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Influence of Lexical Factors on Word-Finding Accuracy, Error Patterns, and Substitution Types

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Abstract

This retrospective, exploratory investigation examined the types of target words that 66 children with/without word-finding difficulties (WFD) had difficulty naming, and the types of errors they made. Words were studied with reference to lexical factors (LFs) that might influence naming performance: word frequency, familiarity, length, phonotactic probability, and lexical neighborhood. For the most part, LFs similarly affected the word finding of children with/without WFD. Target word frequency predicted word-finding success for both groups, and word substitutions and error patterns were affected by the LFs under study. Children tended to produce substitutions that were shorter and higher in frequency, neighborhood frequency, and phonotactic probability than the target word. LFs also influenced children's error patterns. Low word frequency led to form-related blocked errors for both groups, and low neighborhood frequency predicted form- and segment-related phonologic errors for children with WFD only. Theoretical and practical implications of these preliminary findings are discussed.

Keywords

elementary school, disorders, communication, word finding, lexical factors

Word finding (WF) refers to the ability to access words for spontaneous usage. When individuals have difficulties accessing words, they can display delayed or inaccurate responses with a high incidence of repetitions, reformulations, word substitutions, insertions, time fillers, and empty words in the discourse context (German & Simon, 1991). Prevalence rates for children with WF difficulties (WFD) are high among students with specific language impairment (Dockrell, Messer, George, & Wilson, 1998). These WFD can interfere with children's ability to succeed in school, especially when they are faced with academic tasks that require lexical access of words orally, such as answering questions or generating narratives. WFD also correlate with reading difficulties. Second-language child learners have been reported to have more tip-of-the tongue states while reading (Borodkin & Faust, 2012); monolingual children with WFD demonstrate oral reading difficulties on words they can decode silently (German & Newman, 2007); and children with literacy difficulties have been reported to be slower on serial naming tasks (Messer & Dockrell, 2011). Thus, WFD have been shown to have impacts on a variety of tasks necessary for academic success.

To better understand these learners' lexical difficulties, researchers have studied their accuracy and speed in naming, word substitutions, responsiveness to semantic and phonemic cueing, and secondary characteristics such as gestures (German, 2015). A variety of potential causes of WFD have been considered, including gaps in learners' lexicons, fragile semantic representations, shallow phonological representations, and a difficulty retrieving information in the presence of well-elaborated representations in the mental lexicon (Borodkin & Faust, 2012; McGregor, Friedman, Reilly, & Newman, 2002). However, as yet, there has been no consensus as to the source of WFD, and it may well be that different groups of children have different underlying causes. Given the high prevalence rates of WFD among school-age children, the importance of the ability to retrieve words for school success, and the various causes of WFD proposed, further study of the lexical access skills of children with WFD seems warranted.

This study is a retrospective, exploratory investigation of how different properties of words (lexical factors, or LFs) affect the ease with which those words can be retrieved, and the error patterns and substitution types produced when the

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Table 1. Lexical Factors.

Lexical factor studied	Definition	Related research findings
Word Frequency	How frequently a word is used in the language	*Higher frequency* words tend to • be better recognized, • be more easily produced, and • draw out fewer speech errors, while *lower frequency* words are more difficult to retrieve (Jescheniak & Levelt, 1994; Luce & Pisoni, 1998; Vitevitch, 1997). Word frequency predicts phonologic naming errors and target word substitutions, and reading miscues are often of higher frequency than the initial target words (German & Newman, 2004).
Familiarity	How familiar a word is judged to be	*More familiar* words are easier to name (Newman & German, 2005).
Neighborhood Density (ND)	The number of words that differ from the target by a single-phoneme addition, deletion, or substitution	Words with more neighbors (those in high-density neighborhoods) tend to experience competition from their neighbors and be slower to repeat (Luce & Pisoni, 1998), but there are more errors on words from sparse neighborhoods (Vitevitch, 1997). ND predicts form-related errors and target word substitutions, and reading miscues have higher ND than target words (German & Newman, 2004).
Neighborhood Frequency	The average frequency of the word's neighbors	Words with high-frequency neighbors are identified more quickly and accurately in lexical decision tasks (Luce & Pisoni, 1998). Neighborhood frequency predicts form-related naming errors (German & Newman, 2004).
Phonotactic Probability (PP)	The frequency with which a sound or sequence of sounds occurs in the language	Words that are higher in phonotactic probability are easier to learn (Storkel, 2001, 2003; Storkel & Rogers, 2000) and to name aloud (Newman & German, 2005). PP predicts oral reading success (German & Newman, 2007).
Word Length	The word's length, here, in syllables	Longer words tend to be harder to keep in short-term memory (Baddeley, Thomson, & Buchanan, 1975) and, perhaps as a result, tend to be learned later (Storkel, 2004a). They also have fewer lexical neighbors (Storkel, 2004b); its impact on access per se is less clear.

correct words are not retrieved. Because WF is classically defined as a discrepancy between knowing a word and being able to access that same word, we targeted the expressive component of words already learned. Although some children can have shallow phonological representations of words they can comprehend, we studied children who exhibited WFD on words believed to be well-elaborated in their mental lexicons (Borodkin & Faust, 2012). This type of word-retrieval difficulty is implied in the slip- or tip-of-the-tongue phenomena in which an individual temporarily fails to correctly access a word for production that he or she has accessed before, self-corrects, or can access immediately in comprehension.

