

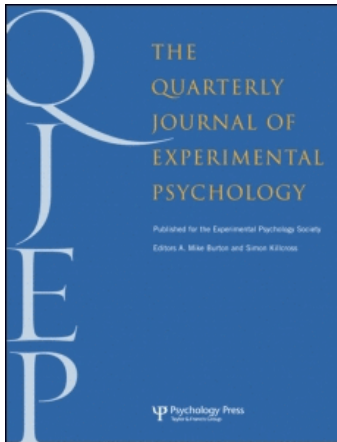
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Marc Brysbaert<sup>ab</sup>; Sara Speybroeck<sup>ab</sup>; Dieter Vanderelst<sup>ab</sup>

<sup>a</sup> Ghent University, Ghent, Belgium <sup>b</sup> Royal Holloway, University of London, Egham, UK

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# Is there room for the BBC in the mental lexicon? On the recognition of acronyms

Marc Brysbaert, Sara Speybroeck, and Dieter Vanderelst

*Ghent University, Ghent, Belgium, and Royal Holloway, University of London, Egham, UK*

It has been suggested that acronyms like BBC are processed like real words. This claim has been based on improved performance with acronyms in the Reicher–Wheeler task, the letter string matching task, the visual feature integration task, and the N400 component in event-related potential (ERP) studies. Unfortunately, in all these tasks performance on acronyms resembled performance on pseudo-words more than performance on words. To further assess the similarity of acronyms and words, we focused on the meaning of the acronyms and used masked priming to examine whether target words can be primed to the same extent with associatively related acronyms as with associatively related words. Such priming was possible at a stimulus onset asynchrony (SOA) of 84 ms. In addition, the priming of the acronyms did not depend on the letter case in which they were presented: The target word “books” was primed as much by isbn and iSbN as by ISBN.

**Keywords:** Mental lexicon; Acronym; Masked priming; Associative priming; Word recognition.

Everyone who has ever lived in the UK has been bewildered by the omnipresence of abbreviations. For instance, foreigners trying to register their used car must pass MOT (not to be confounded with MOD) and send letters to DVLA, hoping they will end up with the desired V5C (not to be mistaken for VIC) rather than the dreaded SORN. Similarly, helpful universities provide their new staff with lists of the most common abbreviations they have to know for proper functioning (especially those related to health and safety).

A search through the internet (see in particular <http://en.wikipedia.org/wiki/Acronym>, retrieved on 15 August 2008) suggests that although abbreviations have been around for a long time (think of

AD and BC), the surge in their usage is a typical 20th-century phenomenon. Abbreviations consisting of the first letters of a fixed expression are usually called acronyms. Originally, this name was limited to abbreviations with orthographically legal letter sequences that could be pronounced (such as NATO, VOSA, HOMER), whereas illegal letter sequences (DVLA, RSPCA) were called initialisms. Gradually, however, the term acronym came to be used to denote all letter sequences consisting of initial letters.

The existence of acronyms raises the question of how they are recognized: Are they processed like words or like pictures? In 1964, Gibson, Bishop, Schiff, and Smith showed that acronyms were more likely to be identified in a perceptual

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Correspondence should be addressed to Marc Brysbaert, Department of Experimental Psychology, Ghent University, Henri Dunantlaan 2, B-9000 Ghent, Belgium. E-mail: marc.brysbaert@ugent.be

identification task than were meaningless letter strings of the same length, but such a finding is in line both with the idea of an acronym as a word and with the hypothesis of an acronym as a picture. Research on the question experienced some further popularity in the 1970s and 1980s, when researchers tried to understand the specifics of two popular tasks at the time.

The first paradigm was the Reicher–Wheeler task. In this paradigm, participants had to identify a letter in a letter string. The most important finding was that letter identification was better when the letter was part of a word (e.g., “F” in FIB) than when it was part of an illegal letter string (e.g., “F” in BFI). This is the so-called word superiority effect (WSE). To understand the mechanisms underlying the WSE, researchers compared letter identification for pseudowords (letter strings that did not form a word but that followed the orthographic rules of the language; e.g., BIF) and illegal letter strings that were familiar acronyms (FBI). Pseudowords were used because they allowed researchers to test the importance of orthographic legality; acronyms were used because they allowed researchers to test the impact of stimulus familiarity.

