Interactions between Word Frequency and Neighborhood Frequency in Lexical Access

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Abstract

In this study, we attempted to determine whether larger *NF* effects occur for low-*WF* words than for high-*WF* words. The experiment employed a lexical-decision task, in which participants were presented with a lists of single items, half of which were words and half were pronounceable nonwords, varied along possible extreme values of high/low *WF* and *NF* for 4- and 5-letter words. The primary theoretical implication of the study is that there is no search process involved in lexical access, rather that lexical access is a selection event based on the level of activation of a lexical entry produced by semantic, orthographic, and phonological information as it is processed pre-perceptually. Some practical implications of the study are a better understanding of dyslexia and ways to improve the reading habits of children.

Interactions between Word Frequency and Neighborhood Frequency in Lexical Access

There are many different characteristics of words in languages that influence readers' perceptions of those words. Psycholinguists have as a goal to better understand how humans generate, perceive, and process visual and auditory languages. One such area of study involves the process by which people see and understand written languages and what factors influence this perception and comprehension. To analyze these factors, psycholinguists have come up with some terms to help describe and organize them. *N* represents the neighborhood size, which is the number of other words of the same length that differ from the target by one letter; *P* represents the number of letter positions in a word that allow for neighbors; *WF* represents word frequency, which is how often a word is used in written language; and *NF* represents neighborhood frequency, which is the number of neighboring cohort members that have a higher *WF* than the target.

Past research has shown that letter-pattern familiarity facilitates word processing and it increases with increases in *N*. However, with increases in *P*, identification is inhibited due to cohort resolution in the search for the correct lexical entry for a word (Johnson, Jankowski, Childers, Miller, Gonsman, & Seifert, 2007). During a lexical-decision task, words and even pronounceable nonwords have an initial neighborhood or cohort with a most active member, and cohort resolution is necessary to decide whether the displayed item is a word or nonword (Johnson, et al., 2007). It is well accepted by most current psycholinguists that printed input (words and nonwords), when initially encoded into a psychological format, is represented by separate preconscious encodings of semantic, orthographic, and phonological information within the perceptual representation system (PRS) (Tulving & Schacter, 1990). That information then activates all of the lexical entries consistent with each of the pieces of information, which results in the activation of a background of lexical clutter (i.e., the cohort members) (Johnson, et al., 2007).

The activation provided to each lexical entry by each of the three information types is assumed to be relative to the *WF* of that entry, and the total activation of an entry is the combination of *WF* and the number of information types providing activation (Johnson, et al., 2007). Thus, if the target has a low *WF* and there are cohort members in the mental lexicon that have a higher *WF* than the target lexical entry (which is the *NF*) and are semantically related to the target, then those cohort members will initially receive more activation than the target lexical entry, that is, before cohort resolution occurs. The lexical entry for the display (target word) would be the only entry that receives activation from all three information types, so that entry should have an activation level superior to the activation levels of its neighboring cohort members, even if the cohort members have a higher *WF* (Johnson, et al., 2007). Because of this, it is assumed that lexical selection can almost always occur without complete cohort resolution, that is, without completely eliminating the activation levels of nontarget lexical entries (i.e., background cohort members) (Johnson, et al., 2007). The elimination of the nontarget lexical entries occurs such that their activation is withdrawn and they fade away when they become inconsistent with the incoming information types, whereas the target lexical entry becomes more activated. Cohort resolution occurs as each information type comes into play.

The perceptual/memorial encoding that occurs before lexical access has been previously modeled in the Pattern-Unit Model (Johnson 1974) and the Atkinson and Shiffrin Model (1968). Lexical activation and selection events have been previously modeled in the Cohort Model (Johnson, 1992; Johnson & Pugh, 1994) and the E-Z Reader Model (Reichle et al. 1999). This study has elaborated on and provided further evidence for these models, which have been partially summarized thus far.

