CICSD

The Lexical Organization and Processing of Text Messages: Evidence From Priming

Pamela A. Smith
Bloomsburg University, Bloomsburg, PA

The study of computer-mediated communication (CMC) includes aspects of communication theory, education, information science, linguistics, sociolinguistics, and technology (Baron, 2005b). One popular type of CMC is text messaging, or "short messaging service" (SMS; Crystal, 2006; Grinter & Eldridge, 2003; Ling & Baron, 2007; Thurlow, 2003), which has been used for a number of years as a method of immediate communication among individuals who are not in direct proximity to one another. The popularity of SMS has been attributed to such factors as its portability, asynchronous nature, and capacity for easily concealed communication (Thompson & Cupples, 2008), in addition to its relatively low expense (Constantiou, Damsgaard, & Knutsen, 2007). Originating in Europe, where it remains popular and economically successful (Constantiou et al., 2007), the use of SMS is rapidly growing in the United States. The number of text messages sent per month exceeded 48.1 billion at the end of 2007, compared to 9.8 billion at the end of 2006 (CTIA: The Wireless Association, 2008). Minutes of cell phone use have grown 1½ times between 2006 and 2007 from 1.5 trillion to 2.1 trillion, but numbers of text messages has increased nearly 4½ times in the same period, from 81 billion to 363 billion (CTIA: The Wireless Association, 2008). SMS is used in both text messaging services via cellular phones and instant messaging through various e-mail service providers (Constantiou et al., 2007). The use of SMS technology has pervaded society such that the abbreviations used in text messaging/instant messaging have become part of the language of pop culture, advertisements, and various other communication media (Crystal, 2006; Subrahmanyam &

ABSTRACT: **Purpose**: Using a priming/lexical decision paradigm and reaction time data, this study sought to determine how individuals store and organize text messages in the lexicon. Specifically, research questions included whether individuals store different types of text messages (numerals and letters) differently, and whether they store them as sums of their components or as individual semantic units.

Method: Fifty-nine undergraduates completed a lexical decision task that featured the use of text messages as primes. These primes and lexical decision stimuli were systematically varied to compare hypothesized associations between them. Reaction times in the lexical decision task were analyzed to determine the closest associations between primes and variables in the lexical decision stimuli.

Results: Reaction times were fastest overall for complex text messages that contained numerals as opposed to those that contained letters only. For singleton text messages, there were no significant differences between reaction times between numerals and letters. Reaction times were also fastest for letter combination text messages paired with lexical decision items that were the component of the text message (e.g., *LOL – LAUGH*). For text messages that were composed of numerals and letters, the reactions times across all associated items were similar.

Conclusions: Results suggest that individuals store and access multiunit text messages composed of numerals and letters differently than they do text messages composed only of letters—a difference that was not seen in singleton text messages. The results further suggest a cognitive component of storage and access of text messages.

KEY WORDS: psycholinguistics, priming, lexical decision, text messaging, computer-mediated communication

1092-5171/10/3701-0027

Greenfield, 2008; Sutherland, 2002; Thompson & Cupples, 2008).

The social reality of SMS is supported by its increasingly diverse use (Murnan, 2005). Specifically, it is used for self-help (Whittaker, 2008), in advertising media (Crystal, 2006; Thompson & Cupples, 2008), in consumer surveys (Balabanis, Mitchell, & Heinonen-Mavrovouniotis, 2007), for facilitation of communication among individuals with communication disabilities (Power, Power, & Rehling, 2007; Schindler, 2003), in educational endeavors (Young, 2008), and for emergency notification (CTIA: The Wireless Association, 2008; Stone, 2007). Such diverse use is consistent with the ease with which it is learned and used.

