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Research Report

Electroencephalographic responses to SMS shortcuts[☆]

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ABSTRACT

As the popularity of sending messages electronically increases, so does the necessity of conveying messages more efficiently. One way of increasing efficiency is to abbreviate words and expressions by combining letters with numbers such as *gr8* for “great,” using acronyms, such as *lol* for “laughing out loud,” or clippings such as *msg* for “message.” The present study compares the processing of shortcuts to the processing of closely matched pseudo-shortcuts. ERPs were recorded while participants were performing a lexical decision task. Response times showed that shortcuts were categorized more slowly as nonwords than pseudo-shortcuts. The ERP results showed no differences between shortcuts and pseudo-shortcuts at time windows 50–150 ms and 150–270 ms, but there were significant differences between 270 and 500 ms. These results suggest that at early stages of word recognition, the orthographic and phonological processing is similar for shortcuts and pseudo-shortcuts. However, at the time of lexical access, shortcuts diverge from pseudo-shortcuts, suggesting that shortcuts activate stored lexical representations.

1. Introduction

The idea of Short Message Service (SMS) was born as part of the development of the Global System for Mobile Communications (GSM) network in the mid-1980s (Crystal, 2008). SMS had a slow start with only 0.4 text messages per month being sent in the late 1990s, but at the beginning of 2001, about 12.2 billion messages per year were sent in the United Kingdom alone (Crystal, 2008). Gartner, the industry analysts, predicted that the total number of SMS sent per year would reach 2.4 trillion by 2010 (Crystal, 2008). As the popularity of sending SMS and communicating online increased, numerous abbreviations were introduced to facilitate the generation of messages. Some abbreviations are combinations of letters and numbers, such as *gr8* for *great*, others are acronyms, such as *lol* for *laughing out loud*, yet others are clippings, such as *msg* for *message*. These abbreviations can now also be found in poetry and spoken communication, and there are even prizes for the best SMS message (e.g., the Golden Thumb). Early use of SMS is related to children's literacy development, as studies have shown that the more text abbreviations preteenage children use in their text messages, the higher they score on tests for reading and vocabulary (Plester et al., 2008).

Despite their popularity, very little is known about the processing of shortcuts. Using shortcuts is efficient and convenient for the sender of the message. However, is it also beneficial for the reader? It had been shown that reading sentences that consisted almost exclusively of SMS language was slower than reading conventionally written sentences (Berger and Coch, 2010; Perea et al., 2009).

However, when shortcuts are used sparingly in a sentence, they appear to cause difficulties only in early stages of word

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recognition. Once word recognition is accomplished, shortcuts are integrated into the sentence context as easily as conventionally written words (Ganushchak et al., submitted for publication-a).

The goal of the present study was to further investigate how readers process shortcuts. Shortcuts and traditionally spelled words differ in many ways. For instance, shortcuts are by definition shorter than words; they are less frequent, have fewer orthographic and phonological neighbours, and have fewer semantic associations than words. All these factors are known to affect electrophysiological responses to written stimuli (e.g., Assadollahi and Pulvermüller, 2001; Hauk et al., 2006; Holcomb et al., 2002; Holcomb, Kounios, Anderson, & West, 1999; Kounios et al., 2009; Van Petten and Kutas, 1990). Here we compared shortcuts with closely matched meaningless strings, called pseudo-shortcuts hereafter. These two types of stimuli differed in lexical status (i.e., whether or not they regularly occurred in the language with a specific meaning) but not in their orthographic characteristics (length, regularity, number of neighbours).

We used a lexical decision task, in which participants were asked to make word/nonword judgements. There are different theories concerning the cognitive processes preceding lexical decisions. One view is that a "word" response is produced as soon as the activation level of a lexical representation exceeds a threshold. A "nonword" response is given if no lexical representation becomes sufficiently activated within a specified period (see Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Grainger and Jacobs, 1996). An alternative view is that a string is accepted as being a word if it is sufficiently familiar and is rejected as a nonword otherwise (e.g., Plaut, 1997). According to both views, different types of information (e.g., orthographic, phonological, and semantic) can affect the decision (e.g., Ratcliff et al., 2004; Yap et al., 2006).

In the present study, participants were asked to categorize both shortcuts and pseudo-shortcuts as nonwords so that the responses could be directly compared. If the lexical status of the stimuli matters, i.e., if shortcuts have unique lexical representations or if they activate the representations of the full word forms they replace, a word response might compete and interfere with the requested nonword response. This should delay the responses relative to the responses for pseudo-shortcuts.