The hypothesis tested in this experiment was that larger *NF* effects occur for low-*WF* words than for high-*WF* words. This is due to the fact that low-*WF* words stand out less from their neighboring cohort members, because *WF* plays a role in the level of activation received by each cohort member: activation for a cohort member is higher for higher-*WF* words. In this experiment, we attempted to address the more general question of whether there is a search process involved in lexical access. We also attempted to provide a better understanding of how people perceive and understand words as they read or hear them. Specifically, a goal for the study was a better understanding of how the different factors that influence lexical access interact with each other to yield the complete experience of understanding written language, which is an essential and ubiquitous human experience. The experimental design employed in this study is a 2x2 factorial within-subject design, concerning interactions between *WF* and *NF* on reaction time (latency).

Method

Participants

Seventy-two undergraduate students (men and women) from the introductory psychology classes volunteered to participate in the experiment, as a way to fulfill a research experience requirement. The participants chose to participate in an experiment rather than the alternative of writing a paper for the course.

Materials

Four lists of 30 4-letter words that varied on dimensions of *WF* and *NF* (i.e., high *WF*, high *NF*; high *WF*, low *NF*; low *WF*, high *NF*; and low *WF*, low *NF*) and four lists of 30 5-letter words that varied similarly on dimensions of *WF* and *NF* were compiled for the experiment. These lists were generated by selecting words of an appropriate *WF*/*NF* level from a comprehensive list of 4-letter and 5-letter words. All word lists along with information on *N, P, WF, and NF* for each word are in Appendices A-H.

Two lists of pronounceable nonwords, 120 each of 4-letters and 5-letters, were compiled by taking words from the comprehensive word lists that were not used in the eight lists of varied *WF*/*NF* words, and changing one letter in each word to convert it to a pronounceable nonword. A computer program had to be written in order to get *N* and *P* information for the nonwords (*WF* information is not applicable for nonwords since they are not used in speech or text). The 4-letter nonwords are in Appendix I and the 5-letter nonwords are in Appendix J.

The computer displays seen by the participants were composed of lists of 4-letter and 5-letter words (50%) and nonwords (50%), in which the word lists were varied similarly on dimensions of *WF* and *NF*. The means of the *N*, *P*, *WF*, and *NF* values were computed for each of the word lists as well (only *N* and *P* for the nonwords). High-*WF* values were defined as 50 or higher for the 4-letter words, and 10 or higher for the 5-letter words, while low-*WF* values were defined as 49 or lower for the 4-letter words, and

9 or lower for the 5-letter words. High-*NF* values were defined as three or higher for the 4-letter and 5-letter words, while low-*NF* values were defined as 2 or lower for the 4-letter and 5-letter words.

The *NF* values were the same for each word in the two 4-letter word lists that had low-*NF* values, and the *NF* values were also the same for each word in the two 4-letter word lists that had high-*NF* values. The same was also true for the two low-*NF* 5-letter word lists and the two high-*NF* 5-letter word lists. See the appendices for the actual word and nonword lists. Since there were four lists shown to each participant (high-high, low-low, high-low, and low-high for *NF* and *WF*), counterbalancing occurred such that the same order of lists was never the same for every group of twenty-four (4! = 24) participants, so there were three iterations of list order for the total number of seventy-two (3 x 24 = 72) participants.

Procedure

Testing occurred in an individual session for each participant for less than half an hour, during which the participant was instructed to watch the display for a word/nonword to appear during the lexical-decision task. The participant was instructed to press the “Z” key for “yes” when a word appeared on the display, and to press the “/?” key for “no” when a nonword appeared on the display for the lexical-decision task. The keyboard was labeled to identify the corresponding “yes” and “no” keys.

