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Tip-of-the-Tongue and Word Retrieval Deficits in Dyslexia

Sarah Hanly[1] and Brian Vandenberg[1]

Abstract

Tip-of-the-tongue (TOT) responses on a picture-naming task were used to test the hypothesis that dyslexia involves phonological, but not semantic, processing deficits. Participants included 16 children with dyslexia and 31 control children between 8 and 10 years of age who did not differ in receptive vocabulary. As hypothesized, children with dyslexia demonstrated more TOTs and proportionally more errors in the phonological, but not semantic, step of word retrieval. Longer and low-frequency words also prompted more TOTs. The groups did not differ in phonological errors on a follow-up recognition task. The results provide evidence of text-independent, on-line phonological processing deficits in readers with dyslexia.

Keywords

dyslexia, phonological processing, tip-of-the-tongue

The picture-naming experimental paradigm allows for the assessment of text-independent cognitive processes involved in retrieval of words from long-term memory. In these tasks, individuals are presented with a picture and must retrieve the name of the object depicted. This is a particularly useful method for examining core cognitive processing deficits in dyslexia that are not tied to the specific challenge of reading written text. Research using this approach indicates that readers with dyslexia have poorer word recall and make more phonological errors than do chronologically aged typical readers and reading-level-matched controls (Nation, Marshall, & Snowling, 2001; Swan & Goswami, 1997; Wolf, 1991; Wolf & Obregón, 1992); are less accurate in word retrieval with longer words or with low-frequency, less familiar words (Swan & Goswami, 1997); and substitute semantically related words or circumlocutions for the target word (Denkla & Rudel, 1976; Miller & Felton, 2001; Nation et al., 2001; Snowling, 2000; Swan & Goswami, 1997; Wolf, 1997). These results indicate that readers with dyslexia experience text-independent difficulties. The picture-naming tasks, however, only assess the endpoint of the word retrieval process and do not provide insight into where, specifically, the breakdown occurs in the word retrieval process. A more fine-grained, process-level understanding would be achieved by combining a theoretical model of the cognitive steps involved in word retrieval with methodological strategies that enable these steps to be empirically examined.

Levelt's two-step model, derived from theories of word retrieval from the field of linguistics, provides a theoretical framework for understanding the difficulties experienced by readers with dyslexia (Levelt, 1999, 2001; Levelt, Roelofs & Meyer, 1999). In this model, the first step is concept activation, triggering retrieval of the semantic representation for the word. Initially, activation spreads to other semantically related concepts but rapidly culminates in the selection of the most strongly activated semantic or meaning-based representation in the speaker's lexicon. In the second step, the specifics of the phonological segments of the target word are identified, permitting the sequential assembly of the articulatory gestures necessary for speech.

Levelt's two-step model of word retrieval affords process-level understanding of the characteristic errors readers with dyslexia make on picture-naming tasks. Readers with dyslexia substitute semantically related words or circumlocutions for the target word; a related word is retrieved, a definition is provided, or a roundabout description is given with many descriptive details and features about the target word. These errors suggest that the semantic features of the

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target concept have been activated (Step 1). Readers with dyslexia also make more phonological errors than do control readers, and a common feature of these errors is that they are phonologically similar in length and sound to the target word. This suggests that readers with dyslexia are unable to retrieve the exact phonological components of the word (Step 2). Breakdown, thus, occurs at the phonological processing step in word retrieval.

The conclusion that readers with dyslexia demonstrate a breakdown in retrieval of phonological representations of words, however, is inferential and not based on direct probing of each step separately. One way to gain experimental access to the two steps, as they occur, is through the tip-of-the-tongue (TOT) experience. In a TOT experience, the speaker is able to provide semantic information about the word but is unable access the word's phonological representation and direct the assembly of the spoken word (Brown, 1991; Burke, MacKay, Worthley, & Wade, 1991; Levelt, 1999). TOTs, thus, provide a "natural experiment" that interrupts word retrieval between the semantic (Step 1) and phonological (Step 2) retrieval process. The typical TOT research paradigm begins with a picture-naming task, and when participants report a TOT, the task is paused and they are asked to give information about the word or to indicate if they do not know the word. If they do give information but are still unable to identify the word, they are then given a forced-choice recognition task consisting of the target word, phonologically similar words and pseudowords, and semantically and perceptually related foils (Faust, Dimitrovsky, & Shacht, 2003). Phonological processing deficits are thus identified in two ways: the occurrence of TOTs, which expose the on-line phonological deficit, and the recognition task, which offers a post-TOT appraisal of the participants' reconstructions of the target word.