Apart from differences between shortcuts and pseudo-shortcuts, we explored whether or not there were any processing differences between two common types of shortcuts, namely shortcuts with and without embedded digits. Shortcuts without embedded digit can be clippings or all-letter acronyms. Clippings are single words formed by means of orthographic abbreviation, for instance by deleting vowels from the word (e.g., *msg* for *message*) or by phonetic respelling (e.g., *u* for *you*). All-letter shortcuts always stand for several words and are formed by combining their first letters (e.g., *lol* for *laughing out loud*). Shortcuts with embedded digits are formed by replacing a word or part of a word with a number (e.g., *d8* for *date*). Letter–digit shortcuts can stand for one word (e.g., *d8*) or for several words (e.g., *g2g* for *got to go*).

Previous lexical decision studies have shown that nonwords are the harder to categorise the more word-like they are in their orthographic and phonological forms. As nonwords become more word-like, participants rely on a more conservative response criterion and use not only orthographic information but also phonological and semantic information to discriminate between words and nonwords (Ratcliff et al., 2004; Yap et al., 2006). Based on these findings, one might predict that letter–digit shortcuts should be categorized faster as nonwords than shortcuts without digits because the embedded digit clearly sets them apart from existing words at the orthographic level. In addition, it has been shown that number concepts get activated even when they are irrelevant for the task (e.g., Pinel et al., 2004). Thus, the digits embedded in digit–letter shortcuts and digit–letter pseudo-shortcuts may initially be processed as numbers. There is evidence that the digits in shortcuts, just like digits in pseudo-shortcuts, briefly activated the corresponding number concepts. However, activation of number concepts is quickly suppressed when the meaning of the shortcut is retrieved. This is not the case for pseudo-shortcuts because they do not map onto lexical representations (Ganushchak et al., 2010). The initial activation of the number concepts might affect the recognition of the shortcuts with than without numbers, because the activation of the number concept might compete with the activation of the meaning of the entire shortcut. No such competition exists for pseudo-shortcuts. Therefore, shortcuts with embedded numbers should be classified as nonwords more slowly than pseudo-shortcuts with embedded digits. The difference between shortcuts and pseudo-shortcuts should be larger for items with than without numbers.

In addition to the decision latencies, we recorded event-related potentials. During the initial stage of word recognition, visual features activate letter representations that compose a word. This process takes about 150 ms (Barber and Kutas, 2007; Holcomb and Grainger, 2006). At this stage, we did not expect any differences in ERP waves between shortcuts and pseudo-shortcuts. However, if digits rapidly activate the associated number concepts, letter–digit shortcuts and letter–digit pseudo-shortcuts might be processed differently from stimuli without embedded digits.

At the later stages of word recognition, after about 250 ms, a sublexical phonological code is activated and a whole-word representation is accessed (Barber and Kutas, 2007; Holcomb and Grainger, 2006). Slattery et al. (2006) showed that phonological coding also occurs during the processing of acronyms (e.g., *BBC*), whose phonological code is a sequence of letter names. In the present study, shortcuts might activate their own phonological representations (e.g., *lol* might activate /lɔl/) or the phonological representation of the corresponding words (e.g., *w8* might activate /weIt/). However, pseudo-shortcuts should not have stored phonological representations. Thus, we predicted that at a sublexical phonological stage ERP waves would diverge for shortcuts vs. pseudo-shortcuts, with larger amplitudes for pseudo-shortcuts than shortcuts at about 250 ms after the stimulus presentation.

Finally, words and pseudowords are known to differ with regard to the N400 component (e.g., Kutas and van Petten, 1994). The N400 is probably the most intensely studied language-related ERP component. It is a component with negative deflection starting around 200 ms and peaking around 400 ms after the onset of a stimulus presentation. It has been interpreted as an index of the ease of accessing lexical information and of the integration of a word into the semantic context (Kutas and Federmeier, 2000). Previous studies have shown larger N400 amplitudes for pseudowords when compared to real words, reflecting increased lexical processing for pseudowords (Kutas and van Petten, 1994). We predicted that shortcuts and pseudo-shortcuts should differ in terms of lexical access because only shortcuts map onto stored lexical representations. We therefore expected a larger N400 component for pseudo-shortcuts than for shortcuts, irrespectively of whether or not they contained digits. In addition, lexical access might be more effortful for letter–digit shortcuts than for pure letter shortcuts leading to an increased N400 response because, as explained above, the activation of representations of digits might interfere with lexical access.

2. Results

2.1. *Response latencies*

Participants rejected pseudo-shortcuts significantly faster (by 24 ms) than shortcuts (*F*(1, 133) = 8.99; *p* = .003; see Table 1). There was also a main effect of type (*F*(1, 133) = 5.51, *p* = .02). Participants were slower to reject all-letter than letter–digit shortcuts (see Table 1). There was no interaction between type and wordness (*F*(1, 133) = 1.21, *p* = .27),[1] but it is possible that there was not sufficient power for the interaction to reach significance (observed power = 0.65). Separate analyses of the effect of wordness per type showed that all-letter pseudo-shortcuts were rejected 30 ms faster than all-letter shortcuts (*F*(1, 90) = 8.72, *p* = .01). The effect of wordness was somewhat smaller for letter–digit shortcuts, with letter–digit pseudo-shortcuts being rejected 15 ms faster than letter–digit shortcuts (*F*(1, 45) = 4.88, *p* = .03).

