The Impact of Lexical Factors on Children's Word-Finding Errors

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This retrospective, exploratory investigation examined the types of target words that 30 children with word-finding difficulties (aged 8 to 12 years) had difficulty naming and the types of errors they made on these words. Words were studied with reference to lexical factors that might influence naming performance: word frequency, age of acquisition, familiarity, and lexical neighborhood. Findings indicated that neighborhood density predicted word-finding success, and target word substitutions and error patterns manifested were affected by the lexical factors under study. Students tended to produce substitutions that were higher in frequency, learned earlier, and that resided in neighborhoods of greater density and higher frequency than the target word. Lexical factors also influenced children's error patterns. Neighborhood density predicted form-related errors: Children produced more blocked errors on words from sparse neighborhoods. Word frequency and neighborhood frequency predicted form-segment-related errors as phonologic errors occurred on rare words and words whose neighbors contained lower frequency, uncommon phonological patterns. This important first step in the examination of how lexical factors have an impact on word-finding errors in children suggests that different types of words are more likely to result in failures of lexical access at different stages of processing. Theoretical and practical implications of these preliminary findings are discussed.

KEY WORDS: word-finding difficulties, lexical access, language and learning disabilities, word frequency, lexical neighborhood

Word-finding difficulties have long been identified among children with language and learning disabilities (LDs) (Johnson & Myklebust, 1967; Kail & Leonard, 1986). These difficulties have been described as a problem using specific words in either confrontation or discourse naming contexts (or both). These word-finding difficulties result in delayed or inaccurate responses with a high incidence of repetitions, reformulations, word substitutions, insertions, time fillers, and empty words (German & Simon, 1991). To better understand these students' lexical difficulties, researchers have studied their speed and accuracy in naming (Snyder & Downey, 1995), word substitutions (Lahey & Edwards, 1999), responsiveness to semantic and phonemic cueing (German, 2000; McGregor, 1994), and ability to produce visual representations of target word referents (McGregor, Friedman, Reilly, & Newman, 2002). Primarily focused on these students' language performance, researchers have speculated as to different causes of naming difficulties, such as gaps in their lexicons, fragile semantic representations, or difficulty retrieving information in the presence of well-elaborated representations in the mental lexicon (Dapretto & Bjork, 2000; McGregor et al., 2002).

Although our investigation is also a study of the lexical access systems of children with word-finding difficulties, we have switched the focus from a study of children's naming performance to a study of the words that initiate this naming performance. It is a retrospective, exploratory investigation of how lexical factors have an impact on children's word-finding errors. We examine the nature of the targets on which children experience word-finding disruptions; that is, we explore the relationship between deficit patterns in word finding and the properties of the words expected to be accessed. Furthermore, we focus on the kind of word-retrieval difficulty 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 can access immediately in comprehension (Dapretto & Bjork, 2000). The children studied in this investigation demonstrated word retrieval-based word-finding problems; they had difficulty retrieving words that were believed to be well elaborated in the mental lexicon (McGregor et al., 2002). Our purpose was to determine whether lexical factors influencing their naming performance—that is, factors about the particular words themselves—could be consistently identified. To that end, we asked the following questions: (a) Would lexical factors of specific words contribute to access failures? (b) Would children's substitutions be prejudiced by these lexical features? (c) Would error patterns be affected by these lexical factors?

Our choice of lexical factors to examine was motivated by work on adult perception and production of spoken words (Luce & Pisoni, 1998), as well as on previous studies of word production in children (Newman & German, 2002; Walley & Metsala, 1992). The error patterns considered were based on an adaptation (German, 2000) of a functional, architectural model of lexical access by Levelt (1989, 1991). Lexical factors and the aspects of lexical access studied are highlighted below.

Lexical Factors

Research on adult perception and production of spoken language has identified the influence of such lexical factors as target word frequency, age-of-acquisition (AOA), and neighborhood density as impacting lexical access. Most of this research has focused on lexical access during perception (Luce & Pisoni, 1998), but some research has examined these factors in speech production as well (Oldfield & Wingfield, 1965). A few studies have examined the influence of these factors on children's lexical access or how these effects may change during development (Dollaghan, 1994; Faust, Dimitrovsky, & Davidi, 1997; Newman & German, 2002; Storkel, 2002; Walley & Metsala, 1992).

In one such examination, Charles-Luce and Luce (1990, 1995) reported that words in children's lexicons have fewer neighbors than do words in adult lexicons and thus should not be easily confused. This ease of discriminability would allow children to use more holistic, rather than segmental, strategies for recognizing words (see Dollaghan, 1994, however, for an opposing argument). Walley, Smith, and Jusczyk (1986) have likewise suggested that kindergarten children's representations may be more holistic than those of adults, and Metsala (1997) has suggested that the developmental change from holistic to segmental representations may continue into the early school years. Moreover, the point at which these changes occur may depend on lexical factors such as similarity with other known words (Metsala & Walley, 1998). These findings suggest that there may be changes over the course of development in how lexical factors influence lexical access.

Metsala (1997) and Storkel (2002) also reported that both neighborhood structure and word frequency influenced spoken-word recognition in early grade-school children. For high-frequency words, recognition was easier for words with few lexical neighbors. Low-frequency words were more poorly recognized overall but showed a facilitory effect of lexical neighborhood; they were better recognized when they had many lexical neighbors. This suggests that the presence of neighbors may help children access the appropriate part of lexical space.

