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

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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. Coltheart & 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 nonwords. 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, monomorphemic 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 /Int/ as in *hint* and /-Ynt/ as in *pint* (see Appendix B). This column indicates that the *-int* → /Int/ 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* → /Int/ 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 inconsistent (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.

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

	Feedback					
	Consistent		Inconsistent		Σ	
	n	%	*n*	%	*n*	%
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.

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 appendices, 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
Stops	b	*b*ig
	p	*p*ig
	d	*d*ay
	t	*t*ip
	g	pi*g*
	k	pi*ck*
Affricates	C	*ch*ip
	J	*j*oke
Strong Fricatives	s	*s*it
	S	*sh*e
	z	*z*one
	Z	a*z*ure
Weak Fricatives	f	*f*ig
	v	*v*an
	T	*th*in
	D	*th*en
	h	*h*og
Nasals	n	*n*ip
	m	*m*an
	G	si*ng*
Syllabic Consonants	N	butt*on*
	M	bott*om*
	L	bott*le*
Glides and Semivowels	l	*l*ip
	r	*r*ip
	w	*w*ig
	y	*y*et
Lax Vowels	E	m*e*t (short e)
	I	p*i*n (short i)
	} (^)	n*u*t (short u)
	U	l*oo*k
Tense Vowels	e	f*a*te (long a)
	@	f*a*t (short a)
	i	m*ea*t (long e)
	Y	p*i*ne (long i)
	o	n*o*te (long o)
	a	n*o*t (short o)
	R	b*ir*d (syllabic /r/)
Diphthongs	u	n*ew*, bl*ue*
	c	l*aw*, th*ough*t
	W	n*ow*, m*ou*th
	O	t*oy*

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

APPENDIX B (Continued)

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

APPENDIX B (Continued)

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

APPENDIX B (Continued)

Spelling	Phonology	Number of Words	Summed Frequency	Example
earl	Rl*	2	24	pearl
earn	Rn*	3	101	learn
earse	Rs*	1	1	hearse
eart	art*	1	176	heart
eash	iS	1	3	leash
eathe	iD	1	7	breathe
eau	o*	1	1	beau
eave	iv*	3	211	leave
eb	Eb*	2	7	web
ebb	Eb*	1	1	ebb
ebt	Et*	1	13	debt
eck	Ek*	9	216	beck
ect	Ekt	1	2	sect
ed	Ed*	10	534	bed
edge	EJ	5	93	wedge
ee	i*	14	1,835	bee
eech	iC*	3	68	speech
eed	id*	14	667	speed
eef	if*	2	43	reef
eek	ik*	8	477	seek
eel	il*	9	346	feel
eem	im*	2	230	seem
eep	ip*	12	537	deep
eer	Ir*	9	101	deer
eet	it*	9	829	feet
eeth	iT*	1	103	teeth
eeve	iv*	1	11	sleeve
eeze	iz*	3	33	breeze
ef	Ef*	1	9	chef
eft	Eft	4	494	left
eg	Eg*	4	75	leg
egg	Eg*	1	12	egg
eige	eZ	1	1	beige
eigh	e*	1	4	weigh
eign	en*	1	7	reign
eik	ik*	1	4	sheik
eil	el*	1	8	veil
eint	ent*	1	2	feint
eir	Er*	2	1,007	their
eird	Ird*	1	10	weird
eize	iz*	1	6	seize
ek	Ek*	1	2	trek
elch	ElC	2	16	belch
eld	Eld	3	269	held
elf	Elf	2	52	shelf
elk	Elk	1	1	elk
ell	El	16	1,591	bell
elm	Elm*	2	7	helm
elp	Elp	3	315	help
else	Els	1	176	else
elsh	ElS	1	4	welsh
elt	Elt*	3	390	belt
elte	Elt*	1	1	svelte
elve	Elv	1	48	twelve
em	Em	4	1,037	gem
eme	im*	2	88	theme
empt	Empt	1	2	tempt
en	En	11	3,018	when
ence	Ens*	4	97	hence
ench	EnC	6	179	bench
end	End*	10	676	trend
ene	in*	2	117	gene
engh	EGT	2	252	strength
ens	Enz	1	12	lens
ense	Ens*	3	335	dense
ent	Ent*	11	1,015	went
ep	Ep	2	150	step
epe	ep*	1	1	crepe
ept	Ept	3	229	kept
epth	EpT	1	53	depth
er	R*	2	1,380	her
erb	Rb*	2	11	herb
erch	RC*	1	1	perch
erd	Rd*	1	23	herd
erge	RJ*	3	13	merge
erk	Rk*	3	37	clerk
erm	Rm*	2	82	term
ern	Rn*	2	24	stern
err	Er*	1	1	err
erse	Rs*	2	30	terse
ert	Rt*	1	2	pert
erth	RT*	1	4	berth
ertz	}tz	1	1	hertz
erve	Rv*	4	125	nerve
es	Es*	1	144	yes
ese	iz*	1	1,000	these
esh	ES	3	138	flesh
esk	Esk	1	65	desk
ess	Es*	8	806	bless
est	Est*	15	1,005	best
et	Et*	12	2,245	bet
etch	EC	5	50	fetch
ete	et*	1	3	fete
eud	ud*	1	1	feud
eum	um*	1	1	rheum
ev	Ev	1	33	rev
eve	iv*	1	19	eve
ewd	ud*	2	11	shrewd
ewn	un*	1	6	strewn
ewt	ut*	1	8	newt
ex	Eks	4	89	flex
ext	Ekst	2	454	text
eye	Y*	1	143	eye
ial	Yl*	1	1	dial
ib	Ib	4	9	crib
ibe	Yb	4	10	tribe
ic	ik*	1	7	chic
ice	Ys*	13	440	dice
ich	IC*	2	1,074	which
iche	IC*	1	3	niche
ick	Ik	19	399	brick
ict	Ikt	1	11	strict
id	Id	9	1,155	slid
ide	Yd*	12	703	bride
idge	IJ	3	120	bridge
idst	Idst	1	19	midst
idth	IdT	1	14	width
ie	Y*	4	174	die
iece	is*	2	141	piece
ief	if*	4	210	brief
iege	iJ	1	6	siege
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	Rl*	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
oothe	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	ord*	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	Rl*	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
usp	}sp	1	2	cusp
uss	}s*	2	5	fuss
ust	}st	10	2,041	bust
utch	}C*	3	21	dutch
ute	ut*	6	18	brute
uth	uT*	1	126	truth
utt	}t*	2	18	butt
utte	ut*	1	1	butte
ux	}ks	2	32	crux
uy	Y*	2	121	guy
uzz	}z*	2	16	buzz
y	Y*	15	2,804	dry
ye	Y*	2	11	rye
yke	Yk*	1	1	dyke
yle	Yl*	1	105	style
ym	Im*	1	2	gym
yme	Ym*	1	3	rhyme
ymn	Im*	1	9	hymn
ymph	Imf	2	3	lymph
yp	Ip*	1	6	gyp
ype	Yp*	1	200	type
ypt	Ipt*	1	1	crypt
yre	Yr*	1	1	pyre
yrrh	R*	1	2	myrrh
yth	IT*	1	35	myth

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

APPENDIX C (Continued)

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

APPENDIX C (Continued)

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

APPENDIX C (Continued)

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

APPENDIX C (Continued)

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

APPENDIX C (Continued)

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

APPENDIX C (Continued)

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

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