Est. 1841 | YORK ST JOHN UNIVERSITY

Nag, Sonali, Snowling, Margaret and Mirkovic, Jelena (2018) The role of language production mechanisms in children's sentence repetition: Evidence from an inflectionally rich language. Applied Psycholinguistics, 39 (2). pp. 303-325.

Downloaded from: https://ray.yorksj.ac.uk/id/eprint/2375/

The version presented here may differ from the published version or version of record. If you intend to cite from the work you are advised to consult the publisher's version: https://doi.org/10.1017/S0142716417000200

Research at York St John (RaY) is an institutional repository. It supports the principles of open access by making the research outputs of the University available in digital form. Copyright of the items stored in RaY reside with the authors and/or other copyright owners. Users may access full text items free of charge, and may download a copy for private study or non-commercial research. For further reuse terms, see licence terms governing individual outputs. Institutional Repositories Policy Statement

RaY

Research at the University of York St John

For more information please contact RaY at ray@yorksj.ac.uk

Running Head: LANGUAGE PRODUCTION MECHANISMS.

The role of language production mechanisms in children's sentence repetition: Evidence from an inflectionally rich language

Sonali Nag

The Promise Foundation and University of Oxford

Margaret J. Snowling

University of Oxford

Jelena Mirković

York St. John University and University of York

In press in Applied Psycholinguistics

doi:10.1017/S0142716417000200

Abstract

We examine the role of language production mechanisms in sentence repetition, a task widely used as a diagnostic tool in developmental disorders. We investigate sentence repetition in five-to-eight-year-old native speakers of Kannada, an inflectionally rich language of India. The inflectional characteristics of the language make it an ideal testing ground for exploring the engagement of grammatical and phonological encoding processes. We presented active, passive, and embedded sentences, and in a subset of the material we also manipulated sentence length. Using accuracy and speech error analyses at the sentence, word and affix level, we provide evidence that individual differences in task performance are influenced by the linguistic properties of the material. These findings clarify the role of key language production mechanisms involved in sentence repetition. We propose that it is the versatility to develop a profile across several language production mechanisms that makes sentence repetition particularly useful as a clinical tool.

Key words: Sentence repetition, language production, language impairment, Kannada, language assessment

The role of language production mechanisms in children's sentence repetition: Evidence from an inflectionally rich language

Sentence repetition is a simple task with the instruction for a verbatim repetition of a just-heard sentence. Since repeating sentences requires their recall from memory, sentence repetition has often been used as a working memory task (e.g., Delcenserie, Genesee, & Gauthier, 2012; Gathercole & Baddeley, 1989). The task, however, involves more than just retrieving an episodic, form-based representation of the sentence. Performance on sentence repetition shows a stable and significant relationship with language and literacy measures over time (English: Hulme, Nash, Gooch, Lervag, & Snowling, 2015; Norwegian: Klem et al., 2014), and it reliably reflects properties of early morphology and syntax in typically developing children (e.g., Devescovi & Caselli, 2007; Gábor & Lukács, 2012; Polišenská, Chiat, & Roy, 2015). Furthermore, the difficulty in repeating sentences with more complex syntactic structures is not fully accounted for by differences in the length of the sentences, assumed to tax working memory (e.g., Moll, Hulme, Nag, & Snowling, 2013). These lines of evidence provide support for the view that language processing systems and working memory are both engaged in sentence repetition. Here we take the discussion about the underpinnings of the task further by focusing on the contribution of language production mechanisms involved in grammatical and phonological encoding to performance on this task.

Language production studies using the nonword repetition task shed light on possible underlying mechanisms in tasks drawing on both linguistic representations and working memory (see Acheson & MacDonald, 2009a, for a review). For example, in a study by Acheson and MacDonald (2009b) participants were required to recall nonword tongue twisters (e.g., *shif seev sif sheev*). In addition to providing standard measures of memory such as recall accuracy, Acheson and MacDonald also analyzed speech errors produced while

recalling the tongue twisters. The speech errors were found to better reflect phonological encoding processes within the language production system than short-term memory constraints. For example, phoneme substitution errors followed positional constraints (e.g., onsets were exchanged with onsets), reflecting long term knowledge of the phonological structure of the language and the constraints of phonological encoding processes in speech production.

In a similar vein, errors in sentence repetition can be expected to reflect long-term knowledge of language and the workings of sentence production mechanisms. Indeed, detailed analyses of the properties of speech errors have been an invaluable tool for understanding sentence production mechanisms in adults, and these analyses have served as the basis of all major models of the language production system (e.g., Bock, 1996; Bock & Levelt, 1994; Goldrick, Ross Baer, Murphy, & Beese-Berk, 2011; Dell, 1986; Dell & O'Seaghdha, 1992). In such models, semantic substitution errors (e.g., saying *cat* when *dog* was intended), typically semantically related to the intended word, are considered to reflect lexical-semantic processing (Bock, 1996); exchange errors such as producing *He called her yesterday* when *She called him yesterday* was intended, reflect grammatical encoding and specifically function assignment, because this type of error reflects exchanges in thematic roles (e.g., subject and object, Bock, 1996); morpheme exchange errors such as producing *discharge replace* when *recharge displace* was required reflect morphological processing (e.g., Melinger, 2003). Thus whereas nonword repetition performance reflects language production mechanisms at the lexical and sublexical level (e.g., Coady & Evans, 2008; Dollaghan & Campbell, 1998), sentence repetition may additionally reflect conceptual processing and grammatical encoding, including the mechanisms of assembling lexical items into meaningful and grammatically correct sentences.

The investigation of the role of sentence production mechanisms in sentence

repetition is particularly pertinent given the wide use of the task as a diagnostic tool in developmental disorders such as specific language impairment (SLI) (Archibald & Joanisse, 2009; Conti-Ramsden, Botting, & Faragher, 2001; Redmond, Thompson, & Goldstein, 2011). Children at family risk for dyslexia (Hulme et al., 2015; Moll et al., 2013) and bi- and multi-lingual children with possible language impairment (Chiat et al., 2013; Nag & Snowling, 2011) also do poorly on this task. The task is also sensitive to the language acquisition history of the child (Delcenserie et al., 2012; Gauthier & Genesee, 2011), and the levels of proficiency attained by learners of an additional language when compared to native monolingual speakers (Chiat et al., 2013; Paradis, 2010). However, the key psycholinguistic mechanisms accounting for individual differences in sentence repetition are still poorly understood. Importantly, the majority of the studies in the literature using sentence repetition have limited the analysis to gross accuracy measures at the level of the whole sentence or of words as categorical units (e.g., Klem et. al., 2015; Riches, 2012; Stokes, Wong, Fletcher, & Leonard, 2006). In the current study, we used speech errors to examine the contribution of specific language production mechanisms to task performance.