Faust and colleagues, in a groundbreaking set of studies, used the TOT paradigm to examine naming difficulties of third- and fourth-grade children with dyslexia (Faust et al., 2003) and adolescents (Faust & Sharfstein-Friedman, 2003) reading in Hebrew. Their results indicated that readers with dyslexia experienced more TOTs, did not differ in semantic information (Step 1), but did display more phonological errors in the recognition task (Step 2). They also named significantly fewer objects but did not differ in the number of objects they did not know. The authors argued that this lack of significance in "don't know" responses indicated that the receptive vocabularies of children with dyslexia were not different from those of the control children.

These studies provide the specificity of focus lacking in previous picture-naming studies with readers with dyslexia. The results must be considered with caution, however, due to important methodological shortcomings. A major focus of the studies was spontaneous recovery from the TOT experience and factors that influence this recovery. The authors interposed an intermediary phonological cueing task to determine if there was a differential effect for readers with dyslexia and typical readers. This not only introduced input that contaminated responses on the subsequent word recognition task but also resulted in very low base rates, with means and standard deviations in the recognition task at or near zero. To circumvent statistical difficulties caused by floor effects for TOT experiences, ceiling effects for correct naming of the target words, and violations of assumptions of homogeneity of variance, the authors used nonparametric statistical analyses. However, nonparametric tests also assume homogeneity of variance and are not appropriate when homoscedasticity is violated and, further, are not appropriate for count data for low-frequency events (Kasuya, 2001; Zimmerman, 1996). Poisson regression modeling is required for these types of data, which also allows for analysis of the effects of word length and frequency on TOTs (Cohen, Cohen, West, & Aiken, 2003; Dunteman & Moon-Ho, 2006; Fox, 1997, 2002; Gardner, Mulvey, & Shaw, 1995), something not done by Faust and colleagues.

Faust and colleagues also did not control for receptive vocabulary; the lack of group differences in "don't know" responses is not a valid or useful measure. Consequently, the differences found between groups on TOTs and phonological processing may result from receptive vocabulary differences. Another problem is that the Faust studies only reported raw TOT frequencies. Gollan and Brown (2006) argue that reporting raw TOTs can be misleading, and they recommend determining the proportion of word retrieval failures at each step in word retrieval. Finally, the studies examined children with dyslexia reading Hebrew, which, at least for beginning readers, is a transparent writing system or orthography (Shimron, 1999). Research in opaque orthographies, like English, is needed to establish that deficits in phonological representation are a universal feature of dyslexia.

This study utilized the TOT picture-naming paradigm to examine differences in semantic and phonological processing in readers with dyslexia and typical readers of English. No intermediary cueing task was used, the effects of word length and frequency were examined, receptive vocabulary was controlled, the proportion of word retrieval failures at each step was determined, and Poisson regression modeling was used to analyze the data. It was hypothesized,

1. Readers with dyslexia will have more TOTs; TOTs will be greater for low-frequency and more phonologically complex words, and these types of words will be significantly more likely to prompt TOTs in dyslexic readers.
2. Readers with dyslexia will not differ in the proportion of failures in retrieval of semantic information (Step 1) but will have significantly

proportionately more failures in retrieval of phonological information (Step 2).

3. Readers with dyslexia will make more phonological errors on the recognition task.

Children between 8 and 10 years of age were examined, as this is an age when typically developing children master basic word-reading skills, and it is also likely that children with long-standing reading difficulties will have received a formal learning disabilities evaluation. Also, children this age are able to accurately monitor their memories and make more reliable judgments about whether they are familiar with the name of an object or simply do not know the name and, hence, accurately identify TOT experiences (Wellman, 1977). Comparisons between readers with dyslexia and typically developing readers often use reading-level-matched younger children as the control group. When differences in reading-related subskills and cognitive processing are found between these two groups, they are viewed as related to cognitive processes that are likely causally related to dyslexia and not likely a consequence of lack of reading experience (Olson, Forsberg, Wise, & Rack, 1994; Snowling, 2000; Stanovich, 1988; Stanovich & Siegel, 1994). However, developmental differences in cognitive processing may obscure genuine differences when older, more developmentally mature readers with dyslexia are compared to younger, less mature, reading-level-matched readers (Bowey, Cain, & Ryan, 1992). These types of developmental differences might obscure genuine differences in TOT experiences if a younger reading-level-matched control group is the comparison group.

