What is the pronunciation for *-ough* and the spelling for /u/? A database for computing feedforward and feedback consistency in English

JOHANNES C. ZIEGLER

Macquarie University, Sydney, New South Wales, Australia

GREGORY O. STONE

Arizona State University, Tempe, Arizona

and

ARTHUR M. JACOBS

*Center for Research in Cognitive Neuroscience, Marseille, France
and Philipps University, Marburg, Germany*

Recent studies suggest that performance attendant on visual word perception is affected not only by feedforward inconsistency (i.e., multiple ways to pronounce a spelling) but also by feedback inconsistency (i.e., multiple ways to spell a pronunciation). In the present study, we provide a statistical analysis of these types of inconsistency for all monosyllabic English words. This database can be used as a tool for controlling, selecting, and constructing stimulus materials for psycholinguistic and neuropsychological research. Such large-scale statistical analyses are necessary devices for developing metrics of inconsistency, for generating hypotheses for psycholinguistic experiments, and for building models of word perception, speech perception, and spelling.

Language learning and reading skill crucially depend on the acquisition of the functional relation between orthography and phonology (loosely, spelling and sound). In most alphabetic writing systems, this functional relation is straightforward: A word's orthography is strongly correlated with its phonology. For example, in English, the spelling pattern *-uck* is always pronounced as in *duck*. Inconsistency arises when a spelling pattern covaries sometimes with one phonological pattern and sometimes with a different phonological pattern (e.g., *-int* as in *pint* and *hint*).

Over the past 30 years, this spelling → phonology inconsistency has generated much research interest. Psycholinguists attempted to isolate rules that best described the mapping of spelling to phonology (Venezky, 1970; Wijk, 1966). Neuropsychologists used inconsistency in the spelling-to-phonology mapping as a tool for investigating different types of acquired dyslexia (Patterson, Marshall, & M. Coltheart, 1985; Patterson & Morton, 1985; Plaut & Shallice, 1993). Educators and psychologists analyzed the way in which children learn to translate spelling to phonology (Bosman & Van Orden, in press; V. Col-

heart & Leahy, 1992; Goswami, 1986, 1988; Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995; Waters, Seidenberg, & Bruck, 1984; Wimmer & Goswami, 1994). Cognitive psychologists proposed models and theories to account for the various facets of inconsistency observed in naming and lexical decision tasks (M. Coltheart, 1978; Forster & Chambers, 1973; Frederiksen & Kroll, 1976; Glushko, 1979; Patterson & Morton, 1985; Taraban & McClelland, 1987; Van Orden & Goldinger, 1994; Waters & Seidenberg, 1985). Finally, computational modelers were challenged to implement processes in simulation models that capture normal and impaired performance for inconsistent words (Brown, 1987; M. Coltheart, Curtis, Atkins, & Haller, 1993; M. Coltheart & Rastle, 1994; Norris, 1994; Plaut, McClelland, Seidenberg, & Patterson, 1996; Plaut & Shallice, 1993; Reggia, Berndt, & D'Autrechy, 1988; Seidenberg & McClelland, 1989; Van Orden, Bosman, Goldinger, & Farrar, in press).

Early research on spelling → phonology inconsistency focused on the mapping between individual graphemes and phonemes (M. Coltheart, 1978; Venezky, 1970; Wijk, 1966). However, in English, more recent research is in favor of a special role for higher levels of correspondences in the mapping of spelling to phonology, such as onsets and rimes (Treiman, 1985; Treiman et al., 1995). In monosyllabic words, the onset is the initial sequence of consonants and the spelling body (or rime) is everything following it. For example, *pint* can be divided into the onset *p-* and the spelling body *-int*. Words are tradi-

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tionally classified as inconsistent if their spelling body maps into more than one pronunciation (e.g., *-int* in *pint* vs. *hint*). They are traditionally classified as consistent if their spelling body has only one possible pronunciation (e.g., *-uck* in *duck*, *luck*). It has been suggested that skilled English readers focus in particular on the correspondences between orthographic and phonological rimes because word pronunciations are more predictable at this level than at the level of individual graphemes and phonemes. This hypothesis is corroborated by a recent statistical analysis of consistency in English (Treiman et al., 1995). These authors showed that the consistency of the rime unit is higher than the consistency of the vowel in isolation (80% vs. 62%). However, for some applications (e.g., constructing and testing models that include grapheme-to-phoneme conversion procedures, analysis of reading errors of acquired dyslexic patients), it may be useful to consider the consistency or reliability of functional units at grain sizes smaller than the rime unit (see Berndt, D'Autrechy, & Reggia, 1994).

In numerous studies, the inconsistency of the spelling-to-sound mapping has been shown to affect reading performance (Andrews, 1982; V. Coltheart & Leahy, 1992; Content, 1991; Content & Peereman, 1992; Glushko, 1979; Jared, McRae, & Seidenberg, 1990; Laxon, Masterson, & V. Coltheart, 1991; Seidenberg, Waters, Barnes, & Tanenhaus, 1984; Taraban & McClelland, 1987; Waters & Seidenberg, 1985). For example, in the naming task, it takes typically longer to read aloud inconsistent words (e.g., *pint*) than consistent words (e.g., *duck*). Occasionally, skilled readers make regularization errors in the naming task—that is, they may incorrectly pronounce *pint* to rhyme with *hint*. Such regularization errors are characteristic of surface dyslexic patients (e.g., Patterson et al., 1985). In contrast, phonological dyslexic patients may correctly pronounce *pint* but fail to pronounce non-words. In both cases, reading impairment is chiefly assessed by testing patients' performance on inconsistent words. In general, consistency effects seem to be stronger for low-frequency inconsistent items than for high-frequency inconsistent items and are often statistically reliable only for low-frequency words (but see Jared, 1995, for consistency effects of high-frequency words).

Until recently, all research on consistency effects investigated only a "feedforward," spelling → phonology effect. However, Stone, Vanhoy, and Van Orden (1997) challenged this "one-way-inconsistency" perspective. They demonstrated that visual word perception is influenced not only by the more "traditional" spelling → phonology inconsistency but also by phonology → spelling inconsistency (i.e., does a phonological body map into more than one spelling). In the context of Stone et al.'s recurrent network account of word perception, words are called *feedforward inconsistent* if their spelling body has more than one possible pronunciation, such as *-int* in *pint* and *hint*. Words are called *feedback inconsistent* if their phonological body has more than one possible spelling, such as */-ip/* in *deep* and *heap*. In fact, Stone et al. found that lexical decision latencies to words that were traditionally labeled as

consistent were longer if they were feedback inconsistent than if they were feedback consistent.

In a different line of research, Ziegler and Jacobs (1995; see also Ziegler, Van Orden, & Jacobs, 1997) recently demonstrated that feedback inconsistency also affects performance in simple graphemic tasks. In a letter search task, they presented pseudohomophones, such as *brane*. Pseudohomophones and homophones are, by definition, feedback inconsistent because their phonology can be spelled in more than one way (e.g., *brane/brain*). The authors found that letter detection performance was worse (longer reaction times [RTs] and more errors) for feedback-inconsistent letter strings (i.e., pseudohomophones) than for feedback-consistent spelling controls.

Most theories of visual word recognition have heavily focused on the feedforward inconsistency of the English language (i.e., a spelling pattern may be pronounced in different ways). Not surprisingly, detailed statistical descriptions of the spelling-to-sound relation in English are available and provide valuable research tools for planning experiments and constructing stimulus materials (e.g., Berndt et al., 1994; Berndt, Reggia, & Mitchum, 1987). However, theories of visual word recognition have virtually ignored the feedback inconsistency of the English language (i.e., a phonological pattern may be spelled in different ways). Consequently, detailed statistical descriptions of the feedback inconsistency of English are rare, and feedback inconsistency has been a neglected source of information in previous studies of visual word recognition. At the end of the introduction, we further specify how existing one-way consistency databases differ from the present database.

Why should we care about feedback inconsistency at all? First, feedback inconsistency is common. Stone et al. (1997) estimated that about 75% of all English monosyllabic words taken from Kučera and Francis (1967) are feedback inconsistent (i.e., their phonological bodies can be spelled in multiple ways). A recent statistical analysis of feedback inconsistency in French obtained similar results. Ziegler, Jacobs, and Stone (1996) calculated that 79.1% of all monosyllabic French words are feedback inconsistent, whereas only 12.4% are feedforward inconsistent. In this article, we suggested that the high degree of feedback inconsistency seems to be responsible for French's reputation as being unpredictable and ambiguous.

Second, feedback inconsistency affects visual word perception. Feedback-consistency effects have been reported in visual lexical decision, naming, and letter search tasks (Hooper & Paap, in press; Stone et al., 1997; Ziegler & Jacobs, 1995; Ziegler et al., 1997). In addition, Ziegler, Montant, and Jacobs (in press) recently replicated the feedback-consistency effect in French. This replication is of particular interest since statistical analyses suggested that the structure of French and English may be comparable with respect to feedback consistency (Ziegler et al., 1996).

Third, feedback inconsistency may explain small and/or unreliable consistency effects in previous studies. Ziegler et al. (1996) analyzed all French words that would traditionally have been classified as consistent on the

basis of spelling to phonology correspondences (87.6% of all monosyllabic words). In traditional experiments on consistency effects, these consistent items serve as control items against which the processing cost of inconsistent items is tested. Ziegler et al. (1996) calculated that 77.4% of these presumably consistent items were, however, feedback inconsistent. Thus, small and/or unreliable consistency effects in previous studies may have resulted from the possibility that many of the presumably consistent control items were feedback inconsistent.