Examining the influence of word properties has been ongoing in the areas of word learning (McKean, Letts, & Howard, 2014; Storkel, 2001, 2003, 2004a), fluency (Bernstein Ratner, Newman, & Strekas, 2009), adult aphasia (Gordon, 2002; Kittredge, Dell, Verkuilen, & Schwartz, 2008; Middleton & Schwartz, 2010), reading (German & Newman, 2007; Hogan, Bowies, Catts, & Storkel, 2011; Schuster, Hawelka, Hutzler, Kronbichler, & Richlan, 2016), expressive language (Maekawa & Storkel, 2006), and WF (German & Newman, 2004; German, Schwanke, & Ravid, 2012; Newman & German, 2002, 2005). These investigations demonstrate that not all words are alike when it comes to their difficulty to access or the errors they induce.

As a result, children's apparent WF skills vary based on the properties of the words they were asked to name (Newman & German, 2002). (See Table 1 for a brief summary of research findings relative to the word properties explored in this study.) For school-age children, words which were more common in the language (high frequency words) were easier to name. Thus, words like "elephant" were easier than words like "aardvark." So, too, were words that were relatively distinct in their sound pattern (words with small word families)—thus, words like "orange" were easier than words like "peach" (which sounds like teach, peek, pitch, etc.). However, there are contradictory results as well; for learners with WFD, words with lower neighborhood density (or smaller word families) were more difficult

to name, rather than easier (German & Newman, 2004). Finally, children found it easier to name words that had a high neighborhood frequency (items that had word families with very common words). This was a relative finding, however—that is, naming success was dependent on both the frequency of the similar (or confusable) words, and whether they were more or less frequent than the target word.

These LFs also appear to have differing effects across the life span (Newman & German, 2005). Prior work suggests that word frequency and neighborhood density both showed larger effects for adolescents than for young adults, but then showed constant effects on lexical access throughout adulthood, as did phonotactic probability (the frequency of the phonemes and phoneme combinations making up the word, a measure of the frequency of its sound pattern). In contrast, older adults were more greatly affected by a word's rated familiarity and age of acquisition than were younger adults; as individuals age, words that were learned later in life and which were judged to be less familiar were more difficult to retrieve than their counterparts.

In addition to affecting whether a word was successfully accessed or not, these word properties also influenced error patterns and substitution types, at least for children with expressive language difficulties (German & Newman, 2004). Children were more likely to block on a target word (rather than produce an actual error) when the words were not similar to many other words, and were more likely to make sound-based errors (such as saying *subrine* for *submarine*) on rare words and words whose neighbors contained uncommon phonological patterns. When children made semantic errors (saying the wrong word), the word they produced tended to be higher in frequency and learned earlier; they also tended to reside in neighborhoods of greater density and higher frequency than the target word. That is, children tended to substitute words that had been known longer and had easier sound patterns. These earlier studies suggest that different types of words are likely to result in different WF error patterns, which may suggest failures of lexical access at different stages of processing.

The current study revisits this line of research, evaluating a new set of words, and directly comparing the impact of LFs on the error patterns and substitution types produced by children with WFD with those who are typical language learning (TL). The LFs studied and the components of lexical access considered are described below.

LFs Studied

The lexical properties studied in this investigation were motivated by previous research suggesting they can influence word accessibility in different groups and contexts. To continue work in this area, we considered the following LFs:

- *Word Frequency*: how often words are used in our language
- *Word Familiarity*: how familiar a word is judged to be
- *Word Length* (here measured in syllables)
- *Neighborhood Density*: the number of known similar-sounding words (lexical neighbors, or words differing in a single phoneme from the target word)
- *Neighborhood Frequency*: the average frequency of those neighbors
- *Phonotactic Probability*: the relative frequency of the phonemes and phoneme combinations within a word (e.g., /t/ is quite common, but the consonant at the end of "sing" is common only word-finally, and the medial consonant in vision is quite rare).

See Table 1 for a brief summary of research findings relative to these word properties.

Components of Lexical Access Studied

We considered the following three aspects of lexical access.

Ease of Retrieval

We considered whether the LFs under study would individually affect accuracy in naming for children with and without WFD.

Error Patterns Implied

We studied the impact of LFs on three error patterns that have been observed in the naming performance of children with WFD (German, 2015) and that denote possible points of disruption in lexical processing. The importance of these error patterns is based on an explanatory lexical model (German, 2015) adapted from a prominent adult speech production model developed by Levelt (1989, 2001) and updated by Goldrick and Rapp (2007). According to this adapted adult production model, there are four stages that are important in single word retrieval:

- The stimulus (a picture or sentence) elicits the conceptual structure or underlying concepts associated with a target word (Bierswisch & Schreuder, 1991).
- The conceptual structure leads to accessing the target word's lemma (its semantic and syntactic features) from among neighboring entries (Garrett, 1991).
- This, in turn, leads to accessing the corresponding phonological features (syllabic frame and sound units) to create a complete phonological schema (Goldrick & Rapp, 2007).
- A motor plan is created and forwarded to lower level articulation processes to produce the word.