To make the behavioural results comparable with the ERP analysis, we repeated the analysis using only participants as random factor. In line with the analysis above, the main effects of type and wordness were significant (*F*(1, 7243) = 35.15, *p* = .001; *F*(1, 7243) = 55.91, *p* = .001, respectively). In this analysis, the interaction between type and wordness was also significant (*F*(1, 7243) = 7.63, *p* = .006). Again, the effect of wordness was significant for all-letter shortcuts (*F*(1, 4742) = 73.03, *p* = .001) and for letter–digit shortcuts (*F*(1, 2503) = 9.10, *p* = .003).

2.2. *Electrophysiological data*

Fig. 1 illustrates the ERP signal for shortcuts, pseudo-shortcuts, and words. No statistical analyses were run to compare words to shortcuts and pseudo-shortcuts because the two types of stimuli were not matched for orthographic and phonological features and required different responses.

Table 1 – Behavioural results: mean reaction times (ms; standard deviations in parentheses) as a function of wordness and type.

Type	Wordness	
	Shortcuts	Pseudo-shortcuts
All-letter items	600 (154)	570 (143)
Letter–digit items	576 (153)	561 (139)

2.2.1. *50–150 ms*

In this time window, none of the main effects was significant (type: *F* < 1; wordness: *F*(1, 18) = 1.32, *p* = .27), and there were no significant interactions (location × type × wordness: *F*(1, 18) = 1.41, *p* = .25; hemisphere × type × wordness: *F*(1, 18) = 1.24, *p* = .28; all other *F* values < 1).[2]

2.2.2. *150 – 270 ms*

Again, there were no significant main effects of type or wordness (both *F* values < 1). There was a significant interaction between location and type (*F*(1, 18) = 5.77, *p* = .03). Follow-up analyses showed that at anterior sites' strings without embedded digits appeared to yield more negative amplitudes than strings with embedded digits (all-letter shortcuts: 3.84 μV; SD = 3.37; letter–digit shortcuts: 4.11 μV; SD = 3.75), whereas the reverse held for posterior sites (all-letter shortcuts: 6.68 μV; SD = 3.98; letter–digit shortcuts: 6.27 μV; SD = 4.29). However, the difference between strings with and without digits was not significant at either of these locations (anterior: *F*(1, 18) = 1.89, *p* = .19; posterior: *F* < 1). The remaining interactions were not significant (location × type × wordness: *F*(1, 18) = 1.36, *p* = .26; hemisphere × type × wordness: *F*(1, 18) = 1.42, *p* = .25; for all other interactions *F* < 1).

2.2.3. *270 – 500 ms*

In this time window, there was a main effect of wordness (*F*(1, 18) = 8.80, *p* = .01) with amplitudes being more negative for pseudo-shortcuts (3.87 μV; SD = 3.60) than for shortcuts (4.97 μV; SD = 4.05; see Figs. 2 and 3). There was no main effect of type (*F* < 1), and despite the visual impression of a slightly larger effect at anterior than posterior sites (see Figs. 2 and 3), none of the interactions was significant (location × type: *F*(1, 18) = 3.53, *p* = .10; hemisphere × type × wordness: *F*(1, 18) = 2.01, p = .17; for all other interactions *F* < 1).

3. Discussion

The aim of the present study was to investigate how shortcuts used in SMS were processed by comparing their processing to that of pseudo-shortcuts. ERP responses showed no differences between the processing of shortcuts and pseudo-shortcuts until about 270 ms after stimulus onset. This suggests that shortcuts

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[1] In additional analyses, we explore whether the reaction times depended on whether the shortcut corresponded to a single word or multiple words. This was not the case (*F*(1, 69) = 2.23, *p* = 0.14).

[2] To investigate the effects of repetition of items, we run an ANOVA with repetition (block 1, block 2, and block 3) as an additional factor. The effect of repetition was minimal, and the overall pattern did not change.

