007; Chapman, 2003; Chapman, Schwartz, & Kay-Raining Bird, 1991; Chapman, Seung, Schwartz, & Kay-Raining Bird, 1998; McDuffie, Chapman, & Abbeduto, 2008). A nuanced approach to examining how various aspects of language develop in this population is imperative for the long-term goal of developing more targeted treatments to improve language and communication. In the present study, we examined receptive vocabulary in individuals with DS, typical development (TD) and non-specific etiology ID. Of particular interest was the development of verb knowledge, which is known to be a predictor of later syntactic development (e.g., Gleitman, 1990).

Broadly speaking, expressive language is delayed in DS relative to receptive language and nonverbal cognitive ability (Chapman, Kay-Raining Bird, & Schwartz, 1990; Chapman et al., 1991; Chapman et al., 1998) and is especially impaired in the areas of speech intelligibility, syntax, and grammatical morphology (Chapman & Hesketh, 2000; Chapman, 1999; 2003; Abbeduto & Chapman, 2005). In contrast, receptive vocabulary has been found to be on par with nonverbal cognitive abilities (Abbeduto et al., 2003). However, individuals with DS perform below their developmental level in receptive, as well as expressive, syntax (Abbeduto et al., 2003; Kernan & Sabsay, 1996; Vicari et al. 2002). Phonological memory, a predictor of vocabulary knowledge in DS (Laws & Gunn, 2004), is also especially impaired (Cairns & Jarrold, 2005; Jarrold, Baddeley & Phillips, 1999; Naess et al., 2011a; 2011b). Despite extensive research on language abilities in DS, basic research on the pattern of lexical comprehension, including differences in the acquisition of word categories (e.g., nouns versus verbs), has yet to be fully examined in this population.

There is considerable evidence that in TD, verb acquisition, in contrast to other categories of words such as nouns, is particularly important to later syntactic development (Bassano, 2000; Bates & MacWhinney, 1982; 1987; Bresnan, 1978; 1982; Chapman, Streim, Crais, Salmon, Strand, & Negri, 1992; Gleitman, 1990; Gropen, Pinker, Hollander, & Goldberg, 1991). Although nouns represent objects, persons, and things and function as subjects or objects of verbs, verbs are more complex and abstract. Verbs contain both semantic and syntactic information, represent actions, mental states, or changes of state and function as predicates, establishing properties of tense and agreement. They are also responsible for linking other words in the sentence together, thereby expressing relational meanings between those words.

Because of their complexity, verbs have been found to be more difficult than nouns for TD children to master (Rice, Buhr, & Nemeth, 1990) and they appear to be disproportionately more difficult for individuals with DS than those with TD (e.g., Hesketh & Chapman, 1998). However, the mechanisms responsible for delays in verb development in DS are not well understood. For example, Hesketh and Chapman (1998) found that individuals with DS produced fewer grammatical and lexical verbs in narrative samples and also produced more utterances that did not contain verbs relative to participants with TD matched on mean

length utterance (MLU; see also Caselli, Monaco, Trasciani, & Vicari, 2008). At the same time, when the participants with DS did include verbs in their utterances, they produced a greater diversity of lexical verbs than the TD controls and performed similarly in their diversity of grammatical verbs. Hesketh and Chapman concluded that individuals with DS may have difficulty accessing rather than comprehending verbs, despite being able to access event contexts and roles associated with the verb.

Others have also reported null and mixed findings when comparing participants with DS and TD on verb development. Grela (2002) found that participants with DS produced lexical verbs as frequently as TD controls matched on MLU during mother-child interactions. However, consistent with Hesketh and Chapman (1998), participants with DS in Grela's study also produced a greater variety of verb types. In contrast, Michael, Ratner, and Newman (2012) reported that participants with DS were more likely to omit verbs in elicited narrative samples than TD participants matched on receptive vocabulary. However, on an experimental, receptive test of lexical knowledge, Michael and colleagues reported no differences between participants with DS and TD. There were also no group differences in Michael et al.'s study on experimental tasks of single verb naming and proportion of target verb responses.

Studies of fast mapping, the ability to learn new words after only one or two exposures to the word (Carey & Bartlett, 1978), have also been informative about lexical comprehension in DS, including the acquisition of verbs. These studies appear to support the hypothesis that learning new verbs is more difficult than learning new nouns for both individuals with TD and DS and may be more difficult for individuals with DS than those with TD (Chapman, 2003; McDuffie, Sindberg, Hesketh, & Chapman, 2007; Rice et al., 1990).

The fast mapping paradigm is limited, however, in explaining lexical development in DS because of confounds with expressive language and phonological memory. Participants in fast-mapping studies may be exposed to novel words in a spoken story or event, such as a magic show, acted out by the investigator. The participants are then asked to retell the story or name the novel word as a measure of production and to name or define the novel word or select its corresponding object as a measure of comprehension. In some instances, both the comprehension and production tasks require the participants to verbally produce an answer, and novel words are presented in the context of a spoken story or action performed by the investigator. It is therefore possible that comprehension in the group with DS is confounded with poor working memory (Jarrold & Baddeley, 2001) and expressive language and speech delays (Chapman et al., 1998; Chapman & Hesketh, 2000), thereby underestimating their true comprehension. A measure in which individuals with DS are tested for comprehension of different word categories without requiring verbal production would be informative. For example, the Peabody Picture Vocabulary Test, which examines knowledge of vocabulary words in isolation without requiring verbal responses by participants, would accomplish this.

The Peabody Picture Vocabulary Test, currently in its fourth edition (PPVT-4; Dunn & Dunn, 2007), is a widely used standardized test of receptive vocabulary that includes nouns, verbs, and adjectives. An experimenter presents a vocabulary word orally, and the participant is prompted to point to the one drawing out of four that depicts the meaning of the word.

