British English norms for the spontaneous completion of three-letter word stems

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Word stem completion tasks involve showing participants a number of words and then later asking them to complete word stems to make a full word. If the stem is completed with one of the studied words, it indicates memory. It is a test widely used to assess both implicit and explicit forms of memory. An important aspect of stimulus selection is that target words should not frequently be generated spontaneously from the word stem, to ensure that production of the word really represents memory. In this article, we present a database of spontaneous stem completion rates for 395 stems from a group of 80 British undergraduate psychology students. It includes information on other characteristics of the words (word frequency, concreteness, imageability, age of acquisition, common part of speech, and number of letters) and, as such, can be used to select suitable words to include in a stem completion task. Supplemental materials for this article may be downloaded from <http://brm.psychonomic-journals.org/content/supplemental>.

Word stem completion (WSC) tasks have a long history of use in psychology, where their initial introduction indicated that implicit memory can be preserved in amnesic patients (Warrington & Weiskrantz, 1970). Participants are shown lists of words, unaware of a later memory task. Subsequently, they are presented with the first few letters of a word and are asked to complete this stem with the first word that comes to mind (see Roediger, Weldon, Stadler, & Riegler, 1992, for a review). Explicit memory versions ask for completions that are remembered from the study list (Greene, 1986). An increase in stem completion levels due to preexposure of the words indicates memory. This methodology is still widely used in tasks ranging from cerebral blood flow measures (Sorond, Schnyer, Serrador, Milberg, & Lipsitz, 2008) to behavioral tasks in healthy participants (Benjamin Clarke & Butler, 2008) and patients (e.g., Alzheimer's disease, LaVoie & Faulkner, 2008; schizophrenia, Pope & Kern, 2006).

The selection of words to use in WSC tasks is critical. The stem must be able to form multiple words when completed. Words should not be proper nouns and should have sufficient frequency for participants to know them and their meanings. They should have relatively matched imageability and concreteness. Information on these characteristics is available through established databases (e.g., M. Wilson, 1988).

One key criterion, particularly important for implicit tasks, is that the words used should not commonly be produced in a spontaneous WSC task. Since participants must generate the first completion that comes to mind, a frequent spontaneous completion reduces the distance between chance and ceiling performance. In imaging

studies, “correct” responses would be more likely to be guesses, adding unwanted noise to the neural signal. Matching low levels of spontaneous WSC across word lists—and ideally, all words—ensures that tasks are sensitive and reliable.

Spontaneous WSC rates are not easily available, and studies have run pilot tests (e.g., Fleischman et al., 2002; D. E. Wilson & Horton, 2002) or approximated rates from whole-word frequency (e.g., Chiarello & Hoyer, 1988; Pope & Kern, 2006). The available databases are based on different languages (Martin et al., 2009; Olofsson & Nyberg, 1992) and, thus, are of limited value to English-speaking populations, or they use few stems (Graf & Williams, 1987; Lee & Leslie, 2003). Data have been collected for 914 stems using American undergraduate students (Shaw, 1997), but completions include multiple (e.g., *air bag*), hyphenated (e.g., *cul-de-sac*), and abbreviated (e.g., *aren't*) words. In addition, raw numbers of completions, rather than more interpretable proportions, have been reported, without any additional information on other characteristics of the words. To the best of our knowledge, there is no large source of rates of spontaneous WSC, particularly using British English; this article presents such a database.

We generated a list of 395 potential three-letter word stems from which each of 80 participants viewed a selection of 200 stems. The participants were asked to complete them with the first word that came to mind. Results are presented as a WSC frequency database including data for each word on frequency, concreteness, imageability, age of acquisition, common part of speech, and number of letters.

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METHOD

Participants

The participants ($N = 80$; 6 of them male; average age, 20 years) were recruited from undergraduate students in the School of Psychological Sciences at the University of Manchester and received course credit for participating. Ethical approval was received from the School of Psychological Sciences Research Ethics Committee.

Materials

A list of 395 three-letter word stems was generated (see the Appendix), using materials from other WSC tasks and identifying stems from the dictionary where multiple words (≥ 4) could be completed.