The usual finding was that both pseudowords and acronyms resulted in better letter identification than illegal, unfamiliar letter strings (e.g., Besner, Davelaar, Alcott, & Parry, 1984; Noice & Hock, 1987; see also Staller & Lappin, 1981, for a related task). Surprisingly, none of these studies included all the conditions. Such a study was published only recently. Laszlo and Federmeier (2007a) compared letter identification in words (DUCT), pseudowords (DAWK), acronyms (HDTV), and illegal letter strings (GHTS). They obtained percentages of identification of, respectively, 88%, 84%, 77%, and 73%. The difference between 77% and 73% was significant and pointed to an acronym superiority effect.

The second paradigm in which acronyms were used was letter string matching. Two strings of letters were presented simultaneously, and participants had to indicate whether the strings were the same or different. The most robust finding in this paradigm again was that participants were faster to

make a decision when the stimuli were familiar words than when they were illegal letter strings. As in the Reicher–Wheeler task, pseudowords and acronyms were used to decide whether the word superiority effect was due to orthographic legality or to familiarity. A typical example is provided by Carr, Posner, Pollatsek, and Snyder (1979, Experiment 1). They compared the times needed to decide that letter strings like FIB–FIB, BIF–BIF, FBI–FBI, and IBF–IBF were the same. They obtained response times of, respectively, 534, 541, 565, and 593 ms, again showing effects of both orthographic regularity (541 vs. 593 ms) and familiarity (565 vs. 593 ms). Other researchers using this task were Henderson (1974), Henderson and Chard (1976), Seymour and Jack (1978), and Besner (1984).

On the basis of the above findings, researchers concluded that acronyms were processed like words and were part of the mental lexicon, despite their orthographic illegality (e.g., Besner et al., 1984; Coltheart, 1978). Besner et al. (1984) added two more pieces of evidence for this conclusion. First, acronyms were recognized better in the right visual field than in the left visual field, in line with words and in contrast to logographs. Second, participants could report more letters from tachistoscopically presented acronyms than from meaningless control stimuli, also when the acronyms were presented in a distorted format by changing the size of one of the letters (e.g., FBi).

Further evidence for the idea that acronyms were recognized like words was published by Prinzmetal and Millis–Wright (1984). They started from the finding that participants more often misattribute a letter’s colour in words than in nonwords. For instance, participants were given the stimulus AGE or VGH and were asked to name the colour of the letter G (each letter had a different colour). When the stimulus was a word, participants erroneously gave the colour of another letter in 9.3% of the trials; with nonwords stimuli this was only so in 5.2% of the trials (Experiment 1). A similar asymmetry was observed for acronyms (11.8%) versus matched meaningless letter sequences (8.5%; Experiment 4).

Research on acronyms recently enjoyed a small revival with the work of Laszlo and Federmeier, who used these stimuli in event-related potential (ERP) experiments. In these experiments the electric brain response to different types of stimuli is registered. An interesting finding here is that the response to words differs reliably from the response to illegal letter strings. In particular, a negative-going deflection around 400 ms (the so-called N400 component) is much stronger for words than for illegal letter strings. A useful design to examine this difference is repetition priming. In this design, the stimuli are presented twice with some trials in between. The usual finding is that the N400 component for words is much smaller the second time than the first time, whereas there is no difference for illegal letter strings. So, by calculating the difference in N400 between the first and the second presentations, researchers can easily compare the extent to which other stimuli resemble words or illegal letter strings. Laszlo and Federmeier (2007b) looked at the repetition priming effects for words, pseudowords, acronyms, and illegal letter strings. Participants were reading words silently and had to press on a button each time they saw a common English first name (names were interspersed randomly in the list of experimental stimuli). The repetition priming effect was significant for words (a priming effect of  $-1.2 \mu\text{V}$ ), pseudowords ( $-1.4 \mu\text{V}$ ), and acronyms ( $-1.9 \mu\text{V}$ ), but not for illegal letter strings ( $-.3 \mu\text{V}$ ). Further analysis indicated that the participants only showed a repetition priming effect for those acronyms they knew, in line with the hypothesis that the priming was due to the familiarity with the stimuli and not to some variable specific to the acronyms used. Laszlo and Federmeier (2008) later replicated the findings in a related design in which words or acronyms were primed by the preceding sentence context.