Because it is easy to administer and score, it has become a popular matching variable for researchers who work with samples of individuals with ID, such as DS, and researchers have reported that it is an appropriate matching variable for DS (Glenn & Cunningham, 2005; Phillips, Loveall, Channell & Conners, 2014). However, despite its wide use as a matching variable for samples with DS, researchers have not typically gone beyond using composite scores, such as total raw score, standardized scores or age-equivalent scores, thereby failing to examine the possibility of differences in performance across word categories. The inclusion of noun, verb and attribute words makes the PPVT-4 an ideal measure for an in-depth analysis of receptive lexical development.

The PPVT-4 has several advantages for use with participants with DS relative to other measures. First, because it requires no verbal response, it is not confounded by poor expressive language. Also, because all four choices are presented simultaneously, the task is not confounded with working memory constraints often observed in DS (Jarrold & Baddeley, 2001). Finally, the PPVT-4 includes many concrete verbs, such as “drinking”, “running” and “yawning,” especially in the beginning of the task. In contrast to abstract verbs such as “seeming” and “respecting” that have no physical referents, concrete verbs are more easily pictured. Because the PPVT-4 includes both nouns and verbs that can be pictured, it is a useful tool for examining knowledge of word categories (i.e., nouns vs. verbs) in DS.

Only one study has analyzed receptive vocabulary error patterns by individuals with DS on the PPVT. Facon, Nuchadee, and Bollengier (2012) conducted a qualitative analysis of receptive vocabulary in DS by utilizing the transformed item difficulties method on the French version of the PPVT (Echelle de Vocabulaire en Images Peabody, EVIP; Dunn, Therialt-Whelan, & Dunn, 1993). Results of their study indicated that when overall receptive vocabulary was held constant, participants with DS had similar profiles to participants with ID and TD on the rank order of individual item difficulty. However, Facon et al. did not compare performance on word categories (i.e., verbs vs. nouns vs. attributes). No studies have yet examined the pattern of lexical development in English-speaking participants with DS using the PPVT.

The first goal of the present study was to clarify the profile of receptive vocabulary development and impairment in DS by conducting an in-depth examination of performance on the PPVT-4. In light of the central role of verbs in theories of language development and their foundational role in the acquisition of syntax, a fuller understanding of verb knowledge is needed to illuminate the nature of the syntactic impairment in DS. A better understanding of this impairment will ultimately lead to the establishment of more targeted interventions to improve language development in this population. So, we addressed the extent to which performance varied across verbs and other word categories.

A second goal was to extend previous research on lexical comprehension in DS by including two comparison groups, both TD and ID. Previous research has predominantly focused on developmental level comparisons, and only compared participants with DS to TD controls. This type of comparison ignores the impact of age on lexical development in DS. In our study the group with TD will serve as a mental-age match, indicative of “typical

development," and the group with ID will serve as both an IQ and a chronological age match. By having these two comparison groups, the language profile of DS can be understood in relation to both typical development and intellectual disability, addressing the issues of extent of delay and syndrome specificity of the PPVT profile observed in DS, respectively.

To address our goals, groups with DS, ID and TD were compared on their performance of different word categories, or item types, on the PPVT-4 (nouns vs. verbs vs. attributes). Further, developmental trajectory analyses were conducted for item types within and between groups across different overall receptive vocabulary abilities. This allowed for a more comprehensive analysis of group performance and word knowledge. We hypothesized that participants with DS would show an altered pattern to that of participants with ID and TD; namely, that individuals with DS would perform similarly to these other groups on noun and attribute items, but significantly worse on verb items, even when overall receptive vocabulary ability was held constant.

2 Method

2.1 Participants

Participants came from a larger study on language development in DS and were recruited from the participant registries of two universities, local community agencies, parent support groups, schools, etc. Eligibility criteria for the larger study included that participants speak English as their native language, use speech as their main way to communicate, not have an autism spectrum disorder diagnosis, and have use of their hands to manipulate cards. Participants also had to pass a vision screener and complete standardized tests of nonverbal ability, receptive grammar and phonological memory. In addition to the criteria for the larger study, participants had to complete the PPVT-4 to be included in the present study.

2.1.1 Participants with DS—In addition to the general eligibility criteria, participants with DS had to be between 10 and 21 years old and pass autism and hearing screeners. To pass the autism screener, participants had to score below 15 (recommended for individuals with developmental disorders, Berument, Rutter, Lord, Pickles & Bailey, 1999) on the Social Communication Questionnaire (SCQ; Rutter, Bailey, & Lord, 2003), a caregiver checklist. Any participants who scored 15 or higher were referred to a clinician for a full diagnostic evaluation, including the Autism Diagnostic Schedule (ADOS; Lord, Rutter, DiLavore & Risi, 1999) and were included in the study if they did not meet criteria for autism. To pass the hearing screener participants had to respond to a tone two out of three times at 30 dB HL or better in at least one ear at 1000, 2000, and 4000 Hz. Of 54 participants with DS in the larger study, 50 met criteria for the present study and were included in data analysis (21 males, 29 females; 37 White Non-Hispanic, 7 White Hispanic, 1 African-American, 4 Multi-Racial, and 1 Other).

2.1.2 Participants with ID—In addition to the general eligibility criteria, participants with ID had to be between 10 and 21 years old, pass autism and hearing screeners (see above), and have a school classification or clinical diagnosis of intellectual disability. Of 30 participants with ID in the larger study, 29 met criteria for the present study and were

included in the data analysis (14 males, 15 females; 25 White Non-Hispanic, 1 White Hispanic, 3 African-American).