Storkel and Rogers (2000) and Storkel (2001) examined the effect of phonotactic probability, the frequency with which a sound or sequence of sounds occurs in the language, on children's word learning. They found that children across a range of ages demonstrated better word learning for words with a more common phonological pattern. Storkel (2001) also reported interactions between this factor and the form of the semantic representation. When a word had a relatively unusual sound sequence, children's errors appeared to be quite random, unrelated to the particular word. She suggested that these words may have less developed semantic representations. In contrast, when children erred on words with common sound patterns, they tended to respond with words that were related semantically to the target word. This implies that the children had successfully accessed the appropriate semantic representation. Storkel proposed that phonotactic information can influence both the development of semantic representations and the connections between these representations and lexical forms.

In an earlier investigation (Newman & German, 2002), we conducted a developmental study examining the impact of lexical factors on the lexical access abilities of 320 primary- and intermediate-grade, typical and atypical language-learning children, across six age

groups. Target words were grouped in dichotomous subsets for each lexical factor under study, low versus high frequency, low versus high neighborhood values, early versus late AOA, and typical versus atypical stress pattern. In this investigation, we found that words that were high in frequency and neighborhood frequency, that were low in neighborhood density and AOA, and that contained the typical stress pattern for the language were easier to name. The number of neighbors that were more frequent than the target word also had an effect on its ease of retrieval. Furthermore, AOA effects decreased with maturation for typically learning children, whereas these effects continued to have an impact on the lexical access of children with word-finding difficulties across the ages studied, suggesting that these children's difficulties in word access may have prevented them from developing strong access paths to these words.

To expand this child database, this more clinically based investigation looks beyond the impact of lexical factors on children's naming accuracy. In this investigation, we also examine the influence of these lexical factors on children's word-finding substitutions and on the error patterns typically manifested by children with word-finding difficulties. Lexical factors considered were target word frequency, AOA, rated familiarity, and lexical neighborhood. These factors are discussed in turn.

Word Frequency

Each word stored in memory has a frequency assignment based on its usage in our language. Research in speech perception indicates that high-frequency words tend to be recognized more quickly (Luce & Pisoni, 1998; Newbigging, 1961; Solomon & Postman, 1952) and identified more accurately (Dirks, Takayanagi, Moshfegh, Noffsinger, & Fausti, 2001) than are low-frequency words. Similarly, high-frequency words are produced more quickly (Jescheniak & Levelt, 1994; Lachman, Shaffer, & Hennrikus, 1974; Oldfield & Wingfield, 1965), are less likely to be involved in speech production errors (Dell, 1988; Vitevitch, 1997, 2002), and result in fewer tip-of-the-tongue states in both young and elderly speakers (Vitevitch & Sommers, 2003) as well as in speakers with aphasia (J. K. Gordon, 2002). Both children with word-finding difficulties and typically developing children have been shown to have more success naming words that are more common in the language (German, 1984; Newman & German, 2002).

AOA

Judgments regarding the age at which a particular word is acquired have been shown to correlate with performance on a number of language tasks. Words rated as having been learned earlier are named quicker, read faster, and decided on sooner, and they are more likely to be retrieved on the basis of partial letter or sound cues than are words learned later in life (Barry, Hirsh, Johnston, & Williams, 2001; Carroll & White, 1973a, 1973b; Garlock, Walley, & Metsala, 2001; Morrison & Ellis, 1995; Morrison, Ellis, & Quinlan, 1992). Mispronunciations are also more likely to be detected for words learned earlier (Walley & Metsala, 1992). Given these findings with access speed, effects on the accuracy of word naming may be expected as well. A word that has been learned more recently has had fewer opportunities to be accessed than a word known for a longer period of time, all other factors being equal. This would result in a less-developed access path and therefore might result in more naming errors on these later-learned words.

Familiarity

Words differ in the extent to which listeners judge them as being well known. Although this correlates to some extent with a word's frequency of occurrence (in that common words are more likely to be well known than are rare words), this correlation is not consistent; many relatively uncommon words are considered quite well known by listeners (e.g., the word *acorn* occurs relatively infrequently, yet is rated by adults as being a highly familiar word; see Nusbaum, Pisoni, & Davis, 1984).

Lexical Neighborhood

According to the neighborhood activation model (Luce & Pisoni, 1998), words in the phonological lexicon are organized according to their phonological similarity to other words. These lexical organizations, referred to as neighborhoods, can be described as either dense, or sparse. For example, the phonological neighborhood of the word *cat* is considered dense, as there are many other words in English that are similar to *cat* (e.g., *bat*, *cot*, and *cap*, among others). In contrast, the neighborhood of the word *vogue* is considered sparse, as it is similar to only four words (e.g., *rogue*, *vague*, *vote*, and *vole*). Findings from word repetition tasks have indicated that responses to words from dense neighborhoods tend to be slower as a result of competition from these similar words (Luce & Pisoni, 1998). Differences in neighborhood density could presumably influence the relative ease of word retrieval as well. Indeed, both semantic (Vitevitch, 1997) and tip-of-the-tongue (Harley & Bown, 1998) errors by adult speakers appear to be more common for words from sparse neighborhoods than for those from dense neighborhoods. Similar advantages of neighborhood density have been found for aphasic speakers (J. K. Gordon, 2002). There is evidence that children also find it easier to produce and remember words that are phonologically similar to other known words (see

Gathercole, Willis, Emslie, & Baddeley, 1991, for evidence from nonword repetition, and see Gathercole, Frankish, Pickering, & Peaker, 1999, for data from immediate serial recall).