Procedure

Stems were presented individually on a computer screen using E-Prime (Psychology Software Tools, Pittsburgh, PA), and the participants were asked to finish each one with the first word that came to mind, avoiding proper nouns. If they could not find a completion within 10 sec, they were asked to enter a question mark. This timed cutoff for responding is in keeping with behavioral tasks (e.g., Fleischman, Wilson, Gabrieli, Bienias, & Bennett, 2004; Roediger et al., 1992). Responses were made by typing the remainder of the word, which appeared on the screen. Each participant viewed a randomly ordered, random selection of 200 stems from the full list of 395 to avoid participant fatigue and maintain motivation. The experiment was self-paced, taking between 8 and 20 min.

RESULTS

Data Cleaning

Data were checked for British spelling, and proper nouns, such as *Manchester*, were excluded. To avoid substantial data loss, exceptions to this were months of the year and days of the week (e.g., for the *fri* stem, *Friday* was produced 71% of the time) and nationalities (e.g., *German* for *ger*), which can be used as adjectives and have a common noun meaning. Individual, well-established proprietary names were not excluded—for example, *sellotape*, *google*, and *hoover*—since these have entered general usage and are not generally viewed as brand distinctive (e.g., *google*, meaning *to search*). Words were excluded when a spelling correction changed the three-letter stem (e.g., *aqua* incorrectly spelled as *acqua* was deleted, whereas *necter* as a misspelling of *nectar* was corrected and included).

Incorrectly spelled words that could not be identified were excluded, as were two-word answers (e.g., *cat woman*). The average number of included words for each participant was 191.5, and each stem was presented to and received a valid response from an average of 38.8 participants (range, 24–61). The mean proportion of a “?” response—that is, when the participants could not think of a word to complete within 10 sec—was 9.57%.

Different derivations of the same word were not amalgamated (e.g., *abbot* and *abbots* were left separate), but it may be appropriate to do this in many circumstances.

Results Output

The results are presented as an online database (see supplemental information for raw data): <http://personalpages.manchester.ac.uk/staff/Andrew.Mayes/wordcount/>.

Using the database, a stem can be selected to view the frequency of the spontaneously completed words. This includes the frequency with which the participants could not produce a word to complete any given stem (shown by a question mark). The database also displays various other characteristics of words (word frequency, concreteness, imageability, age of acquisition, common part of speech, and number of letters), where these norms were available.

We have also generated an example list of 200 words that could be used in memory tasks, with a spontaneous stem completion rate cutoff of less than 5%, for which imageability and concreteness ratings were available (taken from M. Wilson, 1988). This includes words that were never produced as completions but match all the other criteria (see the supplemental information for full details). Since the ratings are available only for a subset of words, it may not always be possible to use them as criteria. However, there will be many other equally suitable approaches to word selection, such as avoiding all stems that are words in themselves (e.g., *cat/tab*) or taking words from the same part of speech (e.g., nouns). The supplemental information allows calculation of WSC rates for specific parts of speech, if needed.

DISCUSSION

We have provided a database of spontaneous WSC rates for 395 stems. At least 24 people gave a valid completion (or indicated they could not think of one) to each stem. These data can be used to ensure that targets in both explicit and implicit memory WSC tasks are not likely to be guessed by participants. Such careful stimulus selection should ensure that memory will be indexed as reliably as possible.

This approach is more likely to be useful than basing selection on whole-word frequency. For example, using the word stem *aut*, the most frequently completed word was *autumn* (51.52%), with *authority* having a much lower rate (3.03%). Comparing these WSC rates against word frequency (Kučera & Francis, 1967, taken from M. Wilson, 1988; Leech, Rayson, & Wilson, 2001), the more frequent completion (*autumn*) has a lower frequency (22 vs. 93 with Kučera & Francis, 1967; 39 vs. 183 with Leech et al., 2001). Using word frequency as an estimate of spontaneous WSC rates may, therefore, be misleading, since it is a variable and, at best, moderate predictor of completion (Graf & Williams, 1987; Shaw, 1997). Our example list of words for memory studies uses a very low cutoff of spontaneous WSC (below 5%). This is an arbitrary level, and the most appropriate level of spontaneous completion rates for optimal priming/cued-recall performance has not been demonstrated. Using words that are never completions in a spontaneous task may in itself bias performance, but having a database providing the information can inform word selection, regardless of criterion chosen.