On the basis of the above findings it would seem safe to assume that the British mental lexicon indeed has room for an acronym like the BBC, even though it violates the English orthography in various ways (e.g., no English

word lacks a vowel, no English word starts with BB or ends on BC). Unfortunately, to a sceptical eye the evidence is less convincing than hoped for.

The main problem is that all the acronym-related effects listed above are obtained with pseudowords as well. This was true for the word superiority effect in the Reicher–Wheeler task, for the word superiority effect in the letter string matching paradigm, for the colour migrations of Prinzmetal and Millis–Wright (1984; see their Experiment 3), and for the N400 priming effects reported by Laszlo and Federmeier (2007b; although in this case the ERP signal of acronyms overall resembled that of words more than that of pseudowords). Given that pseudowords are not represented in the mental lexicon, this raises the question of what exactly causes the difference between acronyms and illegal letter strings. Carr et al. (1979), for instance, argued that in the letter string matching task the difference was due to a shift in the response criterion as a result of stimulus familiarity (participants were faster to respond “same” to familiar stimuli than to unfamiliar stimuli, even before identifying the specific stimuli presented).

A further problem is that there is quite some evidence that acronyms are better processed in their familiar upper-case format than in an unfamiliar format. For instance, Besner et al. (1984; Table 9.4) observed that participants identified tachistoscopically presented acronyms like FBI more often than meaningless control sequences like IBF (56% identification vs. 52% identification). However, no such superiority was found for acronyms presented in lower case; there was even a trend in the reverse direction (50% for fbi vs. 52% for ibf). Similarly, Seymour and Jack (1978) reported a strong effect of letter case for acronyms in a letter string matching task. Participants were faster to indicate that letter strings like RAF–RAF and USA–USA were the same (717 ms) than to indicate that letter strings like raf–raf and usa–usa were the same (771 ms). No similar effect was found for meaningless control strings (807 ms vs. 806 ms). Along the same lines, Hall, Humphreys, and

Cooper (2001) reported a patient with attentional dyslexia who could name more acronyms in upper case (10/40) than in lower case (5/40). In contrast, he read more words in lower case (47/60) than in upper case (37/60). The patient also named more acronyms without spaces between the letters (e.g., GCSE; 27/39) than acronyms with two blank spaces between the letters (G C S E, 20/39).

The fact that acronym processing differs between upper-case and lower-case format contrasts with results from research on visual word recognition. A typical finding here is that letter case is of minor importance. For instance, Rayner, McConkie, and Zola (1980) found no difference in reading speed when participants saw the upcoming words in parafoveal vision in the same case as when they saw them later in foveal vision or in a different case. Similarly, Forster (1998, p. 221) reported an experiment in which the effect of case alternation was examined in masked priming (see below for an explanation of the technique). He observed that the target word DENTIST was primed to the same extent by the masked prime “dentist” as by the masked prime “dEnTĩSt”. Apparently, before written word identification starts, the visual input is translated into abstract letter identities, which allow readers to recognize words independently of the font in which they are written.

All in all, although the evidence for lexical processing of acronyms is suggestive, it would be good if the presumed similarity between acronyms and words could be extended to another paradigm, preferentially one that involves the meaning of the acronyms. A procedure currently popular in visual word recognition research is masked priming (for a review of the literature, see Kinoshita & Lupker, 2003). In this paradigm, a target word is preceded by a prime presented so briefly (typically for around 50 ms) that the

participant cannot identify it. Still, the prime influences the processing of the target.