We used the standard model of language production (e.g., Bock & Levelt, 1994) as the theoretical framework to guide these analyses. According to this model, sentence production starts with the activation of the *'message'* (conceptual representation) of the utterance to be produced, and then engages sentence processing mechanisms in different language production subsystems (see Figure 1, first panel). Within this view, sentence repetition would involve the activation of the conceptual representations of the comprehended sentence ('message' in Figure 1), and the individual lexical items of the heard sentence (Potter & Lombardi, 1990). The lexical items of the to-be-repeated sentence would be assigned the appropriate thematic roles within the functional processing subsystem. Further assembly of the constituent words into syntactic structures, and the morphological

units (particularly the inflections) into words, would occur during positional processing. During phonological encoding the phonological structure of the utterance would be specified. These three broad subsystems of language production are generally agreed on across various theoretical models of production (Bock & Levelt, 1994; Dell, 1986; Vigliocco & Hartsuiker, 2002). The key issues where the models differ are the amount of information flowing from one subsystem to the next, and the level of interactivity between the subsystems (e.g., Goldrick et al. 2011; Heisler, Goffman, & Younger, 2010; Mirković & MacDonald, 2013; Vigliocco & Hartsuiker, 2002).

FIGURE 1 ABOUT HERE

The main aim of the current study was to investigate the contribution of sentence production mechanisms to sentence repetition in 5 to 8 year old native speakers of Kannada. Kannada is a highly inflected and morpho-phonologically complex language of Southern India enabling a focus on grammatical and phonological encoding subsystems known to be vulnerable in children with developmental disorders (e.g., English: Botting & Conti-Ramsden, 2003; Redmond, et al., 2011; Rice, Warren, & Betz, 2005; Dutch: Wilsenach, 2006; Kannada: Sengottuvel & Rao, 2013; for review see Leonard, 2014). We manipulated sentence type in the materials, and we included active, passive, and embedded sentences (see below). In a subset of the analyses we specifically focused on active and passive sentences, two sentence types known to show different developmental trajectories (Demuth, Moloi, & Machobane, 2010; Gordon & Chafetz, 1990). Before outlining the specific aims of the current study, we describe the properties of Kannada which make it particularly suitable for this investigation of sentence repetition.

The Kannada Language

Kannada is a southern Dravidian language spoken by approximately 70 million people. Events are communicated by the grammatical suffixes in content words (Sridhar, 1990).

Examples 1, 2 and 3 illustrate grammatical suffixes in nouns and verbs in three ditransitive structures:

(1) Active:

amma aa magu-vige baTTe haak-id-aLu

mother nom.sg.[1] *that* dem. *child* dat.sg. *dress* acc.sg. *put* pst.3f.sg.

'The mother dressed that child.'

(2) Passive:

amma-ninda aa magu-vige rasam maaD-is-al-aay-it-u

mother abl.sg. *that* dem. *child* dat.sg. *soup* acc.sg. *make*-cause-inf. pass aux.'happen'- pst-3n.sg.

'The soup was made by the mother for that child.'

(3) Embedded:

oDed-iru-va looTa magu-ninda amma-nige niiD-al-aay-it-u.

broken(ness)-happen ptcp be relative prtcp *glass* nom.sg. *child* abl.sg. *mother* dat.sg. *was given* inf.-pass aux 'happen'-pst-3n.sg

'The glass, which was broken, was given to the mother by the child.'

Two properties make Kannada a particularly interesting language to use in sentence repetition. First, Kannada is inflectionally very rich, with inflections used to mark properties such as tense and number as in English, but also grammatical gender and case markings denoting sentential roles (e.g., recipient = dative, direct object = accusative). The

[1] Abbreviations in examples: nom. = nominative, dat. = dative, acc. = accusative, abl. = ablative, dem. = demonstrative, pst. = past tense, 3 = third person, f = feminine, n = neuter, sg. = singular, pass. = passive, ptcp. = participial, inf. = infinitive, aux. = auxiliary.

morphological realisation of specific inflections is influenced by semantic, syntactic and phonological factors (Amritavalli, 2008; Sridhar, 1990). For example, similar to English, in Kannada the verb form must agree with the subject in grammatical number. However, Kannada is a pro-drop language and in sentences where the subject is missing, it is possible to use inflectional information to infer the agent from the person-number-gender markings on the verb; these are produced regardless of whether the subject is overt or covert (e.g., *she dressed: 'haak-id-aLu',* root word-past-3rd person feminine singular). Also prominent in the language are phonological change processes at the word boundaries, referred to as *sandhi.* In English, morpho-phonological processes are seen for example in the change from /f/ to /v/ in noun plurals (e.g. *elf – el**v**es*, *thief – thie**v**es*). We see similar but more complex phenomena in Kannada. For instance, for the genitive marker *–a,* phonemic changes at the boundary may be with '*y*' *and* '*v*' (*daari-**y**a*, 'of the path'; *guru-**v**a*, 'teacher's'), while for the accusative *–annu,* the phonetic value at the boundary is often '*v*' (*pustaka-**v**annu*, 'book') but can change to '*y*' elsewhere (*mane-**y**annu,* 'house'). The morpho-phonological complexity of Kannada makes it an ideal testing ground for the engagement of grammatical and phonological encoding mechanisms.

The second relevant property of Kannada (a predominantly SOV language) is that word order and word count can be kept constant across different syntactic structures (see examples 1 and 2 above). This is different from languages where structure changes often involve word order changes and changes in sentence length (cf. the English translations for examples 1 and 2 above), thus potentially confounding structural changes with memory load.

These properties of the Kannada language allowed us to perform a more thorough analysis of the contribution of different language production subsystems to performance on the sentence repetition task. Thus, in addition to general accuracy measures we also analysed children's speech errors. For sentence-level analyses, the errors were categorized as either

preserving or changing the core event meaning of the target sentence. For word level analyses, we examined morpho-phonological encoding. The highly inflected nature of Kannada allowed us to analyse separately performance on word roots, inflections, and root-inflection boundaries. As argued above, these errors can be revealing about the processing in the conceptual, grammatical and morpho-phonological encoding subsystems respectively. Moreover, these analyses allow examination of the relationship between the language production subsystems and other linguistic areas such as vocabulary and phonological processing as assessed in non-word repetition. Figure 1 (final panel) gives the specific linguistic units that were analysed, with the middle panels showing examples of accurate and inaccurate repetition.

The two specific aims of the current study were:

a. To establish the extent to which the profile of performance on the task is sensitive to the linguistic properties of the material. For this aim we analysed both accurate performance, and different types of speech errors.

b. To examine the extent to which performance on the sentence repetition task can be explained by individual variation in other linguistic skills and child-level factors. For this aim we included measures of general ability, vocabulary, and non-word repetition.

Method

Participants

Native Kannada-speaking children were drawn from five schools in the Bangalore-Tumkur region of the southern state of Karnataka, India (N = 135). All children were considered typically developing based on their performance on cognitive and language tests

(see below for details), but for the lowest performing children, language impairment cannot be ruled out. Our study therefore sampled a wide range of individual differences in language attainment.

Socio-economic status (SES) of participating children was computed based on each parent's educational level, family spending on printed materials and possessions at home. Details were available for 65.9% of the sample. Of these, 3.4%, 66.3% and 30.3% belonged to the lower-middle, middle and upper-middle SES groups respectively. This proportion in each SES band may be considered representative of the SES level of children enrolled in similar schools in the region. The remaining children for whom SES data are not available attended all the same school activities, and did not receive any special financial concessions or tutorial support either in or outside school, suggesting they were drawn from the same SES bands.