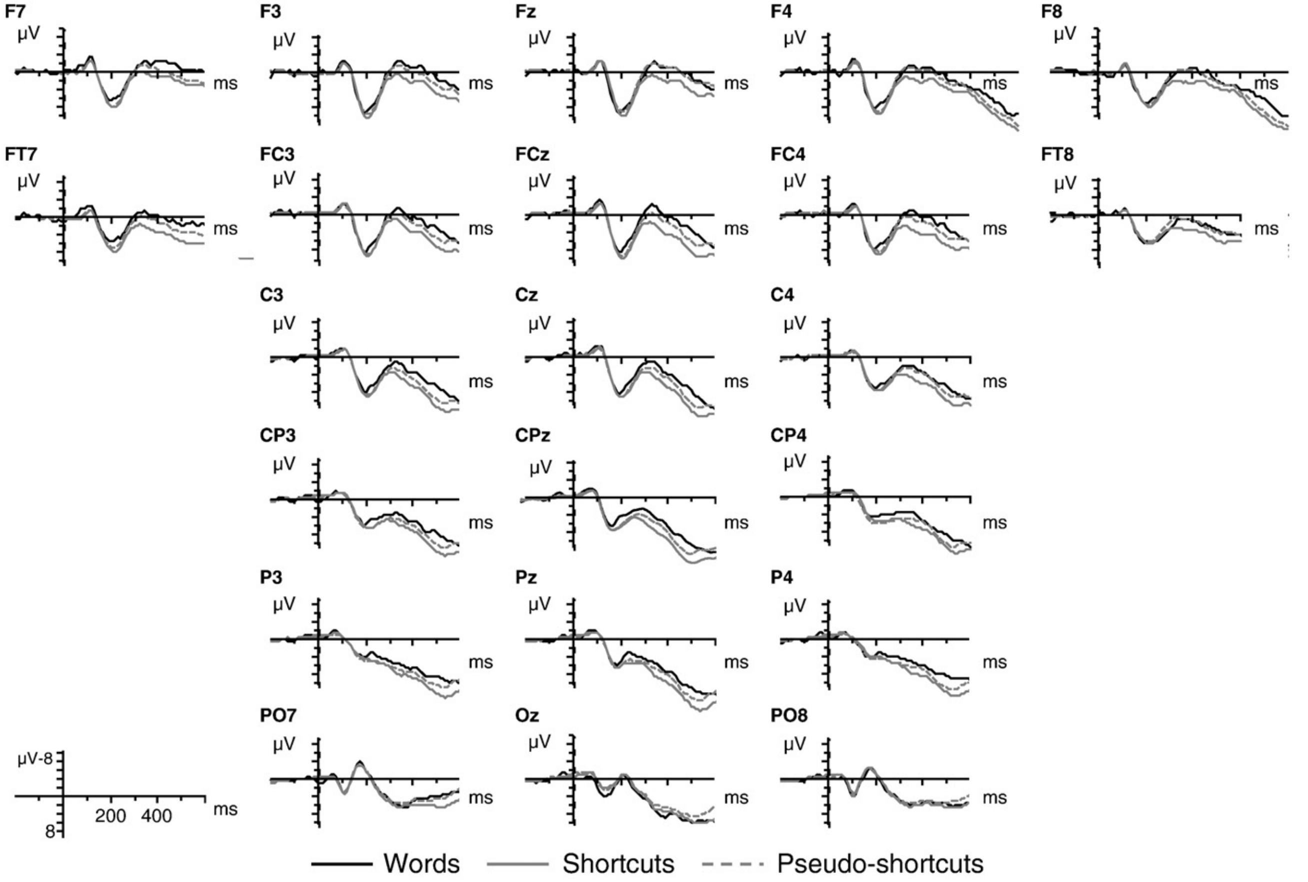

Fig. 1 – Averaged stimulus-locked ERP waveforms for shortcuts (solid grey lines), pseudo-shortcuts (dashed grey lines), and words (solid black lines). The figure depicts a selection of electrodes showing the widespread distribution of the N400 effect.

and pseudo-shortcuts do not differ in terms of orthographic or phonological processing. Shortcuts are primarily used in written language (e.g., sending SMS or online communication), and therefore, the participants perhaps did not retrieve a phonological representations for either shortcuts or pseudo-shortcuts.

As predicted, we found that shortcuts were categorised as nonwords more slowly than pseudo-shortcuts and that the N400 amplitude was more negative for pseudo-shortcuts than for shortcuts. The N400 had a widespread distribution, with somewhat larger amplitudes at frontal sites than posterior ones; however, this trend was not significant. Previous research has shown that pseudowords lead to larger N400 amplitudes than real words (e.g., Kutas and van Petten, 1994) because real words but not pseudowords readily map onto stored lexical entries. Our data suggest that shortcuts are 'word-like' in the sense that they activate stored lexical information stored. This lead to a response conflict and delayed the nonword responses to shortcuts required in the experiment.

The lexical representations activated by the shortcuts could be either the representations of the words that the shortcuts stand for or the specific representations of shortcuts. Based on the results of a companion study (Ganushchak et al., submitted for publication-b), we think that at least some of the shortcuts probably activated unique lexical representations. In that study, we used a masked and overt priming with shortcuts and the corresponding words as primes and target words that were associatively related to the meaning of the entire prime (e.g., *cu/see you*—GOODBYE), to a component of the prime (e.g., *cu/see you*—LOOK), or unrelated to the prime (e.g., *4u/for you*—GOODBYE). Participants had to decide whether or not the targets were existing words of English. We found that the responses were faster for targets preceded by whole related than by unrelated primes for both shortcut and word primes. Priming effect from component-related pairs was present only for word but not for shortcuts pairs. This pattern suggests that the shortcuts rapidly activated the associated meaning but not meaning of the components. This supports the view they the activate unit lexical representations. This conclusion is in line with recent evidence showing that everyday acronyms, such as *STATS*, *FBI*, and *WC*, have their own entries in the mental lexicon (Brysbaert et al., 2009). Furthermore, it has been shown that words and familiar acronyms engage identical processes of semantic access as reflected by the amplitudes of the N400 (Laszlo and Federmeier, 2007a,b; Laszlo and Federmeier, 2008).