2.1.3 TD participants—In addition to the general eligibility criteria, TD participants had to be between 4 and 21 years, be ineligible for special services in school, including those for learning disability, speech and language and giftedness, and not have a diagnosis of attention deficit hyperactivity disorder or autism spectrum disorder. Those age 4–9 were targeted for the present study to use as mental-age matches on nonverbal ability. Of 43 participants age 4–9 with TD in the larger study, 29 met criteria for the present study and were included in data analysis (17 males, 12 females; 16 White Non-Hispanic, 4 White Hispanic, 8 African-American, 1 Multi-Racial).

2.2 Measures

2.2.1 Peabody Picture Vocabulary Test – 4th edition—(PPVT-4; Dunn & Dunn, 2007; 15 min.) was used to measure receptive vocabulary. For each item, four drawings are presented on a page. Participants are asked to point to the drawing that corresponds with the meaning of a word spoken by the examiner. For participants with DS and ID, testing began at the block corresponding to half of their chronological age (e.g., a 16 year-old began at the 8 year start point). This was done in order to reduce total testing time without beginning at a point beyond the expected developmental level of the participant. For participants with TD, testing began at the block corresponding to their chronological age. All other basal and ceiling rules were administered as suggested by the manual. Any items that came before the basal that were not administered were counted as correct. Total raw score correct and percentage correct of nouns, verbs and attributes were used in the present study. Because participants were administered different numbers of noun, verb and attribute items depending on their overall performance, percentage correct of each of these items were used in analyses. Any trials before the basal that were scored as correct were included in the calculation of percentage of nouns, verbs and attributes correct. Therefore, participant scores were based on overlapping, but not identical, sets of items depending on how far they progressed in the PPVT-4.

The PPVT-4 is a standardized norm-referenced test that is appropriate for functioning levels equivalent from 2.5 years to 90+ years. Split half reliability ranges from .89 to .97 for all ages, and test-retest reliabilities range from .92–.93 for all ages. The PPVT-4 also correlates with the Clinical Evaluation of Language Fundamentals, 4th edition from .67 to .79 for ages 5–12 years, with the Expressive Vocabulary Test from .80–.84 for ages 2–81+ years, and with the Comprehensive Assessment of Spoken Language from .37 to .79 for ages 3–12 years (Dunn & Dunn, 2007).

2.2.2 Leiter International Performance Test – Revised, Brief Form—(Leiter-R; Roid & Miller, 1997; 30 min.) was used to measure nonverbal ability. The Brief IQ battery was used in the present study and consists of four subtests: Figure Ground, Form Completion, Sequential Order, and Repeated Patterns. These subtests are administered nonverbally and measure visual spatial and inductive reasoning skills. Growth score values (GSV), raw scores weighted for item difficulty, were used in the present study. Scores can

range from 380 to 560, with higher scores indicating greater ability. The Leiter-R is a standardized norm-referenced test that is appropriate for functioning levels equivalent from 2–21 years. Reliability ranges from .88 to .96, and the Brief Form correlates with the full version of the Leiter-R and the Wechsler Intelligence Scale for Children, 3rd edition at .85 (Roid & Miller, 1997).

2.2.3 Nonword Repetition subtest of the Comprehensive Test of Phonological Processing—(CTOPP; Wagner, Torgesen, & Rashotte, 1999) was used to measure phonological memory. This subtest entails repeating nonwords that range in length from 3 to 15 sounds. Total raw score correct was used in analyses. The CTOPP Nonword Repetition has a test-retest reliability ranging from .68 to .75.

2.3 Procedures

For the larger study, participants were tested individually in a quiet room by a trained examiner. After obtaining both parental consent and child assent (consent was also received from adult participants with ID and DS), participants were tested on a battery of language, phonological memory, and implicit and explicit learning tasks over a series of two to four sessions. Total testing time ranged from three to seven hours, depending on the individual participant. The Leiter-R and the Nonword Repetition subtest of the CTOPP were always administered during the first session, and the PPVT-4 was administered in a random order during one of the following sessions.

3 Results

3.1 Preliminary Data Analyses

Means and standard deviations are listed in Table 1. Correlations are presented in Table 2.

3.1.1 Chronological Age—An independent samples *t*-test was used to compare the groups with ID and DS on chronological age. Results of the *t*-test did not reveal a significant difference between the two groups on chronological age, $t(76) = 1.39$, $p = .17$. However, because the groups could not be considered matched on chronological age (see Mervis & Robinson, 1999), key analyses were conducted both with and without chronological age as a covariate, where appropriate.

3.1.2 Nonverbal cognitive ability—A one-way analysis of variance was used to compare groups on nonverbal ability. The independent variable was group (DS vs. ID vs. TD), and the dependent variable was Leiter-R GSV. There were no serious violations of the assumptions of ANOVA. Results revealed a significant difference between groups, $F(2, 105) = 6.61$, $p = .002$, $\eta^2 = .11$. Post-hoc comparisons using the LSD test for significance indicated that the groups with ID and TD scored significantly higher than the group with DS ($p = .001$ and $p = .015$, respectively). There was not a significant difference between the groups with ID and TD ($p = .42$). Because the groups were not matched on nonverbal cognitive ability, the subsequent ANCOVA and MANCOVA analyses statistically controlled for Leiter-R GSV.