In addition to the number of similar words, the frequency with which those neighbors occur (the average neighborhood frequency) can also influence performance, especially in lexical decision tasks (Luce & Pisoni, 1998). In particular, words with high-frequency neighbors are classified more quickly and accurately than are words with low-frequency neighbors. Other researchers have examined these neighborhood effects using a combined measure (Newman, Sawusch & Luce, 1997), or have looked specifically at the number of neighbors greater in frequency than the target word itself (Newman & German, 2002). Given this range of findings, it seems relevant to consider the impact of lexical neighborhood on the lexical access of children with word-finding difficulties.

Aspects of Children's Lexical Access

This investigation considered three aspects of lexical access as noted in children: the nature of their erred targets, the error patterns implied by their substitutions, and the nature of their target word substitutions. These are discussed in turn.

Nature of Erred Target Words

We first considered whether the lexical factors of a target word might have an impact on a word's ease of retrieval. Rather than compare lexical factors in dichotomous groups (high vs. low frequency, neighborhood, etc.; Newman & German, 2002), we considered whether any of these lexical factors under study would predict ease of target word retrieval.

Error Patterns Implied

This investigation also studied the impact of lexical factors on three error patterns that can be found in the naming performance of children with word-finding difficulties (German, 2000). These three error patterns represent points of disruption discussed in an explanatory lexical model (German, 2000), an adaptation of a prominent adult speech production model by Levelt (1989, 1991). They include (a) lemma-related disruptions, like *boat* for *submarine* (referred to as semantic errors in this investigation), (b) word form-related errors typically demonstrated by either a lack of a response or saying *I don't know* (referred to as blocked errors), and (c) word form segment-related disruptions, like *subrine* for *submarine* (referred to as phonologic errors). We examined whether the lexical factors under study would predict children's error patterns.

Target Word Substitutions

Word-finding substitution analyses have been conducted previously on the naming errors of both adults (Coughlan & Warrington, 1978; Kohn & Goodglass, 1985) and children (Dapretto & Bjork, 2000; Lahey & Edwards, 1999; McGregor et al., 2002). However, earlier studies have focused on the semantic and/or phonological relationships between targets and their corresponding substitutions, rather than on the lexical factors under study here. We were interested in the impact of word frequency, AOA, familiarity, and lexical neighborhood on children's substitutions during lexical disruptions. To this end, we compared both substitutions and their targets relative to these lexical factors to determine which were maintained when a child's lexical access was disrupted. Knowledge of the influence of these factors on substitution selection would also provide insight as to where in the lexical process a disruption might be occurring.

In summary, the present study examined the lexical factors of words for which children with word-finding difficulties manifested word-finding disruptions. Troublesome words and their substitutions were compared with respect to four lexical factors: frequency of occurrence, age-of-acquisition, familiarity, and lexical neighborhood. Of interest was the impact of these features on lexical access relative to (a) predicting ease of retrieval, (b) predicting the error patterns manifested during word-finding disruptions, and (c) the nature of the substitutions produced.

Method

Participants

Thirty Euro-American intermediate-grade children (18 male, 12 female) with LDs and word-finding difficulties participated in this study. Participants were from middle to upper-middle socioeconomic class homes (determined by parents' educational level), ranged in age from 8;0 (years;months) to 12;9, and were enrolled in Grades 3 through 6 in a school for students with LDs. Three ethnic groups were represented in the sample: Caucasian (93.3%), African American (3.3%), and Hispanic (3.3%). Students were referred by the school's speech-language pathologist (SLP).

Diagnostic Criteria

All participants were diagnosed as having an LD by a professionally certified LD specialist. Each student met the definition of specific LD as indicated by state code and/or met the criteria for LD classification as defined in the special education policy statement of the school. Generally, this criterion included Verbal or

Performance IQ scores of 90 or above, a potential achievement discrepancy, and specified strengths. The discrepancy score was based on standard score comparisons using school achievement tests. Sensory and motor handicaps, mental retardation, and cultural or economic disadvantage were not considered primary causes for identification as having an LD.

All students were enrolled in a speech and language therapy program, had been identified by their school SLP as having word-finding difficulties, and were receiving word-finding intervention with related individualized education plan (IEP) goals. We assessed the word-finding skills of these students using both informal and formal measures. All were documented as having word-finding difficulties on an SLP-completed word-finding classroom observation survey (German & German, 1992). Characteristics typical of word-finding difficulties in either single-word or discourse contexts, or both, were marked for all students (e.g., has difficulty remembering names of people, places, or objects that he or she knows; substitutes real words or nonsense words; has difficulty remembering words in conversations; makes false starts and revisions when relating an experience; manifests long delays within sentences when he or she cannot think of a word.) The word-finding quotients (WFQs) of the 27 participants who completed the Test of Word Finding, Second Edition (TWF-2; German, 2000) were in the weak to below average range, indicating word-finding difficulties in single word naming contexts (mean WFQ = 80.92; *SD* = 7.47).