Furthermore, we were interested in comparing the processing of shortcuts with and without embedded digits. In the ERP responses, we found no significant differences in processing

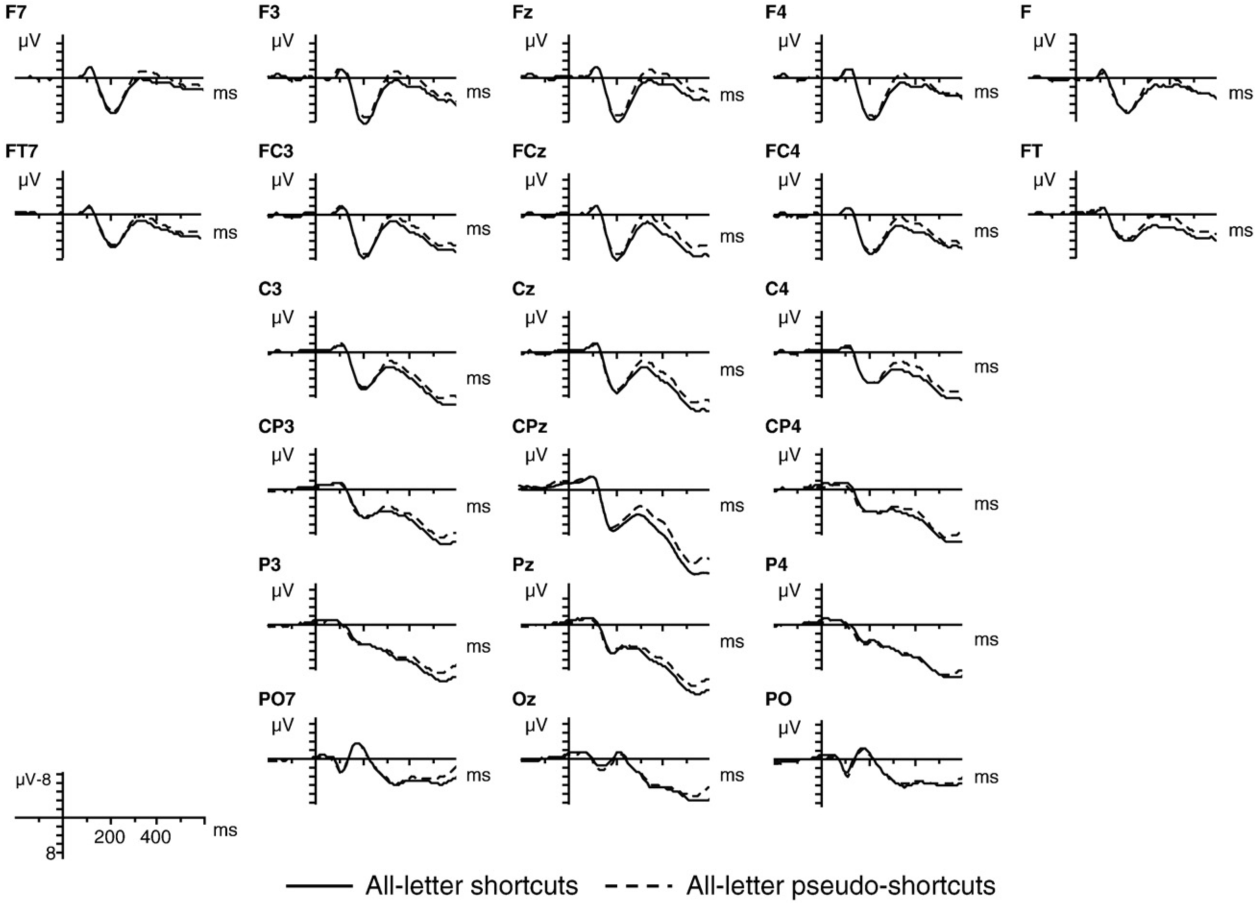

Fig. 2 – Averaged stimulus-locked ERP waveforms for all-letter shortcuts (solid lines) versus all-letter pseudo-shortcuts (dashed lines). The figure depicts a selection of electrodes showing the widespread distribution of the N400 effect.

of shortcuts with and without digits. This indicates that the retrieval of lexical information is not delayed or adversely affected by the presence of the embedded digit in a shortcut. This is in line with the findings of Ganushchak et al. (2010) that embedded digits do not add much to the processing effort of shortcuts. Furthermore, previous research has shown that during lexical access familiarity with a word or an acronym is more important than orthographic regularity (Laszlo and Federmeier, 2007a,b; Laszlo and Federmeier, 2008). Our findings support this since our participants were equally familiar with both types of shortcuts. Note that in the behavioural data we found that shortcuts and pseudo-shortcuts with embedded digits were rejected faster than shortcuts and pseudo-shortcuts without digits. It is not clear why this effect is not reflected in the ERPs. It is possible that the effect on the reaction times was due to strategic effects occurring during response decision, which may not have been picked up in stimulus-locked ERPs.