The children were participants in a larger longitudinal study and were assessed on general ability, vocabulary, nonword repetition and sentence repetition. The battery also included other tests of oral language, cognitive, literacy and numeracy skills not reported here. At the time of the current study the children were between 5 and 8 years of age ($M_{age\ in\ months}$ = 79.79, SD = 8.45) and in the final term in school; 61 children were in the last year of pre-school and 74 in Grade 1. The first language of all children was Kannada. All were receiving literacy instruction in both Kannada and English with the proportion of time given for Kannada lessons equivalent across participating schools. To obtain an estimate of the children's experience with spoken language, we asked parents to list activities at home that were focussed on oral narratives. Activities ranged from narrating of the epic stories and folktales of the region, to sharing folksongs, film songs, community prayers, chants and rhymes, and reading aloud from religious books and contemporary publications for children. The frequency of such activities was rated separately for Kannada and English on a five point

scale (0 = never, 5 = several times a day). Table 1 gives a descriptive summary of the sample characteristics. The frequency of Kannada oral narratives was rated as significantly higher than that of English, $t(88) = 7.713$, $p < .001$, confirming that in this sample of children language experiences at home tended to be in Kannada. Age of onset of English exposure was between one and six-and-half years but experience with English at home was remarkably similar across the group (Table 1, oral narratives in English) and rated as very low, suggesting that English was introduced mainly in school, and that Kannada was the children's main language.

TABLE 1 ABOUT HERE

Materials

General ability. The Coloured Progressive Matrices (Raven, Court, & Raven, 1990) was used to test non-verbal ability. The test requires the child to complete visual patterns by pointing to the correct of six alternatives.

Vocabulary. This 14 item test was constructed by taking every odd item from a longer vocabulary test (Nag, 2008). The correlation between the abridged test and the full test was high, $N = 106$, $r = .937$, $p < .001$. The child had to explain the meaning of words representing actions, qualities, states, time, place and result. Accurate definitions, synonyms and translated equivalents received a score of 3, sentential use of the word and descriptions scored 2 and repeating of the word with an inflection or using idiomatic phrases was given 1 (Cronbach's alpha= .76).

A native Kannada-speaking research assistant trained in coding the different levels of production scored the protocols. The first author independently coded 30% of the protocols randomly selected from within each participating school. Inter-rater agreement was

calculated as the total agreed codes divided by total agreements and disagreements. Inter-rater agreement was 100% for responses coded as 3, and 95% each for responses coded as 2 and 1; all disagreements were around whether word descriptions were idiomatic phrases or the reverse.

Nonword repetition. This 25 item test was styled after the phonology of Kannada but with a set of constraints to derive less word-like items. No nonword contained any Kannada word. The endings of final syllables were always long vowels and more consonants were aspirated because these occur mainly in loan words. For ease of articulation and transcription, consonant clusters were not used and all vowels were long because these are less prone to length reduction. An aspect of Kannada phonology retained in item construction was closed syllables in initial or middle positions with the syllable-final consonant either the legal consonant /l/ or /r/ (e.g., *khaashii**r**taa*, *chhaakhoorii**l**pee*). Five items each of one to five syllable lengths were presented one at a time in a fixed order. Accuracy on the complete syllable string was given a score of 1. The analyses presented here are based on *z* scores derived from the proportion correct (Cronbach's alpha = .77).

Sentence repetition. The 25 item task comprised sentences constructed with early acquired, high frequency words. We included three sentence types: actives, passives and embedded sentences (see examples 1-3 above, and Appendix 1a for the full set of items). The three sentence types differ in syntactic complexity, but they are also likely to differ in frequency (e.g., Demuth et al. 2010). Thus we measured sentence structure frequency through eleven teachers' ratings of the frequency with which the sentences were considered present in the input ('*how often do people say this sentence like this?*') on a four point scale (1 = never, 4 = often). We also measured event plausibility denoted by each sentence using teacher ratings: the same teachers rated each sentence on a five point scale for '*How possible is it for this event to happen?*' (1 = not at all possible, 5 = very possible). Both of these measures

reflect long-term linguistic and conceptual knowledge. The descriptive statistics for all measures are provided in Appendix 1b.

In sentence repetition studies, memory load is often manipulated by increasing word count (e.g., Moll et al., 2013; Polišenská et al., 2015). Following this approach, we manipulated memory load for the active and passive sentences by increasing word count: the sentences in the long condition were similar to the sentences in the short condition in terms of event semantics (who does what to whom), but contained additional adjectives (Appendix 1a). Thus in a subset of the analyses we compared performance on the two sentence types (actives and passives), with two different sentence lengths (short and long). The four conditions were equated in the average Age of Acquisition of the words comprising the sentences. As expected, active sentences were rated as more frequent than passive sentences (the active-short condition was most frequent: sentence type x length interaction: $F(1, 16) = 6.28$, $p = .023$). Longer sentences were rated as less frequent than shorter sentences (main effect of length: $F(1, 16) = 22.82$, $p < .001$). Event plausibility was equated across the two sentence types, but the addition of adjectives reduced event plausibility for the long sentences (main effect of length: $F(1, 16) = 6.75$, $p = .019$)

Procedure.

Children were tested in a quiet room in their school over four 45 minute sessions, two of which were for the tests reported here. The first session covered the general abilities test, nonword repetition and one half of the sentence repetition task; the second covered the vocabulary task and the other half of the sentence repetition task. The sentences were presented in a pseudo-randomized order, divided between the two sessions and counterbalanced across participants. The items were presented in a clear voice by a trained research assistant who was a native speaker of Kannada. The child's responses were directly

transcribed for offline error scoring by research assistants blind to the conditions of the study. The sentence repetition task was always presented at the beginning of the session.

Data Coding.

Figure 1 (middle panels) illustrates performance when sentence repetition is accurate and when there are errors, within the framework of Bock and Levelt's (1994) Model. Performance was analysed at the sentence, word, and affix level. Participants' errors were scored off-line from transcriptions by a trained Kannada-speaking research assistant. Thirty percent of responses from each school were independently coded by the first author. Inter-rater reliability ranged between .76 and .98. The lowest reliability was for nouns coded as nonwords rather than as dialect words, with greater ambiguity on some nouns because they attracted greater dialectal variations.

Sentence level coding. We measured word order accuracy and the length of the produced utterance. Word order was scored as correct when the exact order of the sentence elements was preserved, and length was unchanged. When the repetition was a phrase or a shorter syntactically complete sentence that preserved event semantics, we coded it as Shortened Utterance (see Supplementary Material for examples). When the word order in the produced utterance diverged from the target, we coded word order changes for interchange of the agent and recipient, which produced a significant change in the core event meaning (who did what to whom). A small proportion of errors was due to a shift in the position of the object or the verb where all linguistic components of the message were intact but the serial order had changed. These errors were very rare (~1%) and not analysed further.

Word and affix level coding. Content words (nouns, verbs) with specific grammatical suffixes were scored for accuracy on the root, inflection and the boundary (see supplementary material for examples). We accepted dialect variations for roots of words (e.g., dropping of the glottal fricative /h/ in word initial position, thus *aakidaLu* for *haakidaLu*) and coded all

other substitutions as a semantic change. Since inflections on the semantic substitutions and the boundary could be accurate for the new root-inflection pairing, we included semantic substitutions in the analyses of accuracy on boundaries and inflections. This is a lenient scoring scheme for assessing verbatim memory but given the overall low error rate this scoring scheme allows a wider assessment of the child's morpho-phonological and morpho-syntactic skills.