The receptive language of the participants was judged to be in the average range by their SLP, as documented by the following indicators: (a) age-appropriate language comprehension skills defined by scores on file for the Peabody Picture Vocabulary Test–Revised (PPVT-R; Dunn & Dunn, 1981) (n = 24, M = 102.44, SD = 7.37), the Clinical Evaluation of Language Fundamentals–Third Edition (CELF–3; Semel, Wiig, & Secord, 1995) Receptive Language scores (n = 15, M = 101.25, SD = 9.42), and the Wechsler Intelligence Scale for Children–Third Edition (Wechsler, 1991) Verbal IQ scores (n = 27, M = 102.22, SD = 8.79); (b) no indication of language comprehension problems on their IEP, including no remediation objectives or outcomes specific to language comprehension; and (c) the presence of specific language characteristics as reported on the SLP-completed word-finding observation survey that indicate appropriate receptive language skills, such as "knows the word he or she wants to retrieve, but can't think of it" and "has good understanding of oral language used in class."

Materials

Naming responses, on file, to 106 items from the standardization version of the TWF-2 (German, 2000) were used (see the Appendix). Open-ended sentences (18; e.g., *You hit a ball with a baseball* ____ [bat]) and colored illustrations of noun (65) and verb (23) targets were studied. Stimuli consisted of monosyllabic (e.g., *palm*, *crutch*) and multisyllabic (e.g., *tambourine*, *propeller*) targets, ranging from low to high in frequency of occurrence and representing multiple semantic categories.

Procedure: Test Instructions

Naming tasks were individually administered by the SLPs at the school. Students' responses were recorded, and accuracy was tallied for each item. Errors could consist of a child saying the wrong word, mispronouncing the word, responding that he or she did not know the answer, failing to respond, describing the intended referent, or responding correctly only with a 4-s delay or only after a 3-s delay.

We assessed target word comprehension on erred items. Students were asked to select the erred target word (*tambourine*) from a three-picture field, including the target word (*tambourine*) and two decoy items (*drum, harmonica*). Participants' comprehension scores ranged from 96.23% to 100% across test items. Any item that a particular child did not comprehend was excluded from further error analysis. Overall, 64.4% of the words were named correctly and thus comprehended, 34.4% were inaccurately named but correctly comprehended, and 1.25% were not comprehended.

Procedure: Lexical Factor Coding

We searched for targets presented in the picture-naming and open-ended sentence tasks in a computerized version of Webster's 20,000-word pocket dictionary (Nusbaum, Pisoni & Davis, 1984), and in the Medical Research Council (MRC) Psycholinguistic Database (Coltheart, 1981). In addition, all errors that resulted in real-word substitutions were also examined. A number of different measures were taken for each target word and corresponding substitution. Lexical factors considered are discussed below (see Table 1 for means, standard deviations, and ranges for each lexical factor; see Table 2 for significant correlations between lexical factors under study). As indicated in Table 2, some of the lexical factors under study were intercorrelated.

Frequency of Occurrence

The frequency of occurrence of each word was determined from word counts generated by Kučera and Francis (1967) and was then transformed into a log-frequency value. Frequency counts were summed for homonyms, as they involve the same phonological form; Dell (1990) has found the frequency of the phonological form,

Table 1. Mean, standard deviation, and range for lexical factors of TWF–2 words studied.

Lexical factor	*M*	*SD*	Min	Max
Log frequency of occurrence	2.16	0.70	1.00	3.96
Age of acquisition	307.96	86.94	153.00	534.00
Familiarity	6.93	0.15	6.33	7.00
Neighborhood density	7.20	7.92	0.00	27.00
Neighborhood frequency	1.50	1.01	0.00	3.16

Note. TWF–2 = Test of Word Finding, Second Edition (German, 2000); Min = minimum; Max = maximum.

rather than the frequency of the semantic unit, to be the more relevant factor in speech production errors (see also Levelt, Roelofs, & Meyer, 1999, for a discussion of this issue).

Although these frequency counts are based on an adult corpus, they contain data for many more words than are available in most child corpora and are putatively age-independent, at least for adults. In comparison, child corpora tend to be specific to children of a particular age or grade; since the children in the present study varied in age, there was no single child corpus that was appropriate.

AOA

Norms for AOA were taken from Gilhooly and Logie (1980); they asked listeners to rate the age at which each word was learned, ranging from 1 (age 0–2 years) to 7 (age 13 years and older). Ratings were then multiplied by 100 to produce a range from 100 to 700. Subjective ratings such as these have been shown to be highly correlated with objective measures, and thus appear to be a valid measure of true AOA (Gilhooly & Gilhooly, 1980).

Familiarity

Adult familiarity ratings were taken from Nusbaum, Pisoni, and Davis (1984). These were based on a 7-point scale, on which 7 represents a highly familiar word.

Table 2. Correlations among lexical factors of TWF–2 words studied.