The reaction time (RT) and accuracy (correctness) were measured for each of the participants’ responses to each trial of the lexical-decision task. A positive correlation between response latency (RT) and accuracy (correctness) was expected for the lexical-decision task, based on the results of previous similar experiments; however, the error pattern was analyzed for any speed/accuracy tradeoff. Typically though, participants tend to be slower when they are unsure of the response; hence a speed/accuracy tradeoff is uncommon and unlikely. Nonwords were not analyzed, since they were used only for the sake of implementing a lexical-decision task, not for the data themselves. Also, only "yes" responses were analyzed since a "no" response would indicate a perceived nonword.

A few problems were encountered during the course of the experiment. For the lexical-decision task, the nonword "SHEEG" was placed in the word list by mistake in place of the word "SHEER" and the error was not discovered until the experiment was well underway. Given that the response was recorded as an error, the mistake only affects the error data and is not noticeable. There were some participants for whom English was a second language that skewed the data somewhat, but the RT/error for each participant in each *WF*/*NF* condition is the median rather than the mean, so that outliers from such participants could be filtered out of the analysis and such a problem seems to have had very little impact on the overall significance of the study.

Results

This experiment used a 2x2 factorial within-subject design intended to characterize the expected *WF* and *NF* effects and to establish the expected interaction between *WF* and *NF*. An *F* statistic was computed using a within-subject ANOVA test based on the "yes" results of the lexical-decision task. Participants responded more quickly to high-*WF* words than low-*WF* words, causing a statistically significant *WF* effect: $F(1, 71) = 195.88$, $p<.001$ for *WF*. Participants responded more quickly to high-*NF* words than low-*NF* words, causing a statistically significant *NF* effect: $F(1, 71) =$

54.67, p<.001 for *NF*. Reaction time increased much more for low-*WF* words than for high-*WF* words as *NF* decreased, causing a statistically significant two-way *WF*/*NF* interaction: *F*(1, 71) = 29.97, p<.001 for *WF* x *NF*. Participants responded more slowly to 5-letter words than to 4-letter words, causing a statistically significant word length effect: *F*(1, 71) = 36.39, p<.001 for word length. There was not a statistically significant two-way word length/*WF* interaction: *F*(1, 71) = 1.94, p=.168 for word length x *WF*. There also was not a statistically significant two-way word length/NF interaction: *F*(1, 71) = 0.68, p=.41 for word length x *NF*. There was a statistically significant three-way word length/*WF*/*NF* interaction: *F*(1, 71) = 15.45, p<.001 for word length x *WF* x *NF*.

RT (ms) for "Yes" Responses to 4- and 5-letter Words

	High *WF*	Low *WF*	Mean
High *NF*	568	604	586
Low *NF*	573	659	616
Mean	570	631	601

RT (ms) for "Yes" Responses to 4-letter Words

	High *WF*	Low *WF*	Mean
High *NF*	554	598	576
Low *NF*	568	640	604
Mean	561	619	590

RT (ms) for "Yes" Responses to 5-letter Words

	High *WF*	Low *WF*	Mean
High *NF*	581	610	596
Low *NF*	577	677	627
Mean	579	644	611

As expected, there was an interaction between *WF* and *NF* on RT, such that the *NF* effect was greater for low-*WF* words than for high-*WF* words, as indicated by the *F* values for reaction time and the graphical representation of the data in Figure 1.