For nouns, we focussed on dative markers which were available in all sentences (25 tokens). The errors in case markings reflect grammatical encoding processes, both for thematic role assignment and at the positional levels of processing. Among verbs, categorization of errors becomes highly ambiguous in passive and embedded sentences because here the verbs carry several inflectional markers which can interact with each other (e.g. *koDisalaayitu: koDu-is-al-aay-it-u*, root-causative-infinitive- passive-tense-person-number-gender marker). Thus the focus of the verb analysis was on active sentences (10 tokens), where the verbs contain only tense and Person-Number-Gender (PNG) markers (e.g., *koTTaLu,* root-tense-PNG markers), reflecting positional processing and subject-verb agreement (e.g., Bock & Miller, 1991; Eberhard, Cutting, & Bock, 2005). Finally, for both noun and verb items we analyzed morpho-phonological encoding processes (e.g., Levelt, Roelofs, & Meyer, 1999), specifically on the boundary between the root and the inflection when it required a morphologically conditioned change (e.g., *amma + -ige = amma-nige, mother* dat.sg.). The number of unique boundary changes was 7 and 2 across nouns and verbs respectively. A small proportion of all responses (~1%) were omissions, non-productions and nonwords and these were not included when computing the word level measures[2].

[2] Formulae for calculation of proportions: If X = frequency of accurate productions, Y = frequency of word order changes and Z = frequency of shortened utterances, and A = total of all non-productions, nonsense productions, sentences with additions and shift in position of object or verb; then Proportion of X = X/ (X + Y + Z), Proportion of Y = Y/ (X + Y + Z) and Proportion of Z = Z/ (X + Y + Z).

Results

The analyses are reported separately for sentence- and word-level measures. For both sets of measures we start with a summary of the overall performance, followed by the analyses examining the relationship between linguistic properties of the materials and performance on the task. Here we used the analysis of variance on arcsine transformed proportions of different types of responses (arcsine transformation was used to correct distributional issues when using proportional data), and correlational analyses. The final analyses examined individual variation using mixed-effects modelling of sentence properties and child-level factors, and correlational analyses of word-level linguistic properties and child-level variables.

Sentence level measures

Performance on sentence level measures is summarized in Table 2. Overall, the children's mean sentence repetition accuracy was 69%. The majority of incorrectly produced sentences were a shortened utterance, and a smaller proportion the change in word order (agent-recipient); the change in word order reflected a greater disruption in event meaning when compared to shortened utterances. Sixty percent of shortened sentences were thematically close to the target sentence, with a large proportion of productions being an omitted noun phrase in an otherwise grammatically accurate sentence. Thus, instead of saying '*the girl dressed the child'* a shorter sentence response would be '*dressed*+PNG markers *the child'*, indicating that the event semantics was preserved since the verb was correctly marked for agent properties (see Supplementary Material). These findings suggest that the sentence recall encompassed the conceptual representation of the message rather than only an episodic, form-based representation (e.g., Potter & Lombardi, 1990).

TABLE 2 ABOUT HERE

Sentence type influenced the accuracy of sentence repetition, with the highest accuracy for actives and lowest accuracy for embedded sentences. We next examined the influence of sentence type and length on task performance by focusing on active and passive sentences. Actives were produced with higher accuracy than passives, $F(1, 134) = 230.23$, $p < .001$. Across both sentence types, shorter sentences were produced with higher accuracy than longer sentences, $F(1, 134) = 170.21$, $p < .001$, with no sentence type by length interaction, $F(1, 134) = 2.70$, *ns*.

Passive sentences showed significantly more word order changes ($F(1,134) = 116.77$, $p < .001$) and shortened utterances ($F(1,134) = 62.50$, $p < .001$) than active sentences; and longer sentences had more shortened utterances ($F(1,134) = 53.50$, $p < .001$) and word order changes ($F(1,134) = 70.67$, $p < .001$). However, with increasing length, passives 'suffer' greater disruption in event meaning than actives, with more agent-recipient interchanges (sentence type x length interaction: $F(1, 134) = 25.30$, $p < .001$).

Rated structure frequency positively correlated with word order accuracy ($r = .58$, $p < .001$), and less frequent sentence structures showed more shortened utterances ($r = -.55$, $p < .01$). Frequency did not correlate with word order changes *(*$r = -.28$, *ns*). Event plausibility did not correlate with performance on the task (accuracy: $r = .20$, *ns*; shortened utterances: $r = .02$, *ns*; word order changes: $r = -.20$, *ns*). This pattern of correlations suggests that the sentence repetition task is tapping linguistic representations in long-term memory as reflected in the estimated frequency of the sentence structures.

Individual differences and sentence-level measures

We next examined correlations between the sentence level measures and cognitive-linguistic measures of vocabulary and nonword repetition after controlling for both age and general abilities which were significant correlates (Table 3). Both vocabulary and nonword

repetition showed a moderate positive correlation with word order accuracy, and a negative moderate association with shortened utterances. Associations with word order changes were statistically non-significant.

TABLE 3 ABOUT HERE

To assess the predictors of individual differences in the ability to repeat the word order of sentences accurately, we examined several child level measures as well as the contribution of structure frequency. A mixed effects logistic regression model (xtmelogit in Stata 12) was used with participants and items treated as crossed random effects. We first assessed the effects of each predictor in a series of univariate regression models. At the child level these included vocabulary, nonword repetition, age and general abilities, and at the sentence level, rated structure frequency (word count and event plausibility were not correlates). All five measures were significant predictors of variation in word order accuracy. Each measure was next considered in a more complex simultaneous regression model. From the complex model, effects that were non-significant were dropped until a parsimonious final model in which all predictors were significant was obtained iteratively. The parsimonious final model showed that frequency of sentences, and vocabulary scores, nonword repetition scores and child's age are the predictors of word order accuracy (Table 4).

In summary, sentence repetition performance analysed at the global sentence level revealed that sentence type, frequency and length affect performance, and this in turn is predicted by the child-level variables of age, vocabulary, and phonological skill as measured by nonword repetition.

TABLE 4 ABOUT HERE

Word and affix level measures

Nouns with the dative case marker *-ige* and verbs with the tense+PNG markers (*-idaLu, -id-anu*) were scored for accuracy on the roots, inflections and the morpho-phonological changes at the boundary between the root and inflection (e.g., for *ammaniga* error on $amma^{root} - n^{boundary}$ $-ige^{inflecion}$). We hypothesised that the three measures reflect different aspects of processing within the language production system (Figure 1): the production of roots reflects encoding at the message-lexical level, inflections reflect grammatical encoding, and the boundary between the inflection and root, the interface between grammatical and phonological encoding. The descriptive summaries for these measures for the nouns and verbs of interest are given in Table 5.