The most appropriate control group is typically developing readers matched in receptive vocabulary with the readers with dyslexia. Assessing receptive vocabulary does not require a verbal response and, thus, is not confounded by word retrieval difficulties in readers with dyslexia. As this study examined text-independent deficits in dyslexia, it was less important to match the readers with dyslexia and control group readers on word-reading skill or reading comprehension. Furthermore, studies with older and younger adults have found that fluent picture-naming and TOT experiences are significantly influenced by experience (Gollan & Brown, 2006). The TOT paradigm is not well researched in children, so until the influence of experience on word retrieval and TOT experiences in children has been more thoroughly examined, it is best to use same-age controls and control for possible confounds in receptive vocabulary.

Method

Participants

Children with dyslexia were recruited through the special school district and charter public schools in a Midwestern metropolitan area, and control children were recruited through schools in the same area and by word of mouth by parents whose children had participated in the study. A total of 47 children (15 girls, 32 boys) participated in the study; 16 in the dyslexic group (4 girls, 12 boys) and 31 in the control group (11 girls, 20 boys). The average age was 9.6 years ($SD = 0.79$), and 43 of the 47 children were Caucasian; 1 African American child was in the dyslexic group, and 1 African American, 1 biracial, and 1 Asian child was each in the control group. The children with dyslexia met the criteria of a diagnosis of Learning Disability in Basic Reading and had, at minimum, a 20-point discrepancy between their IQs and word or pseudoword reading scores on standardized measures of reading and IQ. The average discrepancy between IQ and word or pseudoword reading in the dyslexic group was 30 points (2 *SD*s). Assessment of children with dyslexia was conducted by their respective school districts, and their parents allowed access to these records for verification of their children's diagnoses. There were no comparable records for the control children because only children with suspected learning disabilities received the standardized cognitive/achievement testing. Thus, children in both groups were given a measure of receptive vocabulary to ensure that the groups did not differ on this variable.

Measures

Peabody Picture Vocabulary Test, Third Edition (PPVT-III). The PPVT-III is an individually administered, norm-referenced test of receptive vocabulary for individuals ages 2½ to 90. Each item consists of a picture plate with a set of four black-and-white illustrations. One advantage of the PPVT-III for this study is that no verbal response is required; children can point to the correct picture or refer to it by number. In this study, the PPVT-III provided a means of controlling for vocabulary development between the control and dyslexic groups. The PPVT-III has demonstrated good reliability for children between 8 and 10 years of age and also good convergent validity with other intelligence tests (Williams & Wang, 1997).

Naming task. Picture-naming stimuli were selected from a set of black-and-white line drawings of common objects available as freeware from the International Picture Naming Project (IPNP; Szekely et al., 2003, 2005). The stimuli were chosen to represent the four types of target words: short high frequency, short low frequency, long high frequency, and long low frequency. Short target words were four phonemes in length or shorter. Long target words were six or more phonemes. Low-frequency target words had frequency ratings of less than 10 per million and high-frequency target words had ratings of greater than 20 per million (Carroll, Davies, & Richman, 1971). Target words were selected that previously had been demonstrated in studies with children to have a dominant target name (Cycowicz, Friedman, Rothstein, & Snodgrass, 1997; Szekely et al., 2003, 2005). Some target words were not available as picture stimuli in the IPNP database, so drawings were made or images were obtained for these words. Pilot testing and subsequent analysis of results revealed problems with some words, which were consequently omitted, leaving a total of 143 words: 39 high-frequency short words, 34 high-frequency long words, 35 low-frequency short words, and 35 low-frequency long words. The presentation of the stimuli was organized using a randomized block design, as the stimuli were randomized in blocks of four pictures, with one picture of each type of target word in each block (varying in word length and frequency). The order of the stimuli was constant across participants.