Particularly interesting for the present topic is masked associative priming. In this paradigm, target words are preceded by primes that are associatively related. Associatively related words are words that participants spontaneously report as the first word that comes to mind upon hearing a probe word (e.g., chair–table). The general finding is that target words are processed faster after associatively related primes than after unrelated control primes. For instance, Lukatela and Turvey (1994) reported that the naming latency for the target word “frog” was 20 ms faster when it was primed by “TOAD” than when it was primed by “TOLLED”. Drieghe and Brysbaert (2002) repeated this finding and extended it to a lexical decision task (i.e., participants had to decide whether the target stimulus was a word or not). Alameda, Cuetos, and Brysbaert (2003) subsequently showed that associative priming is not limited to words, but can also be observed with numbers as targets (e.g., Boeing–747).<sup>1</sup>

In the experiment below we compared associative priming with acronyms and words. A first list of target words was primed with associatively related words (e.g., FIB–LIE) and with matched unrelated words (e.g., HIM–LIE). A second list of words was primed with associatively related acronyms (e.g., BLT–SANDWICH) or with matched unrelated acronyms (STN–SANDWICH). In addition, the related primes could be presented in upper case (FIB, BLT), in lower case (fib, blt), or in mixed case (fIb, bLt). The predictions were straightforward: If acronyms have the same lexical representations as words, we expected to find the same priming effects with acronyms as with words. Because associative priming is not form based (there is no priming from “choir” on “table” or from “chaim” on “table”), this type of priming is particularly well suited to investigate the lexicality of acronyms.

<sup>1</sup> Although the associative priming effect is well established, there is still discussion about its theoretical interpretation, in particular to what extent the effect is due to semantic feature overlap between prime and target, to functional relationships between prime and target, and to the co-occurrence of prime and target in texts and discourse (see Bueno & Frenck-Mestre, 2008; Hutchison, 2003; Lucas, 2000; McRae & Boisvert, 1998; and Perea & Rosa, 2002, for further discussion).



## EXPERIMENT

### Method

#### *Participants*

A group of 24 undergraduate students from Royal Holloway, University of London took part in the experiment in exchange for course credit. All participants were native speakers of English and had normal or corrected-to normal vision.

#### *Stimulus material*

The experimental stimuli consisted of 96 prime–target pairs (see the Appendix). Half of the primes were acronyms; the other half were words. All targets were words. For each target there was a related and an unrelated prime. The unrelated primes were obtained by swapping related primes and targets. The related primes could be displayed in upper case, in lower case, or in mixed case. The unrelated primes were always displayed in upper case (as we had no predictions concerning case differences for this type of prime).

The acronyms were selected from an undergraduate student's research project in which students at Royal Holloway had been presented with a list of 170 familiar acronyms (James, 2004). They were asked to write down the first associate that came to mind. Out of this list, the 48 acronyms with the most frequent associates were chosen. The average association strength was 71.9%. The acronym primes were 2 to 5 letters long, and their associated targets were 3 to 12 letters long. The 48 word primes were selected from the Edinburgh Associative Thesaurus (Kiss, Armstrong, Milroy, & Piper, 1973). The word primes and targets were matched with the acronym primes and targets in association strength and in length. Four lists were created according to a Latin-square design, each including 96 prime–target pairs, so that no

participant saw a prime or a target twice. Each participant was presented with one of the four lists.

The filler stimuli consisted of 96 matched pairs of primes and nonword targets. Half of the filler primes were acronyms; the other half were words. The primes of the filler trials were presented in the same case as those of the test trials (i.e., half upper case, a quarter lower case, and a quarter mixed case). The filler stimuli had been made by starting from prime–target pairs similar to those used in the test trials and then changing a letter of the target, so that it became a legal nonword.