This adapted adult production model implies that semantic and phonological aspects of words are accessed from

two different but interacting cognitive processes. This leads to two potential causes of WF errors. Either the semantic aspects of words are inaccessible (making the phonological features unavailable also) or the semantic features are accessible, but the phonological features are evasive. Based on this underlying implication, German (2015) hypothesized that WF disruptions may occur at one of three points in the lexical process, each leading to a different characteristic error type: a disruption in accessing the semantic features of the word, a disruption at the juncture point between the semantic and phonological lexicons, or a disruption in accessing the phonological features of the word. A failure to access the semantic features leads to lemma-related semantic disruptions, such as saying *guitar* for *violin* or *peacock* for *flamingo*, which we henceforth refer to as Error Pattern 1. A failure at the juncture point between systems typically leads to Form-Related Blocked disruptions: either a delayed or absent response, or a metacognitive comment indicating a WF failure (e.g., saying *I don't know* or *I forget* or *what is that one called?).* We refer to these as Error Pattern 2 in this research. A failure to successfully access the phonological form of the word leads to Error Pattern 3, Form- and Segment-Related Phonologic disruptions, where the word's sound pattern is only partially activated, resulting in either a phonological substitution (saying *merry-around* for *merry-go-round*) or saying a phonetically similar but semantically unrelated word (*harm* for *harp*). We hypothesize that the LFs of the words might lead to disruptions at different points in the lexical process, and thereby investigating these LFs may provide insights as to where in the process of lexical access a disruption is occurring.

Target Word Substitutions

We also considered the nature of children's WF substitutions. We compared the LFs present in the target word as compared to the erred response. Whereas earlier studies have focused only on semantic and/or phonological relationships between targets and their substitutions (Lahey & Edwards, 1999; McGregor & Appel, 2002), we were interested in which of the LFs were maintained when a child's lexical access was disrupted. We believe that understanding how these factors influence substitution selection could indicate what word properties might be easier to retrieve as evidenced by their presence in target word substitutions.

In summary, we contrasted the lexical access skills of children with and without WFD to address three questions. The first analysis explored the nature of the words on which children erred, examining whether specific properties of the words would affect the ease of naming. Our second analysis explored the types of error patterns children manifested, studying whether particular properties of the target words led to different error patterns. Finally, our third analysis compared erred words to their substitutions to determine which lexical properties were maintained versus changed when a child's WF was disrupted. Accordingly, we asked the following research questions for children with and without WFD:

Research Question 1: Do LFs of words affect ease of retrieval during confrontation naming tasks?
Research Question 2: Do LFs of target words differentiate error patterns, that is, do they lead to errors presumed to occur at different points in the lexical access process?
Research Question 3: When children produce a substitute word, do LFs affect these substitutions?

Method

Participants

Learners in this investigation were selected from the standardization sample of the *Test of Word Finding–Third Edition* (TWF-3; German, 2015), and had originally been chosen for standardizing the clinical test. Two groups (N = 66) of matched intermediate-grade children were identified for this study: those with known WFD (20 male, 13 female) and those who exhibited TL (21 male, 12 female, one child could not be matched for gender but was matched for all other demographic categories). Selected learners were from middle to upper-middle socioeconomic class homes (determined by parents' educational level), and were matched for school grade (36). They ranged in age from 8 years 0 months to 12 years 10 months. Ethnic groups represented in the sample were Caucasian (95%), African American (2%), and Asian (3%)—participants were 6% Hispanic and 94% non-Hispanic.

Diagnostic information on file. All children had been reported to have normal auditory and visual acuity. TL children had never been referred for special education services, had never received speech and language services, and were noted to have no disabilities that would affect WF, according to their parents and/or teacher. Students with WFD had been identified as having WFD by the school's speech-language pathologist (SLP). They were enrolled in a speech and language therapy program and were receiving WF intervention with related individualized education plan (IEP) goals.

WF assessment. The TWF-3 (German, 2015) had been administered prior to this study as part of a national standardization program. On the TWF-3, children who earn a WF index (WFI) above 90 are judged to have average to very strong WF skills. Children who earn a TWF-3 WFI of less than 90 are judged to have below-average to very weak WF skills because these students' scores are in the bottom 25% of the general population. In this investigation,

TL participants selected had earned a mean WFI of 106.7 (*SD* = 8.1) indicating average WF skills, whereas children with WFD selected had earned a mean WFI of 80.0 (*SD* = 7.0) indicating below-average WF skills; the two groups differed significantly, $t(64) = 14.29$, $p < .0001$, $\eta^2 = .87$.