The stimuli were presented on a laptop computer. For each stimulus, a fixation point (+) was presented at the center of the screen for 500 milliseconds, followed by the stimulus, which was presented for up to 20,000 milliseconds, and then followed by a second fixation point (·). When children named the picture correctly, the next stimulus was presented immediately. The presentation of the stimuli was briefly interrupted when the children responded incorrectly, reported a TOT experience, or reported that they did not know the name of the stimulus. When this happened, the children were first prompted to provide another response or to provide any information they could about the word they were attempting to retrieve, and then they were presented with the recognition task for that stimulus word. The presentation of the stimuli via the computer was resumed after completion of this task. Children's responses were digitally recorded for later review. Two independent raters, who were blind to the children's reading status, coded whether children's TOT responses were semantically related to the target word. The mean agreement was 92%, with a range of 83% to 100%.

Recognition task. The recognition task for a target word was administered when a TOT or "don't know" response was given in the picture-naming task. The target word and four foils were printed in 48 point on an 8″-×-11.5″ card. Two foils were phonologically related to the target word, a real word, and a pseudoword; the third foil was from the same semantic category as the target word; and the fourth foil was perceptually related to the target word. The five words were written in random order and were read aloud to the children as the examiner pointed to each word.

Receptive vocabulary task. The receptive vocabulary task was developed in the same format of the PPVT-III. This task was administered after completion of the picture-naming task for any target words that were incorrectly named or not known. For each target word, a picture plate was created consisting of four black-and-white pictures, one of which was the target word. The children were asked to identify which of the four picture stimuli was the target word spoken by the examiner.

Response Coding

A correct response (*got*) was coded when children responded with the correct target name for the picture. A TOT (*tot*) was coded when children reported a TOT experience and were able to provide semantic information about the target word or when children did not explicitly report a TOT but reported that they were thinking of a word, were able to provide accurate semantic information about the target word, and identified the target word or one of the phonological foils as the word they were trying to recall on the recognition task. Phonological errors (*phon*) were coded when children selected either the phonological word or pseudoword foils on the recognition task.

Procedure

Children were tested individually in one session in their homes, and all children received $10 for participating in the study. The children were asked if they were familiar with the expression "It's on the tip-of-my-tongue," and if so, if they could recall a time when they had experienced a TOT. The examiner provided an example of a time when she had experienced a TOT. After describing her experience, the examiner again asked children who at first reported being unsure whether they could recall ever experiencing a TOT, and all children reported being familiar with the experience. Eight trial pictures were presented before the onset of the stimuli in the picture-naming task, and several of these pictures were selected to elicit incorrect, TOT, or "don't know" responses, providing opportunities for children to become familiar with the recognition task.

When children provided an incorrect name to one of the stimuli, reported a TOT experience, reported that they did not know the name of the stimulus, or if 20,000 milliseconds elapsed without a response, the picture-naming task was paused briefly. Children were prompted to provide another response or provide any information they could think of about the word they were attempting to retrieve. If the children persisted in not being able to retrieve the correct name of the stimulus, the recognition task for that target word was administered: The children were prompted to choose the name of the stimulus from a group that included the target word and four foils, which were presented and read aloud to the children. Upon completion of this task, the PPVT-III was administered. Responses throughout the procedure were digitally recorded.

Results

Preliminary Analyses

Preliminary analyses indicated that the dyslexic and control groups did not significantly differ in gender, age, or receptive vocabulary as measured by the PPVT-III.

Table 1. Poisson Regression Model for Tip-of-the-Tongue Experiences

Predictor	Estimate	Standard Error	z value
(Intercept)	0.000	0.088	0.001
Group	0.343	0.150	2.285*
Length	0.530	0.125	4.242***
Frequency	1.920	0.125	15.362***
Group × Length	0.066	0.212	0.311
Group × Frequency	0.038	0.212	0.178
Length × Frequency	–0.381	0.177	–2.158*
Group × Length × Frequency	0.085	0.300	0.284

*$p < .05$. ***$p < .001$.