Each participant was presented with a total of 192 prime–target pairs. A practice session containing 20 prime–target pairs preceded the actual experiment. All stimuli were presented in black on a white background and were printed in a bold Times New Roman font (12 points). The targets were always presented in upper-case letters.

#### *Procedure*

Participants were tested individually. Stimulus presentation and response measurement were controlled by the DMDX software (Forster & Forster, 2003). All stimuli were presented at the centre of a 14-inch screen. On each trial, a forward mask was presented on the screen for 300 ms. The mask consisted of 14 “#” signs and had the same size and font as the prime and the target. Then the prime was displayed for 48 ms followed by a backward mask for 36 ms (making the total stimulus onset asynchrony, SOA, equal to  $48 + 36 = 84$  ms).<sup>2</sup> The backward mask consisted of 14 “#” signs and had the same font as the forward mask but a bigger size (13 points). After presentation of the backward mask, the target was displayed and stayed on the screen until the participant made a response.

Participants were asked to decide as quickly and as accurately as possible whether the string they saw was a real English word or a nonword by pressing the right and left shift key, respectively.

<sup>2</sup> It is not clear how critical this SOA is. James (2004) found priming with acronyms at an SOA of 50 ms (only including related vs. unrelated upper-case primes), but in at least two unpublished experiments we were unable to replicate this finding with SOAs of 48 ms. In all likelihood, whether or not it is possible to obtain significant priming with acronyms at SOAs below 50 ms depends on the brightness (or the overall energy) of the primes (Tzur & Frost, 2007).

The participants were not informed about the presence of the primes. Each participant received a different permutation of the stimulus list.

## Results

Four items with word primes (see \* in Appendix) were omitted from the analysis because the average percentage of errors (76 %) on these items was too high. Incorrect responses (3.3%) and reaction times less than 200 ms or greater than 1,500 ms (0.2%) were excluded from the latency analysis. The analyses were run across participants ( $F_1$  analysis) and across items ( $F_2$  analysis). Reaction times of the correct responses and percentages of errors were submitted to separate analyses of variance (ANOVAs) based on a 2 ("prime type": acronym or word)  $\times$  4 ("relatedness condition": related upper case, related lower case, related mixed case, and unrelated to the target) design. Mean reaction times (RTs) and percentage of errors are given in Table 1.

### RT analysis

There was a significant main effect of prime type,  $F_1(1, 23) = 11.19$ ,  $MSE = 2,418$ ,  $p < .01$ ;  $F_2(1, 84) = 3.80$ ,  $MSE = 11,150$ ,  $p < .06$ , and of relatedness condition,  $F_1(3, 69) = 7.73$ ,  $MSE = 1,431$ ,  $p < .01$ ;  $F_2(3, 252) = 6.61$ ,  $MSE = 3,087$ ,  $p < .01$ , but no interaction between both variables,  $F_1(3, 69) = 0.09$ ,  $MSE = 1,859$ ;  $F_2(3, 252) = 0.27$ ,  $MSE = 3,087$ . Planned comparisons for the acronyms showed that the differences between each of the related conditions (upper case, lower case, and mixed case) and the unrelated condition

were significant (all  $p_1$ s  $< .03$ , all  $p_2$ s  $< .05$ ) and that there were no reliable differences between the related conditions ( $F_1 < 1$ ;  $F_2 < 1$ ).

To investigate whether the associative priming effect depended on the orthographic legality of the acronyms, we made a distinction between the 20 related primes that were orthographically legal (e.g., AOL, ABS, CAB, BAFTA) and the 28 that were illegal (i.e., ABC, GCSE, BLT, BMW, . . .; see the Appendix). A  $2 \times 2 F_2$  analysis on these stimuli including prime relatedness (the average of the related conditions vs. the unrelated condition; repeated measure) and orthographic legality (legal vs. illegal; between-items variable) yielded a significant effect of prime relatedness,  $F_2(1, 40) = 8.08$ ,  $MSE = 2,422$ ,  $p < .01$ , and no interaction between prime relatedness and orthographic legality,  $F_2(1, 40) = 0.18$ ,  $MSE = 2,422$ . For the 28 orthographically illegal primes, there was a 25-ms difference between the related ( $M = 603$  ms) and the unrelated condition ( $M = 628$  ms), which was next to significant in the usual two-tailed  $F$ -test,  $F_2(1, 24) = 3.85$ ,  $MSE = 2,215$ ,  $p < .062$ . As in the overall analysis, there were no significant differences between the related primes,  $F_2(2, 48) = 0.84$ ,  $MSE = 3,642$ .