3.1.3 Phonological memory—A one-way analysis of variance was used to compare the groups on phonological memory. The independent variable was group (DS vs. ID vs. TD), and the dependent variable was CTOPP Nonword Repetition raw score. There were no serious violations of the assumptions of ANOVA. Results revealed a significant difference between groups, $F(2, 105) = 5.50$, $p = .005$, $\eta^2 = .095$. Post-hoc comparisons using the LSD test indicated that the groups with ID and TD scored significantly higher than the group with DS ($p = .01$ and $p = .005$, respectively). There was not a significant difference between the groups with ID and TD ($p = .86$). Because the groups were not matched on phonological memory, and because it was expected to be a significant predictor of receptive vocabulary (Laws & Gunn, 2004), the subsequent ANCOVA and MANCOVA analyses statistically controlled for CTOPP Nonword Repetition.

3.1.4 Group comparison on receptive vocabulary—A one-way analysis of variance was used to compare groups on overall receptive vocabulary. The independent variable was group (DS vs. ID vs. TD), and the dependent variable was total raw score on the PPVT-4. There were no serious violations of the assumptions of ANOVA. Results of the ANOVA revealed a significant difference between groups on PPVT-4 raw score, $F(2, 105) = 12.84$, $p < .001$, $\eta^2 = .196$. Post-hoc comparisons using the LSD test indicated that the group with ID performed significantly better than both groups with TD and DS (p's < .001). There was not a significant difference between the groups DS and TD ($p = .67$).

Following the ANOVA, a one-way ANCOVA was used to compare groups on overall receptive vocabulary while statistically controlling for nonverbal cognitive ability and phonological memory. The covariates were Leiter-R GSV and CTOPP Nonword Repetition raw score. There were no serious violations of the assumptions of ANCOVA. Results of the ANCOVA revealed a significant difference between groups on PPVT-4 raw score, $F(2, 103) = 11.70$, $p < .001$, $\eta_p^2 = .185$. In regards to the covariates, there was also a significant relationship between Leiter-R GSV and PPVT-4 scores across groups, $F(1, 103) = 46.83$, $p < .001$, $\eta_p^2 = .313$, and CTOPP Nonword Repetition and PPVT-4 scores across groups, $F(1, 103) = 8.13$, $p = .005$, $\eta_p^2 = .073$.

Post-hoc comparisons using the LSD test indicated that, after controlling for nonverbal cognitive ability and phonological memory, the group with ID performed better than both groups with TD and DS ($p < .001$ and $p = .003$, respectively), and that the group with DS also performed significantly better than the group with TD ($p = .039$) despite having a slightly lower unadjusted mean score. Additional ANCOVAs were used to compare groups with ID and DS on overall receptive vocabulary while statistically controlling for age and IQ (independently and in combination with each other and the other covariates) since the two groups were not equivalent on these variables of interest. The pattern of results remained the same, namely that the group with ID performed significantly better than the group with DS (all p's < .05).

3.2 Primary Data Analyses

3.2.1 Group comparisons on PPVT-4 item types—To compare groups on comprehension of nouns, verbs and attributes, a one-way MANCOVA was conducted while

statistically controlling for nonverbal cognitive ability and phonological memory. The independent variable was group (DS vs. ID vs. TD), and the three dependent variables were: percentage of nouns, verbs and attributes correct on the PPVT-4. The covariates were Leiter-R GSV and CTOPP Nonword Repetition raw score. Percentage of nouns correct was not normally distributed for the group with ID, and percentage of attributes correct and Nonword Repetition raw score were not normally distributed for the group with DS. However, according to Tabachnick and Fidell (2007), a sample size that produces at least 20 degrees of freedom in the univariate case should ensure robustness for violations of normality. There were no other serious violations of MANCOVA.

Results of the MANCOVA revealed a significant difference between groups on the combined dependent variables, Pillai's Trace = .12, $F(6, 204) = 2.25$, $p = .04$, $\eta_p^2 = .062$. In regards to the covariates, there was also a significant relationship between Leiter GSV and the combined dependent variables, Pillai's Trace = .21, $F(3, 101) = 8.78$, $p < .001$, $\eta_p^2 = .21$. However, there was not a significant relationship between Nonword Repetition and the combined dependent variables ($p = .17$).

When the results for the dependent variables were considered separately, the only difference to reach statistical significance, using a Bonferroni adjusted alpha level of .017, was percentage of verbs correct, $F(2, 103) = 5.99$, $p = .003$, $\eta_p^2 = .10$. The group with ID scored significantly higher on average than the group with DS ($p = .001$) and the group with TD ($p = .02$). The main effect of Group for the percentages of nouns and attributes correct were nonsignificant, $p = .09$ and $p = .37$, respectively.

The difference between groups on percentage correct of verbs remained when performance on the PPVT-4 was added to the covariates. We controlled for the other PPVT-4 item types (nouns and attributes) as opposed to the PPVT-4 overall raw score because overall raw score was used in the calculation of the dependent variable: percentage of verbs correct. Results of the ANCOVA revealed a significant difference between groups, $F(2, 101) = 3.45$, $p = .036$, $\eta_p^2 = .064$, with the group with ID performing significantly better than the group with DS ($p = .01$). All other pairwise comparisons were nonsignificant.

Additional ANCOVAs were again used to compare groups with ID and DS on percentage of verbs correct while statistically controlling for age and IQ (independently and in combination with each other and the other covariates) since the two groups were not equivalent on these variables of interest. Again, the pattern of results remained the same; namely, the group with ID performed significantly better than the group with DS (all p's < .05).

3.3 Between-Groups Developmental trajectory analysis

3.3.1 Analytic Approach—To further analyze the relationship between groups on the PPVT-4 items (nouns, verbs, and attributes), we examined differences between groups relative to PPVT-4 raw score by performing a cross-sectional developmental trajectory analysis as described by Thomas et al. (2009). This method adapts the Analysis of Covariance (ANCOVA) function using SPSS's General Linear Model. *Traditionally*, one assumption of ANCOVA is that the covariate has the same relation to the dependent variable

in each group, which is found by the lack of a significant group x covariate interaction. However, for the present trajectory analysis, we specifically tested whether PPVT-4 raw score (the covariate) has a *different* relation to performance (noun/verb/attribute) across groups. The ANCOVA, therefore, tested group differences in slope, which was indicated by the group x PPVT-4 raw score interaction.