Lexical factors	Log frequency	1	2	3	4
1. Age of acquisition	−.42*	—			
2. Familiarity	.26*	.17	—		
3. Neighborhood density	.41*	−.35	.13	—	
4. Neighborhood frequency	.25*	−.23	.06	.67*	—

*$p < .05$.

Neighborhood Density

This index represents the number of words in the lexicon that differ from the target or error word by a single phoneme addition, deletion, or substitution. Only words with familiarity ratings of at least 6.0 on the 7-point scale (Nusbaum et al., 1984) were considered to be neighbors for these analyses, to avoid the inclusion of neighbors unlikely to be known by our participants.

Mean Neighborhood Frequency

This index refers to the mean log frequency of occurrence of all words determined to be neighbors in the analysis above.

Procedure: Target Word Accuracy and Error Pattern Analyses

Target Word Accuracy

For the analyses of overall accuracy and of error patterns, we tabulated the lexical factors for each of the 106 target items. In addition, each word's overall accuracy score across the 30 participants was calculated

Error Pattern Analysis

To determine error patterns, we first collected all of the children's errors into a corpus of 1,055 items. The target word substitutions were used to classify these errors into one of three error patterns. Because lemma entries are organized around taxonomic and thematic connections (McGregor & Appel, 2002) and form entries are organized according to phonological closeness, substitutions that had a semantic relation with the target word (*cricket* for *grasshopper*) were judged to be lemma-related disruptions (semantic errors); substitutions that were phonological approximations (*grasper* for *grasshopper*) of the target word (e.g., exchanges, shifts, substitutions, additions, and omissions) were judged to be word form segment-related disruptions (phonologic errors). Responses to known target words passed in the comprehension check that were correct but delayed, that did not contain any attributes of the target word (no response or *I don't know*), or that described the target word (*It is green* for *grasshopper*) were judged to be disruptions in accessing a target word's form (blocked errors) (Faust, Dimitrovsky, & Davidi, 1997; Kay & Ellis, 1987; McGregor, 1994). Of the 1,055 errors, 945 fell into one of these three types. Other errors consisted of verb form errors (*run* for *running*), miscellaneous errors, or errors that were both delayed and incorrect. After each error had been classified, the total number of errors of each type was summed for each of the 106 target words. This provided a summary value of the number of times each target word led to each error pattern.

Scoring Reliability

Trained scorers identified each error as being one of these three types. Training consisted of applying oral and written descriptions of the response categories to written examples of each response type. To measure the reliability of the scoring procedures used to determine the error patterns, two trained scorers examined six randomly selected protocols. Agreement between the two scorers ranged from 80% to 94%, with a mean of 88%.

Procedure: Substitution Analysis

For the comparison of target words and their corresponding substitutions, only participants' real-word substitutions of a semantically related nature were considered. Thus, this analysis used only a subset (404 errors) of the errors that all of the children made; excluded from the analysis were all errors in which a child failed to respond, responded with a circumlocution, or responded with the correct answer after a delay (4 s or more). Furthermore, because we were primarily interested in whether lexical factors would influence errors when words were related conceptually, or at a lemma level, we also excluded from this analysis all errors that were related to the target only on the basis of phonology, whether real words or not. Most phonetically related errors consisted of either mispronunciations, which did not result in real words, or phonetically related whole-word errors such as malapropisms. Because we assumed the latter would inevitably be quite similar to the target word on neighborhood characteristics, we did not include those errors in this analysis. Last, average values for each of the lexical factors under consideration (word frequency, AOA, familiarity, and neighborhood factors) were calculated for each child's set of word-finding substitutions and corresponding target words. This value served as the unit of analysis.

Results

To investigate which lexical factors might (a) predict word retrieval success, (b) predict types of error patterns manifested, and (c) influence target word substitutions, we conducted stepwise regression analyses and a series of paired *t* tests and analyses of variance (ANOVAs) on the lexical factors under study. These analyses are reported below.

Analysis 1: Lexical Factors That Might Predict Retrieval Accuracy

As a first step in examining the role of lexical factors on target word retrieval, we examined whether the lexical factors under consideration could predict which words children would name successfully. First, we calculated accuracy scores for each of the 106 test words. Second, we performed a stepwise regression on these accuracy scores with the independent variables of word frequency, familiarity, number of neighbors, and average neighborhood frequency (AOA was excluded because values were unavailable for most of the words). A number of factors were independently correlated with accuracy scores (familiarity, $r = .19$, $p = .067$; frequency, $r = .16$, $p = .12$; number of neighbors, $r = .26$, $p = .011$; average frequency of neighbors, $r = .20$, $p = .055$), but only number of neighbors contributed significantly to the regression formula, $F(1, 90) = 6.66$, $p < .02$. Thus, it appears that the number of neighbors a target word has is a significant predictor of the likelihood that a child will succeed or err in retrieving that word (see J. K. Gordon, 2002, for similar results with aphasic patients). This suggests that the phonological characteristics of a target word, not just its semantic aspects, may be an important factor in the likelihood of successful retrieval.