TABLE 5 ABOUT HERE

Among roots, 84% of substitutions on noun roots and 79% on verb roots were semantically related to the target word, suggestive of conceptual representation of the message playing a greater role in word-level recall than form-based representation. Among nouns, there were more errors on roots than inflections, while among verbs, inflections were more vulnerable. One possible reason for this difference between the two word types is that each sentence contained two or more nouns which were conceptually similar (e.g., boy-girl, mother-child, brother-sister), and conceptual similarity is a well known factor which produces interference in processing at the message level (e.g., Ferreira & Firato, 2002; Gennari, Mirković, & MacDonald, 2012). Thus an increased rate of noun root errors may reflect interference processes at the conceptual level of the language production system. The relatively greater frequency of inflection errors on verbs may reflect the additional complexity of verb inflections relative to noun inflections: the nouns in the sentences were

only marked for case (denoting their agent/object/recipient role), whereas the verbs conveyed several pieces of grammatical information: tense, person, number, and gender, including agreement with the subject. Errors on the boundary between the root and the inflection were more common in nouns than in verbs perhaps because of the greater variety of boundary changes sampled across nouns than across verbs.

Individual differences and word and affix level measures

We next examined the errors on roots and inflections, for which we individually summed the noun and verb scores and derived a z score which we named as the Root error score and the Inflection error score. Similarly for the errors on boundaries, we derived a z score and named this the Boundary error score. After controlling for age, the associations between inflection and boundary error scores with vocabulary and nonword repetition were in the moderate range while for root error scores, the association with nonword repetition but not vocabulary was statistically significant (Table 6).

TABLE 6 ABOUT HERE

Of interest was also the strength of associations across the linguistic units. We expected that phonological encoding would have a stronger association with the morpho-phonological units (word boundaries) than the morphology units (inflections), reflecting relatively more contribution from processing at the phonological encoding subsystem of language production (Levelt et al., 1999). When additionally controlling for vocabulary (Table 6), the association of nonword repetition with inflection errors was no longer significant, suggesting that inflectional errors may be more indicative of processing errors at the conceptual-grammatical than the phonological encoding level (Bock & Levelt, 1994; Vigliocco & Hartsuiker, 2002). In contrast, the association between nonword repetition and

morpho-phonological boundary errors remained significant, which may be taken as evidence for the role of phonological encoding over and above the contributions of conceptual-lexical knowledge and grammatical encoding. In addition, when we controlled for age and nonword repetition scores (Table 6), the association of vocabulary with both inflection errors and boundary errors remained significant. This finding provides evidence of the involvement of lexical knowledge in both morpho-syntactic and morpho-phonological encoding within the language production system. An unexpected finding was that the root error score was not associated with either vocabulary (when nonword repetition was controlled), nor with nonword repetition (when vocabulary was controlled; Table 6).

Discussion

The two main aims of the current study were first, to explore the extent to which performance on the sentence repetition task is sensitive to linguistic properties of the materials, and second, to explore what factors influence the performance of individual children. To this end, we analysed accuracy and error profiles on the task with children aged 5 to 8 years in Kannada, an inflectionally rich language.

We found that children's performance was influenced by linguistic properties of the materials. First, at the sentence level, accuracy was higher with active than passive sentences, and the error analyses demonstrated that an increase in length caused more disruption in thematic role assignment in passives, as evidenced by agent-recipient errors. The difference between actives and passives was at least partly driven by the difference in structure frequency, which was a strong and unique predictor of sentence repetition accuracy. Second, we found a different profile of errors for verbs and nouns. The complexity of verb inflection, which included information about tense, person, number, and gender, made them more vulnerable to inflection errors, whereas nouns had more root and root-inflection boundary

errors. We argue that semantic competition ensuing from the presence of similar nouns in the same sentence may have contributed to the errors on the root, whereas boundary errors are due to morpho-phonological changes being more common in nouns than in verbs.

We also found that different factors contributed to individual variation in performance on the task. First, both lexical-conceptual knowledge and phonological processing, measured as vocabulary and nonword repetition scores, showed moderate positive correlations with word order accuracy in sentence recall and negative moderate associations with a syntactically acceptable but shortened sentence recall (shortened utterances). Second, frequently encountered syntactic structures were repeated more accurately than less frequently encountered structures, and older children, arguably with more language experience, performed better than younger children. Furthermore, structure frequency was a unique predictor of accuracy with word order in sentences, and this was over and above child level predictors of age, vocabulary knowledge and accuracy on nonword repetition. Third, in word-level analyses, morphological (inflection) errors and errors on units that demand greater phonological encoding (boundary errors) showed a different pattern of association with cognitive-linguistic variables. Among morphological errors, accuracy with case markers on nouns and tense and person-number-gender markers on verbs was associated with better performance on a vocabulary task. Moreover, even though there were associations with phonological encoding as assessed by nonword repetition, these associations disappeared when vocabulary knowledge was controlled. In contrast, for boundary units which required greater phonological encoding because of phonological change processes, the associations between error rate and nonword repetition performance remained even after vocabulary knowledge had been controlled. Together, these analyses demonstrate that individual differences in performance on sentence repetition are related to individual differences in lexical-conceptual knowledge and phonological processing.

In parallel, we found sentence length to affect verbatim memory for the sentences, with lower accuracy, and more shortened utterances and word order changes seen on longer sentences. While increased sentence length has typically been interpreted as increasing memory load (e.g., Moll et al., 2013; Polišenská et al., 2015), in our materials longer sentences were also rated as denoting less plausible events. Thus, the sentence length effect cannot be attributed purely to an increase in memory load. Further evidence of the interaction between sentence length and linguistic properties of the materials was found in word-order errors, and specifically an increase in agent-recipient errors in long passives relative to long actives.

Together, our findings provide converging evidence with other studies demonstrating the role of psycholinguistic mechanisms and long-term linguistic knowledge in sentence repetition performance (e.g., Devescovi & Caselli, 2007; Gábor & Lukács, 2012; Riches, 2012; Polišenská et al., 2015). A unique contribution of our study is that with an inflectionally complex language such as Kannada, we were able to assess and demonstrate the engagement of several language production subsystems within a single task. Beyond the involvement of processing at the conceptual level, we examined processing at the morphological and phonological levels. Bringing attention to phonology and morpho-phonology in sentence repetition is in line with proposals of the specific role of phonological encoding in the maintenance of verbal serial order (MacDonald, 2013). Moreover, the finding that lexical knowledge plays a role in both morpho-syntactic and morpho-phonological processing provides additional evidence in support of more interactive models of language production (e.g., Vigliocco & Hartsuiker, 2002). Our study thus provides an example of how cross-linguistic research in language production can potentially drive theory development about performance during sentence repetition (Jaeger & Norcliffe, 2009).

An implication of a fine-grained evaluation such as the one we conducted is that tasks may be designed to target specific language subsystems (e.g., sentence structures to target positional encoding, or inflections for morpho-phonological encoding). Such tasks may better capture individual differences and offer a tool for investigating developmental trajectories of language production mechanisms. This is particularly relevant because the task of sentence repetition has become a critical tool in the assessment of children in clinical settings (e.g., Conti-Ramsden et al., 2001).