Table 2. Poisson Regression Model for Percentage of Errors at Step 1

Predictor	Estimate	Standard Error	z value
(Intercept)	0.433	0.088	4.899**
Group	0.161	0.150	1.073
Length	1.098	0.125	8.783***
Frequency	2.165	0.125	17.321***
Group × Length	0.233	0.212	1.098
Group × Frequency	–0.015	0.212	–0.072
Length × Frequency	–0.754	0.177	–4.264***
Group × Length × Frequency	0.194	0.300	0.645

**$p < .01$. ***$p < .001$.

Each of the variables, *tot,* and *phon* are count data and had a distribution with a modal value of 0 and a positively skewed tail, reflecting the fact that TOT experiences and phonological errors were rare events; the most common outcome was correct naming of the picture stimulus. The distributions of these variables violate assumptions of homogeneity of variance and normality necessary for ordinary least squares regression or ANOVA. The Poisson regression is the most appropriate to model assess count data for rare events, permits analysis of count data without transformation, and does not assume that the error terms or dependent variables are normally distributed. The best fit of this data set was the square root link function (Cohen et al., 2003; Dunteman & Moon-Ho, 2006; Fox, 1997, 2002; Gardner et al., 1995).

Main Analysis

The first hypothesis was that children with dyslexia would report more TOT experiences, that low-frequency and phonologically longer words would elicit more TOT experiences, and that these words would be more problematic for children with dyslexia than for their typically reading peers. A full-factorial Poisson regression analysis was used to examine the relation of the independent variables, group (dyslexic or control), word length (short or long), and word frequency (high or low) with tip-of-the-tongue, *tot*. The overall fit of the model was significant, $\chi^2 = 160.73$, $df = 7$, $p < .001$. McFadden's ρ^2, which provides a measure of association and is related to R^2 in ordinary least squares regression, was .72, indicating that the model accounted for 72% of the variance. The parameter estimates for the Poisson model of *tot* indicated significant main effects for group, length, and frequency (see Table 1). As predicted, children with dyslexia ($M = 3.26$, $SD = 3.53$) experienced more TOT experiences than did control children ($M = 2.06$, $SD = 2.54$), $p < .05$. TOT experiences were more likely with long words ($M = 2.82$, $SD = 3.11$) than with short words ($M = 2.14$, $SD = 2.79$), $p < .001$, and with low-frequency words ($M = 4.69$, $SD = 2.71$) than with high-frequency words ($M = 0.26$, $SD = 0.65$), $p < .001$. The only significant interaction effect in the model was between word length and word frequency, $p < .05$, indicating that the effect of word length on TOT experiences was more pronounced with low-frequency words than with high-frequency words. Contrary to predictions, no interaction effects were found for group-by-word characteristics.

The second hypothesis was that readers with dyslexia would not differ in the proportion of failures in the retrieval of semantic information (Step 1) but would differ in the proportion of failures in the retrieval (Step 2) of phonological information. Two new variables were created to test this hypothesis. Word retrieval failures at Step 1 involve words that are either not in the participant's lexicon or for which semantic information cannot be accessed. Both successful naming of the target (*got*) and TOT experiences (*tot*) reflect retrieval of semantic information about the target word. Thus, the proportion of failures at Step 1 can be computed by subtracting successful retrievals at Step 1 (*tot* + *got*) from the total number of target words (*N*) and dividing by the total number of target words (*N*):

$$\text{Step 1} = \frac{N - (tot + got)}{N}$$

Success or failure at Step 2 occurs only with target words for which semantic information was successfully retrieved. Both TOT experiences (*tot*) and successful target naming (*got*) reflect successful retrieval of semantic information (Step 1). However, although in a TOT experience the semantic information for the target word is retrieved, the phonological representation is not, and there is a failure at Step 2 of word retrieval. The proportion of failures at Step 2 is calculated as the ratio of failures at Step 2 (*tot*) to successes at Step 1 (*tot* + *got*):

Table 3. Poisson Regression Model for Percentage of Errors at Step 2

Predictor	Estimate	Standard Error	z value
(Intercept)	0.000	0.088	0.002
Group	0.594	0.150	3.958***
Length	0.918	0.125	7.347***
Frequency	3.359	0.125	26.869***
Group × Length	0.150	0.212	0.708
Group × Frequency	0.069	0.212	0.327
Length × Frequency	–0.594	0.177	–3.363***
Group × Length × Frequency	0.306	0.300	1.019