Finally, feedback inconsistency should be an important variable for research on spelling (e.g., Bosman & Van Orden, in press; Holmes & Ng, 1993; Kreiner & Gough, 1990). Multiple possibilities of mapping phonology into spelling should clearly affect spelling performance. Spelling in a feedback-inconsistent language (e.g., French) should be harder than in a feedback-consistent language (e.g., German). The availability of statistical descriptions concerning feedback inconsistency may provide a useful tool for further research on spelling. Considering these four arguments, it seems clear that psycholinguistic experiments should be controlled for feedback consistency, and further research is needed to specify its influence.

The present database provides the lacking information concerning the feedback inconsistency of English. This database complements already existing descriptions of the English structure (e.g., Berndt et al., 1994; Berndt et al., 1987; Hanna, Hanna, Hodges, & Rudorf, 1966; Treiman et al., 1995; Venezky, 1970; Wijk, 1966) in three respects: (1) it presents all consistent and inconsistent correspondences for orthographic and phonological rimes rather than for individual graphemes and phonemes; (2) it lists all feedforward-inconsistent (spelling → phonology) bodies with their corresponding phonological bodies, and, more importantly, it lists all feedback-inconsistent (phonology → spelling) bodies with their corresponding spelling bodies; and (3) it provides statistical information concerning feedforward- and feedback-inconsistent bodies (e.g., number and frequency of “enemies” and “friends”; see below for a definition). This information should be valuable for selecting word stimuli, constructing nonword stimuli, and developing measures of inconsistency. Moreover, such detailed analyses of a language’s structure are necessary for building and testing models of word perception and spelling in which the processing of one linguistic item is influenced by the entire set of items the model knows, as in current connectionist models of reading (Grainger & Jacobs, 1996; Jacobs & Grainger, 1992, 1994; McClelland & Rumelhart, 1981; Plaut et al., 1996; Stone & Van Orden, 1994; Ziegler, Rey, & Jacobs, in press; see Frauenfelder, Baayen, Hellwig, & Schreuder, 1993, and Treiman et al., 1995, for similar arguments).

METHOD

Corpus

For the present analysis, a database of 2,694 words was generated. This database contained virtually all monosyllabic, monomor-

phemic words in Kučera and Francis (1967). All derived statistics were based on this set of words. The frequency counts were also taken from Kučera and Francis.

Phonology codes in the present study were based on the VAX phonology system, a coding system that contains keyboard-compatible phonemic symbols. The major part of these phonology codes was entered at the University of Indiana according to pronunciations given in the *Webster Pocket Dictionary*. Additional codings were entered at the Arizona State University. When transcribing speech into a coding system, a major issue concerns the breadth of transcription. Broad transcriptions group speech sounds into a few, large categories. Subtle distinctions (e.g., coarticulation effects) are generally ignored. In contrast, narrow descriptions group speech sounds into more, smaller categories. If the description is too broad, words that “sound different” to most speakers may be treated as having the same pronunciation. If the description is too narrow, words that “sound alike” to most speakers may be treated as having different pronunciations. The present coding represents an attempt to strike a good balance between broad and narrow transcriptions, partially because it was done to satisfy a variety of applications, including research on reading, word perception, and speech perception. A key to these keyboard-compatible phonology codes is given in Appendix A.

Word Decomposition

All monosyllabic words were broken down into their initial onset (consonant cluster) and their spelling body. For example, *pint* was divided into the onset *p-* and the spelling body *-int*. For all spelling bodies, the corresponding phonological bodies were extracted. Similarly, for all phonological bodies the corresponding spelling bodies were extracted.

Feedforward Consistency

A spelling body was feedforward consistent if it mapped into one and only one phonological body. All words containing this spelling body were feedforward consistent. A spelling body was considered feedforward inconsistent if it could be mapped into more than one phonological body. For example, the spelling body *-int* has more than one phonological body, /Ynt/ as in *pint* and /Int/ as in *hint*. Therefore, the spelling body *-int* is feedforward inconsistent, and all words containing the spelling body *-int* are feedforward inconsistent. Note that, according to this definition, mappings with only one representative example are considered to be consistent. This may seem odd because words with only one representative example have unique spellings (e.g., *yacht*) and are often considered to be “strange” words (Waters & Seidenberg, 1985). However, these words also tend to be highly feedback inconsistent (common phonology but unique spelling). Therefore, by accepting our definition of consistency and considering feedback consistency as a source of inconsistency, we offer a parsimonious definition for a word being a “strange” word. Appendix B gives all feedforward-consistent and feedforward-inconsistent spelling bodies with their corresponding phonological bodies.

Feedback Consistency

A phonological body was feedback consistent if it mapped into one and only one spelling body. All words containing this phonological body were feedback consistent. For example, the phonological body /-ob/ can only be spelled *-obe*. Therefore, the phonological body /-ob/ and all words containing it (e.g., *probe*) are feedback consistent. A phonological body was considered feedback inconsistent if it could be mapped into more than one spelling body. For example, the phonological body /-ip/ can be spelled *-eep* and *-eap*. Therefore, the phonological body /-ip/ and all words containing it (e.g., *deep* and *heap*) are feedback inconsistent. Appendix C gives all feedback-consistent and feedback-inconsistent phonological bodies with their corresponding spelling bodies.

Bidirectional Inconsistency

In Appendices B and C, an asterisk behind each mapping indicates whether a particular mapping is inconsistent in the other direction. Therefore, an asterisk behind an inconsistent mapping implies that this mapping is bidirectionally inconsistent. For example, Appendix B lists all feedforward-inconsistent (spelling → phonology) spelling bodies with their corresponding phonological bodies. An asterisk behind a particular phonological body indicates that this phonological body is also inconsistent in the other direction (i.e., from phonology to spelling). Appendix C lists all feedback-inconsistent (phonology → spelling) bodies. Therefore, an asterisk behind a particular spelling body indicates that this spelling body is also inconsistent in the other direction (i.e., from spelling to phonology). Thus, this information can be used to immediately determine whether a mapping is inconsistent in the other direction without going back and forth between the appendixes.

Number of "Friends" and "Enemies"

In Appendices B and C, we provide a column for the number of words in which a particular mapping occurs. For example, consider the inconsistent mapping of the spelling body *-int* into the phonological bodies /nt/ as in *hint* and /Ynt/ as in *pint* (see Appendix B). This column indicates that the *-int* → /nt/ mapping occurs in 9 words, whereas the *-int* → /Ynt/ mapping occurs only in *pint*. Consequently, this column can be used to determine the number of "friends" and "enemies" of a particular mapping (Jared et al., 1990). In the feedforward direction, "friends" are words with a similar spelling pattern and a similar pronunciation, and "enemies" are words with a similar spelling pattern but a different pronunciation. Accordingly, *hint* has 8 "friends" and 1 "enemy"; *pint* has 0 "friends" and 9 "enemies." Jared et al. (1990) suggested that the size of the consistency effect depends on the number and the frequency of a word's "friends" and "enemies." Note that the information in this column can easily be converted into conditional probabilities previously used by Berndt et al. (1987) and Ziegler et al. (1996). For this purpose, the frequency of a particular mapping, say *-int* → /Ynt/, must be divided by the total frequency of all possible mappings of *-int*.

Frequency of "Friends" and "Enemies"

In Appendices B and C, we also provide a column for the summed frequency (in *x*/million; Kučera & Francis, 1967) of the words in which a particular mapping occurs. Taking the example from above, the summed frequency of the inconsistent *-int* → /nt/ mapping is 52 occurrences per million, whereas the summed frequency for the *-int* → /Ynt/ mapping is 13 occurrences per million. Note that in this column word frequencies greater than 1,000 occurrences per million were truncated to 1,000 occurrences per million. This was done to avoid having these statistics inflated by a few very frequent items (cf. Jared et al., 1990). This column can be used to determine the summed frequency of "enemies" and "friends." Taking the example from above, the summed frequency of *hint*'s "friends" is greater (52 occurrences per million including *hint*) than the frequency of its "enemy" *pint* (13 occurrences per million).

RESULTS AND DISCUSSION

The summary statistics for the crossed analysis of feedforward and feedback consistency are given in Table 1. As concerns the generality of our analysis, the population of monosyllabic words constitutes nearly two thirds (62%) of all word occurrences in Kučera and Francis (1967). Therefore, the following analysis presents a broad estimate of bidirectional inconsistency of English.

The major result of the present analysis is that 72.3% of all monosyllabic English words are feedback inconsis-

Table 1
Analysis of Crossed-Consistency Conditions
Based on the Number of Words Within Each Condition

	Feedback				Σ	
	Consistent		Inconsistent			
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Feedforward						
Consistent	521	19.3	1,345	49.9	1,866	69.3
Inconsistent	225	8.4	603	22.4	828	30.7
Σ	746	27.7	1,948	72.3	2,694	

Note—"Feedforward" refers to the mapping of spelling to phonology. "Feedback" refers to the mapping of phonology to spelling.

tent (their phonological body has more than one spelling) and 30.7% are feedforward inconsistent (their spelling body has more than one pronunciation). As a comparison, 79.1% of all French monosyllabic words are feedback inconsistent and 12.4% are feedforward inconsistent (Ziegler et al., 1996). Therefore, French is more inconsistent than English from phonology to spelling; it is less inconsistent than English from spelling to phonology.