### Error analysis

The main effect of prime type was significant in the analysis by participants,  $F_1(1, 23) = 63.7$ ,  $p < .01$ ;  $F_2(1, 84) = 3.04$ ,  $p > .08$ . The percentage of errors was higher for the list of target words preceded by word primes than for the list of target words preceded by acronyms. No other effect was significant.

Table 1. Mean RTs, percentage of errors, and standard deviations of the experiment

	Type							
	Related upper		Related lower		Related mixed		Unrelated	
	RT	Error	RT	Error	RT	Error	RT	Error
Acronym	604 (71)	0.3 (1.7)	598 (72)	3.5 (6.0)	600 (68)	2.8 (4.7)	631 (85)	3.5 (4.9)
Word	583 (54)	8.4 (7.8)	578 (73)	12.3 (10.2)	571 (48)	8.4 (10.4)	607 (78)	11.4 (10.8)

Note: Mean reaction times (RTs) in ms. Standard deviations in parentheses.

## Discussion

In this paper we investigated whether visual acronyms are processed like written words or like pictures. We did so by comparing the masked priming effect of associatively related acronyms with that of associatively related words. In addition, we manipulated the letter case of the related primes, to see whether the priming effect of acronyms would be limited to the familiar upper-case format.

We first replicated the masked associative priming effect with word primes previously reported by Lukatela and Turvey (1994) and Drieghe and Brysbaert (2002): Participants were about 30 ms faster to decide that the target was a word when it was preceded by an associatively related prime word than when it was preceded by an unrelated prime word. In addition, as expected on the basis of Forster (1998), we found the same priming effect for primes presented in lower case, upper case, or mixed case.

More importantly, we obtained exactly the same priming effects for acronym primes. Not only was the effect of the same size, but it also did not depend on whether the acronyms were presented in their familiar format (upper case) or whether they were presented in unfamiliar formats (lower case or mixed case). The latter finding is particularly convincing for the lexical processing of acronyms. As mentioned in the introduction, there is quite some evidence that acronyms as targets in a perceptual identification task or a string matching task are more easily processed in their familiar upper-case format than in lower-case format (Besner et al., 1984; Hall et al., 2001; Seymour & Jack, 1978). However, this does not seem to be the case for the automatic processes tapped into by the masked priming paradigm. Forster (1998, p. 221) made a similar observation when he noticed that cAsE aLtErNaTiOn does not affect the masked priming effect, whereas it usually slows down target processing (e.g., it takes longer to accept the target dEnTiSt as a word in lexical decision than the target DENTIST). Forster hypothesized that case alternation may have its effect after lexical access, when the contents of the lexical entry are checked

against the input (as also proposed by Besner, 1983). Lexical access would be based entirely on abstract letter identities, in line with the findings reported here, both for words and for acronyms.

The fact that acronyms like BBC are part of the mental lexicon further suggests that orthographic legality is no prerequisite for inclusion (see the analysis limited to the illegal acronyms in the Results section). This raises an interesting question. Given that there are strong connections between orthographic and phonological word representations and that phonological information is involved in visual word recognition, how then does the phonological code of illegal acronyms look?

This issue was recently addressed by Slattery, Pollatsek, and Rayner (2006). They reasoned that the phonological representation of BBC might simply be the three-syllable word BeeBeeCee. To test this idea, they made use of the fact that the indefinite article in English is “a” before a consonant and “an” before a vowel. So, would readers prefer “a FBI agent” or “an FBI agent”? Similarly, would they prefer “a USA official” or “an USA official”? Slattery et al. (2006) investigated the issue by tracking the eye movements of students reading sentences that contained those sequences. In line with their hypothesis, Slattery et al. found consistently shorter first-fixation durations for phonological consistent pairings like “an FBI agent” and “a USA official” than for phonological inconsistent pairings like “a FBI agent” and “an USA official”.