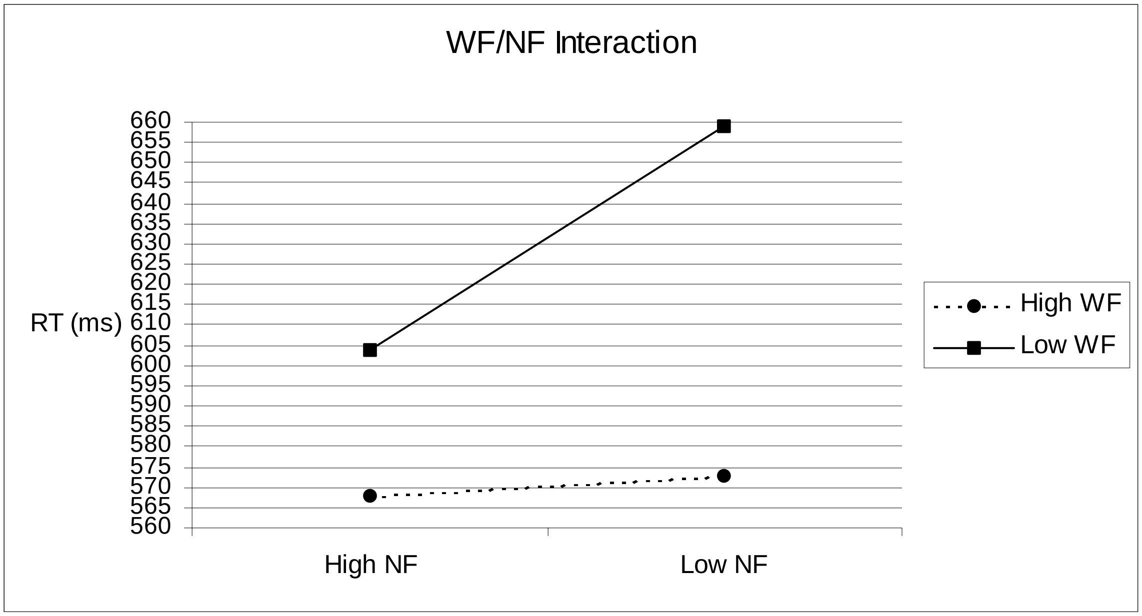

Figure 1. Interaction between *WF* and *NF*, such that the *NF* effect was greater for low-*WF* words than for high-*WF* words.

For the error data from the lexical-decision task, $F(1, 71) = 176.35$, $p<.001$ for *WF*; $F(1, 71) = 55.74$, $p<.001$ for *NF*, $F(1, 71) = 27.45$, $p<.001$ for word length, $F(1, 71) = 122.06$, $p<.001$ for *WF* x *NF*, $F(1, 71) = 6.46$, $p=.013$ for word length x *WF*, $F(1, 71) = 1.56$, $p=.22$ for word length x *NF*, and $F(1, 71) = 5.88$, $p=.018$ for word length x *WF* x *NF*. As expected, there was no speed/accuracy tradeoff, which is indicated by the barely existent positive correlation between RT and number of errors, $r = .07$. A negative correlation would indicate a speed/accuracy tradeoff.

Errors for "Yes" Responses to 4- and 5-letter Words

	High *WF*	Low *WF*	Mean
High *NF*	6.44	10.08	8.26
Low *NF*	4.85	18.49	11.67
Mean	5.64	13.29	9.97

Errors for "Yes" Responses to 4-letter Words

	High *WF*	Low *WF*	Mean
High *NF*	5.01	8.47	6.74
Low *NF*	4.85	16.43	10.64
Mean	4.93	12.45	8.69

Errors for "Yes" Responses to 5-letter Words

	High *WF*	Low *WF*	Mean
High *NF*	7.86	11.69	9.78
Low *NF*	4.86	20.56	12.71
Mean	6.36	16.13	11.24

Discussion

As hypothesized, an interaction does exist between *NF* and *WF*, such that the effect of low vs. high *NF* is greater for low-*WF* words than for high-*WF* words. While reaction time decreased for both high- and low-*WF* words when *NF* is higher, the decrease was much more noticeable for the low-*WF* words than for the high-*WF* words. One surprising occurrence was that participants responded faster to high-*NF* words than to low-*NF* words. This is surprising because logic would suggest that reaction time should increase as *NF* increases, i.e., as the number of neighbors with a higher *WF* than the target increases, because this would lead to an increase in the background lexical clutter. However, it may be that *NF* is similar to *N*, in that the more neighbors, the faster (lower) RT is, due to increased letter-pattern familiarity. This suggests that rather than incorrect cohort members being more disruptive in the lexical access for low-*WF* words than for high-*WF* words, *NF* actually facilitates lexical access is some complicated manner that is not yet understood, possibly via letter-pattern familiarity.