If we look at all the words that would traditionally be classified as consistent on the basis of spelling-to-sound correspondences (69.3% of all the words), 72.1% of them are feedback inconsistent. Therefore, on average, about 7 out of 10 items chosen by investigators as consistent are, in fact, feedback inconsistent. This might explain contradictory and unreliable findings concerning consistency effects in English and French.

The mean word frequency (with a ceiling of 1,000 per million) for feedforward-inconsistent words (149 per million) is greater than that for feedforward consistent words (62 per million). Similarly, mean frequency for feedback inconsistent words (108 per million) is greater than that for feedback consistent words (47 per million). Note that words inconsistent in both directions have an especially high mean frequency (181 per million). This pattern of results corroborates the French analysis (Ziegler et al., 1996), suggesting that irregularities are more likely in common words than in uncommon words. This can have at least two reasons. First, frequently used words are more likely to survive linguistic evolution in irregular form than are less frequent words. Second, the more frequently a word is used, the higher the chances that its pronunciation or spelling is transformed and becomes irregular (see Ellis, 1993, for a discussion).

In previous studies, inconsistency and irregularity have often been treated as binary variables. However, the degree of (in)consistency seems to be important (Jared et al., 1990). Therefore, metrics of inconsistency are needed (Massaro & Cohen, 1994; Rosson, 1985; Venezky & Massaro, 1987). In our present appendixes, information concerning the number and summed frequency of "enemies" and "friends" could be used to generate such metrics of inconsistency based on the bidirectional inconsistencies as they occur in a corpus of all monosyllabic English words.

CONCLUSION

In conclusion, a monosyllabic English word selected at random is likely to be feedback inconsistent (72.3%) but feedforward consistent (69.3%). Since feedback inconsistency seems to affect performance in lexical decision, perceptual identification, and naming tasks (Hooper & Paap, in press; Stone & Vanhoy, 1994; Stone et al., 1997; Ziegler & Jacobs, 1995; Ziegler, Montant, & Jacobs, in press; Ziegler et al., 1997), stimuli in psycholinguistic experiments need to be controlled on this variable, and systematic research is needed to further quantify the influence of feedback inconsistency. The present work is a first step in that direction, providing a tool for controlling and selecting word stimuli, constructing nonword stimuli, developing quantitative metrics of inconsistency, and generating hypotheses for further research and modeling.

Availability

The appendices are available on disk via anonymous ftp on frogmouth.bhs.mq.edu.au in the jziegler/brmic directory.

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APPENDIX A

Key to Phonetic Symbols

Phonetic Classes	Phonetic Symbol	Examples	Phonetic Classes	Phonetic Symbol	Examples
Stops	b	<i>big</i>	Glides and Semivowels	l	<i>lip</i>
	p	<i>pig</i>		r	<i>rip</i>
	d	<i>day</i>		w	<i>wig</i>
	t	<i>tip</i>		y	<i>yet</i>
	g	<i>pig</i>	Lax Vowels	E	<i>met</i> (short e)
	k	<i>pick</i>		I	<i>pin</i> (short i)
Affricates	C	<i>chip</i>		} (^)	<i>nut</i> (short u)
	J	<i>joke</i>		U	<i>look</i>
Strong Fricatives	s	<i>sit</i>	Tense Vowels	e	<i>fate</i> (long a)
	S	<i>she</i>		@	<i>fat</i> (short a)
	z	<i>zone</i>		i	<i>meat</i> (long e)
	Z	<i>azure</i>		Y	<i>pine</i> (long i)
Weak Fricatives	f	<i>fig</i>		o	<i>note</i> (long o)
	v	<i>van</i>		a	<i>not</i> (short o)
	T	<i>thin</i>	Diphthongs	R	<i>bird</i> (syllabic /r/)
	D	<i>then</i>		u	<i>new, blue</i>
	h	<i>hog</i>		c	<i>law, thought</i>
Nasals	n	<i>nip</i>		W	<i>now, mouth</i>
	m	<i>man</i>		O	<i>toy</i>
	G	<i>sing</i>			
Syllabic Consonants	N	<i>button</i>			
	M	<i>bottom</i>			
	L	<i>bottle</i>			

APPENDIX B

Feedforward (spelling → phonology) mappings for inconsistent and consistent spelling bodies.
An asterisk (*) indicates whether a phonological body is inconsistent in the other direction (i.e., from phonology to spelling). "Number of Words" refers to the number of all words in which a particular mapping occurs.
"Summed Frequency" gives the summed frequency of all words in which a particular mapping occurs.

Spelling	Phonology	Number of Words	Summed Frequency	Example	Spelling	Phonology	Number of Words	Summed Frequency	Example
Inconsistent Mappings					ash	@S*	18	129	cash
a	a*	3	44	pa		aS*	1	2	squash
	e*	1	1,000	a		cS	1	37	wash
ache	@S*	1	1	cache	asp	@sp	3	22	rasp
	ek*	1	4	ache		asp	1	2	wasp
ad	@d*	13	1,308	sad	aste	@st*	1	3	caste
	ad*	1	18	squad		est*	4	113	taste
ade	@d*	1	1	bade	at	@t	14	2,436	that
	ed*	9	1,234	made		at*	2	1,007	what
aid	@d*	1	1	plaid	atch	@C	8	125	catch
	ed*	6	405	maid		cC	1	81	watch
	Ed*	1	1,000	said	ath	@T	5	85	path
all	@l*	1	267	shall		aT	1	1	swath
	cl*	13	2,401	ball	aunt	@nt*	1	22	aunt
alve	@lv	1	3	valve		cnt*	4	15	haunt
	@v*	1	3	salve	aut	ct*	1	9	taut
am	@m*	11	284	swam		Wt*	1	1	kraut
	am*	1	1	pram	ave	@v*	1	1,000	have
amp	@mp	10	129	stamp		ev*	11	507	brave
	amp*	1	5	swamp	ea	e*	1	3	yea
an	@n	15	4,448	than		i*	4	148	flea
	an*	3	6	swan	ead	Ed*	9	885	head
anch	@nC	2	60	ranch		id*	4	182	read
	cnC*	1	1	stanch	eaf	Ef*	1	12	deaf
and	@nd	11	1,961	stand		if*	2	18	leaf
	and*	1	1	wand	eak	ek*	2	103	steak
ange	@nJ	1	2	flange		ik*	11	189	bleak
	enJ	3	484	change	ear	Er*	4	109	wear
ant	@nt*	7	189	plant		Ir*	15	1,583	clear
	cnt*	1	328	want	eard	Ird*	1	26	beard
ap	@p	19	161	wrap		Rd*	1	241	heard
	ap*	1	2	swap	earth	arT	1	4	hearth
ar	ar*	11	868	bar		RT*	2	153	earth
	or*	1	464	war	ease	is*	4	35	cease
arce	ars*	1	3	farce		iz*	3	110	tease
	Ers	1	6	scarce	east	Est*	1	11	breast
ard	ard*	5	270	yard		ist*	5	539	beast
	ord*	1	25	ward	eat	Et*	2	65	great
are	ar*	1	1,000	are		et*	1	670	sweat
	Er*	17	574	bare		it*	12	397	beat
arf	arf	1	4	scarf	eath	ET	2	330	death
	orf	2	7	dwarf		iT*	2	12	wreath
arm	arm	4	270	harm	een	In*	1	1,000	been
	orm*	2	70	warm		in*	8	505	green
arn	arn	3	46	barn	eeze	is*	1	3	geese
	orn*	1	11	warn		iz*	1	9	cheese
arp	arp	2	73	sharp	eight	et*	3	252	weight
	orp*	1	4	warp		Yt*	1	35	height
art	art*	9	932	part	ein	en*	2	28	vein
	ort*	3	17	wart		Yn*	1	18	stein
as	@s*	1	98	gas	ere	Er*	3	1,939	there
	@z*	2	2,000	has		Ir*	3	819	here
	z*	1	1,000	was		R*	1	1,000	were
ase	es*	4	475	vase	ew	o*	1	6	sew
	ez*	2	107	phase		u*	16	2,311	blew

APPENDIX B (Continued)