Vocabulary comprehension assessment. Participants with WFD were judged to have age-appropriate vocabulary comprehension as documented by the following indicators: (a) age-appropriate scores on file for the *Peabody Picture Vocabulary Test* (PPVT-R or PPVT-IV; Dunn & Dunn, 1997, 2007; $n = 33$, $M = 97.6$, $SD = 7.5$), (b) age appropriate vocabulary comprehension skills as reported by their SLP, and (c) no indication of vocabulary comprehension difficulties on learners, IEPs, including no remediation objectives or outcomes specific to vocabulary comprehension. In addition, participants earned a vocabulary comprehension score of 98% to 100% on TWF-3 target words.

Materials

To assess whether LFs of target words affected children's WF performance on the TWF-3, naming responses on file to 103 items from the standardization version of the TWF-3 were used. Naming responses to colored illustrations of nouns (58 targets) and verbs (23 targets, present progressive only [*bowing*, *running*]), and 22 open-ended sentences ("The cloth flowing down Superman's back is a red ____ [*cape*]."") were studied. Noun stimuli consisted of monosyllabic (e.g., *hook*, *vase*) and multisyllabic (e.g., *pyramid*, *binoculars*) targets representing multiple semantic categories. TWF-3 verbs were named in both present-tense and past-tense contexts, and many of the verbs' base word forms were the same in both tenses. Thus, to avoid overweighting of particular words, all past-tense naming instances in the analyses were excluded.

Procedure

Item scoring and target word comprehension. Naming tasks were individually administered by trained examiners to both TL children and children with WFD; responses were recorded and scored for accuracy. Word comprehension was assessed on erred items. Students were asked to select the erred target word (*fountain*) from among three picture choices (the target word and two decoys; for example, *mountain*, *sprinkler*). When comprehension was inaccurate, the naming response was not considered a WF error.

Interscorer reliability. Examiners were given scoring directions as to what constitutes an error and a delayed response. To demonstrate interscorer reliability for scoring naming accuracy of the TWF-3 word lists, 10 word lists were randomly selected and independently scored by two trained individuals. The scorers' results were correlated and resulting coefficients were .99, indicating nearly perfect scoring agreement. This reliability measure was based on the full standardization data, rather than being specific to the data for participants selected for this study. The classification of target word responses used to address Question 2 (which examines whether LFs differentiate error patterns) was completed for each of the children by one author and guided by agreed definitions of what constitutes each of the three error types (semantic errors implied Error Pattern 1, IDK or delays implied Error Pattern 2, and phonological substitutions implied Error Pattern 3). When classification of responses was not clear, categorization was discussed and agreed upon among authors. (Because we juried our categorization decisions, we did not go back and check reliability on this classification; this is a potential limitation of the study, but given the large number of errors (see procedures), it is unlikely that any individual miscategorizations would greatly influence the results).

LF coding. Targets presented in the picture-naming, open-ended sentence, and verb-naming tasks were researched for their LFs using a computerized version of Webster's 20,000-word pocket dictionary (Nusbaum, Pisoni, & Davis, 1984) and an online database (Vitevitch & Luce, 2004). In addition, for Question 3 (which examines the items children substituted for intended words), all real-word substitutions were similarly examined. Frequency of occurrence for words and neighbors were based on Kucera and Francis's (1967) norms and were then transformed into log-frequency values. Adult familiarity ratings were based on a 7-point scale, where 7 represents a highly familiar word, taken from Nusbaum et al. (1984). The number of neighbors for each target word was measured based on words in the Webster's 20,000-word dictionary (Luce & Pisoni, 1998). For all calculations, only words with familiarity ratings of at least 6.0 on the 7-point scale were considered to be neighbors, so as to avoid the inclusion of neighbors unlikely to be known by our participants. Finally, for phonotactic probability, we first calculated the likelihood of each phoneme occurring in that position in a word, and summed these values (Vitevitch & Luce, 2004). Other studies have explored frequency of phoneme combinations, as well, but these are typically highly correlated measures, and indeed led to the same pattern of results here; we therefore report measures based on individual phoneme frequency alone. Because this approach leads to a length confound, we then normalized this measure using the method recommended by Storkel (2004b).

Target word-naming accuracy. Our initial analyses examined whether LFs influenced children's overall naming. To do this, we first measured the overall accuracy for each word (for each of the two groups), and calculated the LFs for each of these target words. We then performed a stepwise

regression using naming accuracy as the dependent variable and the various LFs as independent variables, performed separately for each group (WF and TL).

Error pattern analysis. To identify error patterns, children's responses were first collected into a corpus of over 1,800 instances. Excluded from classification were chained errors, or errors that were related to an implied substitution (e.g., *shake* [instead of snake] for *eel*; $n = 15$); visual misperceptions of the picture, generally indicating that the learner was focusing on the wrong aspect of the image (e.g., *night* for *igloo; bottle cap* for *pill;* $n = 21$); morphological errors (errors of verb tense, in which the base morpheme was produced correctly; for example, *bowed* for *bowing*); and unintelligible responses that could not be clearly identified ($n = 19$). The remaining target word substitutions (approximately 1,600) were classified (or categorized) into the three TWF-3 error patterns discussed earlier (essentially, semantic errors, blocked errors, and phonetic errors). We then performed stepwise regressions for each error type separately (as we did for overall accuracy) to examine which factors contributed to a particular type of WF difficulty.