3.3.2 Preliminary Analyses—There were no serious violations of normality for any variable. To prepare for the cross-sectional developmental trajectory analysis, scatterplots for noun, verb, and attribute performance over PPVT-4 raw score were created within each group to visually examine linearity. No clear nonlinear trends were found. Cook's D values were calculated separately within each group for noun, verb, and attribute performance to determine whether any points were exerting undue influence on the analysis. A value greater than 1.00 would indicate undue influence, but no such values were found. Finally, the PPVT-4 raw score variable was transformed so that the lowest score in the analysis was set equal to zero. This allowed for greater interpretability of the intercepts of the trajectory analyses.

3.3.3 Nouns—The cross-sectional developmental trajectory for percent correct for nouns over PPVT-4 raw score showed no overall effect of Group, $F(2, 102) = 0.35$, $p = .704$, $\eta_p^2 = .007$. Thus, at the lowest PPVT-4 raw score in the data set, the regression lines for the groups were not significantly different. Additionally, there was no significant Group x PPVT-4 raw score interaction, $F(2, 102) = 0.15$, $p = .857$, $\eta_p^2 = .003$. Therefore, increases in noun performance as a function of PPVT-4 raw score were similar across the three groups.

3.3.4 Verbs—The cross-sectional developmental trajectory for percent correct on verbs over PPVT-4 raw score showed a significant overall effect of Group, $F(2, 102) = 3.14$, $p = .047$, $\eta_p^2 = .058$. Thus, at the lowest PPVT-4 raw score in the data set, the regression lines for the groups were significantly different. Post-hoc comparisons using the LSD test revealed a significant difference between the DS and ID intercepts ($p = .012$). No significant differences were found in the DS and TD intercepts ($p = .157$) or in the ID and TD intercepts ($p = .250$). There was no significant Group x PPVT-4 raw score interaction, $F(2, 102) = 1.49$, $p = .230$, $\eta_p^2 = .028$; therefore, increases in verb performance as a function of PPVT-4 raw score were similar across the three groups. See Figure 1.

3.3.5 Attributes—The cross-sectional developmental trajectory for percent correct on attributes over PPVT-4 raw score showed no overall effect of Group, $F(2, 102) = 0.54$, $p = .586$, $\eta_p^2 = .010$. Thus, at the lowest PPVT-4 raw score in the data set, the regression lines for the groups were not significantly different. Additionally, there was no significant Group x PPVT-4 raw score interaction, $F(2, 102) = 0.27$, $p = .767$, $\eta_p^2 = .005$; therefore, increases in attribute performance as a function of PPVT-4 raw score were similar across the three groups.

3.4 Within-Groups Developmental trajectory analysis

3.4.1 Analytic Approach—Using the method described by Thomas et al. (2009), we compared overall differences in item type within each group (DS, ID, or TD) using a one-

way repeated measures ANOVA. We also examined differences in slopes of the three item types within each group using an ANCOVA to compare PPVT-4 raw score-based trajectories. For the trajectory analyses, item type was the within-subjects factor, PPVT-4 raw score was the covariate, and Item Type x PPVT-4 raw score was the interaction term

3.4.2 Down syndrome—The one-way repeated measures ANOVA showed a significant effect for item type, $F(1, 49) = 101.16$, $p < .001$, $\eta_p^2 = .674$. Pairwise comparisons using a Bonferroni correction revealed that the participants with DS performed significantly better on nouns ($M = .81$, $SD = .06$) than both verbs ($M = .75$, $SD = .09$) and attributes ($M = .64$, $SD = .12$) and significantly better on verbs than attributes, all p-values < .001 (see Figure 2). The cross-sectional developmental trajectory did not yield a significant slope difference for item types, $F(1, 48) = 0.002$, $p = .963$, $\eta_p^2 < .001$; therefore, increases in item performance as a function of PPVT-4 raw score were similar in the group with DS.

3.4.3 Intellectual Disability—The one-way repeated measures ANOVA showed a significant effect for item type, $F(1, 28) = 53.69$, $p < .001$, $\eta_p^2 = .657$. Pairwise comparisons using a Bonferroni correction revealed that the participants with ID performed significantly better on nouns ($M = .86$, $SD = .06$) and verbs ($M = .84$, $SD = .07$) than on attributes ($M = .71$, $SD = .11$), all p-values < .001. The cross-sectional developmental trajectory did not find a significant slope difference for item types, $F(1, 27) = 0.49$, $p = .491$, $\eta_p^2 = .018$; therefore, increases in item performance as a function of PPVT-4 raw score were similar in the group with ID.

3.4.4 Typically Developing—The one-way repeated measures ANOVA showed a significant effect for item type, $F(1, 28) = 35.45$, $p < .001$, $\eta_p^2 = .559$. Pairwise comparisons using a Bonferroni correction revealed that the participants with TD performed significantly better on nouns ($M = .83$, $SD = .05$) than on both verbs ($M = .79$, $SD = .08$; $p = .010$) and attributes ($M = .70$, $SD = .11$; $p < .001$) and significantly better on verbs than attributes ($p = .002$). The cross-sectional developmental trajectory did not find a significant slope difference for item types, $F(1, 27) = 0.002$, $p = .964$, $\eta_p^2 < .001$; therefore, increases in item performance as a function of PPVT-4 raw score were similar in the group with TD.