Implications for assessment

Information about performance patterns across different linguistic units is of theoretical interest because in almost all assessments of language in childhood disorders a pattern of strengths and weaknesses has been found (c.f., Rice et al., 2005). Moreover, sentence repetition accuracy has been a useful marker of specific language impairment (e.g., Conti-Ramsden et al., 2001). We found children's performance with sentence repetition reflected processing across the message, grammatical encoding and phonological encoding subsystems. This task thus shares the engagement of phonological processing with the nonword repetition task, but it provides additional insights into the language production mechanisms. We also found certain manipulations in the sentence condition were more demanding (e.g., introduction of adjectives). These findings indicate that the sentence repetition task can be used to develop a performance profile across several language production mechanisms, shedding more light on the reasons why this deceptively simple task has been an exceptionally useful clinical tool. Furthermore, the sentence repetition task offers itself as a quick assessment in educational settings.

A further implication is that the language subsystems framework provides a common model which can accommodate the varieties of complexity found across languages. As such it can inform the development of badly needed clinical instruments suitable for cross-

linguistic research and practice (e.g., Leonard, 2014; Rice et al., 2005). Tests developed within the language subsystems framework would also allow for interesting comparisons with other language tasks including nonword repetition, which would shed additional light on any possible interactions between different language production representations and mechanisms.

To our knowledge this is the first study to examine both grammatical and phonological encoding in sentence repetition and the pattern of associations between these and cognitive-linguistic measures such as vocabulary knowledge and nonword repetition within a model of the language production system. The findings provide support for growing evidence that the entire language system is recruited during sentence repetition while being sensitive to language-specific characteristics (e.g., inflections in Kannada: Nag & Snowling, 2011; prepositions in English: Moll et al., 2013). Other studies have shown that the task has been sensitive to subtle individual differences, particularly to variations at the lower end of the distribution (e.g., English: Conti-Ramsden et al., 2001; Rice, et al., 2005; Redmond et al., 2011; Dutch: Wilsenach 2006). It would therefore seem that a language subsystems approach to understanding individual differences during sentence repetition is a promising one providing a window into the nature of language production mechanisms and language development.

Appendix 1a: Sentence Repetition Items

Description	Sentences
Active Short	*akka aa huDuganige kaagada koTTaLu* *huDuga huDugige ondu laaDu koTTanu* *huDugi aa maguvige baTTe haakidaLu* *huDugi ii guruvige pustaka koTTaLu* *amma aa magaLige uppiTTu kaLuhisidaLu*
Active Long	*aa chuuTi magaLu daNida raitanige tampu majjige koTTaLu* *ondu jaaNa huDugi naachida huDuganige sihi jileebi niiDidaLu* *aa tunTa magu jaaNa huDuganige harida patrike toorisidanu* *ondu oLLeya huDugi hosa huDuganige niili pencilu koTTaLu* *aa chuuTi vyaapaari tunTa huDuganige chikka kathe heeLidanu*
Passive Short	*guruvinda huDuganige ondu pustaka koDisalaayitu* *ammaninda aa maganige uppiTTu maaDisalaayitu* *ondu huDuganinda akkanige kaagada koDisalaayitu* *huDuganinda huDugige ondu laaDu niiDisalaayitu* *ganDasininda ii hengasige aDuge tayaarisalaayitu*
Passive Long	*tunTa maguvinda jaaNa huDuganige harida patrike toorisalaayitu* *oLLeya huDugiyinda hosa huDuganige niili pencilu koDisalaayitu* *doDDa ganDasininda puTTa maguvige bisi haalu niiDisalaayitu* *daNida athitige oLLeya ajjiyinda tiLi majjige koDisalaayitu* *hosa huDuganige jaaNa huDugiyinda sihi jileebi tayaarisalaayitu*
Embedded	*biLiyaagiruva gulaabi huDugiyinda geLatigaagi kiiLalaayitu* *oDediruva looTa tammaninda akkanige niiDalaayitu* *teLLagiruva langa hengasininda huDugigaagi koDisalaayitu* *phaLaphaLavaagiruva raakhi tangiyinda aNNanige kaTTalaayitu* *mukhyavaagiruva patra guruvigaagi vidhyaarthiyinda kaLuhisalaayitu*

Appendix 1b: Item properties in different conditions in the sentence repetition task (Means).

	Active Short	Passive Short	Embedded	Active Long	Passive Long
Word count	5	5	5	8	7
Average Age of Acquisition of words in sentence	3.52	3.69	4.29	3.99	3.97
Event plausibility	4.38	3.90	3.80	3.56	3.44
Rated frequency	3.00	2.11	1.80	2.00	1.80

Acknowledgements

Sonali Nag, Department of Early Childhood and Primary School Programmes, The Promise Foundation and Department of Experimental Psychology, University of Oxford; Margaret J. Snowling, Department of Experimental Psychology, University of Oxford and Jelena Mirković, School of Psychological and Social Sciences, York St John University and Department of Psychology, University of York.

This work was funded by a research grant to SN under the Newton International Fellowship. We would like to thank the children who participated in the study; Emma Hayiou-Thomas and R. Amritavalli for inputs during the construction of the sentence repetition task; the teachers who helped with item ratings; Arpana N. M., Laxmi Sutar, Sudharshana, Kala B, Mini Krishna and Riona Lall for data collection and coding; and Maryellen MacDonald and an anonymous reviewer for their comments.

Correspondence concerning this article should be addressed to:

Sonali Nag, The Promise Foundation, 231, C. H. Layout, B. Hosahalli Road, Sarjapura, Bangalore 562125, India. email: sonalinag@t-p-f.org, or

Jelena Mirković, School of Psychological and Social Sciences, York St John University, York, YO31 7EX, UK. email: j.mirkovic@yorksj.ac.uk

References

Acheson, D. J., & MacDonald, M. C. (2009a). Verbal working memory and language production: Common approaches to the serial ordering of verbal information. *Psychological Bulletin, 135*, 50-68.

Acheson, D. J., & MacDonald, M. C. (2009b). Twisting tongues and memories: Explorations of the relationship between language production and verbal working memory. *Journal of Memory and Language, 60*, 329-350.

Amritavalli, R. (2008). The origins of functional and lexical categories: Tense-aspect and adjectives in Dravidian. *Nanzan Linguistics.* 4, 1 – 20.

Archibald, L.M., & Gathercole, S. E. (2006). Short-term and working memory in Specific Language Impairment. *International Journal of Language and Communication Disorders,* 41, 675-693.

Archibald, L. M. D., & Joanisse, M. F. (2009). On the Sensitivity and Specificity of Nonword Repetition and Sentence Recall to Language and Memory Impairments in Children. *Journal of Speech, Language and Hearing Research*, 52(4): 899 - 914.

Bock, K. (1996). Language production: Methods and methodologies. *Psychological Bulletin & Review, 3,* 395-421.

Bock, K., & Levelt, W. J. M. (1994). Language production: Grammatical encoding. In M. A. Gernsbacher (Ed.), *Handbook of Psycholinguistics* (pp. 945-984). Orlando, FL: Academic Press.

Bock, K., & Miller, C. A. (1991). Broken agreement. *Cognitive Psychology*, *23*, 45-93.

Bock, K. J., & Warren, R. K. (1985). Conceptual accessibility and syntactic structure in sentence formulation. *Cognition*, *21*, 47-67.

Botting N. F., & Conti-Ramsden G. M. (2003). Autism, primary pragmatic difficulties, and specific language impairment: can we distinguish them using psycholinguistic markers? *Dev Med Child Neurol*, 45(8), 515-24.