Spelling	Phonology	Number of Words	Summed Frequency	Example	Spelling	Phonology	Number of Words	Summed Frequency	Example
ey	e*	3	1,019	grey	ool	Ul*	1	10	wool
	j*	1	92	key		ul*	6	758	tool
i	i*	1	5	ski	oose	us*	3	60	noose
	Y*	2	1,002	pi		uz*	1	50	choose
iend	End*	1	133	friend	oot	Ut*	2	71	foot
	ind	1	3	fiend		ut*	7	88	root
ild	Ild*	1	1	gild	ooth	uD*	1	42	smooth
	Yld	3	283	child		uT*	2	27	tooth
imb	Im*	1	5	limb	ord	ord*	5	137	lord
	Ym*	1	12	climb		Rd*	1	274	word
ind	Ind	1	63	wind	ork	ork*	3	33	pork
	Ynd	7	1,096	bind		Rk*	1	760	work
int	Int	9	52	hint	orm	orm*	3	406	storm
	Ynt	1	13	pint		Rm*	1	4	worm
irk	Irk	1	1	kirk	orth	orT	2	277	forth
	Rk*	2	4	smirk		RT*	1	94	worth
is	Is*	1	1,000	this	ose	os*	2	245	dose
	Iz*	2	2,000	his		oz*	7	1,067	chose
ise	Ys*	1	1	vise		uz*	2	310	lose
	Yz*	2	138	rise	oss	as	2	5	dross
ist	Ist	7	204	list		cs*	6	180	loss
	Yst	1	97	christ		os*	1	66	gross
ithe	YD	2	6	lithe	ost	cst	3	408	lost
	YT	1	2	blithe		ost*	4	1,131	host
ive	Iv*	2	568	give	ot	at*	18	2,034	plot
	Yv	7	425	five		o*	1	1	mot
o	o*	3	1,642	go	oth	cT	4	48	moth
	u*	4	4,000	do		oT*	1	730	both
oad	cd*	1	84	broad	ou	u*	1	1,000	you
	od*	4	263	load		W*	1	14	thou
oe	o*	4	25	toe	ouch	WC	4	22	couch
	u*	1	14	shoe		}C*	1	87	touch
og	ag	2	3	clog	ouge	uZ	1	7	rouge
	cg	7	117	dog		WJ	1	1	gouge
olf	Ulf	1	6	wolf	ough	cf*	2	10	cough
	}lf*	1	34	golf		o*	2	455	dough
oll	al	2	15	doll		u*	1	974	through
	ol*	5	67	roll		W*	1	2	bough
om	um*	1	146	whom		}f*	2	83	tough
	}m*	1	1,000	from	oul	ol*	1	48	soul
omb	am*	1	38	bomb		ul*	1	1	ghoul
	om*	1	6	comb		Wl*	1	6	foul
	um*	2	12	tomb	ould	old*	1	1	mould
ome	om*	4	569	dome		Ud*	3	2,888	could
	}m*	2	1,630	come	oup	u*	1	5	coup
on	an*	3	31	don		up*	2	406	group
	cn*	1	1,000	on	our	or*	2	427	four
	}n*	3	261	son		R*	1	923	your
once	ans	1	1	nonce		Ur*	1	43	tour
	}ns	1	499	once		Wr	6	1,194	flour
one	cn*	1	195	gone	ouse	Ws	4	605	mouse
	on*	12	275	bone		Wz	2	5	spouse
	}n*	3	1,427	done	outh	uT*	1	82	youth
ont	cnt*	1	2	wont		WT	3	344	mouth
	}nt*	1	221	front	ove	ov*	11	98	dove
ood	Ud*	4	1,086	good		uv*	2	224	move
	ud*	3	193	food		}v*	3	243	love
	}d*	2	140	blood	ow	o*	14	1,590	snow
oof	Uf	1	2	hoof		W*	9	1,889	plow
	uf	3	100	proof	owl	ol*	1	23	bowl
						Wl*	6	15	fowl

APPENDIX B (Continued)

Spelling	Phonology	Number of Words	Summed Frequency	Example	Spelling	Phonology	Number of Words	Summed Frequency	Example
own	on*	6	1,278	known	ang	@G	9	126	gang
	Wn*	8	1,325	brown	angst	aGst	1	2	angst
ube	Ub	1	1	rube	ank	@Gk*	18	312	tank
	ub	2	32	tube	ants	@ns*	1	9	pants
uise	uz*	2	5	bruise	ape	ep*	7	154	shape
	Yz*	1	6	guise	aph	@f*	1	17	graph
ull	Ul*	3	295	pull	apse	@ps	1	6	lapse
	l	6	60	null	apt	@pt	2	16	rapt
unk	}Gk*	11	89	punk	aque	@k*	1	2	plaque
	nk	1	1	gunk	arb	arb	1	3	garb
use	us*	1	2	ruse	arc	ark*	1	41	arc
	uz*	3	598	fuse	arch	arC	3	137	march
ush	US	2	51	bush	arge	arJ	3	490	large
	S	10	96	brush	ark	ark*	8	400	bark
ut	Ut*	1	437	put	arse	ars*	1	5	sparse
	t*	8	1,271	but	arsh	arS	2	16	harsh
	Consistent Mappings				artz	orts	1	1	quartz
ab	@b	10	52	grab	arve	arv	2	4	starve
abe	eb	1	8	babe	ask	@sk	5	203	mask
ace	es*	10	1,371	face	ass	@s*	10	602	glass
acht	at*	1	4	yacht	ast	@st*	8	1,166	blast
ack	@k*	20	1,525	track	ate	et*	16	1,492	date
act	@kt	5	758	fact	athe	eD	2	5	bathe
adge	@J	1	5	badge	att	at*	1	2	watt
afe	ef	3	61	safe	auce	cs*	1	20	sauce
aff	@f*	1	113	staff	auche	oS	1	1	gauche
aft	@ft	6	68	draft	aud	cd*	1	8	fraud
ag	@g	13	114	bag	auge	eJ*	1	16	gauge
age	eJ*	8	554	stage	augh	@f*	1	28	laugh
ague	eg	2	31	vague	aught	ct*	3	150	taught
ah	a*	1	2	shah	aul	cl*	1	6	haul
aight	et*	1	123	straight	ault	clt*	2	24	fault
ail	el*	16	232	fail	aunch	cnC*	3	15	launch
aim	em*	2	135	claim	ause	cz*	3	160	cause
ain	en*	16	690	pain	auve	ov*	1	1	mauve
aint	ent*	5	91	paint	auze	cz*	1	1	gauze
air	Er*	7	630	fair	aw	c*	14	799	saw
aise	ez*	3	70	raise	awe	c*	1	5	awe
aisle	Yl*	1	6	aisle	awk	ck*	2	15	hawk
aist	est*	1	13	waist	awl	cl*	6	21	crawl
ait	et*	5	109	wait	awn	cn*	5	49	fawn
aith	eT	1	111	faith	ax	@ks*	4	217	wax
aive	ev*	1	1	waive	axe	@ks*	1	6	axe
ake	ek*	16	1,660	cake	ay	e*	22	4,129	bay
al	@l*	2	7	pal	aye	Y*	1	2	aye
ald	cld	2	6	bald	aze	ez*	9	48	blaze
ale	el*	12	249	male	azz	@z*	1	99	jazz
alf	@f*	2	286	half	e	i*	5	5,000	she
alk	ck*	3	257	talk	eace	is*	1	201	peace
alm	am*	3	61	calm	each	iC*	7	1,104	beach
alp	@lp	1	4	scalp	eague	ig	1	69	league
alse	cls*	1	29	scalp	eah	@	1	25	yeah
alt	clt*	3	57	salt	eal	il*	8	206	zeal
altz	cls*	1	1	waltz	ealm	Elm*	1	19	realm
amb	@m*	1	7	lamb	ealt	Elt*	1	22	dealt
ame	em*	12	1,903	flame	ealth	EIT	3	132	health
amn	@m*	1	32	damn	eam	im*	9	285	team
anc	@Gk*	1	1	franc	ean	in*	7	361	bean
ance	@ns*	6	274	lance	eant	Ent*	1	100	meant
ane	en*	7	177	crane	eap	ip*	4	56	heap
					earch	RC*	1	66	search

APPENDIX B (Continued)