Substitution analysis. For the comparison of target words and their corresponding substitutions, only participants' real-word substitutions were considered. Thus, this analysis used only a subset of the errors that all of the children made; excluded from the analysis were all errors in which a child failed to respond, or responded with a delayed correct answer (4s or greater), as there was no substitution in these cases. We also excluded trials in which the child responded with a circumlocution (not a single word), or responded with a nonword phonological substitution (*bangjo* for *banjo*). Average values for each of the LFs under consideration were calculated for each child's set of WF substitutions and corresponding target words. An average across the set of errors made by each child was then determined; thus, our end result was a value, for each participant, of the average measure of that LF in both the intended words and the substitutions. We then compared target words and their substitutions with regard to each factor.

Results

The results are presented below according to the three questions posed in this investigation; statistical comparisons and a summary of results can be found in Table 2.

Question 1

For children with and without WFD, do LFs of words affect ease of retrieval during confrontation naming tasks (e.g., picture naming and sentence completion naming)? Children with known WFD had more difficulty naming the target words than did TL children. On average, 9.4 of the children with WFD erred on each of the TWF-3 words in this study whereas 4.6 of the TL children erred on these words, a significant difference: $t(98) = 6.96$, $p < .0001$. To determine which factors appeared to primarily affect learners' performance, we examined the set of factors via a stepwise multiple regression. For both groups, word frequency was the only significant predictor of children's naming accuracy (TL: $F = 9.50$, $p = .0003$; WF: $F = 10.60$, $p = .002$). Thus, even though children with WFD had more difficulty with naming than did TL children, the nature of the lexical effects was comparable across groups (TL, WFD) and was primarily driven by the frequency of the word they were trying to access.

Question 2

For children with and without WFD, do LFs of target words differentiate error patterns? To address this research question, LFs were measured for each erred target. Next, each error was classified according to the three error patterns under study (Error Pattern 1, Lemma-Related Semantic Error; Error Pattern 2, Form-Related Blocked Error, and Error Pattern 3, Form- and Segment-Related Phonologic Error). We then conducted additional stepwise hierarchical regressions for each error pattern separately.

None of our LFs predicted the likelihood of children making Error Pattern 1, Lemma-Related Semantic Errors. However, LFs did predict the likelihood of the other two error types, and did so somewhat differently for the two groups. For TL children, Error Pattern 2, Form-Related Blocked Error, was predicted by both a word's frequency ($t = -2.64$, $p = .01$) and length ($t = 2.46$, $p < .02$); the overall regression was highly significant ($F = 9.19$, $p < .0001$). However, nothing predicted Error Pattern 3, Form- and Segment-Related Phonologic errors, for TL children, perhaps because there were few such errors ($n = 44$, compared with 145 such errors for children with WFD). For learners with WFD, Error Pattern 2, Form-Related Blocked Error, was predicted by word frequency alone ($t = -3.66$, $p < .0001$); length did not contribute to the regression (overall: $F = 13.42$, $p < .0001$). Error Pattern 3, Form- and Segment-Related Phonologic Error, was predicted by neighborhood frequency ($t = -3.61$, $p < .0001$, and overall regression, $F = 12.97$, $p = .001$).

We then conducted a *comparative* analysis, contrasting the three error patterns with regard to the LFs that may trigger their occurrence. We conducted a two-way ANOVA for each LF, with error pattern (three levels) and group (two levels: WF and TL) as independent variables. This allowed us to consider whether the words that lead to, for instance, Error Pattern 1, Lemma-Related Semantic Errors, are higher or lower in (average) frequency (or other properties) than those that lead to either Error Pattern 2, Form-Related Blocked Errors, or Error Pattern 3, Form- and Segment-Related Phonologic Errors.

Table 2. Results Summary.

Question	Topic	Statistical approach	Participant group	Conceptual result	Statistical result
Analysis 1	Overall accuracy	Multiple regression	TL	Word frequency predicts accuracy	$F = 9.50$, $p = .0003$
			WF	Word frequency predicts accuracy	$F = 10.60$, $p = .002$
Analysis 2	Likelihood of Error Pattern 1	Multiple regression	TL	Nothing predicts likelihood of Lemma-Related Semantic Errors	*ns*
			WF	Nothing predicts likelihood of Lemma-Related Semantic Errors	*ns*
	Likelihood of Error Pattern 2	Multiple regression	TL	Form-Related Blocked Errors were predicted by both a word's frequency and length	$F = 9.19$, $p < .0001$
			WF	Form-Related Blocked Errors were predicted by a word's frequency alone	$F = 13.42$, $p < .0001$
	Likelihood of Error Pattern 3	Multiple regression	TL	Nothing predicts Form- and Segment-Related Phonologic Errors	*ns*
			WF	Form- and Segment-Related Phonologic Errors were predicted by neighborhood frequency	$F = 12.97$, $p = .001$
	Lexical factor differences across error types	2 group × 3 error pattern ANOVA	Both groups	Lemma-Related Semantic Errors occur on words that have more neighbors, are shorter, and have more common phonotactic patterns	Neighborhood density: $F(2, 1385) = 11.22$, $p < .0001$; length: $F(2, 1385) = 6.46$, $p = .002$; phonotactic probability: $F(2, 1385) = 3.09$, $p < .05$
				Form-Related Blocked Errors occur on lower frequency words	$F(2, 1212) = 9.26$, $p < .0001$
Analysis 3	Comparison of targets versus errors	2 (group) × 2 set (target vs. substitution) ANOVA	Both groups	Children substituted more common (high-frequency) words	$F(1, 62) = 199.0$, $p < .0001$
				Children substituted shorter words	$F(1, 63) = 10.55$, $p = .002$
				Children substituted words with higher neighborhood frequency	$F(1, 63) = 12.76$, $p = .001$
				Children substituted words with more common phonemes	$F(1, 63) = 15.06$, $p < .0001$