The broader theoretical implication of these results is that lexical access is not a search process, but is rather a process in which the most activated lexical entry is selected as the correct one, such that a search is not necessary for lexical access to occur. If lexical access were a search process, then the time to respond to a low-*WF* word and a high-*WF* word with the same *NF* should be the same, since the target lexical entry should be the next most available entry once the incorrect lexical entries are rejected for both low-*WF* and high-*WF* words. This is due to the fact that a search process is based only on *WF*, rather than a combination of *WF* with the three information types. A search process involves the comparison of each cohort to the target based on *WF*, until the correct lexical entry for the target is found. The search process begins with the highest *WF* cohort and works its way down through the descending *WF* cohorts. Theoretically, in a search process, the larger the *N*, the longer the search should take, since there are more lexical entries through which to search, and *P* would be irrelevant to a search process. This contradicts past studies that demonstrate that in reality, a larger *N* actually facilitates processing instead of inhibiting it, and a larger P actually inhibits processing instead of proving to be irrelevant. Also, since the *NF* remained the same for low-*WF* and high-*WF* words, the time for lexical access to occur should be the same if lexical access is a search process, but there was a difference, which invalidates a search process.

The data from this experiment refute such a claim of a search process. To the contrary, our data show that for high-*WF* targets, the total activation for the target lexical entry (based on all three information types, which eliminate the cohort members as the information types are received) exceeds that of the nontarget *NF* cohort members. Lexical access is a selection process—not a search process. A selection is made when a cohort member clearly stands out against the cohort background clutter and can even be wrong, which can occur when a selection is made before cohort resolution is complete.

The broader practical implications of this study apply to the improved understanding of dyslexia and to the improvement of reading skills in children learning to read. By understanding lexical access as permitted by this study, it can be better understood why dyslexics have problems with lexical access, which may be due to the fact that the initial orthographic information may not be sufficient to make the target lexical entry stand out against the cohort background clutter. Thus, dyslexics should be encouraged to delay lexical selection until phonological and/or graphic information is also present. Also, this study may be used to improve the manner in which children learn to read. This is due to the fact that, since semantic information is available first, children tend to make semantic errors while reading because they select a cohort that is semantically related to the target, rather than waiting for cohort resolution to progress, which decreases the probability of selecting the correct lexical entry to match the target. Thus, children should be taught to delay lexical selection until all information types are available (i.e., until cohort resolution is complete), or at least until more of the information types are available, so that the probability of their selecting the correct lexical entry is higher.

There are several studies that would be logical follow-ups to this study. One study might involve determining whether *NF* effects occur due to similarity along more than one dimension of similarity, such as both semantically and orthographically (e.g., sing and song), which may account for the large background clutter of activated cohorts in the target display. Another such study should attempt find the extent to which high *WF*-

words are less disrupted in a lexical-decision task by having a large *P*. That issue could not be addressed by this experiment, since neither *P*, nor *N* values were controlled. A third study might look at the nonwords themselves by examining their characteristics other than semantic information, which they do not have by definition. One final study that could be done would be the same as this study, except that a naming task could be used in place of the lexical-decision task, so without the nonwords, such that participants speak a word into a microphone when it appears on the monitor, so that RT can be recorded and analyzed. Such a naming task study would further substantiate the results of this study and we are currently having participants come in for the naming task study.