4 Discussion

The goals of this study were to clarify the profile of receptive vocabulary development in DS and to evaluate the syndrome specificity of that profile. The profile of receptive vocabulary development in DS was examined by comparing the comprehension of word categories (nouns vs. verbs vs. attributes) in individuals with DS. Because of their importance to later syntactic development (e.g. see Bassano, 2000), we were especially interested in the comprehension of verbs. Two comparison groups were included: TD and ID. Our findings were consistent with previous research findings of participants with DS performing as well as TD comparisons on tests of verb knowledge (e.g. Grela, 2002; Michael et al., 2012). However, the group with ID performed significantly better than both of the other groups on overall receptive vocabulary and significantly better than the group with DS on verb knowledge.

On overall receptive vocabulary, the group with ID performed better than both the groups with DS and TD, even after nonverbal cognitive ability and phonological memory were added as covariates. Further analysis revealed that this difference was driven by group differences in verb knowledge, with the group with ID performing significantly better than the other two groups on verbs, but not on nouns or attributes. When overall receptive vocabulary was added as a covariate, the difference between groups with ID and DS remained significant with a small to medium effect size (Cohen, 1988; Privitera, 2012). There were no differences between the groups with DS and TD on verb knowledge.

Between-group and within-group developmental trajectory analyses also confirmed this pattern. A between-groups trajectory on *verb* performance relative to overall receptive vocabulary knowledge was the only between-groups trajectory analysis to reach statistical significance, indicating a difference between intercepts for the groups with ID and DS. Thus, the group with ID performed significantly better on verb items than the group with DS, and this was true over the entire developmental range studied, as reflected in a nonsignificant difference in slope. There were no significant group differences on noun or attribute items in terms of intercept or slope. Between-groups trajectories examining noun and attribute performance relative to receptive vocabulary knowledge were not significant.

Within-groups trajectories showed a similar pattern for the DS and TD groups; namely, that participants in these groups performed better on nouns than both verbs and attributes over the entire developmental range studied. In contrast, the group with ID performed better on both nouns and verbs than attributes. Results for the groups with DS and TD are consistent with previous studies indicating that learning verbs is more difficult than learning nouns (Chapman, 2003; McDuffie et al., 2007; Rice et al., 1990). However, this pattern did not maintain for the group with ID, who did not exhibit differences in comprehension of nouns versus verbs. When considered together, the pattern of results suggests that this group of participants with ID was stronger in receptive vocabulary and verb knowledge than both the groups with TD and DS.

Both age and cognitive ability, or a combination thereof, could explain the relative strength in the group with ID. Previous research has found a significant relationship between chronological age and receptive vocabulary in participants with ID and DS (Facon, Bollengier, & Grubar, 1993; Facon & Facon-Bollengier, 1997; Facon, Grubar & Gardez, 1998). Several researchers have also noted the benefit of chronological age, and the additional life experience it affords, to receptive vocabulary in participants with ID and DS (Facon et al., 1998; Chapman, 2006). However, other researchers have failed to find significant relationships between chronological age and vocabulary in younger children with DS, but instead found that vocabulary size was more strongly related to developmental age (Zampini & D'Odorico; 2013). Correlations among variables in the present study suggest both chronological age and cognitive ability are significant correlates of receptive vocabulary for participants with DS, whereas only cognitive ability correlates with receptive vocabulary in the participants with ID.

In the present study, the group with ID demonstrated statistically higher nonverbal ability scores than the group with DS and were slightly, though not significantly, older than the

group with DS. In contrast, they were significantly older than the group with TD but had slightly lower, though not significantly so, nonverbal ability scores. Although we statistically controlled for these variables in analyses, they still may have impacted group performance. It is possible that at younger ages, individuals with ID, including those in the present study, also struggle with learning verbs relative to nouns. As they age, these individuals may become more adept than individuals with DS to improve verb knowledge, something we would also expect to see in older TD children. Thus, a likely explanation for the findings in the present study is that the participants with ID were able to use their extra life experiences, in combination with other cognitive skills that are less impaired than in DS, to understand a greater number of verbs than the younger TD participants.

Because phonological memory is known to be both impaired (e.g. Cairns & Jarrold, 2005) and a predictor of vocabulary (e.g. Laws & Gunn, 2004) in DS, it was expected to account for significant group differences in verb comprehension and thus was statistically controlled. Although phonological memory was impaired in our sample of participants with DS relative to both the groups with ID and TD, the group with ID still performed better than the group with DS on overall receptive vocabulary and verb knowledge, even after statistically controlling for phonological memory. However, the pattern of results in the DS-TD contrast changed after adding phonological memory as a covariate. Despite having slightly lower unadjusted overall receptive vocabulary scores, the group with DS performed significantly better than the group with TD on overall receptive vocabulary after controlling for phonological memory. This pattern, however, did not maintain for group comparisons on word categories. After controlling for nonverbal ability and phonological memory, no group differences were found between the groups with DS and TD on verb knowledge.

The verb comprehension difference in participants with DS relative to others with ID may help explain prior studies that indicate impairments in verb production in DS (e.g. Hesketh & Chapman, 1998; Michael et al., 2012). Previous researchers have hypothesized that individuals with DS may struggle to produce verbs because of difficulties in cognitively accessing those verbs (Hesketh & Chapman, 1998). However, most previous studies on verb development in DS have primarily used narrative samples to measure verb production (Grela, 2002; Hesketh & Chapman, 1998) and included comparison groups of younger, TD children (Grela, 2002; Hesketh & Chapman, 1998; Michael et al., 2012). These studies have reported somewhat mixed results. Michael and colleagues were the first to examine verb comprehension both receptively and in isolation and found no differences in verb knowledge between participants with DS and TD controls. Our results are consistent with those of Michael and colleagues.