Analysis 2: Lexical Factors That Might Predict Error Patterns

The goal of this set of analyses was to examine whether lexical factors might predict the error patterns children demonstrated. First, erred target words were assigned a value for each of the lexical factors under study. Second, target words were classified according to one of the three error patterns under study, on the basis of the nature of the corresponding substitution they elicited during a word-finding block: the lemma-related, semantic error pattern (substitutions that shared target word meaning); the form-related, blocked error pattern (no response, target word description, or correct, but delayed response, 4 s or more); or the form- and segment-related, phonologic error pattern (mispronunciations accessing only some part of the phonological schema). Three additional stepwise regression analyses were then performed using the number of errors for each error pattern as the dependent variables. For the semantic error pattern, none of the factors predicted the likelihood of children making a semantic error. Individual correlations were relatively slight (familiarity, $r = -.10$, $p = .34$; frequency, $r = -.11$, $p = .29$; number of neighbors, $r = -.03$, $p = .75$; and average frequency of neighbors, $r = .03$, $p = .80$). This suggests that semantic errors tend to occur for reasons other than lexical factors of word form studied in this investigation. This is not entirely surprising, as semantic errors are generally, although not always, viewed as being an indication of difficulty accessing a word's

lemma and/or word meaning (Levelt, 1989), rather than its lexical form.

For blocked and phonological error patterns, the findings were more helpful. The blocked error pattern was predicted by the number of neighbors (neighborhood density), $F(1, 90) = 8.03$, $p < .01$. Words from sparse neighborhoods resulted in more blocked errors than words from dense neighborhoods (correlation between number of blocked errors and number of neighbors, $r = –.29$, $p = .006$). This might suggest that blocked errors occur when listeners fail to gain access to the appropriate region of lexical space. When an item has more neighbors, the access paths to that region of the lexicon may be stronger, making access easier and blocking less likely to occur. Although other factors correlated with the number of blocked errors, they failed to substantially contribute to the equation, suggesting they play less of a role in the likelihood of these errors (familiarity, $r = –.16$, $p = .13$; frequency, $r = –.15$, $p = .16$; average frequency of neighbors, $r = –.28$, $p = .01$).

The phonologic error pattern was predicted by a combination of a target word's frequency and the frequency of its lexical neighbors, $F(2, 88) = 8.26$, $p < .0005$, with more phonologic errors on low frequency target words and words with low frequency neighbors. Thus, the phonologic error appears to occur more often in rare words ($r = –.29$, $p = .006$) and in words with uncommon neighbors ($r = –.34$, $p = .001$). The latter may actually be a result of the frequency with which the word's sound patterns occur. If a word has very high-frequency neighbors, then the phonemes and phoneme combinations within that word tend to be encountered quite often. This may make those sound patterns easier to access. In contrast, if a word has only low-frequency neighbors, it implies that the phonemes and phoneme combinations within that word are encountered less often. This is especially true when the target word itself is low in frequency. This finding suggests that phonological errors may be the result of trying to produce a word with relatively uncommon sound patterns. Although number of neighbors also correlated with these errors ($r = –.26$, $p = .01$), as did word familiarity ($r = –.19$, $p = .07$), these factors did not substantially contribute to the equation.

Analysis 3: Impact of Lexical Factors on Substitutions

These next analyses examined the nature of the substitutions produced during a word-finding block. Eta-squared values were computed for all analyses to indicate the magnitude of effect. As a correlational-type indicator of "proportion of variance accounted for," an eta-squared value of .01 indicated a small effect, a value of .06 represented a medium effect, and a value of .14 or greater represented a large effect size (Cohen, 1988). Lexical factors considered were target word frequency, familiarity, AOA, neighborhood density, and neighborhood frequency. For each participant, the average values for each of these factors were determined both for the target words and their substitutions. A series of *t* tests were conducted comparing these values.

Frequency of Occurrence

To examine the impact of frequency of occurrence on substitutions, we generated mean log frequency ratings for each target word and its substitution (available for 316 of the 404 semantic errors) for each child. We then conducted statistical comparisons between average values for erred targets and for their corresponding substitutions relative to their log frequency of occurrence (mean log frequency of erred targets = 2.13, $SD = 0.19$; mean of substitution = 2.39, $SD = .23$). Significant log frequency differences, $t(29) = 6.92$, $p < .0001$, were substantiated, indicating that students were more likely to produce substitutions that were higher in frequency of occurrence than the target word ($\eta^2 = .62$).

AOA

AOA ratings were also generated for each erred target word and corresponding substitution for each child. Statistical comparisons between these average values (mean AOA index for erred target words = 309.9, $SD = 59.1$; for substitutions, $M = 287.8$, $SD = 68.5$) showed significant differences, $t(28) = –2.31$, $p < .05$. Students were more likely to produce substitutions that were learned earlier than the target word ($\eta^2 = .17$).

Degree of Familiarity

Familiarity ratings were generated for each erred target word and its corresponding substitution (available for 316 of the 404 semantic errors) and averaged across the words for each child. However, statistical comparisons did not reveal significant differences (erred targets' $M = 6.92$, $SD = .04$; for substitutions, $M = 6.94$, $SD = .06$), $t(29) = 1.26$, $p > .05$, indicating that substitutions did not differ from targets on this lexical factor ($\eta^2 = .05$).