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Appendix A

High WF, High NF 4-Letter Words

Word	WF	N	P	NF
REAR	51	17	3	8
FELL	92	13	4	7
TALL	55	16	4	7
FILL	50	13	3	7
LIVE	177	14	3	6
DEAR	54	15	3	6
POST	84	12	4	5
WINE	72	22	4	5
CELL	65	12	3	5
MINE	59	20	4	5
BEAR	57	20	4	5
THEN	1377	7	3	4
BALL	110	17	4	4
FILE	81	12	3	4
FAST	78	13	3	4
SHOP	63	10	4	4
WIND	63	13	4	4
VAST	61	11	3	4
LOSE	58	12	3	4
LAKE	54	18	4	4
PAIR	50	7	3	4
HEAR	153	18	4	3
HALL	152	19	4	3
LEAD	129	13	4	3
FEAR	127	13	2	3
FEED	123	11	4	3
GAME	123	17	4	3
TEST	119	13	3	3
DATE	103	17	4	3
RAIN	70	13	3	3
Mean:	130	14.27	3.50	4.43

Appendix B

High WF, High NF 5-Letter Words

Word	WF	N	P	NF
TIGHT	28	8	1	7
STARE	14	14	4	7
SIGHT	86	8	1	6
SHAKE	17	11	3	6
FIGHT	98	8	1	5
WOUND	28	8	2	5
LEVER	14	11	5	5
EIGHT	104	8	1	4
SHORE	61	12	5	4
POUND	28	7	1	4
DRAIN	18	4	2	4
TRICK	15	7	4	4
STEEP	13	6	2	4
PATCH	13	10	3	4
LIGHT	333	8	1	3
BOUND	42	7	1	3
CHOSE	37	6	4	3
PRIZE	28	3	1	3
TRACE	23	7	4	3
SHAME	21	6	1	3
STAKE	20	9	3	3
CROWN	19	6	3	3
STALL	18	6	3	3
LIVER	16	10	4	3
SWEEP	15	5	3	3
SHEER	15	8	5	3
SWORE	14	6	2	3
GROVE	14	6	5	3
BRACE	14	7	3	3
HANDY	13	4	2	3
Mean:	39	7.53	2.67	3.90

Appendix C

High WF, Low NF 4-Letter Words

Word	WF	N	P	NF
SOON	199	8	3	0
ROAD	197	10	4	0
IDEA	195	1	1	0
CALL	188	16	4	0
KEPT	186	1	1	0
VIEW	186	0	0	0
DARK	185	11	4	0
ELSE	176	1	1	0
DATA	173	2	2	0
COLD	171	11	3	0
SORT	164	10	3	0
ARMY	132	0	0	0
STEP	131	5	3	0
NOTE	127	12	2	0
MAIN	119	12	2	0
BORN	113	13	4	0
STAY	113	8	2	0
UNIT	103	1	1	0
NEWS	102	3	3	0
RISE	102	12	4	0
JAZZ	99	0	0	0
POET	99	5	3	0
SIGN	94	1	1	0
SHIP	83	8	4	0
TEAM	83	10	4	0
NECK	81	5	1	0
TRIP	81	6	3	0
GRAY	80	8	3	0
LADY	80	7	3	0
EDGE	78	2	2	0
Mean:	131	6.30	2.37	0

Appendix D

High WF, Low NF 5-Letter Words

Word	WF	N	P	NF
ROUTE	43	2	1	0
RAPID	43	3	2	0
PORCH	43	6	3	0
OCCUR	43	0	0	0
DRAMA	43	1	1	0
CLOTH	43	4	4	0
URBAN	42	0	0	0
REPLY	42	1	1	0
HARDY	42	5	4	0
SHIFT	41	3	3	0
ROUGH	41	9	2	0
QUEEN	41	3	2	0
FUNNY	41	6	2	0
SHEAR	40	5	3	0
PROOF	40	0	0	0
GRACE	40	7	2	0
FOCUS	40	2	1	0
PIANO	38	0	0	0
ONSET	38	1	1	0
NOISE	37	4	3	0
MAGIC	37	0	0	0
ADMIT	37	0	0	0
LYING	36	2	1	0
HURRY	36	5	2	0
GUIDE	36	4	2	0
ERROR	36	0	0	0
DIRTY	36	1	1	0
BAKER	36	6	1	0
FRUIT	35	1	1	0
OCEAN	34	0	0	0
Mean:	39	2.70	1.43	0