***$p < .001$.

Table 4. Poisson Regression Model for Phonological Recognition Errors

Predictor	Estimate	Standard Error	z value
(Intercept)	0.000	0.000	0.000
Group	0.000	0.154	0.000
Length	0.000	0.127	0.000
Frequency	0.596	0.127	4.690***
Group × Length	0.000	0.218	0.000
Group × Frequency	0.234	0.218	1.073
Length × Frequency	–0.057	0.180	–0.317
Group × Length × Frequency	–0.111	0.308	–0.360

***$p < .001$.

$$\text{Step 2} = \frac{tot}{(tot + got)}$$

Poisson regression requires that the dependent variable assume only integer values; thus, the proportion of failures at Step 1 and Step 2 was converted to percentage failures at each step, *pcstep1* and *pcstep2*. The variables *pcstep1* and *pcstep2* can be conceptualized as the rate of failures in word retrieval at Step 1 and Step 2 per 100 words. The distributions of the *pcstep1* and *pcstep2* variables were positively skewed with a modal value of 0, as the most common outcome at each step of word retrieval is success.

A Poisson square root link function regression analysis was used to test the hypothesis that there would be no group differences in failures of semantic retrieval (Step 1), examining the relation of group, word length, and word frequency with *pcstep1*. The overall fit of the model of was significant, $\chi^2 = 830.16$, $df = 7$, $p < .0001$, and McFadden's $\rho^2 = .44$, indicating that the model accounted for 44% of the variance. The parameter estimates for the Poisson model indicated significant main effects for word length and word frequency (see Table 2). Children were more likely to have difficulty retrieving semantic information for long words ($M = 6.38$, $SD = 7.61$) than for short words ($M = 3.63$, $SD = 5.72$), $p < .001$, and for low-frequency words ($M = 8.48$, $SD = 7.88$) than for high-frequency words ($M = 1.53$, $SD = 2.80$), $p < .001$. The only significant interaction effect in the model was between word length and word frequency, $p < .001$, indicating that the effect of word length on the likelihood of not being able to retrieve semantic information about a target word was more pronounced with low-frequency words than with high-frequency words. As predicted, group was not a significant predictor of word retrieval failures at Step 1.

A similar Poisson regression analysis was used to test the hypothesis that readers with dyslexia would exhibit more failure in Step 2, examining the relation of group, word length, and word frequency. The overall fit of the model was significant, $\chi^2 = 2{,}161.10$, $df = 7$, $p < .0001$, and McFadden's $\rho^2 = .71$, indicating that the model accounted for 71% of the variance. The parameter estimates indicated significant main effects for group, word length, and word frequency (see Table 3). Children with dyslexia ($M = 10.59$, $SD = 12.44$) were more likely to fail to retrieve phonological information for target words than were control children ($M = 6.42$, $SD = 8.05$), $p < .001$. Failure to retrieve phonological information was more likely with long words ($M = 9.18$, $SD = 11.04$) than with short words ($M = 6.55$, $SD = 8.61$), $p < .001$, and for low-frequency words ($M = 14.92$, $SD = 9.75$) than for high-frequency words ($M = 0.816$, $SD = 2.04$), $p < .001$. The only significant interaction effect in the model was between word length and word frequency, $p < .001$, indicating that the effect of word length on retrieval of phonological information about a target word was more pronounced with low-frequency words than with high-frequency words. As predicted, readers with dyslexia, even when matched for receptive vocabulary, had significantly more failures retrieving phonological information than did their typically reading peers.

The third prediction, that readers with dyslexia would make more phonological errors on the recognition task, was tested with a Poisson regression model that examined the relation of group, word frequency, and word length with phonological errors, *phon.* The overall fit of the model of was significant, $\chi^2 = 11.13$, $df = 7$, $p < .0001$, and McFadden's $\rho^2 = .36$, indicating that the model accounted for 36% of the variance (see Table 4). The estimates for the Poisson model indicated that only word frequency was significant, $p < .001$; children were more likely to choose a phonological foil when attempting to resolve a TOT for a low-frequency target word. Contrary to prediction, children with dyslexia were not significantly more likely to make phonological errors.