Neighborhood Density

The number of neighbors was determined for each target word and corresponding substitution (available for 316 of the 404 semantic errors) and averaged for each child (mean neighborhood density index for targets = 6.66, $SD = 2.17$; for substitutions, $M = 8.65$, $SD = 2.83$). Significant differences emerged, $t(29) = 3.04$, $p < .005$; neighborhood density of substitutes was greater than

that for the target words, suggesting that students erred by substituting words with more neighbors ($\eta^2 = .24$).

Average Log Frequency of Occurrence of Target Word Neighbors

We calculated the average log frequency of occurrence of neighbors for each target word and its corresponding substitution and averaged them for each child. Statistical comparisons were conducted between these values (mean log frequency of neighbors for erred targets = 1.51, $SD = .32$; for substitutions, $M = 1.67$, $SD = .30$). Only marginal differences emerged, $t(29) = 1.85$, $p < .075$; neighbors of substitutes tended to be higher in log frequency of occurrence than were neighbors of the target word, but this effect was relatively weak ($\eta^2 = .11$).

Summary

This investigation is an important first step in an examination of how lexical factors have an impact on word-finding errors in children. Our preliminary findings suggest that lexical factors predict word-finding accuracy. Words that have many neighbors appear to lead to successful retrieval (Analysis 1); those with few neighbors appear to be particularly problematic for children. Lexical factors also predicted the error patterns that children might produce (Analysis 2). Neighborhood and frequency features influenced the occurrence of both blocked and phonologic errors. Blocked errors were more likely to occur on words that resided in sparse neighborhoods. This may suggest that the lexical space of words with fewer neighbors is more difficult to access. It may be that when an item has more neighbors, the access paths to that region of the lexicon are stronger, and blocking is less likely to occur. Phonologic errors were more likely to occur in words low in frequency with low frequency neighbors, suggesting that this error pattern might be the result of difficulty accessing uncommon phonological patterns.

When children make errors, lexical factors also influence the types of substitutions likely to emerge. Words that were higher in frequency, learned earlier, and contained very common phonological patterns shared with many words (dense, high-frequency neighborhood) were more likely to serve as substitutions for more difficult words (Analysis 3). This suggests that phonological patterns that occur more frequently (dense, high-frequency neighborhoods) result in easier lexical access paths. Somewhat surprisingly, this was the case even when the items examined were limited to those resulting in semantic errors (Analysis 3), where one might expect phonological factors to have little influence. This may imply that later lexical stages have an impact on earlier stages in the retrieval process.

General Discussion

To examine the impact of lexical factors on students' word-finding skills, we posed three questions. These questions are considered in turn.

1. For children with word-finding difficulties, would such lexical factors as a word's frequency of occurrence, familiarity, and lexical neighborhood predict a word's ease of retrieval during confrontation naming tasks?

Although all the factors were correlated with word accuracy, only the number of neighbors emerged as a significant predictor. More naming errors were produced in target words that had fewer neighbors. Neighborhood effects on ease of retrieval have been reported in earlier studies with varying findings. That is, depending on the specific nature of the word's neighbors (frequency of occurrence, etc.), studies have reported both more errors (Vitevitch & Sommers, 2003) and fewer errors (Newman & German, 2002) on words residing in sparse neighborhoods. Although reconciliation of these differences awaits further investigation, the theoretical implications suggested by these neighborhood effects are noteworthy; these students' word finding errors were most likely occurring after lemma selection because the sound-based organization inherent in neighborhood indices is specific to the phonological lexicon. Neighborhood effects would not have existed unless the children had reached the point where they were attempting to access the phonological code for the target word (Levelt, 1999).

2. For children with word-finding difficulties, do lexical factors of target words predict error patterns?

In this investigation, we also studied the impact of lexical factors on three error patterns identified to be present in the responses of children with word finding difficulties, (a) lemma-related disruptions (semantic errors), (b) word form-related errors (blocked errors), and (c) word form segment-related disruptions (phonologic errors; German, 2000). These three error patterns studied in this investigation represent disruptions discussed in an explanatory lexical model (German, 2000) adapted from a prominent adult speech production model by Levelt (1989, 1991). Although this adapted model is limited in scope and simplified compared to the models of Levelt (1989, 1991) and others (Levelt et al., 1999), it provides a blueprint for lexical access with a focus on those stages and disruptions believed to be significant in this process. According to this model, there are four stages important in single word retrieval. In Stage 1, the stimulus (a picture or sentence) elicits the conceptual structure or underlying concepts associated with a target word (Bierwisch & Schreuder, 1991). In Stage 2, this conceptual structure accesses the target word's lemma (its semantic and syntactic features) from among neighboring entries (Garrett, 1991). In Stage 3, the

lemma accesses the entry's corresponding phonological features (its syllabic frame and sound units) to create a complete phonological schema (Levelt, 1991). Finally, in Stage 4, a motor plan is created and forwarded to lower-level articulation processes in order to produce the word. The assumption that the semantic and phonological aspects of words are accessed from two independent structures (Stages 2 and 3 above; Garrett, 1991; B. Gordon, 1997; Levelt, 1989, 1991) suggests three potential disturbances of lexical access: (a) semantic aspects of a target word may be inaccessible to a child, making the phonological features unavailable also; (b) the semantic features may be accessible but subsequent retrieval of the word's phonological features, syllabic structure, and/or phoneme segments may be blocked; or (c) only partial elicitation of the word's phonological features occurs.