Spelling	Phonology	Number of Words	Summed Frequency	Example	Spelling	Phonology	Number of Words	Summed Frequency	Example
earl	RI*	2	24	pearl	ene	in*	2	117	gene
earn	Rn*	3	101	learn	ength	EGT	2	252	strength
earse	Rs*	1	1	hearse	ens	Enz	1	12	lens
eart	art*	1	176	heart	ense	Ens*	3	335	dense
eash	iS	1	3	leash	ent	Ent*	11	1,015	went
eathe	iD	1	7	breathe	ep	Ep	2	150	step
eau	o*	1	1	beau	epe	ep*	1	1	crepe
eave	iv*	3	211	leave	ept	Ept	3	229	kept
eb	Eb*	2	7	web	epth	EpT	1	53	depth
ebb	Eb*	1	1	ebb	er	R*	2	1,380	her
ebt	Et*	1	13	debt	erb	Rb*	2	11	herb
eck	Ek*	9	216	beck	erch	RC*	1	1	perch
ect	Ekt	1	2	sect	erd	Rd*	1	23	herd
ed	Ed*	10	534	bed	erge	RJ*	3	13	merge
edge	EJ	5	93	wedge	erk	Rk*	3	37	clerk
ee	i*	14	1,835	bee	erm	Rm*	2	82	term
eech	iC*	3	68	speech	ern	Rn*	2	24	stern
eed	id*	14	667	speed	err	Er*	1	1	err
eef	if*	2	43	reef	erse	Rs*	2	30	terse
EEK	ik*	8	477	seek	ert	Rt*	1	2	pert
eel	il*	9	346	feel	erth	RT*	1	4	berth
eem	im*	2	230	seem	ertz	}tz	1	1	hertz
eep	ip*	12	537	deep	erve	Rv*	4	125	nerve
eer	Ir*	9	101	deer	es	Es*	1	144	yes
eet	it*	9	829	feet	ese	iz*	1	1,000	these
eeth	iT*	1	103	teeth	esh	ES	3	138	flesh
eeve	iv*	1	11	sleeve	esk	Esk	1	65	desk
eeze	iz*	3	33	breeze	ess	Es*	8	806	bless
ef	Ef*	1	9	chef	est	Est*	15	1,005	best
eft	Eft	4	494	left	et	Et*	12	2,245	bet
eg	Eg*	4	75	leg	etch	EC	5	50	fetch
egg	Eg*	1	12	egg	ete	et*	1	3	fete
eige	eZ	1	1	beige	eud	ud*	1	1	feud
eigh	e*	1	4	weigh	eum	um*	1	1	rheum
eign	en*	1	7	reign	ev	Ev	1	33	rev
eik	ik*	1	4	sheik	eve	iv*	1	19	eve
eil	el*	1	8	veil	ewd	ud*	2	11	shrewd
eint	ent*	1	2	feint	ewn	un*	1	6	strewn
eir	Er*	2	1,007	their	ewt	ut*	1	8	newt
eird	Ird*	1	10	weird	ex	Eks	4	89	flex
eize	iz*	1	6	seize	ext	Ekst	2	454	text
ek	Ek*	1	2	trek	eye	Y*	1	143	eye
elch	ElC	2	16	belch	ial	Yl*	1	1	dial
eld	Eld	3	269	held	ib	Ib	4	9	crib
elf	Elf	2	52	shelf	ibe	Yb	4	10	tribe
elk	Elk	1	1	elk	ic	ik*	1	7	chic
ell	El	16	1,591	bell	ice	Ys*	13	440	dice
elm	Elm*	2	7	helm	ich	IC*	2	1,074	which
elp	Elp	3	315	help	iche	IC*	1	3	niche
else	Els	1	176	else	ick	Ik	19	399	brick
elsh	EIS	1	4	welsh	ict	Ikt	1	11	strict
elt	Elt*	3	390	belt	id	Id	9	1,155	slid
elte	Elt*	1	1	svelte	ide	Yd*	12	703	bride
elve	Elv	1	48	twelve	idge	IJ	3	120	bridge
em	Em	4	1,037	gem	idst	Idst	1	19	midst
eme	im*	2	88	theme	idth	IdT	1	14	width
empt	Empt	1	2	tempt	ie	Y*	4	174	die
en	En	11	3,018	when	iece	is*	2	141	piece
ence	Ens*	4	97	hence	ief	if*	4	210	brief
ench	EnC	6	179	bench	iege	iJ	1	6	siege
end	End*	10	676	trend	iek	ik*	1	5	shriek

APPENDIX B (Continued)

Spelling	Phonology	Number of Words	Summed Frequency	Example	Spelling	Phonology	Number of Words	Summed Frequency	Example
ield	ild	4	318	field	iss	Is*	5	295	miss
ien	in*	2	3	lien	it	It	17	1,493	quit
ier	Ir*	1	4	pier	itch	IC*	9	102	witch
ierce	Irs	2	14	fierce	ite	Yt*	12	904	bite
iest	ist*	1	16	priest	ith	IT*	3	1,055	with
ieu	u*	1	5	lieu	itz	Its	1	3	blitz
ieve	Iv*	1	1	sieve	ix	Iks	3	247	six
iew	u*	1	186	view	iz	Iz*	2	4	quiz
ieze	iz*	1	13	frieze	ize	Yz*	2	169	size
if	If*	1	1,000	if	oa	o*	1	1	whoa
ife	Yf	5	1,026	knife	oach	oC	4	28	coach
iff	If*	5	44	stiff	oaf	of	1	4	loaf
ift	Ift	7	153	lift	oak	ok*	4	26	cloak
ig	Ig	12	480	pig	oal	ol*	3	94	goal
igh	Y*	4	604	thigh	oam	om*	2	43	foam
ight	Yt*	15	2,529	blight	oan	on*	3	49	moan
ign	Yn*	1	94	sign	oap	op*	1	22	soap
ike	Yk*	6	1,188	like	oar	or*	2	14	boar
il	Il*	1	1	nil	oard	ord*	1	239	board
ile	Yl*	8	919	mile	oarse	ors*	2	15	coarse
ilge	IlJ	1	2	bilge	oast	ost*	4	98	toast
ilk	Ilk	2	61	milk	oat	ot*	7	184	boat
ill	Il*	23	2,371	fill	oath	oT*	2	9	oath
ilm	Ilm	1	96	film	oax	oks	1	1	coax
ilt	Ilt*	5	15	tilt	ob	ab	10	318	job
ilth	IlT	2	3	filth	obe	ob	4	28	lobe
im	Im*	12	1,102	him	oc	ak*	1	10	bloc
ime	Ym*	6	1,097	rime	ock	ak*	13	419	block
imp	Imp	4	18	shrimp	od	ad*	9	364	sod
impse	Imps	1	16	glimpse	odd	ad*	1	44	odd
in	In*	17	1,367	bin	ode	od*	4	111	code
inc	IGk*	1	10	zinc	odge	aJ	2	30	lodge
ince	Ins*	4	664	prince	of	}v*	1	1,000	of
inch	InC	4	51	pinch	off	cf*	1	639	off
ine	Yn*	15	721	wine	oft	cft	3	64	loft
ing	IG	16	876	bring	ogue	og	2	7	vogue
inge	InJ	4	22	hinge	ohn	an*	1	362	john
ink	IGk*	15	647	drink	oice	Os	2	339	choice
inn	In*	1	9	inn	oid	Od	1	10	void
inse	Ins*	1	6	rinse	oil	Ol	7	171	boil
inx	IGks	2	2	sphinx	oin	On	4	80	soil
ip	Ip*	20	377	chip	oint	Ont	2	434	point
ipe	Yp*	6	51	wipe	oise	Oz	2	43	noise
ipt	Ipt*	1	11	script	oist	Ost	2	12	moist
ique	ik*	2	4	clique	oke	ok*	11	273	joke
ir	R*	4	107	whir	old	old*	9	1,585	told
irch	RC*	1	2	birch	ole	ol*	9	532	hole
ird	Rd*	3	222	bird	olk	ok*	2	35	folk
ire	Yr*	8	278	wire	olt	olt	3	32	colt
irge	RJ*	1	2	dirge	olve	clv	1	20	solve
irl	RI*	3	225	girl	omp	amp*	3	3	romp
irm	Rm*	1	109	firm	ompt	ampt	1	11	prompt
irst	Rst*	2	1,004	first	ond	and*	3	84	pond
irt	Rt*	6	101	dirt	onde	and*	1	20	blonde
irth	RT*	3	76	birth	ong	cG	8	1,167	wrong
isc	Isk*	1	6	disc	onge	}nJ*	1	7	sponge
ish	IS	3	161	wish	ongue	}G*	1	35	tongue
isk	Isk*	3	86	disk	onk	}Gk*	1	16	monk
isle	Yl*	2	6	lisle	onth	}nT	1	130	month
isp	Isp	2	10	crisp	onze	anz	1	11	bronze
isque	Isk*	1	6	bisque	oo	u*	2	843	too

APPENDIX B (Continued)

Spelling	Phonology	Number of Words	Summed Frequency	Example	Spelling	Phonology	Number of Words	Summed Frequency	Example
ook	Uk	8	1,133	took	ub	}b	10	196	club
oom	um*	8	448	room	uce	us*	2	10	truce
oon	un*	6	295	soon	uch	}C*	2	1,937	much
oop	up*	11	58	loop	uck	}k	12	242	duck
oor	or*	1	116	door	uct	}kt	1	1	duct
oost	ust	2	16	boost	ud	}d*	6	53	bud
ooth	uD*	1	2	tooth	ude	ud*	3	41	nude
oove	uv*	1	2	groove	udge	}J	5	93	judge
ooze	uz*	2	6	booze	ue	u*	8	577	blue
op	ap*	15	509	shop	uel	ul*	2	32	fuel
ope	op*	9	305	slope	uess	Es*	1	56	guess
or	or*	3	2,195	for	uest	Est*	1	39	guest
orb	orb	1	1	orb	uff	}f*	10	64	bluff
orce	ors*	1	230	force	ug	}g	15	117	rug
orch	orC	2	45	porch	uge	uJ	1	54	huge
orde	ord*	1	2	horde	uice	us*	2	13	juice
ore	or*	17	1,409	bore	uide	Yd*	1	36	guide
orge	orJ	2	11	gorge	uild	Ild*	2	93	build
orgue	org	1	1	morgue	uile	Yl*	1	1	guile
orld	Rld	1	787	world	uilt	Ilt*	2	136	built
orn	orn*	8	238	born	uit	ut*	2	83	fruit
orne	orn*	1	9	borne	uite	it*	1	27	suite
orp	orp*	1	2	thorp	uke	uk	3	13	duke
orps	or*	1	110	corps	ulb	}lb	1	7	bulb
orpse	orps	1	7	corpse	ulch	}lC	1	6	mulch
orque	ork*	1	5	torque	ule	ul*	2	77	rule
orse	Rs*	1	50	worse	ulf	}lf*	1	22	gulf
orst	Rst*	1	35	worst	ulge	}lJ	1	5	bulge
ort	ort*	6	471	fort	ulk	}lk	3	19	bulk
osh	aS*	1	4	gosh	ulp	}lp	2	7	pulp
osque	ask	1	10	mosque	ulse	}ls	1	9	pulse
otch	aC	2	11	scotch	ult	}lt	1	11	cult
ote	ot*	5	401	note	um	}m*	12	100	gum
othe	oD	1	1	clothe	umb	}m*	5	35	numb
oubt	Wt*	1	114	doubt	ume	um*	2	3	plume
oud	Wd*	3	98	proud	ump	}mp	14	78	jump
ought	ct*	7	996	bought	un	}n*	11	520	sun
oun	Wn*	1	1	noun	unch	}nC	6	65	bunch
ounce	Wns	2	11	bounce	und	}nd	1	62	fund
ound	Wnd	9	1,123	sound	une	un*	4	105	june
oung	}G*	1	385	young	ung	}G*	12	196	lung
ounge	WnJ	1	9	lounge	unge	}nJ*	2	9	plunge
ount	Wnt	2	75	count	unt	}nt*	8	28	hunt
oupe	up*	1	3	troupe	up	}p	4	1,048	cup
ource	ors*	1	94	source	ur	R*	4	31	blur
ourd	rd*	1	2	gourd	urb	Rb*	1	13	curb
ourge	RJ*	1	2	scourge	urch	RC*	2	351	church
ourn	orn*	1	2	mourn	urd	Rd*	1	2	curd
ourse	ors*	1	465	course	ure	Ur*	4	355	cure
ourt	ort*	1	230	court	urf	Rf	2	4	turf
oust	Wst	2	4	oust	urge	RJ*	4	33	purge
out	Wt*	13	1,039	out	urk	Rk*	2	6	turk
oute	ut*	1	44	route	url	RI*	2	5	curl
owd	Wd*	1	53	crowd	urn	Rn*	3	251	turn
owe	o*	1	10	owe	urr	R*	1	5	burr
ox	aks	3	88	fox	urse	Rs*	3	42	curse
oy	O	6	294	boy	urst	Rst*	1	33	burst
oze	oz*	1	5	froze	urt	Rt*	3	71	curt
u	u*	2	18	flu	urve	Rv*	1	45	curve
uard	ard*	1	48	guard	us	}s*	3	418	bus
uave	av	1	2	suave	usk	}sk	2	19	rusk