Taken together, our results indicate that shortcuts were more difficult to categorise as nonwords than pseudo-shortcuts, demonstrating that they activated stored lexical representation. The ERP results complemented this finding by suggesting that the processing of shortcuts and pseudo-shortcuts did not differ at the orthographic or phonological level but at a lexical/semantic level. Overall, our results suggest that embedded digits do not add much to the processing effort of shortcuts and do not interfere with the lexical access.

4. Experimental procedures

4.1. *Participants*

Twenty-two students of the University of Birmingham (18 females) took part in the experiment (average age: 19.3 years, SD = 0.9 years). All participants were right-handed native speakers of English and had normal or corrected-to-normal vision. Participants gave written informed consent before participating in the study. They received course credits for their participation. Because of technical problems, the data from three participants were excluded from the analyses.

4.2. *Materials and design*

The experimental items consisted of 72 shortcuts, 72 pseudo-shortcuts, and 144 words. The 72 shortcuts consisted of 24 letter–digit shortcuts (e.g., *gr8* for '*great*') and 48 pure-letter shortcuts. The latter group of stimuli consisted of 30 clippings

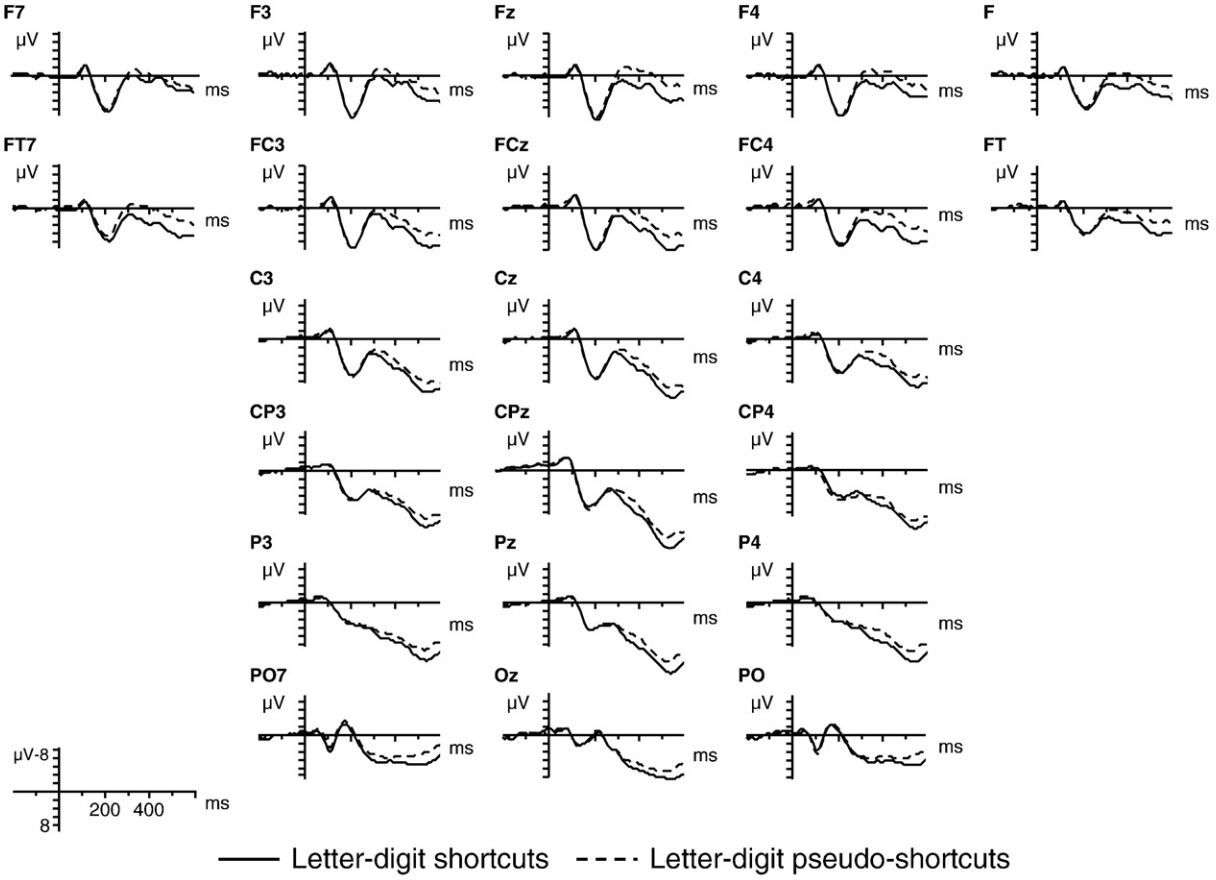

Fig. 3 – Averaged stimulus-locked ERP waveforms for letter–digit shortcuts (solid lines) versus letter–digit pseudo-shortcuts (dashed lines). The figure depicts a selection of electrodes showing the widespread distribution of the N400 effect.