Appendix E

Low WF, High NF 4-Letter Words

Word	WF	N	P	NF
NAIL	6	12	2	8
CORD	6	8	4	7
MAZE	6	15	4	7
LACE	7	16	4	7
COIL	6	14	4	6
HIND	6	8	3	6
BANG	7	14	3	5
MINT	7	14	4	5
HOOK	5	11	3	5
PECK	5	12	3	5
VILE	5	11	3	5
LASH	6	15	4	4
LOOM	6	11	3	4
ROAM	6	7	4	4
RUDE	6	8	4	4
SLIT	6	10	4	4
SLOT	6	13	4	4
SUNK	6	7	4	4
LUSH	5	7	2	4
SPIN	5	5	3	4
BREW	4	6	3	4
HAZE	7	13	3	3
LURE	7	13	4	3
OVEN	7	4	3	3
BLOT	6	7	4	3
COMB	6	4	2	3
GOAT	6	8	4	3
RAMP	6	9	3	3
BALD	5	8	3	3
BUMP	5	7	1	3
Mean:	5.90	9.90	3.30	4.43

Appendix F

Low WF, High NF 5-Letter Words

Word	WF	N	P	NF
GRAZE	1	8	3	7
HOUND	7	7	1	7
SLING	1	8	4	6
SCARE	3	10	4	6
FROWN	1	5	2	5
POACH	1	7	3	5
SLEET	1	6	3	5
MINER	1	7	3	4
CREAK	1	5	3	4
SNOUT	1	6	3	4
SPOUT	1	5	2	4
TAINT	1	4	2	4
BROOM	2	5	3	4
CLICK	2	10	4	4
BUNNY	1	5	2	3
CRANK	1	8	4	3
CRUST	1	4	4	3
FLAKE	1	5	4	3
GIRTH	1	3	2	3
GIVER	1	5	3	3
GRAFT	1	4	3	3
LEARY	1	7	3	3
MUNCH	1	3	2	3
SKATE	1	3	1	3
SNOOP	1	6	2	3
SPILL	1	7	3	3
TONIC	1	5	3	3
WREAK	1	4	2	3
BLUSH	2	4	2	3
BREAK	2	7	4	3
Mean:	1.40	5.80	2.83	3.90

Appendix G

Low WF, Low NF 4-Letter Words

Word	WF	N	P	NF
OMIT	1	1	1	0
LAVA	1	2	2	0
ICED	1	0	0	0
OOZE	2	4	2	0
JERK	2	3	2	0
CUSP	2	1	1	0
CRUX	2	2	1	0
AJAR	2	2	1	0
AFAR	2	3	2	0
UNDO	3	0	0	0
GASP	3	5	3	0
GARB	3	2	2	0
RAFT	4	8	4	0
APEX	4	0	0	0
IDOL	7	0	0	0
ENVY	7	0	0	0
EXIT	7	2	1	0
TAUT	8	3	2	0
OBEY	8	0	0	0
BIAS	8	1	1	0
SUDS	9	0	0	0
SLAB	9	11	4	0
ALLY	9	1	1	0
ACRE	10	2	1	0
VOID	10	0	0	0
VETO	10	0	0	0
ECHO	10	0	0	0
PLEA	11	1	1	0
DUKE	11	5	3	0
TROT	12	3	2	0
Mean:	5.93	2.07	1.23	0

