Word and Sentence Production Fluency in Dyslexic Adults

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ABSTRACT

This study investigates the relationship between sentence production, word reading, working memory (WM) and vocabulary in adults with developmental dyslexia (DD). 11 adults with DD and 104 normal readers (NR) completed a battery of WM and vocabulary tasks that included a timed single word reading test. From the large group of NR, two subgroups were identified—one matched to the DD group on receptive and expressive vocabulary, one matched to the DD group on short-term and WM. The experimental sentence production task required participants to produce sentences including 3 stimulus words presented orthographically. Responses were scored for fluency, grammaticality and completeness; response times for correct sentences were obtained.

Due to the presentation modality of stimuli, we predicted that word reading ability would limit the performance of those with DD, in terms of overall accuracy and fluency of production. Participants with DD performed more poorly on the task than normal readers; however, the association with word reading was complicated by a strong relationship between word reading accuracy and short term phonological memory in DD and WM-matched NR. Interestingly, there was no relation between word reading and sentence production times, nor was there a relationship between fluency of sentence production and other measures.

METHODS

Participants

104 normal readers and 14 adults reporting reading disabilities were tested. 3 of the latter were excluded for concomitant language impairments. From among the normal readers, 2 subgroups with 11 participants each were matched to the group with developmental dyslexia: one matched on vocabulary scores (V-match) and one matched on memory scores (WM-Match).

Procedure

Screening. Participants reporting reading disability completed a 2-hour screening, to confirm diagnosis of developmental dyslexia. Below normal scores on a combination of Word Attack, Nonword Reading, spelling or phonological awareness measures were inclusionary criteria. Participants with scores below 80 on passage comprehension test of the WRMT were excluded from the study. Tasks used for the screening and group scores are available on the handout.

Experiment. In one 90-120 minute session, participants completed a battery that included 3 verbal working memory (WM) tasks, 2 vocabulary tasks, a word reading task, and a sentence production (SntPro) task. Responses were digitally recoded and transcribed.

Table 1. Scores on Working Memory and Vocabulary Tasks

	Normal Readers N=104	V-Match NR N=11	WM-Match NR N=11	DD N=11
Digit Span Forward (STM)	10.0/14 (2.2)*	10.8 (2.0)*	7.6 (2.0)	7.7 (1.6)
Digit Span Backward	8.6/14 (2.3)*	9.4 (2.2)*	7.1 (1.3)	6.1 (2.0)
Digit Ordering	20.9/24 (2.7)*	20.6 (3.0)*	18.3 (2.3)	17.4 (3.4)
WAIS-R voc.	58.0/70 (7.0)	52.3 (7.7)	55.6 (7.9)	52.7 (7.5)
Shipley voc.	32.5 (2.6)*	29.6 (3.3)	31.3 (3.0)	29.6 (4.7)
Word Reading Acc.	.89 (.06)*	.86 (.06)*	.84 (.09)	.76 (.10)
Word Reading RT (ms)	892 (194)*	939 (213)*	894 (176)*	1299 (500)

*Scores differed from DD group at p < .05

Sentence Production Task

A 3-word stimulus was presented in a vertical array on a computer screen. Participants had to produce a grammatical sentence that included all 3 words, used in any order. Stimuli disappeared from the screen when the computer detected a response. Responses were digitally recorded and transcribed verbatim for scoring.

Stimuli included a verb in past participle form, an animate and an inanimate noun. The verb was always in the center position; the position of animate and inanimate nouns varied by item and subject. Nouns were chosen to be plausible arguments of a particular verb.

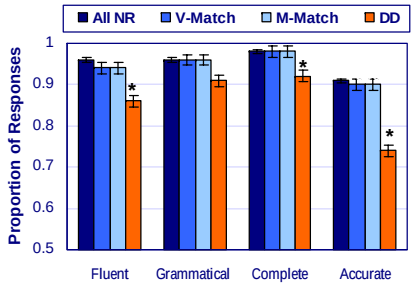
Scoring

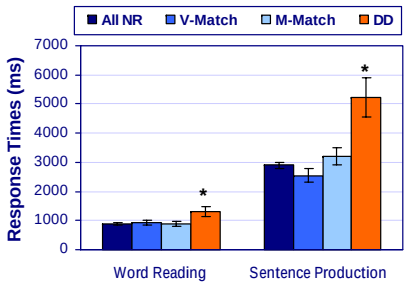
Responses were scored on 3 dimensions and one aggregate:

- Fluent responses contained no ums, repeated words, reformulations or long pauses.
- Grammatical responses were completely grammatical and coherent.
- Complete responses included all 3 stimulus words, as shown in the stimuli.
- Accurate responses were fluent, grammatical, and complete.
- Response times were calculated only using Accurate responses.

RESULTS

Sentence Production Performance





- V-Match and M-Match subgroups did not differ from the rest of the NR group on any measure
- The DD group produced significantly fewer fluent, complete and accurate responses than NR groups
- DD and NR marginally differed in grammatical responses (p=.06).