APPENDIX B (Continued)

Spelling	Phonology	Number of Words	Summed Frequency	Example	Spelling	Phonology	Number of Words	Summed Frequency	Example
usp	}sp	1	2	culp	yke	Yk*	1	1	dyke
uss	}s*	2	5	fuss	yle	Yl*	1	105	style
ust	}st	10	2,041	bust	ym	Im*	1	2	gym
utch	}C*	3	21	dutch	yme	Ym*	1	3	rhyme
ute	ut*	6	18	brute	ymn	Im*	1	9	hymn
uth	uT*	1	126	truth	ymph	Imf	2	3	lymph
utt	}t*	2	18	butt	yp	Ip*	1	6	gyp
utte	ut*	1	1	butte	ype	Yp*	1	200	type
ux	}ks	2	32	crux	ypt	Ipt*	1	1	crypt
uy	Y*	2	121	guy	yre	Yr*	1	1	pyre
uzz	}z*	2	16	buzz	yrrh	R*	1	2	myrrh
y	Y*	15	2,804	dry	yth	IT*	1	35	myth
ye	Y*	2	11	rye					

APPENDIX C

Feedback (phonology → spelling) mappings for inconsistent and consistent phonological bodies.
 An asterisk (*) indicates whether a spelling body is inconsistent in the other direction (i.e., from spelling to phonology). “Number of Words” refers to the number of all words in which a particular mapping occurs.
 “Summed Frequency” gives the summed frequency of all words in which a particular mapping occurs.

Phonology	Spelling	Number of Words	Summed Frequency	Example	Phonology	Spelling	Number of Words	Summed Frequency	Example
Inconsistent Mappings					ak	ock	13	419	clock
@d	ad*	13	1,308	sad		oc	1	10	bloc
	ade*	1	1	bade	am	alm	3	61	calm
	aid*	1	1	plaid		am*	1	1	pram
@f	alf	2	286	half		omb*	1	38	bomb
	aff	1	113	staff	amp	omp	3	3	pomp
	aph	1	17	graph		amp*	1	5	swamp
@Gk	augh	1	28	laugh	an	an*	3	6	swan
	ank	18	312	blank		on*	3	31	don
	anc	1	1	franc		ohn	1	362	john
@k	ack	20	1,525	crack	and	ond	3	84	fond
	aque	1	2	plaque		onde	1	20	blonde
@ks	ax	4	217	tax		and*	1	1	wand
	axe	1	6	axe	ap	op	15	509	chop
@l	al	2	7	pal		ap*	1	2	swap
	all*	1	267	shall	ar	ar*	11	868	car
@m	am*	11	284	slam		are*	1	1,000	are
	amb	1	7	lamb	ard	ard*	5	270	yard
	amn	1	32	damn		uard	1	48	guard
@ns	ance	6	274	lance	ark	ark	8	400	mark
	ants	1	9	pants		arc	1	41	arc
@nt	ant*	7	189	grant	ars	arse	1	5	sparse
	aunt*	1	22	aunt		arce*	1	3	farce
@S	ash*	18	129	cash	art	art*	9	932	start
	ache*	1	1	cache		eart	1	176	heart
@s	ass	10	602	mass	aS	osh	1	4	gosh
	as*	1	98	gas		ash*	1	2	squash
@st	ast	8	1,166	mast	at	ot*	18	2,034	knot
	aste*	1	3	caste		at*	2	1,007	squat
@v	alve*	1	3	salve		acht	1	4	yacht
	ave*	1	1,000	have		att	1	2	watt
@z	as*	2	2,000	has	c	aw	14	799	flaw
	azz	1	99	jazz		awe	1	5	awe
a	a*	3	44	pa	cd	aud	1	8	fraud
	ah	1	2	shah		oad*	1	84	broad
ad	od	9	364	rod	cf	ough*	2	10	cough
	odd	1	44	odd		off	1	639	off
	ad*	1	18	squad	ck	alk	3	257	walk
						awk	2	15	hawk

APPENDIX C (Continued)

Phonology	Spelling	Number of Words	Summed Frequency	Example	Phonology	Spelling	Number of Words	Summed Frequency	Example
cl	all*	13	2,401	wall	End	end	10	676	spend
	awl	6	21	crawl		iend*	1	133	friend
	aul	1	6	haul	Ens	ence	4	97	fence
cls	alse	1	29	false		ense	3	335	tense
	altz	1	1	waltz	Ent	ent	11	1,015	went
clt	alt	3	57	salt		eant	1	100	meant
	aolt	2	24	fault	ent	aint	5	91	faint
cn	awn	5	49	yawn		eint	1	2	feint
	on*	1	1,000	on	ep	ape	7	154	grape
	one*	1	195	gone		epe	1	1	crepe
cnC	aunch	3	15	launch	Er	are*	17	574	share
	anch*	1	1	stanch		air	7	630	chair
cnt	aunt*	4	15	haunt		ear*	4	109	swear
	ant*	1	328	want		ere*	3	1,939	where
	ont*	1	2	wont		eir	2	1,007	their
	oss*	6	180	boss		err	1	1	err
cs	auce	1	20	sauce	es	ace	10	1,371	race
	ought	7	996	bought		ase*	4	475	case
ct	aught	3	150	taught	Es	ess	8	806	dress
	aut*	1	9	taut		es	1	144	yes
cz	ause	3	160	pause	Est	uess	1	56	guess
	auze	1	1	gauze		est	15	1,005	chest
e	ay	22	4,129	play		uest	1	39	guest
	ey*	3	1,019	they		east*	1	11	breast
	eigh	1	4	weigh		aste*	4	113	haste
	a*	1	1,000	a	Et	aist	1	13	waist
	ea*	1	3	yea		et	12	2,245	wet
	eb	2	7	web	et	eat*	2	65	sweat
	ebb	1	1	ebb		ebt	1	13	debt
Ed	ed	10	534	bed		ate	16	1,492	date
	ead*	9	885	head		ait	5	109	wait
	aid*	1	1,000	said		eight*	3	252	weight
ed	ade*	9	1,234	shade		aight	1	123	straight
	aid*	6	405	maid		ete	1	3	fete
Ef	ef	1	9	chef		eat*	1	670	great
	eaf*	1	12	deaf	ev	ave*	11	507	brave
Eg	eg	4	75	beg		aive	1	1	waive
	egg	1	12	egg	ez	aze	9	48	gaze
eJ	age	8	554	page		aise	3	70	raise
	auge	1	16	gauge	i	ase*	2	107	phase
ek	ake	16	1,660	bake		ee	14	1,835	knee
	eak*	2	103	break		e	5	5,000	she
	ache*	1	4	ache		ea*	4	148	plea
Ek	eck	9	216	wreck		ey*	1	92	key
	ek	1	2	trek		i*	1	5	ski
el	ail	16	232	jail	IC	itch	9	102	pitch
	ale	12	249	scale		ich	2	1,074	rich
	eil	1	8	veil	iC	iche	1	3	niche
Elm	elm	2	7	helm		each	7	1,104	reach
	ealm	1	19	realm	id	eech	3	68	speech
Elt	elt	3	390	melt		eed	14	667	speed
	ealt	1	22	dealt	if	ead*	4	182	plead
	elte	1	1	svelte		ief	4	210	chief
em	ame	12	1,903	frame		eef	2	43	beef
	aim	2	135	claim		eaf*	2	18	leaf
en	ain	16	690	brain	If	iff	5	44	cliff
	ane	7	177	crane		if	1	1,000	if
	ein*	2	28	vein	IGk	ink	15	647	pink
	eign	1	7	reign		inc	1	10	zinc