Discussion

Picture-naming tasks offer the opportunity to assess text-independent cognitive processing deficits in readers with dyslexia. The research from this paradigm, when examined from the perspective of Levelt's two-step model of word retrieval, suggests that problems encountered by readers with dyslexia occur in Step 2, phonological processing. This conclusion, however, is inferential, as picture-naming tasks yield endpoint analyses of word retrieval. The TOT experience affords a unique opportunity to examine on-line processing, as word retrieval is interrupted between the semantic and phonological steps. If dyslexia involves a disruption in phonological processing, then it would be expected that readers with dyslexia would experience more TOTs.

The results confirm this hypothesis; readers with dyslexia exhibited more TOTs than did typical readers. Furthermore, readers with dyslexia did not differ in the proportion of failures to retrieve semantic information (Step 1) but evinced significantly proportionately more failures in word retrieval of phonological information (Step 2). These results are not likely due to differences between the groups in receptive vocabulary, as there were no differences on the measure of this variable.

The results of the recognition task, however, failed to confirm the hypothesis that readers with dyslexia would select more phonological foils when attempting to resolve a TOT experience. Overall, both children with dyslexia and control children were accurate in selecting the target word from the foils on the recognition task, and neither group demonstrated significant phonological confusion. The recognition task is a less stringent assessment of phonological processing than the TOT experience because the TOT assesses failures in word recall, whereas, as its name suggests, the recognition task only requires recognition of the target word. The lack of errors by both groups no doubt contributed to the failure to find significant differences on this task.

The results also support prior research that word length and frequency play an important role in word retrieval. Longer and less frequent words prompted more TOTs and posed greater difficulty in both semantic (Step 1) and phonological (Step 2) processing. The results, however, failed to support the expectation that these words' characteristics would prompt more TOT and phonological processing errors for readers with dyslexia. This lack of significance may be due to a lack of power. TOT experiences were very low frequency events, and the sample size, although relatively large for studies of readers with dyslexia, is statistically small, allowing for the detection of only the most robust differences. In addition, stimuli were selected that could be easily visually represented, elicit a dominant response, and avoid confusion. Other studies, however, have presented picture stimuli in conjunction with a semantic clue or stimuli that were part of a more complex picture (e.g., Dietrich & Brady, 2001). It is possible that these strategies may enable using less concrete and more phonologically complex words, thus increasing the potential power to discriminate between dyslexic and control groups. The results do underscore that word characteristics are important factors in TOT picture-naming tasks, and future research will need to be mindful of the particular stimuli employed.

The results of this study extend the findings of Faust and colleagues to English-speaking readers, demonstrating that in both Hebrew and English readers with dyslexia experience text-independent phonological processing difficulties. Furthermore, this study included methodological and statistical refinements, including examining TOT without an intermediary cueing task, using Poisson regressive modeling, controlling for receptive vocabulary, and employing standard TOT protocols used with other populations, thus providing a more exacting test and a more accurate analysis of text-independent cognitive processing in dyslexia. The convergence of results lends greater confidence to the hypothesis that text-independent phonological processing deficits are linked to dyslexia.

The limitations of this study suggest future directions for research. Larger sample sizes and inclusion of more-challenging words would increase the power to detect possible differences between word characteristics and dyslexia and also to detect group differences on the recognition task. Furthermore, the cognitive deficits associated with dyslexia are presumed to be universal and persistent, suggesting that similar differences in TOT experiences should be found in other languages and for older children and adults. This is yet to be examined. The picture-naming TOT paradigm offers unique opportunity to examine cognitive processing deficits in dyslexia, and the convergent results of this study with those of Faust and colleagues underscore the importance of continuing this fruitful line of research.

One challenge to this line of research is posed by the emergence of an alternative definition of dyslexia that focuses on failure to respond to intervention, not an IQ-achievement discrepancy (e.g., Fuchs, Fuchs, & Compton, 2004). This definition would encompass a more diverse population of struggling readers and would include poor readers who suffer from vocabulary and semantic deficits. Such children likely have been excluded from this study, so the results may pertain only to a subset of children labeled *dyslexic* under this alternative approach. This, too, is worthy of future research.

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