Coady, J. A., & Evans, J. L. (2008). Uses and interpretations of non-word repetition tasks in children with and without specific language impairments (SLI). *International Journal of Language & Communication Disorders, 43*, 1-40.

Conti-Ramsden, G., Botting, N., & Faragher, B. (2001). Psycholinguistic markers for specific language impairment (SLI). *Journal of Child Psychology and Psychiatry, 42*, 741-748.

Chiat, S., Armon-Lotem, S., Marinis, T., Polišenská, K., Roy, P., & Seeff-Gabriel, B. (2013). The assessment of language abilities in sequential bilingual children: the potential of sentence imitation tasks, 56-86. In V. C. M. Gathercole (Ed.), *Issues in the assessment of Bilinguals.* Bristol: Multilingual Matters.

Delcenserie, A., Genesee, F., & Gauthier, K. (2012). Language abilities of internationally adopted children from China during the early school years: Evidence for early age effects? *Applied Psycholinguistics*. doi:10.1017/S0142716411000865

Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review, 93*, 283-321.

Dell, G. S. (1990). Effects of frequency and vocabulary type on phonological speech errors. *Language and Cognitive Processes*, *5*, 313-349.

Dell, G. S., & O'Seaghdha, P. G. (1992). Stages of lexical access in language production. *Cognition, 42,* 287-314.

Demuth, K., Moloi, F., & Machobane, M. (2010). 3-Year-olds' comprehension, production, and generalization of Sesotho passives. *Cognition*, *115*, 238-251.

Devescovi, A., & Caselli, C. M. (2007). Sentence repetition as a measure of early grammatical development in Italian. *International Journal of Language & Communication Disorders*, *42*, 187-208.

Dollaghan, C., & Campbell, T.F. (1998). Nonword repetition and child language impairment. *Journal of Speech, Language and Hearing Research, 41*, 1136–1146.

Eberhard, K. M., Cutting, J. C., & Bock, K. (2005). Making syntax of sense: number agreement in sentence production. *Psychological Review*, *112*, 531.

Ferreira, V. S., & Firato, C. E. (2002). Proactive interference effects in sentence production. *Psychonomic Bulletin & Review, 9*, 795-800.

Gábor, B., & Lukács, A. (2012). Early morphological productivity in Hungarian: Evidence from sentence repetition and elicited production. *Journal of Child Language*, 411-442.

Gauthier, K., & Genesee, F. (2011). Language development in internationally-adopted children: A special case of early second language learning. *Child Development, 82*, 1–15.

Gennari, S. P., Mirković, J., & MacDonald, M. C. (2012). Animacy and competition in relative clause production: A cross-linguistic investigation. *Cognitive Psychology*, 65, 141-176.

Goldrick, M., Baker, H. R., Murphy, A., & Baese-Berk, M. (2011). Interaction and representational integration: Evidence from speech errors. *Cognition*, *121*, 58-72.

Gordon, P., & Chafetz, J. (1990). Verb-based versus class-based accounts of actionality effects in children's comprehension of passives. *Cognition*, *36*, 227-254.

Harley, T. A., & MacAndrew, S. B. (2001). Constraints upon word substitution speech errors. *Journal of Psycholinguistic Research*, *30*, 395-418.

Heisler, L., Goffman, L., & Younger, B. (2010). Lexical and articulatory interactions in children's language production. *Developmental Science, 13*, 722-730.

Hulme, C., Nash, H. M., Gooch, D., Lervåg, A. & Snowling, M. J. (2015). The foundations of literacy development in children at familial risk of dyslexia. *Psychological Science*. *26 (12),* 1877-1886.

Jaeger, T. F., & Norcliffe, E. 2009. The cross-linguistic study of sentence production: State of the art and a call for action. *Language and Linguistic Compass, 3*, 866-887.

Klem, M., Melby-Lervåg, M.; Hagtvet, B.; Lyster, S-A. H.; Gustafsson. J-E; & Hulme, C. (2014). Sentence repetition is a measure of children's language skills rather than working memory limitations. *Developmental Science*, 1–9. DOI: 10.1111/desc.12202

Leonard, L. B. (2014). Specific language impairment across languages. *Child Development Perspectives*, *8*(1), 1-5.

Levelt, W.J.M., Roelofs, A., & Meyer, A.S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences, 22,* 1-38.

Lombardi, L., & Potter, M. C. (1992). The regeneration of syntax in short term memory. *Journal of Memory and Language, 31,* 713-733.

MacDonald, M. C. (2013). How language production shapes language form and comprehension. *Frontiers in Psychology*, *4*.

MacDonald, M. C., & Christiansen, M. H. (2002). Reassessing working memory: A comment on Just & Carpenter (1992) and Waters & Caplan (1996). *Psychological Review*, *109*, 35–

54.

McDonald, J. L., Bock, K., & Kelly, M. H. (1993). Word and world order: Semantic, phonological, and metrical determinants of serial position. *Cognitive Psychology*, *25*, 188-230.

Melinger, A. (2003). Morphological structure in the lexical representation of prefixed words: Evidence from speech errors. *Language and Cognitive Processes*, *18*, 335-362.

Mirković, J., & MacDonald, M. C. (2013). When singular and plural are both grammatical: Semantic and morphophonological effects in agreement. *Journal of Memory and Language, 69*, 277-298.

Moll, K., Hulme, C., Nag, S., & Snowling, M. J. (2013). Sentence repetition as a marker of language skills in children with dyslexia. *Applied Psycholinguistics*. 1-19, doi:10.1017/S0142716413000209

Nag, S. (2008). *Chili pili padabhandara* (Chili Pili Vocabulary Test). Bangalore: The Promise Foundation.

Nag, S. (2012). *Kannada Age of Acquisition Corpus*. Bangalore: The Promise Foundation.

Nag S., & Snowling M. (2011). Cognitive profiles of poor readers of Kannada. *Reading and Writing: an Interdisciplinary Journal, 24*(6), 657-676.

Paradis, J. (2010). The interface between bilingual development and specific language impairment. *Applied Psycholinguistics*, 31, 227-252.

Polišenská, K., Chiat, S., & Roy, P. (2015). Sentence repetition: what does the task measure? *International Journal of Language & Communication Disorders, 50* (1),106–118

Potter, M. C., & Lombardi, L. (1990). Regeneration in the short-term recall of sentences. *Journal of Memory and Language, 29,* 633-654.

Raven, J.C., Court, J.H., & Raven, J. (1995). Manual for Raven's Progressive Matrices and Vocabulary Scales. Section 2, The Coloured Progressive Matrices. Oxford, England: Oxford Psychologists Press.

Redmond, S. M., Thompson, H. L., & Goldstein, S. (2011). Psycholinguistic profiling differentiates Specific Language Impairment from typical development and from Attention-Deficit/Hyperactivity Disorder. *Journal of Speech, Language and Hearing*, *54*, 99-117.

Rice, M., Warren, S. F., & Betz, S. K. (2005). Language symptoms of developmental language disorders. An overview of autism, Downs syndrome, fragile X, specific language impairment, & Williams syndrome. *Applied Psycholinguistics*, *26*, 7-27.