So, there is some evidence that orthographically illegal acronyms have their own multisyllabic phonological representation consisting of the full letter names. This too is in line with the idea that there is room in the British lexicon for “words” like BBC, DVLA, V5C, RSPCA, HBSC (and hundreds more). Whether this may be interpreted as an encouragement to further increase the number of acronyms in the English language is a different matter that cannot be addressed on the basis of the present data.

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## APPENDIX

## Stimuli used in the experiments

## 1. Acronyms

<i>Primes</i>					
<i>Related</i>					
<i>Upper</i>	<i>Lower</i>	<i>Mixed</i>	<i>Unrelated</i>	<i>Target</i>	<i>Assoc. strength</i>
ABC	abc	aBc	RSPCA	ALPHABET	62 <sup>+</sup>
ABS	abs	aBs	VCR	BRAKES	60
AOL	aol	aOl	VIP	INTERNET	60
BAFTA	bafta	bAfTa	GCSE	AWARD	68
BLT	blt	bLt	STN	SANDWICH	64 <sup>+</sup>
BMW	bmw	bMw	UHT	CAR	90 <sup>+</sup>
BMX	bmX	bMx	KFC	BIKE	84 <sup>+</sup>
BP	bp	bP	ISBN	PETROL	72 <sup>+</sup>
BRO	bro	bRo	NBA	BROTHER	80
CAB	cab	cAb	SMS	TAXI	78
CNN	cnn	cNn	MTV	NEWS	68 <sup>+</sup>
DOA	doa	dOa	LAPD	DEAD	56
DVLA	dvla	dVIA	H2O	DRIVING	64 <sup>+</sup>
FC	fc	fC	IT	FOOTBALL	80 <sup>+</sup>
FM	fm	fM	USA	RADIO	80 <sup>+</sup>
GCSE	gcse	gCsE	BAFTA	EXAM	70 <sup>+</sup>
H2O	h2o	h2o	DVLA	WATER	100 <sup>+</sup>
HGV	hgv	hGv	TA	LORRY	56 <sup>+</sup>
HQ	hq	hQ	TV	HEADQUARTERS	68 <sup>+</sup>
HSBC	hsbc	hSbC	USSR	BANK	86 <sup>+</sup>
ISBN	isbn	iSbN	BP	BOOKS	66 <sup>+</sup>
IT	it	iT	FC	COMPUTER	68
KFC	kfc	kFc	BMX	CHICKEN	86 <sup>+</sup>

(Continued overleaf)

1. *Acronyms* (Continued)

<i>Primes</i>					
<i>Related</i>					
<i>Upper</i>	<i>Lower</i>	<i>Mixed</i>	<i>Unrelated</i>	<i>Target</i>	<i>Assoc. strength</i>
LAPD	lapd	lApD	DOA	POLICE	76 <sup>+</sup>
LED	led	lEd	VAT	LIGHT	62
MAX	max	mAx	NY	MAXIMUM	78
MTV	mtv	mTv	CNN	MUSIC	70 <sup>+</sup>
NBA	nba	nBa	BRO	BASKETBALL	64 <sup>+</sup>
NSPCC	nspcc	nSpCc	UCI	CHILDREN	78 <sup>+</sup>
NY	ny	nY	MAX	NEW YORK	68
OAP	oap	oAp	SOS	OLD	60
PO	po	pO	WC	POST	74
RSPCA	rspca	rSpCa	ABC	ANIMAL	80 <sup>+</sup>
SMS	sms	sMs	CAB	TEXT	66 <sup>+</sup>
SOS	sos	sOs	OAP	HELP	70
STATS	stats	sTaTs	UCAS	STATISTICS	60
STN	stn	sTn	BLT	STATION	86 <sup>+</sup>
TA	ta	tA	HGV	ARMY	64
TV	tv	tV	HQ	TELEVISION	76 <sup>+</sup>
UCAS	ucas	uCaS	STATS	UNIVERSITY	72
UCI	uci	uCi	NSPCC	CINEMA	58
UHT	uht	uHt	BMW	MILK	100 <sup>+</sup>
USA	usa	uSa	FM	AMERICA	58
USSR	ussr	uSsR	HSBC	RUSSIA	58 <sup>+</sup>
VAT	vat	vAt	LED	TAX	88
VCR	vcr	vCr	ABS	VIDEO	82 <sup>+</sup>
VIP	vip	vIp	AOL	IMPORTANT	62
WC	wc	wC	PO	TOILET	74 <sup>+</sup>