The database presented is based on a sample of U.K. undergraduate psychology students. Although these responses may not extrapolate to other populations, the data can help

indicate words that are more appropriate than others. The importance of culturally appropriate norms is highlighted by a comparison against an American college population (Shaw, 1997). Their data would have excluded 23% of the words in our example list, since the stem completion rates from their sample were above 5%. However, against other published rates from North American samples, we can show a good match. Comparing rates for lists published in Brooks, Gibson, Friedman, and Yesavage (1999), our database produces mean rates for each list (where stems overlap) that are different only by an average of 1.9%. This suggests at least some utility for non-British samples.

In combination with other established databases on word characteristics (e.g., Leech et al., 2001; Stadthagen-Gonzalez & Davis, 2006; M. Wilson, 1988), our data provide additional information for stimulus selection. This should be helpful to those conducting WSC memory studies, due to the large number of stems and the participants sampled, who represent the population used in many experiments run in universities. The database allows researchers to control for spontaneous completion rates, an often overlooked, but critically important, aspect of word selection.

AUTHOR NOTE

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SUPPLEMENTAL MATERIALS

The raw data discussed in this article, as well as norms for 200 words that may be used in stem completion studies, may be downloaded from <http://brm.psychonomic-journals.org/content/supplemental>.

APPENDIX
List of All Word Stems Used

aba	ana	bio	cli	emp	gle	inv	men	pea	rav	sol	tra
abb	anc	bir	clo	enc	glo	jac	mer	pen	rea	sou	tre
abd	ang	bis	coc	end	gol	jer	met	per	rec	spa	tri
abi	ani	bla	com	ent	goo	jou	mil	pet	ref	spe	tro
abl	ann	blo	cor	epi	gor	jun	min	pha	reg	spi	tru
abo	ant	blu	cou	esc	gra	kil	mis	pho	rel	squ	tur
abr	apo	boo	cra	est	gre	kin	mod	pic	rep	sta	twi
abs	app	bou	cre	exp	gri	kit	mon	pil	res	ste	ult
aca	ara	bra	cri	fac	gro	kna	mor	pit	rin	sti	uni
acc	arb	bre	cur	fal	gua	kni	mos	pla	ris	sto	vac
ach	arc	bri	dan	fam	gui	kno	mot	ple	roa	str	val
acq	arm	bro	deb	fan	hab	lan	mou	plo	roo	stu	van
acr	arr	bur	def	fat	hal	lar	mus	plu	rou	suc	var
act	art	but	del	fea	han	lat	mut	pol	rus	sul	ven
add	asp	cab	dem	fel	har	lea	nat	pom	sab	sum	ver
adj	ass	cal	dep	fer	hea	leg	nec	pop	sac	sup	vic
adm	ast	cam	des	fil	her	lib	neg	por	sag	sur	vil
ado	att	can	det	fin	hil	lig	neu	pos	sal	swe	vis
adv	aut	cap	dia	fla	hin	lim	nig	pou	sat	swi	vit
aer	awa	car	dis	fle	hol	lin	not	pra	sca	tab	vol
aff	bac	cas	doc	for	hom	loc	obs	pre	sco	tac	wag
afr	bal	cat	dra	fra	hoo	loo	occ	pri	scr	tal	wal
aft	ban	cel	dre	fre	hor	lum	oct	pro	scu	tan	war
ali	bar	cen	dri	fri	hou	mac	off	psy	sec	tar	wea
all	bas	cer	dro	fro	hum	mag	ope	pul	sel	tee	whi
alm	bat	cha	duc	gal	hun	mal	ora	pun	sen	tel	wil
alo	bea	che	dun	gam	hyd	man	org	pur	ser	ten	win
alt	bee	chi	dyn	gan	ill	mar	pal	qua	sha	ter	woo
ama	beg	cho	ear	gar	imp	mat	pan	qui	she	thi	wor
amb	beh	chu	eff	gau	inc	mea	pap	rac	shi	thr	wre
ami	bel	cir	ele	gen	ind	med	par	rad	sho	thu	wri
amo	ben	cla	eli	ger	ins	mel	pas	rai	sin	tom	yea
amp	ber	cle	emb	gla	int	mem	pat	ran	sla	tor	

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