APPENDIX C (Continued)

Phonology	Spelling	Number of Words	Summed Frequency	Example	Phonology	Spelling	Number of Words	Summed Frequency	Example
ik	eak*	11	189	speak	iv	eave	3	211	weave
	eek	8	477	creek		eeve	1	11	sleeve
	ique	2	4	clique		eve	1	19	eve
	eik	1	4	sheik	Iv	ive*	2	568	give
	ic	1	7	chic		ieve	1	1	sieve
il	iek	1	5	shriek	iz	eeze	3	33	breeze
	ill	23	2,371	pill		ease*	3	110	tease
il	il	1	1	nil		eize	1	6	seize
	eel	9	346	feel		ese	1	1,000	these
ild	eal	8	206	deal		ieze	1	13	frieze
	uild	2	93	build		eese*	1	9	cheese
ilt	ild*	1	1	gild	Iz	iz	2	4	quiz
	ilt	5	15	tilt		is*	2	2,000	his
im	uilt	2	136	built	o	ow*	14	1,590	slow
	eam	9	285	team		oe*	4	25	toe
Im	eem	2	230	deem		o*	3	1,642	go
	eme	2	88	theme		ough*	2	455	dough
In	im	12	1,102	swim		eau	1	1	beau
	ym	1	2	gym		oa	1	1	whoa
	ymn	1	9	hymn		owe	1	10	owe
	imb*	1	5	limb		ew*	1	6	sew
in	in	17	1,367	skin		ot*	1	1	mot
	inn	1	9	inn	od	ode	4	111	code
	een*	1	1,000	been		oad*	4	263	load
in	een*	8	505	queen	ok	oke	11	273	joke
	ean	7	361	clean		oak	4	26	soak
	ene	2	117	scene	ol	olk	2	35	folk
Ins	ien	2	3	lien		ole	9	532	hole
	ince	4	664	since	old	oll*	5	67	toll
ip	inse	1	6	rinse		oal	3	94	goal
	eep	12	537	sweep		owl*	1	23	bowl
Ip	eap	4	56	cheap		oul*	1	48	soul
	ip	20	377	trip		old	9	1,585	told
lpt	yp	1	6	gyp		ould*	1	1	mould
	ipt	1	11	script	om	ome*	4	569	home
Ir	ypt	1	1	crypt		oam	2	43	foam
	ear*	15	1,583	fear	on	omb*	1	6	comb
	eer	9	101	peer		one*	12	275	phone
	ere*	3	819	mere		own*	6	1,278	grown
Ird	ier	1	4	pier	op	oan	3	49	groan
	eird	1	10	weird		ope	9	305	rope
Is	eard*	1	26	beard	or	oap	1	22	soap
	iss	5	295	kiss		ore	17	1,409	core
is	is*	1	1,000	this		or	3	2,195	nor
	ease*	4	35	cease		oar	2	14	roar
	iece	2	141	niece		our*	2	427	four
	eace	1	201	peace	ord	oor	1	116	poor
Isk	eese*	1	3	geese		orps	1	110	corps
	isk	3	86	risk		ar*	1	464	war
	isc	1	6	disc		ord*	5	137	lord
ist	isque	1	6	bisque		oard	1	239	board
	east*	5	539	feast		orde	1	2	horde
it	iest	1	16	priest		ourd	1	2	gourd
	eat*	12	397	beat		ard*	1	25	ward
	eet	9	829	sheet	ork	ork*	3	33	pork
IT	uite	1	27	suite		orque	1	5	torque
	ith	3	1,055	with	orm	orm*	3	406	storm
iT	yth	1	35	myth		arm*	2	70	warm
	eath*	2	12	wreath	orn	orn	8	238	corn
	eeth	1	103	teeth		orne	1	9	borne
						ourn	1	2	mourn
						arn*	1	11	warn

APPENDIX C (Continued)

Phonology	Spelling	Number of Words	Summed Frequency	Example	Phonology	Spelling	Number of Words	Summed Frequency	Example
orp	orp	1	2	warp	Rst	irst	2	1,004	thirst
	arp*	1	4	thorp		orst	1	35	worst
ors	oarse	2	15	hoarse	Rt	urst	1	33	burst
	orce	1	230	force		irt	6	101	dirt
	ource	1	94	source		urt	3	71	hurt
	ourse	1	465	course	RT	ert	1	2	pert
ort	ort	6	471	port		irth	3	76	birth
	art*	3	17	wart		earth*	2	153	earth
	ourt	1	230	court		erth	1	4	berth
os	ose*	2	245	close	Rv	orth*	1	94	worth
	oss*	1	66	gross		erve	4	125	nerve
ost	oast	4	98	coast	u	urve	1	45	curve
	ost*	4	1,131	post		ew*	16	2,311	new
ot	oat	7	184	throat		ue	8	577	true
	ote	5	401	wrote		o*	4	4,000	who
oT	oath	2	9	loath		oo	2	843	too
	oth*	1	730	both		u	2	18	flu
ov	ove*	11	98	stove		ieu	1	5	lieu
	auve	1	1	mauve		iew	1	186	view
oz	ose*	7	1,067	prose		oe*	1	14	shoe
	oze	1	5	froze		ou*	1	1,000	you
R	ir	4	107	stir		oup*	1	5	coup
	ur	4	31	blur		ough*	1	974	through
	er	2	1,380	her	Ud	ood*	4	1,086	good
	urr	1	5	burr		ould*	3	2,888	should
	yr rh	1	2	myrrh	ud	ude	3	41	rude
	ere*	1	1,000	were		ood*	3	193	food
	our*	1	923	your		ewd	2	11	lewd
	erb	2	11	verb		eud	1	1	feud
Rb	urb	1	13	curb	uD	oothe	1	2	soothe
	urch	2	351	church		ooth*	1	42	smooth
RC	earch	1	66	search	ul	ool*	6	758	cool
	erch	1	1	perch		uel	2	32	fuel
	irch	1	2	birch		ule	2	77	rule
	ird	3	222	bird		oul*	1	1	ghoul
	erd	1	23	herd	Ul	ull*	3	295	full
	urd	1	2	curd		ool*	1	10	wool
	eard*	1	241	heard	um	oom	8	448	room
	ord*	1	274	word		ume	2	3	plume
RJ	urge	4	33	purge		omb*	2	12	tomb
	erge	3	13	merge		eum	1	1	rheum
	irge	1	2	dirge	un	om*	1	146	whom
	ourge	1	2	scourge		oon	6	295	noon
Rk	erk	3	37	clerk		une	4	105	june
	urk	2	6	turk		ewn	1	6	strewn
	irk*	2	4	smirk	up	oop	11	58	loop
	ork*	1	760	work		oup*	2	406	group
Rl	irl	3	225	girl	Ur	oupe	1	3	troupe
	earl	2	24	pearl		ure	4	355	sure
	url	2	5	hurl	us	our*	1	43	tour
Rm	erm	2	82	term		oose*	3	60	loose
	irm	1	109	firm		uce	2	10	truce
	orm*	1	4	worm		uice	2	13	juice
Rn	earn	3	101	learn		use*	1	2	ruse
	urn	3	251	turn		oot*	7	88	root
	ern	2	24	fern	ut	ute	6	18	lute
Rs	ur se	3	42	nurse		uit	2	83	fruit
	erse	2	30	verse		ewt	1	8	newt
	earse	1	1	hearse		oute	1	44	route
	orse	1	50	worse		utte	1	1	butte

APPENDIX C (Continued)