*Note:* <sup>+</sup>Related prime that is orthographically illegal.

## 2. Words

<i>Primes</i>					
<i>Related</i>					
<i>Upper</i>	<i>Lower</i>	<i>Mixed</i>	<i>Unrelated</i>	<i>Target</i>	<i>Assoc. strength</i>
ARK	ark	aRk	RANT	NOAH	74
BITS	bits	bItS	DING	PIECES	68
BOYS	boys	bOyS	KINGS	GIRLS	80
COPS	cops	cOps	ZEBRA	ROBBERS	66
CORE	core	cOrE	TROVE	APPLE	76
DING	ding	dInG	BITS	DONG*	88
DONOR	donor	dOnOr	ERROR	BLOOD	87
EAST	east	eAsT	SUET	WEST	84
EDAM	edam	eDaM	MUM	CHEESE	71
ELM	elm	eLm	HE	TREE	78
ERROR	error	eRrOr	DONOR	MISTAKE	52
FIB	fib	flb	HIM	LIE	69
FRY'S	fry's	fRy's	ITCH	CHOCOLATE	58
HE	he	hE	ELM	SHE	73
HERE	here	hErE	HOT	THERE	69
HIM	him	hIm	FIB	HER	76
HIS	his	hIs	PING	HERS	63
HONG	hong	hOnG	LOW	KONG*	89
HOT	hot	hOt	HERE	COLD	64
IN	in	iN	NO	OUT	65
ITCH	itch	iTcH	FRY'S	SCRATCH	67
JESUS	jesus	jEsUs	NAPE	CHRIST	68
KINGS	kings	kInGs	BOYS	QUEENS	63
LEO	leo	lEo	MOO	LION	60
LOAF	loaf	lOaF	NOOK	BREAD	77
LOW	low	lOw	HONG	HIGH	67
MEN	men	mEn	NEW	WOMEN	72
MOO	moo	mOo	LEO	COW	70
MUM	mum	mUm	EDAM	DAD	69
NAPE	nape	nApE	JESUS	NECK	79
NEW	new	nEw	MEN	OLD	63
NO	no	nO	IN	YES	71
NOOK	nook	nOoK	LOAF	CRANNY*	75
ON	on	oN	UP	OFF	64
ONE	one	oNe	POD	TWO	63
PEW	pew	pEw	PUP	CHURCH	60
PING	ping	pInG	HIS	PONG*	85
PINS	pins	pInS	RUNGS	NEEDLES	76
POD	pod	pOd	ONE	PEA	66
PUP	pup	pUp	PEW	DOG	63
RANT	rant	rAnT	ARK	RAVE	86
RUNGS	rungs	rUnGs	PINS	LADDER	82
SILL	sill	sILL	WEB	WINDOW	78
SUET	suet	sUeT	EAST	PUDDING	76
TROVE	trove	tRoVe	CORE	TREASURE	82
UP	up	uP	ON	DOWN	72
WEB	web	wEb	SILL	SPIDER	66
ZEBRA	zebra	zEbRa	COPS	CROSSING	61

Note: \*Items omitted from the analysis because the average percentage of errors was too high.