Appendix H

Low WF, Low NF 5-Letter Words

Word	WF	N	P	NF
ACRID	1	0	0	0
AFOOT	1	0	0	0
ALIAS	1	0	0	0
ANNEX	1	0	0	0
ANTIC	1	0	0	0
ANVIL	1	0	0	0
ASKEW	1	1	1	0
ASSAY	1	0	0	0
AXIOM	1	0	0	0
BISON	1	2	2	0
BRIAR	1	2	2	0
CACHE	1	1	1	0
CAMEL	1	3	2	0
CAMEO	1	1	1	0
CEDAR	1	1	1	0
CORNY	1	2	2	0
CRYPT	1	0	0	0
DEITY	1	1	1	0
DIGIT	1	0	0	0
EQUIP	1	0	0	0
ERASE	1	0	0	0
EVADE	1	0	0	0
FELON	1	1	1	0
FLIRT	1	0	0	0
FLUKE	1	3	2	0
FLUTE	1	3	2	0
GASSY	1	0	0	0
GAWKY	1	0	0	0
GAZER	1	2	2	0
GENIE	1	1	1	0
Mean:	1	0.80	0.70	0

Appendix I

4-Letter Nonwords

REAZ	DILK	CHIW
FING	WOAL	RITH
FALP	OUFT	AKSO
TALG	HEEK	HERI
HAIB	PUCH	YEAW
WHOK	CEAP	HILF
CLUF	BRIP	TRUB
BLUV	EASH	JUZA
CITU	SHAN	POER
LOMP	VANP	SIRN
TARK	FORX	LUDY
KELB	YALF	JART
TACU	RIRE	AENT
FOSE	CAIP	UBLY
CRIV	BAMT	UNGE
ANEP	SMUY	ALAX
STEV	TEEB	FURE
LEVU	AFUD	AJAP
TILP	SHEN	IRTA
LOSK	HILV	OJIT
SNUP	TEXE	ECRE
PERB	BERE	SONP
MENJ	NAON	UGIT
CHAY	DUCY	GACT
WORB	PREW	HUIZ
BEAS	EWAM	PIHR
TOMT	WULT	GORN
SANX	BRYN	WALD
MODU	CUFE	PROR
FORY	CAIR	DIGH
YERL	KILG	MUNE
BOOL	FENT	CLUW
GEAL	LURT	CAXY
HIME	FUSH	GRAH
GUTH	VOTH	IARN
MEFT	ZERA	NENE
COIB	GLOC	ZADE
FOAB	AKEN	VACT
DUOK	HIRY	PONE
HIRM	BIRR	WORA

Appendix J

5-Letter Nonwords

STAVI	PHISE	STELE
NOOSY	CIVID	LEGAV
PRILK	JUDLE	BROVE
TERSA	SELID	ALGOP
BOOTU	BRIAF	FORCH
REMEL	TIGLE	UNATY
MOULT	ENSER	CLEAD
CEMEZ	FULPY	SWOAT
GOLLO	OFLER	DRALN
WRALK	ETEND	QUICH
CRODE	TRULG	FIPTY
MIBER	WUTCH	THICH
FLANG	ROAND	DRESK
CRULP	DRILK	ASIKE
GLANG	TRAIB	SCILE
MERJY	SOUCH	PLOCK
FORTA	SPEEN	VONOR
THINP	AWARK	GROSP
STARD	BEFIN	CHAIB
HANCH	BROID	BORTH
SPAVE	LEARO	SKEEP
HAFLE	SHAPO	EMPLE
VUNCH	BAILD	DREAV
CRUSP	FIXEL	RISLE
FUSTO	SPOBE	DRAVE
DOWEB	TOLCH	BEOTH
GLEAP	BREEK	MEBAL
BUILE	CARVY	ODEAT
BRASK	CHELK	COIST
OTTEL	COTER	SCULA
PLICE	ENEMO	INTEB
FRUSH	DALCK	URMED
MUNLE	EQUAP	TOFTE
QUIEL	NOTEP	NUVEL
SNIFE	OLBER	EWIST
STORA	WORCH	SMILK
TWILK	USIAL	VINOR
FRAVE	CLAIG	HENTH
STARP	HAPSY	ALOID
UPKER	SHABE	ONKLE