The current findings also extend these results and suggest that individuals with DS may not comprehend verbs as well as other individuals with ID. The current study had several limitations. First, because the samples were not well matched on nonverbal ability, we had to statistically control for this variable. However, despite statistically controlling for group differences in nonverbal cognitive ability, there were still significant group differences in lexical comprehension, indicating that nonverbal cognitive ability was not the sole predictor of group performance on the PPVT-4. Further, although the participants were not significantly different in terms of age, they could also not be considered equivalent, and we

did not control for academic experiences or speech and language therapy. A third limitation of the present study is the older ages of our participants with ID and DS. Future studies may wish to examine verb development in younger participants so as to track its emergence.

The present study was a first examination of the pattern of lexical development in English-speaking participants with DS in contrast to both TD and ID comparison groups. Despite using the conceptually easier PPVT-4, in contrast to other measures of receptive vocabulary, the group with DS did not perform as well as participants with ID. The finding that individuals with DS may struggle with verb comprehension relative to peers with ID has implications for language development and training in DS. Because of the importance of verbs in syntactic development, teachers, therapists and parents may want to pay special attention to verb training for individuals with DS. Additional training in verb comprehension could potentially benefit verb production and syntax development. Future studies should also consider focusing on the relationship between comprehension and production of verbs and syntax in DS.

Acknowledgments

We would like to thank the families and participants who participated in our study. We would also like to thank the recruiters and testers from all sites. This research was supported by E. K. Shriver NICHD grants R01 HD055345 and U54 HD079125.

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Highlights

- Individuals with DS performed similarly to TD participants on verb comprehension but worse than participants with ID
- Groups with DS and TD showed the same pattern of lexical knowledge, performing better on nouns than both verbs and attributes
- In contrast, the group with ID performed similarly on nouns and verbs, but worse on attributes

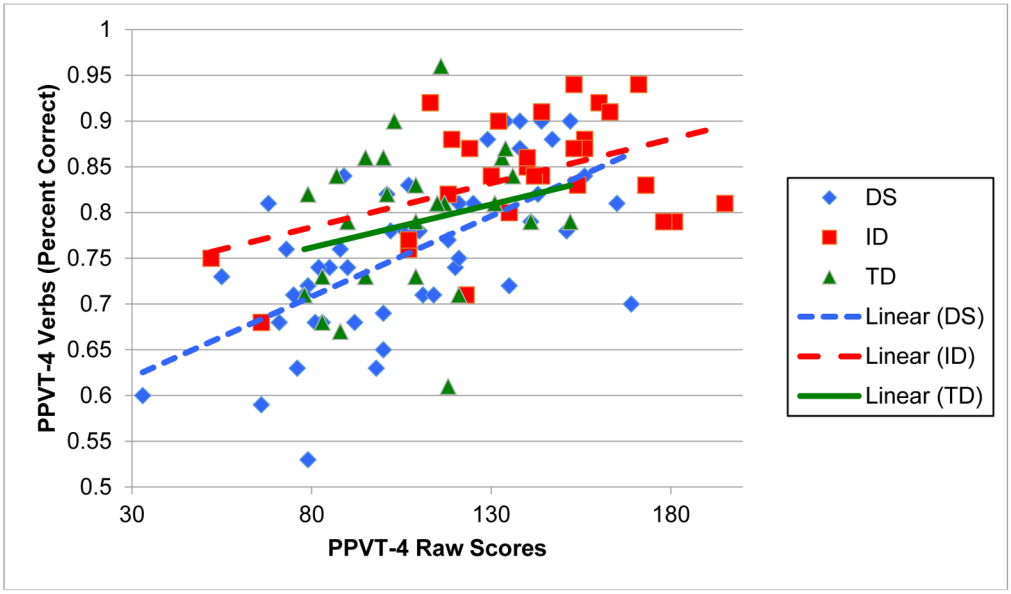

Figure 1.
Verb Performance over PPVT-4 Raw Scores.

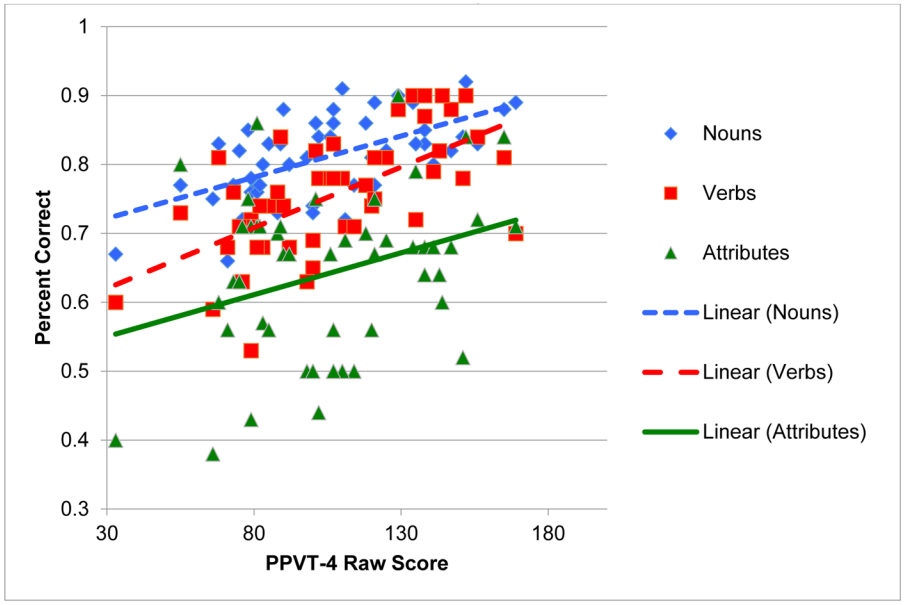

Figure 2.
Noun, Verb, and Attribute Performance in Group with DS over PPVT-4 Raw Scores.