- The DD group was significantly slower than NR and NR subgroups, on word reading and sentence production.
- MANOVA effect of Group: $F(6, 218) = 5.619$, $p < .0001$, $\eta^2 = .13$
- DD were disproportionately slower on sentence production relative to Word Reading

Stepwise Regressions

Predicting Sentence Production Accuracy

- As predicted Word Reading Accuracy accounted for significant portions of variance in SntPro Accuracy for 3 of the 4 groups
  - **DD**: $r^2 = .41$, $p = .03$
  - V-Match: $r^2 = .20$, ns
  - **WM-Match**: $r^2 = .47$, $p = .02$
  - **All NR**: $r^2 = .07$, $p < .01$

Stepwise Regressions (using all predictors in Table 1) did not confirm these effects!

- **DD**: only one factor entered the equation
  - Digit Span Forward: $r^2 = .44$, $p = .03$
  - DSF and Word Reading Accuracy correlated, $r = .75$, $p < .01$.
- **V-Match**: No significant predictors
- **WM-Match**: 1 factors entered the equation
  - Word Reading Accuracy: $r^2 = .47$, $p = .02$
- **All NR**: 2 Factors accounted for 17% of the variance, $p < .001$
  - Shipley (reading) vocabulary: $r^2 = .11$
  - Digit Ordering: $r^2 = .06$

Predicting Sentence Production Times

- As predicted, word reading times accounted for significant variance sentence production times for 3 of 4 groups
  - **DD**: $r^2 = .45$, $p < .03$
  - **V-Match**: $r^2 = .41$, $p < .04$
  - **WM-Match**: $r^2 = .11$, ns
  - **All NR**: $r^2 = .21$, $p < .001$

Stepwise Regression (using all Predictors in Table 1) did not confirm all of these effects

- **DD**: Two factors accounted for 71% of the variance, $p < .01$
  - 1st Digit Ordering: $r^2 = .50$
  - 2nd Word Reading Accuracy: $r^2 = .21$
- **V-Match**: 1 factor entered the equation
  - Word Reading Accuracy: $r^2 = .78$, $p < .01$
- **WM-Match**: 1 factor entered the equation
  - Digit Span Forward: $r^2 = .50$, $p < .02$
- **All NR**: 2 factors accounted for 27% of the variance, $p < .001$
  - Word Reading RT: $r^2 = .21$
  - WAIS vocabulary: $r^2 = .06$

Error Subtypes: Grammatical Responses

- **DD**: Word Reading accuracy: $r^2 = .59$, $p < .01$
- V-match: no predictors
- **WM-Match**: 2 variables accounted for 91% of the variance, $p < .001$
  - Word Reading accuracy: $r^2 = .81$,
  - Digit span forward: $r^2 = .10$
- **All NR**: Digit ordering: $r^2 = .13$, $p < .01$

Error Subtypes: Complete Responses

Word reading accuracy predicted the proportion of complete responses in 3 of the 4 groups.

- **DD**: $r^2 = .58$, $p < .01$
- V-match: $r^2 = .20$, ns
- **WM-match**: $r^2 = .41$, $p < .03$
- **All NR**: $r^2 = .08$, $p < .01$

Error Subtypes: Fluent Responses

There were no predictors of the number of fluent responses in any of these groups.

CONCLUSIONS

- **Goal of the study:** Compare sentence production (SntPro) in adults with DD to a large group of normal readers (NR), and to subgroups of the NR matched to the DD sample on vocabulary or working memory (WM) scores.
- **Hypotheses**
  1) Performance on word reading and SntPro would correlate in all groups.
  2) Sentence production performance would correlate with vocabulary and WM abilities, but the DD group would be limited by word reading ability due to the reading demands of the SntPro task.
- Adults with DD were less accurate on word reading and SntPro than all NR, but were disproportionately impaired on sentence production.
  - Sentence production in NR was predicted by receptive vocabulary and WM (digit ordering) skills.
    - In unimpaired individuals, the current task taps knowledge of words and the ability to manipulate words without losing them from memory.
  - Sentence production in the WM-match group was predicted by word reading accuracy.
  - DD group's scores were predicted by either phonological memory or word reading accuracy, which were highly correlated in this group.
    - Either of these abilities (or both independently) could account for performance on this task, which required reading and retention of words for sentence production
    - However, we suspect that a latent variable is influencing performance:
      - **The ability to efficiently encode and store accurate phonological representations for later use.**
      - Inability to accomplish this would limit both phonological memory and the acquisition of the phonological forms of words.
        - May also slow later access and production of words & sentences.
      - This variable is associated with: overall accuracy, the proportion of complete responses, and the proportion of grammatical sentences in individuals with either DD or low WM.
        - Effects on grammar suggest deficits in this ability may impair acquisition of regularities that extend beyond the single word.
    - No predictors for fluency of sentence production were identified.
- Only the NR group showed the expected association between Word Reading RT and SntPro RT. Most language skills were highly correlated in NR.
  - V-Match group: similar to NR.
    - SntPro RTs correlated with all language measures except receptive vocabulary, but highest correlation was with word reading accuracy.
      - **People with efficient phonological encoding for later retrieval also have faster access to phonological sequences for output.**
    - NB: Word Reading accuracy & DSF did not correlate in this group.
- This was not true in the WM-match and DD groups.
  - WM-Match: SntPro RTs were associated with differences in STM
    - **People with poor phonological encoding for retrieval also have slow access to phonological sequences for output.**
  - DD: SntPro RTs were predicted by Digit Ordering
    - Demands for ordering linguistic material significantly slowed SntPro.
    - Word reading accuracy also shared variance with SntPro RTs
    - **Thus, impaired phonological representations in DD may make word representations particularly difficult to manipulate.**

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