Through these analyses, we found that words leading to Error Pattern 2, Form-Related Blocked Errors, tended to be lower in frequency (mean log frequency = 1.65) than those leading to Error Pattern 3 (mean log frequency = 1.76) or Error Pattern 1 (mean log frequency = 1.83); $F(2, 1212) = 9.26$, $p < .0001$; there was no overall effect of group, $F(1, 1212) = 1.15$, $p = .28$, nor any Group × Type interaction, $F(2, 1212) = 0.33$, $p = .72$, suggesting that the error patterns of both groups were affected similarly by word frequency.

Furthermore, words that led to Error Pattern 2, Form-Related Blocked Errors, and Error Pattern 3, Form- and Segment-Related Phonologic Errors, tended to be different from the words that led to Error Pattern 1, Lemma-Related Semantic Errors: The words tended to have fewer neighbors ($M = 7.8$ for Error Pattern 1 versus 5.6 for Error Pattern 2 and 5.3 for Error Pattern 3, $F[2, 1385] = 11.22$, $p < .0001$, $\eta_p^2 = .016$); the words were longer (1.7 syllables for Error Pattern 1 vs. 1.9 and 2.0 for Error Patterns 2 and 3, $F[2, 1385] = 6.46$, $p = .002$, $\eta_p^2 = .01$); and the words had less common sound patterns (phoneme probability z scores of .11 for Error Pattern 1 versus –.02 and .02 for Error Patterns 2 and 3, $F[2, 1385] = 3.09$, $p < .05$, $\eta_p^2 = .004$). In all cases, these effects were similar across groups (TL, WFD; there were no overall group effects nor interactions with group). This contrasts somewhat with the results from the regression. For example, the words leading to Error Patterns 2 and 3 tended to be longer (based on the comparative analysis), but length only appeared as a predictor for TL children in Error Pattern 2. This difference may be the result of correlations among the different LFs, which limits the extent to which they show up as predictors in the regression analyses.

Question 3

For children with and without WFD, do the LFs of the target word affect the substitutions produced during the WF disruption? Our third set of analyses compared the types of

target words children missed to the types of words they substituted. For each participant, the average values for each of the LFs under consideration were determined both for the target words and their real-word substitutions; these were then averaged for each child, and analyzed with a 2 (group) × 2 (set: target vs. substitution) ANOVA, with partial eta-squared as a measure of effect size.

Children tended to err by naming words that were more frequent than the target: mean log frequency targets = 1.84; mean log frequency substitutions = 2.34; $F(1, 62) = 199.0$, $p < .0001$, $\eta_p^2 = .762$; and shorter than the targets: mean length of 1.69 syllables for targets, 1.57 syllables for substitutions $F(1, 63) = 10.55$, $p = .002$, $\eta_p^2 = .143$. But in neither case was there any effect of group (frequency: $F[1, 62] = 0$, $p = .99$; length: $F[1, 63] = 0.47$, $p = .49$); nor any interaction between group and set (frequency: $F[1, 62] = 1.24$, $p = .27$; length: $F[1, 63] = 0.47$, $p = .50$). There was also a marginal effect of rated word familiarity, $F(1, 62) = 2.99$, $p = .089$, $\eta_p^2 = .046$, with a tendency to err toward more familiar words (intended: 6.88, substitution: 6.92), but there was again no effect of group, $F(1, 62) = 0.28$, $p = .598$, nor any interaction, $F(1, 62) = .043$, $p = .84$.

In terms of neighborhood properties, there was no effect of neighborhood density (the number of neighbors of a word) on children's substitutions, $F(1, 63) = 0.46$, $p = .50$, $\eta_p^2 = .007$; nor any effect of group, $F(1, 63) = 0$, $p = .994$; or Group × Set interaction, $F(1, 63) = 1.17$, $p = .28$. However, there were significant effects of neighborhood frequency, or how common those neighbors were, $F(1, 63) = 12.76$, $p = .001$, $\eta_p^2 = .168$. Children tended to substitute words with higher neighborhood frequencies than the target word ($M = 1.64$, vs. 1.44 for targets); these high-frequency neighbors may have "pulled" the child to the substitute word. There was no effect of group, $F(1, 63) = 2.27$, $p = .14$, nor any interaction, $F(1, 63) = 1.48$, $p = .23$, suggesting this tendency was comparable across groups. Finally, children tended to substitute words that had higher phonotactic probabilities (phonemes of higher frequency): average z scores = .30 versus .09, $F(1, 63) = 15.06$, $p < .0001$, $\eta_p^2 = .193$, but there was again no effect of group, $F(1, 63) = 2.72$, $p = .10$, nor any interaction, $F(1, 63) = 0.17$, $p = .68$. In all, both groups of children seemed to err toward "easier" words, words that were more common, shorter, more familiar, and with higher frequency sound patterns.