(e.g., *msg* for '*message*'), and 18 all-letter shortcuts (e.g., *lol* for '*laughing out loud*').[3] For each shortcut, a corresponding nonshortcut was created by replacing one or two letters (e.g., *gr8* – *qr8*; see Appendix A). Words and pseudowords were matched for length (3.32 letters, SD = 0.9 letters; 3.21 letters, SD = 1.1 letters, respectively). Each item was repeated three times, which resulted in a total of 72 trials for letter–digit shortcuts, 90 trials for clippings, and 54 trials for all-letter shortcuts. In addition to experimental trials, there were 20 practice trials featuring 10 words and 10 nonwords that did not occur as experimental trials. All items appeared were presented in bold in *Courier New* font type. Font size was 18 points. Visual angle was 1.15° by 0.57°.

4.3. *Procedure*

Each trial started with the presentation of a fixation point in the centre of the screen for a duration varying between 500 and 1000 ms (mean: 750 ms), followed by the word or nonword, which remained on the screen for 500 ms. Then a blank screen was presented for 1800 ms. Participants were asked to press the left key of a response pad when the letter string was an English word and to press a right key when the letter string was not an English word. Participants were told that by words we meant letter strings that one would find in common dictionaries (e.g., cat) and that for the purposes of the current experiment abbreviations (e.g., BBC) were not considered words. They were instructed to respond as fast and as accurately as possible. After the completion of the ERP experiment, the participants were given a listing of all shortcuts used in the experiment and were asked to write down their meanings.

4.4. *Apparatus and electrophysiological recording*

The electroencephalogram (EEG) was recorded using an EEG cap containing 128 Ag/AgCl electrodes, including all standard locations of the extended International 10/20 system. All electrodes were offline re-referenced to the average of the left and right mastoids. The EEG was collected by BioSemi ActiView; the EEG signal was digitized at a rate of 512 Hz with a band-pass filter of DC-128 Hz. Lateral eye movements were measured using a bipolar montage of two electrodes placed on the right and left external canthus. Vertical eye movements were measured using a bipolar montage of two electrodes placed above and below the eyes.

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[3] Because of the explorative nature of the study, we wanted to investigate whether or not results were dependent on whether the shortcut corresponded to a single word or multiple words. The analysis showed no effects. Therefore, shortcuts were grouped to form all-letter and letter–digit categories.

Participants' responses were recorded using a Cedrus RB-530 response pad.

4.5. *Data analysis*

Epochs from −200 ms to +600 ms were obtained relative to the onset of a target word, including a 200-ms prestimulus baseline. The EEG signal was corrected for ocular artefacts, using the algorithm of Gratton et al. (1983). To correct for nonocular artefacts, epochs with amplitudes above or below 50 μV were rejected. The EEG signal was filtered with a high-pass filter of 0.1 Hz/24 dB and a low-pass filter of 20 Hz/24 dB. Mean amplitude values were calculated per participant and per condition for three poststimulus time windows: 50–150 ms, 150–270 ms, and 270–500 ms. These windows were chosen based on the visual inspection of the waves and previous literature on visual word recognition.

Analyses were performed for nonword trials. We used the questionnaire data to determine which shortcuts each participant knew. For each participant, we eliminated from the analyses all shortcuts they did not know. We also removed the corresponding pseudo-shortcuts. This was the case for on average of 2.4 all-letter shortcuts and 1.3 letter–digit shortcuts (SD = 1.0) per participant. Since the average error rate for the lexical decision judgements was very low (0.4%), no error analysis was conducted. Analyses of reaction times and of the amplitudes of the ERP waveforms were performed on correct trials only. Trials with reaction times shorter than 300 ms or longer than 1500 ms were excluded from all analyses (1.2% of trials).

Mean reaction times were submitted to mixed-effects model analysis. Mixed-effect modelling allows for simultaneous inclusion of multiple random factors (Brysbaert, 2007; Quené and van den Bergh, 2008). In the present study, participants and items were included as random factors. The crossed fixed factors were wordness (shortcut vs. pseudo-shortcut) and type (all-letter strings vs. letter–digit strings). Before analysis, reaction times were transformed to their logarithmic values to remove the intrinsic positive skew and nonnormality of their distribution (Keene, 1995; Limpert et al., 2001; Quené and van den Bergh, 2008).