Table 1

Means and Standard Deviations (SD) of Sample Descriptives

	DS *n* = 50		ID *n* = 29*		TD *n* = 29	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Age	14.91	3.20	15.89	2.59	6.03	1.48
	(10.25–21.92)		*(10.25–20.67)*		*(4.08–8.92)*	
GSV	466.98	10.92	475.45	9.16	473.17	11.74
	(448–492)		*(458–487)*		*(459–496)*	
AE	5.35	1.16	6.22	1.04	6.03	1.44
	(3.58–8.42)		*(4.42–7.63)*		*(4.50–9.13)*	
IQ	44.74	8.64	52.54	10.84	105.00	15.06
	(36–71)		*(36–77)*		*(79–135)*	
NR	5.56	3.13	7.38	2.92	7.52	2.66
	(1–11)		*(0–13)*		*(0–11)*	
PPVTraw	106.54	30.87	138.93	31.60	109.38	20.01
	(33–169)		*(52–195)*		*(78–152)*	
PPVTest 95% CI	*114.60*	*3.07(SE)*	*130.46*	*3.98(SE)*	*103.96*	*3.94(SE)*
	(108.51–120.69)		*(122.57–138.35)*		*(96.15–111.76)*	
Noun	.81	.06	.86	.06	.83	.05
	(.66–.92)		*(.70–.92)*		*(.70–.91)*	
NounEst 95% CI	*.82*	*.01(SE)*	*.85*	*.01(SE)*	*.82*	*.01(SE)*
	(.81–.84)		*(.83–.87)*		*(.80–.84)*	
Verb	.75	.09	.84	.07	.79	.08
	(.53–.90)		*(.68–.94)*		*(.61–.96)*	
VerbEst 95% CI	*.77*	*.01(SE)*	*.83*	*.01(SE)*	*.78*	*.01(SE)*
	(.75–.79)		*(.80–.86)*		*(.76–.81)*	
Attribute	.64	.12	.71	.11	.70	.11
	(.38–.90)		*(.47–.89)*		*(.50–.94)*	
AttribEst 95% CI	*.66*	*.02(SE)*	*.69*	*.02(SE)*	*.69*	*.02(SE)*
	(.63–.69)		*(.65–.73)*		*(.65–.73)*	

Note: GSV = Leiter Growth Score Value. Age = Chronological age. IQ = Leiter Intelligence Quotient. AE = Leiter age equivalent scores. NR = Nonword Repetition raw score. PPVTraw = PPVT raw score. PPVTest = PPVT estimated marginal means from ANCOVA analysis. SE = standard error. CI = confidence interval. Noun = PPVT percentage of nouns correct. NounEst = noun estimated marginal means from MANCOVA analysis. Verb = PPVT percentage of verbs correct. VerbEst = verb estimated marginal means from MANCOVA analysis. Attrib = PPVT percentage of attributes correct. AttribEst = attribute estimated marginal means from MANCOVA analysis.

*one participant was adopted and birthdate was not known; this participant's age and IQ are therefore not calculated into group means

Res Dev Disabil. Author manuscript; available in PMC 2017 August 01.

Table 2

Correlations Among Variables for the Group with DS (corrected for Leiter-R GSV below the diagonal)

	GSV	Age	NR	PPVTraw	Noun	Verb	Attrib
GSV	--	.37*	.58**	.70**	.53**	.46*	.16
Age	--	--	.24	.28^	.24	.26	-.08
NR	--	−.04	--	.64**	.30*	.25	.24
PPVTraw	--	.02	.40*	--	.61**	.62**	.32*
Noun	--	.06	−.01	.40*	--	.63**	.29*
Verb	--	.10	−.02	.48*	.51**	--	.33*
Attrib	--	−.15	.19	.29*	.24	.29*	--

Correlations Among Variables for the Group with ID (corrected for Leiter-R GSV below the diagonal)

	GSV	Age	NR	PPVTraw	Noun	Verb	Attrib
GSV	--	.19	.38*	.63**	.52*	.34	.58*
Age	--	--	.25	.29	.15	.09	.16
NR	--	.20	--	.29	.19	−.05	.45*
PPVTraw	--	.23	.06	--	.71**	.46*	.48*
Noun	--	.07	−.01	.61*	--	.67**	.25
Verb	--	.04	−.21	.35	.62*	--	.15
Attrib	--	.08	.31	.21	−.09	−.07	--

Correlations Among Variables for the Group with TD (corrected for Leiter-R GSV below the diagonal)

	GSV	Age	NR	PPVTraw	Noun	Verb	Attrib
GSV	--	.79**	.35	.70**	.51*	.27	.20
Age	--	--	.23	.56*	.53*	.52*	.23
NR	--	−.08	--	.39*	.51*	.30	.24
PPVTraw	--	.03	.22	--	.42*	.25	.17
Noun	--	.24	.41*	.10	--	.49*	.06
Verb	--	.52*	.23	.09	.43*	--	.13
Attrib	--	.12	.19	.05	−.06	.08	--

Note: GSV = Leiter Growth Score Value. Age = Chronological age. NR = Nonword Repetition raw score. PPVTraw = PPVT raw score. Noun = PPVT percentage of nouns correct. Verb = PPVT percentage of verbs correct. Attrib = PPVT percentage of attributes correct.

** $p < .001$, two-tailed.

* $p < .05$, two-tailed.

^ $p < .06$