Discussion

In this investigation, we asked whether the naming performance of learners with and without WFD would differ based on the LFs of words they are asked to retrieve and whether the LFs studied would affect learners' ease of retrieval, manifestations of error patterns, and nature of target word substitutions. Although LFs of words, for the most part, did not differentiate the naming skills of learners with and without WFD, LFs of target words did affect both groups of learners' WF in terms of naming accuracy, error pattern types, and nature of substitutions. Below our research questions and corresponding findings are highlighted and their implications for both WF diagnosis and intervention are considered.

Research Questions and Findings

Question 1. For children with and without WFD, do LFs of words affect ease of retrieval during confrontation naming tasks? In our first analysis, we examined the impact of LFs of words on learners' WF accuracy. We found that word frequency predicted WF errors. Although children with WFD had poorer naming overall, children with and without WFD produced more errors on low-frequency words. This suggests that even for children who have atypical lexical access, the organization of the lexicon itself remains constant, with words that are encountered more frequently being easier to access.

Question 2. For children with and without WFD, do LFs of target words differentiate error patterns? In contrast to other studies of LF effects that combine across WF errors, we studied the impact of LFs on three possible error patterns identified to be present in the responses of children with WFD (German, 2015; German & Newman, 2004). The findings indicated that LFs did predict Form-Based Error patterns in both groups. TL children were more likely to experience "tip of the tongue" type errors (Error Pattern 2) on low frequency, longer words, whereas children with WFD tended to experience Error Pattern 2 on low-frequency words regardless of their length. Neighborhood frequency (how common word neighbors were) also predicted the likelihood that children with WFD would experience Form- and Segment-Related Phonologic errors (Error Pattern 3). These findings suggest that the two groups may differ in how LFs influence the display of these particular error patterns.

Looking deeper at each error pattern reveals different results. Below we report that the comparative analysis provides insights into what types of words lead to disruptions at different points in processing.

Error Pattern 1: Lemma-related semantic errors. Semantic errors were more likely to occur when a word had a higher frequency, higher neighborhood density, was shorter, and had a higher phonological probability (phonemes of higher frequency). So even though children had accessed the word's conceptual structure (Stage 1 in our model), they had difficulty accessing the correct lemma of words that had many neighbors and common sound patterns. As a result, their lemma selection was inaccurate. One could hypothesize that these semantic errors might have been the result of internal competition within the lexicon between words in the same semantic network (*nut* for *acorn*, a semantic neighbor; Ovchinnikova, 2007). Alternatively, feedback

from the phonological lexicon (Dell & Gordon, 2003) may have interfered with target word selection. That is, another entry in the target word's semantic network (*nut*, semantic neighbor) may have had inherent phonological properties which resulted in easier lexical access paths. If so, the form of the semantic neighbor (*nut*) could override lexical access of the target word (*acorn*), producing an error.

Error Pattern 2: Form-related blocked errors and Error Pattern 3: Form- and segment-related phonologic errors. These two error types showed similar patterns of behavior. Although children successfully retrieved the correct lemma, they had difficulty either identifying the appropriate form to match that lemma or locating the word's phonological space (Error Pattern 2), or accessing the complete phonological schema of the target word (Error Pattern 3). These types of errors occurred on longer multisyllabic words, of low frequency, with less common sound patterns and, as reported in earlier investigations (German & Newman, 2004), on words residing in sparse neighborhoods. It is reasonable to assume that because these errors occur on words accessed less often (low frequency) and having fewer neighbors, they may have been less rehearsed. Thus, one could hypothesize that because these words are not accessed frequently, the word's form may be less salient and more evasive to the learner. Because the access paths leading to the word are underused, the word may be vulnerable to competitors or other word blocking forms (Burke, MacKay, Worthley, & Wade, 1991). These underpracticed access paths may also be more susceptible to transmission deficits that interfere with access to the phonological features of the target word (Borodkin & Faust, 2012). The children in this investigation did tend to err toward shorter, more frequent/familiar words, with more common sound patterns, indicating that they favored words whose pathways were more deeply entrenched in the lexicon.

These findings suggest that it is of value to look at the WF error patterns that learners produce as LFs affect these error patterns differently. Although the extent to which this error pattern model is descriptive of children's lexical retrieval requires further investigation, the presence of different LF effects on these error patterns for both learners with and without WF difficulties suggests that these errors may be indicative of distinct types of lexical access difficulty. That is, when a child reports a tip-of-the-tongue or a blocked error, this may signify a different kind of WF difficulty than does a semantic error. If so, simply tallying children's WF errors may be combining across very different types of access problems.