The mean amplitudes of the ERP waveforms were submitted to repeated-measures ANOVAs with wordness (shortcut vs. pseudo-shortcut) and type (all-letter items and letter–digit items), hemisphere (left hemisphere vs. right hemisphere), and location as independent variables (anterior, i.e., F5, AFF7h, AF7, AF5h, AFF5h, F3, F1, AF3h, F7, F6, AFF8h, AF8, AF6h, AFF6h, F4, F2, AF4h, F8, FFC5h, FFC3h, FFC1h, FFC2h, FFC4h, FFC6h, FC5, FCC5h, C5, C3, FCC3h, FC3, FC1, C1, FCC1h, FC6, FCC6h, C6, C4, FCC4h, FC4, FC2, C2, FCC2h vs. posterior, i.e., CCP1h, CCP5h, CPP5h, CP3, CPP3h, CCP3h, CP1, CP5, CPP1h, CCP2h, CCP6h, CPP6h, CP4, CPP4h, CCP4h, CP2, CP6, CPP2h, TTP7h, TPP7h, P7, P5, P3, P1, PPO5h, PPO3h, PPO1h, PO7, PO5h, PO3h, POO1, TTP8h, TPP8h, P8, P6, P4, P2, PPO6h, PPO4h, PPO2h, PO8, PO6h, PO4h, POO3).[4] This led to a division of electrodes into four areas. The areas were chosen after visual inspection to investigate localization and lateralization of the occurring effects.

Appendix A. List of stimuli used in the experiment (LL—all-letter acronyms, LN—letter–digit acronyms)

Shortcut	Nonshortcut	Type	Conventional spelling of shortcuts	Words (fillers)
ezy	eze	LL	easy	arc
u	e	LL	you	as
cm	zq	LL	come	at
wot	wut	LL	what	awe
shud	shub	LL	should	balk
fwd	fyd	LL	forward	bull
thru	lhru	LL	through	coma
wknd	wcnd	LL	weekend	dill
skool	slool	LL	school	ferry
prsn	prcn	LL	person	fizz
grats	grals	LL	congratulations	flute
luv	luw	LL	love	gin
msg	mqg	LL	message	gnu
b	d	LL	be	if
nvm	nvy	LL	never mind	jaw
pls	plw	LL	please	lap
wk	wq	LL	week	mug
cus	czs	LL	because	nut
txt	lxt	LL	text	pea
bak	buk	LL	back	saw
wckd	wchd	LL	wicked	snug
jk	za	LL	joke	so
spk	skk	LL	speak	tap
wen	wew	LL	when	tar
thx	tkx	LL	thanks	tom
sry	srj	LL	sorry	zap
ppl	ppj	LL	people	zip
yr	zr	LL	year	zoo
rgds	rqds	LL	regards	zoom
dinr	binr	LL	dinner	leg
ruok	ruak	LL	are you ok	aloe
btw	jtw	LL	by the way	ant
bff	zff	LL	best friend forever	axe
blog	btog	LL	web log	bike
np	jp	LL	no problem	bud
bbl	btq	LL	be back later	fog
bb	jj	LL	bye bye	in
brb	brj	LL	be right back	jug
omg	qmg	LL	oh my god	lam
cu	jz	LL	see you	of
bf	xf	LL	boy friend	on
cya	cja	LL	see you	pet
lol	loh	LL	laugh out loud	rag
werubn	werupn	LL	where have you been	statue
gf	gv	LL	girl friend	we
sys	zys	LL	see you soon	wit
rofl	roff	LL	roll on the floor laughing	wolf
werru	merru	LL	where are you	he
sme1	zme1	LN	someone	beef
sum1	sud1	LN	someone	bike
t2go	l2go	LN	time to go	clue
g2g	q2q	LN	got to go	cod
wan2	wam2	LN	want to	crab
4u	4o	LN	for you	do
2nite	2mite	LN	tonight	druid

(continued on next page)

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[4] Mixed-effect analysis was not possible for EEG data because there were no available data for items.

Appendix A *(continued)*

Shortcut	Nonshortcut	Type	Conventional spelling of shortcuts	Words (fillers)
n1	m1	LN	nice one	emu
in2	iu2	LN	Into	fox
1daful	1baful	LN	wonderful	garlic
ne1	ni1	LN	anyone	gum
no1	mo1	LN	no one	ink
b4	d4	LN	before	it
2 day	2doy	LN	today	monk
h8	k8	LN	hate	my
d8	p8	LN	date	or
w8	v8	LN	wait	paw
ttul8r	ktul8r	LN	talk to you later	pirate
l8r	t8r	LN	later	pun
2moro	2noro	LN	tomorrow	troll
l8	t8	LN	late	up
m8	s8	LN	mate	us
4ever	4ewer	LN	forever	fork

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