Phonology	Spelling	Number of Words	Summed Frequency	Example	Phonology	Spelling	Number of Words	Summed Frequency	Example
Ut	oot*	2	71	foot	}C	utch	3	21	dutch
	ut*	1	437	put		uch	2	1,937	such
uT	ooth*	2	27	tooth		ouch*	1	87	touch
	uth	1	126	truth	}d	ud	6	53	mud
	outh*	1	82	youth		ood*	2	140	blood
uv	ove*	2	224	prove	}f	uff	10	64	stuff
	oove	1	2	groove		ough*	2	83	rough
uz	use*	3	598	muse	}G	ung	12	196	lung
	ooze	2	6	booze		ongue	1	35	tongue
	uise*	2	5	bruise		oung	1	385	young
	ose*	2	310	lose	}Gk	unk*	11	89	drunk
	oose*	1	50	choose		onk	1	16	monk
W	ow*	9	1,889	plow	}lf	ulf	1	22	gulf
	ou*	1	14	thou		olf*	1	34	golf
	ough*	1	2	bough	}m	um	12	100	drum
Wd	oud	3	98	proud		umb	5	35	numb
	owd	1	53	crowd		ome*	2	1,630	come
Wl	owl*	6	15	fowl		om*	1	1,000	from
	oul*	1	6	foul	}n	un	11	520	fun
Wn	own*	8	1,325	brown		on*	3	261	won
	oun	1	1	noun		one*	3	1,427	none
Wt	out	13	1,039	trout	}nJ	unge	2	9	plunge
	oubt	1	114	doubt		onge	1	7	sponge
	aut*	1	1	kraut	}nt	unt	8	28	hunt
Y	y	15	2,804	dry		ont*	1	221	front
	ie	4	174	tie	}s	us	3	418	plus
	igh	4	604	high		uss	2	5	fuss
	uy	2	121	buy	}t	ut*	8	1,271	nut
	ye	2	11	bye		utt	2	18	putt
	i*	2	1,002	pi	}v	ove*	3	243	glove
	aye	1	2	aye		of	1	1,000	of
	eye	1	143	eye	}z	uzz	2	16	buzz
Yd	ide	12	703	side		as*	1	1,000	was
	uide	1	36	guide	Consistent Mappings				
Yk	ike	6	1,188	hike	@	eah	1	25	yeah
	yke	1	1	dyke	@b	ab	10	52	cab
Yl	ile	8	919	smile	@C	atch*	8	125	catch
	isle	2	6	lisle	@ft	aft	6	68	shaft
	aisle	1	6	aisle	@g	ag	13	114	tag
	ial	1	1	dial	@G	ang	9	126	bang
	uile	1	1	guile	@J	adge	1	5	badge
	yle	1	105	style	@kt	act	5	758	fact
Ym	ime	6	1,097	prime	@lp	alp	1	4	scalp
	yme	1	3	rhyme	@lv	alve*	1	3	valve
	imb*	1	12	climb	@mp	amp*	10	129	lamb
Yn	ine	15	721	pine	@n	an*	15	4,448	van
	ign	1	94	sign	@nC	anch*	2	60	branch
	ein*	1	18	stein	@nd	and*	11	1,961	sand
Yp	ipe	6	51	wipe	@nJ	ange*	1	2	flange
	ype	1	200	type	@p	ap*	19	161	snap
Yr	ire	8	278	tire	@ps	apse	1	6	lapse
	yre	1	1	pyre	@pt	apt	2	16	apt
Ys	ice	13	440	vice	@sk	ask	5	203	task
	ise*	1	1	vise	@sp	asp*	3	22	grasp
Yt	ight	15	2,529	flight	@t	at*	14	2,436	flat
	ite	12	904	white	@T	ath*	5	85	path
	eight*	1	35	height	ab	ob	10	318	job
Yz	ize	2	169	size	aC	otch	2	11	scotch
	ise*	2	138	wise	ag	og*	2	3	flog
	uise*	1	6	guise					

APPENDIX C (Continued)

Phonology	Spelling	Number of Words	Summed Frequency	Example	Phonology	Spelling	Number of Words	Summed Frequency	Example
aGst	angst	1	2	angst	Ers	arce*	1	6	scarce
aJ	odge	2	30	lodge	ES	esh	3	138	mesh
aks	ox	3	88	fox	Esk	esk	1	65	desk
al	oll*	2	15	doll	eT	aith	1	111	faith
ampt	ompt	1	11	prompt	ET	eath*	2	330	breath
ans	once*	1	1	nonce	Ev	ev	1	33	rev
anz	onze	1	11	bronze	eZ	eige	1	1	beige
arb	arb	1	3	garb	Ib	ib	4	9	crib
arC	arch	3	137	march	iD	eathe	1	7	breathe
arf	arf*	1	4	scarf	Id	id	9	1,155	lid
arJ	arge	3	490	charge	Idst	idst	1	19	midst
arm	arm*	4	270	charm	IdT	idth	1	14	width
arn	arn*	3	46	barn	Ift	ift	7	153	drift
arp	arp*	2	73	sharp	ig	eague	1	69	league
arS	arsh	2	16	marsh	Ig	ig	12	480	pig
arT	earth*	1	4	hearth	IG	ing	16	876	sing
arv	arve	2	4	carve	IGks	inx	2	2	sphinx
as	oss*	2	5	dross	IJ	idge	3	120	ridge
ask	osque	1	10	mosque	iJ	iege	1	6	siege
asp	asp*	1	2	wasp	Ik	ick	19	399	slick
aT	ath*	1	1	swath	Iks	ix	3	247	mix
av	uave	1	2	suave	Ikt	ict	1	11	strict
cC	atch*	1	81	watch	ild	ield	4	318	yield
cft	oft	3	64	loft	IlJ	ilge	1	2	bilge
cG	ong	8	1,167	song	Ilk	ilk	2	61	silk
cg	og*	7	117	frog	Ilm	ilm	1	96	film
cld	ald	2	6	bald	IlT	ilth	2	3	filth
clv	olve	1	20	solve	Imf	ymph	2	3	lymph
cS	ash*	1	37	wash	Imp	imp	4	18	limp
cst	ost*	3	408	lost	Imps	impse	1	16	glimpse
cT	oth*	4	48	cloth	InC	inch	4	51	cinch
eb	abe	1	8	babe	ind	iend*	1	3	fiend
EC	etch	5	50	fetch	Ind	ind*	1	63	wind
eD	athe	2	5	bathe	InJ	inge	4	22	fringe
ef	afe	3	61	safe	Int	int*	9	52	hint
Eft	eft	4	494	theft	Irk	irk*	1	1	kirk
eg	ague	2	31	vague	Irs	ierce	2	14	pierce
EGT	ength	2	252	length	iS	eash	1	3	leash
EJ	edge	5	93	ledge	IS	ish	3	161	dish
Eks	ex	4	89	flex	Isp	isp	2	10	crisp
Ekst	ext	2	454	text	Ist	ist*	7	204	twist
Ekt	ect	1	2	sect	It	it	17	1,493	quit
El	ell	16	1,591	bell	Its	itz	1	3	blitz
ElC	elch	2	16	welch	O	oy	6	294	joy
Eld	eld	3	269	weld	ob	obe	4	28	lobe
Elf	elf	2	52	shelf	oC	oach	4	28	coach
Elk	elk	1	1	elk	Od	oid	1	10	void
Elp	elp	3	315	help	oD	othe	1	1	clothe
Els	else	1	176	else	of	oaf	1	4	loaf
ElS	elsh	1	4	welsh	og	ogue	2	7	vogue
EIT	ealth	3	132	wealth	oks	oax	1	1	coax
Elv	elve	1	48	twelve	Ol	oil	7	171	spoil
Em	em	4	1,037	stem	olt	olt	3	32	bolt
Empt	empt	1	2	tempt	On	oin	4	80	coin
En	en	11	3,018	pen	Ont	oint	2	434	joint
EnC	ench	6	179	bench	orb	orb	1	1	orb
enJ	ange*	3	484	strange	orC	orch	2	45	porch
Enz	ens	1	12	lens	orf	arf*	2	7	wharf
Ep	ep	2	150	prep	org	orgue	1	1	morgue
Ept	ept	3	229	swept	orJ	orge	2	11	forge
EpT	epth	1	53	depth	orps	orpse	1	7	corpse

APPENDIX C (Continued)

Phonology	Spelling	Number of Words	Summed Frequency	Example	Phonology	Spelling	Number of Words	Summed Frequency	Example
orT	orth*	2	277	forth	Yld	ild*	3	283	mild
orts	artz	1	1	quartz	Ynd	ind*	7	1,096	bind
oS	auche	1	1	gauche	Ynt	int*	1	13	pint
Os	oice	2	339	choice	Yst	ist*	1	97	christ
Ost	oist	2	12	moist	YT	ithe*	1	2	blithe
Oz	oise	2	43	poise	Yv	ive*	7	425	strive
Rf	urf	2	4	turf	}b	ub	10	196	hub
Rld	orld	1	787	world	}g	ug	15	117	slug
Ub	ube*	1	1	rube	}J	udge	5	93	judge
uh	ube*	2	32	tube	}k	uck	12	242	duck
Uf	oof*	1	2	hoof	}ks	ux	2	32	crux
uf	oof*	3	100	roof	}kt	uct	1	1	duct
uJ	uge	1	54	huge	}l	ull*	6	60	dull
Uk	ook	8	1,133	hook	}lb	ulb	1	7	bulb
uk	uke	3	13	duke	}lC	ulch	1	6	mulch
Ulf	olf*	1	6	wolf	}lJ	ulge	1	5	bulge
US	ush*	2	51	bush	}lk	ulk	3	19	bulk
ust	oost	2	16	boost	}lp	ulp	2	7	pulp
uZ	ouge*	1	7	rouge	}ls	ulse	1	9	pulse
WC	ouch*	4	22	couch	}lt	ult	1	11	cult
WJ	ouge*	1	1	gouge	}mp	ump	14	78	bump
Wnd	ound	9	1,123	hound	}nC	unch	6	65	punch
WnJ	ounge	1	9	lounge	}nd	und	1	62	fund
Wns	ounce	2	11	bounce	}nk	unk*	1	1	gunk
Wnt	ount	2	75	mount	}ns	once*	1	499	once
Wr	our*	6	1,194	flour	}nT	onth	1	130	month
Ws	ouse*	4	605	mouse	}p	up	4	1,048	pup
Wst	oust	2	4	joust	}S	ush*	10	96	lush
WT	outh*	3	344	mouth	}sk	usk	2	19	dusk
Wz	ouse*	2	5	spouse	}sp	usp	1	2	cusp
Yb	ibe	4	10	tribe	}st	ust	10	2,041	rust
YD	ithe*	2	6	lithe	}tz	ertz	1	1	hertz
Yf	ife	5	1,026	knife					

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