Riches, N. G. (2012). Sentence repetition in children with specific language impairment: an investigation of underlying mechanisms. *International Journal of Language & Communication Disorders*, *47*(5), 499-510.

Sengottuvel, K., & Rao, P. K.S. (2013). Aspects of grammar sensitive to procedural memory deficits in children with specific language impairment. *Research in Developmental Disabilities. 34*, 3317–3331

Snowling, M. J., Duff, F. J., Nash, H. M., & Hulme, C. (2015). Language profiles and literacy outcomes of children with resolving, emerging, or persisting language impairments; *Journal of Child Psychology and Psychiatry*, doi:10.1111/jcpp.12497

Sridhar, S. N. (1990). *Kannada: Descriptive Grammar*. Routledge.

Stokes, S. F., Wong, A., Fletcher, P., & Leonard, L. B. (2006). Nonword repetition and sentence repetition as clinical markers of specific language impairment: The case of Cantonese. *Journal of Speech, Language and Hearing Research*, 49, 219 – 236.

Vigliocco, G., & Hartsuiker, R. J. (2002). The interplay of meaning, sound, and syntax in sentence production. *Psychological Bulletin, 128*, 442.

Wilsenach, C. (2006). *Syntactic Processing in Developmental Dyslexia and in Specific Language Impairment*. University of Utrecht: LOT Dissertation Series.

Table 1

Descriptive Summary of the Sample Characteristics, Language Experiences and Cognitive-linguistic Variables (N = 135)

Measures	*M*	*SD*	95% CI
Age	79.79	8.45	(78.35, 81.22)
General abilities	25.92	5.58	(24.97, 26.87)
Measures of language experience [a]			
Oral narratives in Kannada	3.06	1.23	(2.80, 3.31)
Oral narratives in English	1.78	.88	(1.59, 1.96)
Age of Onset for English	54.92	15.36	(51.69, 58.16)
Other measures			
Vocabulary	18.01	6.26	(16.94, 19.07)
Nonword repetition	19.96	3.68	(19.34, 20.59)

Note. CI = Confidence Interval.

Raw scores (Max.): General abilities (36), Oral narratives in Kannada (5) and in English (5), Vocabulary (42) and Nonword repetition (25). Measure in months: Age and Age of Onset for English.

[a] Data are available for 67% of the sample.

Table 2

Descriptive Summaries of Proportion Scores for Accurate and Error Responses during Sentence Repetition

Measure	*M*	*SD*
Total score		
Word order accuracy	.69	.21
Error response		
Shortened utterances	.23	.21
Word order changes	.07	.06
Scores by condition[a]		
Word order accuracy		
Active Short	.94	.15
Active Long	.75	.30
Passive Short	.75	.31
Passive Long	.50	.31
Embedded	.48	.31
Error response: shortened utterances[b]		
Active Short	.05	.14
Active Long	.22	.29
Passive Short	.19	.28
Passive Long	.30	.34
Embedded	.45	.34
Error response: word order changes[c]		
Active Short	.01	.03
Active Long	.04	.11
Passive Short	.06	.13
Passive Long	.20	.20
Embedded	.06	.12

Note. [a]Five sentences per condition. [b] Typically preserves core event meaning. [c] Typically changes core event meaning

Table 3

Associations between Cognitive-linguistic and Sentence Repetition measures with Age and General Abilities partialed out (above the line) and their zero order correlations (below the line).

	Age	General Ability[1]	Vocabulary	Nonword repetition	Word order accuracy	Shortened utterance	Word order change
Age							
General Ability	.455***						
Vocabulary	.405***	.398***		.231**	.357***	-.382***	.094^{ns}
Nonword repetition	.313***	.207*	.337***		.382***	-.386***	-.029^{ns}
Word order accuracy	.438***	.397***	.505***	.468***		-.953***	-.117^{ns}
Shortened utterance	-.442***	-.411***	-.527***	-.472***	-.964***		.191*
Word order change	.045^{ns}	.079^{ns}	.117^{ns}	.046^{ns}	-.068^{ns}	-.200*	

Note: [1]Performance on Raven's Progressive Matrices. ^{ns} $p > .05$, *$p < .05$, ***$p < .001$

Table 4

Effects of Item Level Variable of Frequency and Child Level Variables of Vocabulary, Nonword Repetition and Age on Accuracy of Word Order during Sentence Repetition.

Variable	Coefficient	Std. error	*z*	*p*	95% CI
Frequency	14.84	2.99	4.96	0.000	[8.97, 20.72]
Vocabulary	.09	.02	4.68	0.000	[.06, .14]
Nonword repetition	.52	.12	4.15	0.000	[.27, .76]
Age	.04	.02	2.60	0.009	[.01, .07]

Table 5

Means (and Standard Deviations) of Proportion Scores on Word Level Accuracy and Errors Responses during Sentence Repetition

Word type	*Accurate responses*[a]	*Error responses*		
		Root	Inflection[b]	Boundary[b]
Nouns	.61 (.23)	.22 (.12)	.03 (.09)	.13 (.14)
Verbs	.73 (.23)	.05 (.06)	.17 (.17)	.05 (.09)

Note. [a] Inclusive of dialect variations [b] These are computed ignoring semantics, ie. both correct and substitutions on roots included.

Table 6

Correlations between Vocabulary, Nonword Repetition and Error Scores on Roots, Inflections and Boundaries

Analysis	Variable	Root error score	Inflection error score	Boundary error score
Age Controlled	Vocabulary[a]	- .065 [ns]	-.381***	-.349 ***
	Nonword repetition[a]	-.184 *	-.244**	-.489 ***
Age and Vocabulary Controlled	Nonword repetition	-.176 [ns]	.168 [ns]	-.444 ***
Age and Nonword Repetition Controlled	Vocabulary	-.022 [ns]	-.341***	-.270**

Note. [a] Association between vocabulary and nonword repetition with age controlled: $r = .246$*.

[ns] $p > .05$, *$p < .05$, **$p < .01$, ***$p < .001$

Language production subsystems	Bock & Levelt Model	During Sentence Repetition		Specific targets analysed in our study
		Accurate production	Inaccurate production [a]	
	Message (conceptual representation)	Target Sentence	Target Sentence	
Grammatical encoding	Functional processing • Lexical selection • Function assignment	Accurate root words Accurate event structure (who did what to whom)	Substitution of root words Inaccurate event structure[b]	Noun with Dative case marker
	Positional processing • Constituent processing • Inflections	Accurate word order Accurate inflections	Changes in word order[b] Shortened utterances[c] Errors on inflections[b]	Verb with Tense and Person, Number and Gender markers Word order
Phonological encoding	Phonological encoding	Accurate mopho-phonological boundaries	Errors on morpho-phonological boundaries[c]	Morpho-phonological boundaries in Nouns, Verbs
	To output system	Accurate Sentence Repetition	Inaccurate Sentence Repetition	

Note. [a]Errors may be in one or more aspects of processing. [b] Typically changes core event meaning. [c] Typically preserves core event meaning.

Figure 1. The language subsystems in sentence repetition. This figure illustrates Bock and Levelt's (1994) model, performance on specific linguistic units during accurate and inaccurate sentence repetition, and the areas of analysis in the current study.