Although the extent to which this model is descriptive of children's lexical retrieval can only be determined from further investigation, the presence of lexical factor effects on error patterns in this investigation can be interpreted as an indication that disruptions in the stages of lexical access may underlie these children's word-finding blocks. For example, neighborhood density predicted the likelihood of children making a blocked error. Although children successfully retrieved the correct lemma, they had difficulty identifying the appropriate form to match that lemma. That is, they had difficulty going from Stage 2 to Stage 3 in the model above.

Furthermore, the frequency of a word and its neighbors predicted the likelihood of children producing phonologic errors; low frequency words and words whose neighbors were low frequency were more difficult to access. These frequency and neighborhood effects are likely caused by troublesome target words which have neighbors that are less common in the language, and as a result contain phonemes and phoneme combinations that are less common. This means that those segments and segment combinations are not accessed frequently, and thus, may have relatively underdeveloped access paths. Apparently, the children with word-finding difficulties had difficulty accessing the phonological schema of words with unusual phonemes or low-frequency phoneme sequences, a difficulty in Stage 3 of the adapted model above as evidenced by their phonologic errors in this analysis.

For children with word-finding difficulties, the presence of lexical factor effects on error patterns can be interpreted as another indication of an underlying disruption in their lexical access system during word-finding blocks. More specifically, the findings that blocked and phonologic error patterns occurred more often on target words that were lower in frequency and that these patterns were influenced by lexical neighborhood suggest that organizational features of the phonological lexicon influenced these children's word-finding performance.

3. For children with word-finding difficulties, do the lexical factors of the target word have an impact on the substitutions produced during the word-finding disruption?

The present results indicate that various lexical factors of words may influence substitutions produced during word-finding blocks. Students with word-finding difficulties were more likely to substitute words that were higher in frequency and learned earlier than the intended word. They also produced substitutions that resided in denser neighborhoods, containing residents of higher frequency, than did the target words.

Previous investigations have indicated that these lexical factors can facilitate retrieval of target words, so that high-frequency and earlier-learned words from high-frequency neighborhoods are easier to access (Newman & German, 2002). It may be that this same facilitation occurred in this investigation; yet here it was to the students' disadvantage. These lexical factors may have facilitated selection of word substitutions over the intended target word. Since target word substitutions were of higher frequency, were learned earlier than the target, and were from more dense neighborhoods with higher-frequency residents, they may have been easier to access than actual target words.

As a result of their lexical access difficulties, students with word-finding difficulties may have been vulnerable when attempting to retrieve words with these inherent lexical disadvantages. However, these preliminary findings do suggest that students with word-finding difficulties had reached a lexical space for the target word beyond the lemma level, as otherwise neighborhood density and the average frequency of those neighbors would not have influenced selection of target word substitutions. Yet these children obviously failed to pick out the correct form from among its neighbors. Their semantic errors may have been the result of poor availability of target word forms compared with that of those words' neighbors, as more frequent forms from more dense neighborhoods displaced less frequent ones from sparser neighborhoods (Garrett, 1991). This suggests that one source of naming failure for these students may have been neighborhood competition (Newman & German, 2002).

These findings have practical implications for students who have word retrieval difficulties. If lexical factors of target words influence ease of retrieval and type of lexical disruptions and the substitutions produced, as this investigation suggests, one may be able to predict the occurrence and type of word-finding errors these children will make on the basis of knowledge of the lexical factors of the words to be retrieved. In doing so,

clinicians could carry out a strategic, research-based, word-finding intervention program, matching the retrieval strategies to the specific target words to be accessed. For example, if words from sparse neighborhoods are likely to cause blocked errors, such evasive words could be paired with phonological associative cues (German, 2002) to make the target word's form more salient for future use. In contrast, to reduce phonologic errors on low-frequency target words from sparse neighborhoods, clinicians could link word parts to phonological mnemonic cues in order to make troublesome syllables salient and apply metalinguistic (syllable-dividing) and rehearsal strategies, making syllabic structures and phonological schemas more explicit and automatic for the learner.

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Appendix. Target words from the standardization version of the Test of Word Finding, Second Edition.

acorn	canoe	ferris wheel	lighthouse	rides	thanksgiving
anchor	cape	fighting	lotion	rose	thermometer
animals	cardinal	fish	measuring	running	thread
antenna	catching	flame	merry-go-round	scarecrow	throwing
appliances	celery	flowers	microscope	singing	throne
banjo	checkers	foods	musician	skating	towing
barrel	cheering	fruit	oiling	skiing	transportation
binoculars	chopsticks	furniture	operator	sole	trunk
birds	clown	games	palm	spinning	tulip
blender	conductor	goggles	parade	spoke	tusk
blowing	crib	grasshopper	patch	stump	vegetables
boats	crutch	handlebars	peeling	submarine	violin
bridge	curling	harp	picking	suspenders	watering
buffalo	dairy	holidays	pineapple	swimming	weighing
bulldozer	dancing	hoof	plants	switch	wishbone
calculator	digging	horseshoe	polish	swordfish	writing
calf	dominoes	insects	propeller	tambourine	yolk
candles	drinking	instruments	puppet		