Question 3. For children with and without WFD, do the LFs of target words affect the substitutions produced during WF disruptions? This investigation indicated that when learners made WF errors, LFs also influenced the type of substitutions that they selected. Learners were more likely to produce substituted words that were shorter and higher in frequency, neighborhood frequency, and phonotactic probability than the target word. Previous investigations have indicated that form-based LFs, such as target word frequency and neighborhood frequency, can facilitate retrieval, thus making some words easier to retrieve than others (Newman & German, 2002). It may be that the same facilitation occurred in this investigation, but for the target word substitution over the intended word. This could support competition (Ovchinnikova, 2007) as a source for these learners' WF disruptions in the phonological lexicon. Furthermore, because these influencing LFs were form based, it appears that learners' disruptions were in a lexical space beyond the lemma level, as otherwise phonological LFs would not have had an influence on the substitution selected.

Noteworthy, too, is the similarity of performance, across all three analyses, between our two student groups, as it underscores the reality of our findings for both typical and atypical language learners. Although further investigations are needed, it appears from this study that for both groups, the nature of the target word (defined by LFs in this study) influences ease of retrieval, the type of WF error patterns displayed, and the type of substitutions produced.

Implications for Differential Diagnosis of WF and Vocabulary Selection for WF Intervention

The findings from this investigation provide further support for the presence of three partially distinct WF error patterns previously identified in the oral language (German & Newman, 2004) and the oral reading (German & Newman, 2007) of learners with WFD. It supports the presence of these error patterns in yet another group of students, suggesting that disruptions in the stages of lexical access may underlie children's WF. Although the extent to which these error patterns are descriptive of all children's lexical retrieval awaits further investigation, the presence of LF effects on WF error patterns in children with and without WFD in this investigation can be interpreted as further support for conceptualizing learners' WFD using a differential diagnostic model of WF.

In addition, if these error patterns are descriptive of children's WF error patterns, a comprehensive assessment of children's WF skills would warrant inclusion of differential diagnostic procedures to identify different WF error patterns. Simply concluding that a learner has WFD may be insufficiently detailed. Rather, completing a differential diagnosis of learners' WF would increase clinicians' awareness of potentially three different error types present in learners with WFD, an insight that would be important if differentiated WF intervention is to be planned.

The findings from this investigation also have implications for determining which vocabulary to treat during WF intervention. Once a clinician chooses the content of target vocabulary (e.g., science), the selection of which vocabulary to treat within that unit of study (e.g., unit on weather) could be further guided by a word's form-based LFs. This is

because certain form-based word properties appear to be more difficult to access for certain learners. Researchers have recommended attention be paid to a word's phonotactic probability (German et al., 2012; Montgomery, 2007). Clinicians might also want to consider word frequency, length, and neighborhood density, as ease of retrieval was adversely affected by these lexical variables as well. This word selection process could be further refined by noting which word properties lead to which error patterns. For example, in a classroom unit on weather, for learners who display Error Pattern 1, the clinician may want to target words that are short, high frequency, have many neighbors, and have common sounds patterns, like *air* or *gas*, as such words tend to result in this type of semantic error. In contrast, for learners who produce Error Pattern 2, clinicians may want to focus on those words that are low frequency, have less common sound patterns, and few neighbors, like cloud names, *cumulus* or *cirrus*, as these types of words seem to be particularly problematic for such children. Or for learners who manifest Error Pattern 3, clinicians may want to treat longer words with less common sound patterns, like *meteorologist*, as length and uncommon sound patterns appeared to impede lexical access in learners with this WF profile.

Clearly, there may be other patterns in individual children, and clinicians will need to consider their individual client's vocabulary difficulties before making treatment decisions. However, the patterns here serve as a useful starting point for clinicians to consider when selecting target words for students with WF difficulties.

Summary and Future Research Questions

In conclusion, this investigation considered the impact of form-based word properties on the naming performance of learners with and without WF difficulties. Our interest was twofold. First, we wanted to expand earlier work to determine whether the nature of the target word affects the naming skills of learners with intact WF systems in a similar way as it does to learners with compromised WF systems. The findings indicated that even though learners with and without WFD difficulties differed in the quantity of WF errors produced, the impact of word properties on their naming was, for the most part, similar. This finding suggests that there is reality to the prospect that the nature of a word can affect ease of retrieval, the nature of error patterns, and the type of substitutions produced in a WF disruption. Therefore, it would seem reasonable to recommend that one attend to the LFs of words taught to both TL and learners with WFD. Second, we wanted to explore, from the perspective of the target word, whether WF error patterns discussed in the literature had reality for both learners with and without WFD. The findings indicated that for both learners with and without WF difficulties, words with specific LFs tended to draw out the three error patterns under study. We interpreted this finding to support the reality of three WF error patterns in learners with and without WF difficulties. Even so, many research questions still remain open. Are the error patterns distinct or mixed among learners with WFD and TL? Are there additional WF error patterns that should be considered in the differential diagnosis of WFD? Can selecting target words based on form-based LFs improve WF intervention success? Do the error patterns studied represent disruption points in the lexical process as hypothesized? Do the WF error patterns observed in confrontation naming tasks present themselves in discourse contexts as well? These questions remain to be addressed in the future.

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