In addition to its prevalence in mainstream society, SMS/text messaging is also providing assistance for individuals with disabilities as a social/pragmatic communication modality (Power et al., 2007; Schindler, 2003). CMC is often a component of augmentative communication systems, both for individuals with physical disabilities (Abascal & Civit, 2000) and for those with communication deficits associated with pervasive developmental disorders (Rajendran & Mitchell, 2006). Improving device access to compensate for physical disability continues to be a focus of research and development in the augmentative technology industry, improving access to CMC for all individuals. Assistive technology already permits individuals with physical and/or communicative limitations to communicate in new ways, which may include CMC and/or SMS/text messaging (Johansen & Hansen, 2006; Power et al., 2007). Age is not necessarily a barrier to the use of this technology; two thirds of the U.S. population between the ages of 55 and 65 are Internet users (Charness & Holley, 2004). For maximal use throughout the life span, the sensory, motor, and linguistic issues that are involved in using CMC should be examined, and the information should be used in training programs, as many older users report that lack of familiarity is a large barrier to their use (Mann, Helal, Davenport, Justiss, Tomita, & Kemp, 2004). A greater understanding of the structure and representational nature of CMC might help make this technology more easily learned by more potential users.

Scholarly inquiry regarding CMC has examined the linguistic, pragmatic, and social use of SMS. E-mail and other online communications have been researched for their linguistic content as well as their social and pragmatic conventions (Baron, 2004; Crystal, 2006; Fox, Bukatiko, Hallahan, & Crawford, 2007; Grinter & Eldridge, 2003; Herring, 1996, 1999, 2004; Neviarouskaya, Prendinger, & Ishizuka, 2007). The "language" of CMC/SMS is often criticized (Thurlow, 2003, 2007). There is debate about this communication system and resultant detraction from standard language form and use. Although some argue that language structure and use suffer due to the increasing use of text messaging (Sutherland, 2002), others disagree (Baron, 2005a, 2005b; Crystal, 2006; Thurlow, 2003, 2007), believing that use of these alternative modalities enhances language use among societal groups as a whole (Crystal, 2006; Thurlow, 2003, 2007).

In order to examine the linguistic nature of text messaging, questions about structure and semantics in CMC must be addressed. Do the acronyms and abbreviations that are used in text messaging carry their own level(s) of representational meaning? Although not examined specifically with regard to text messaging, there is evidence that acronyms carry lexical representations and are a means to access semantics via visual recognition tasks (Laszlo & Federmeier, 2007, 2008; Noice & Hock, 1987; Taft, 1984). There is also evidence that visual presentation of numerals provides access to the lexicon based on their visual similarity to letters (Perea, Dun, & Carreiras, 2008). However, lexical aspects of SMS/text messages, which encompass different types of encoding in addition to acronyms, and seem to use numerals in a representational fashion, have not been studied. Recent advertisements and more widespread use of SMS in popular culture suggest that these short messages may carry representational meaning and may be stored in the user's lexicon. An exploration into the mechanisms for the lexical organization and access of text messaging items is the focus of this report.

Researching Lexical Organization

In psycholinguistics, there are numerous models for organizing the linguistic system. *Spreading activation* models of lexical organization and visual word recognition describe the lexical system as a collection of "nodes," or levels of stored representations being connected by "associations" (Collins & Loftus, 1975; McClelland & Rumelhart, 1981; Seidenberg & McClelland, 1989). Spreading activation models do not specify a precise organization of lexical items, but rather the variables of frequency of use and familiarity seem to be important in any one individual's levels of representation and strength of associations. Stronger or closer representations may be formed by experience, familiarity, or personal relevance of a lexical item. This type of model accounts for individual differences in lexical organization and simultaneously explains the effects of word frequency and familiarity. *Parallel distributive* models of visual word recognition and reading specify ordered processes that are used in the complex activity of translating orthographic items to conceptual thought to production. These models are designed to account for learning and to explain individual differences in learning patterns, often through computational analysis. The merits of various models of lexical organization and processing are debated in the literature, and it is beyond the scope of this report to espouse one model versus another. However, the depth and complexity of scholarly work in modeling linguistic processing is consistent with the premise that there is a level of representation and organization of the meaningful units that is particular to the vocabulary of CMC.

Evidence for language processing models comes largely from experimental data in the realm of psycholinguistics. One type of data is derived from priming studies (McNamara, 1992; Meyer & Schvaneveldt, 1971; Perea & Rosa, 2002; Ray, 2008; Ray & Bly, 2008). Priming is an experimental technique that is often used in conjunction with lexical decision (LD) tasks. An item (prime) is presented for a measured period of milliseconds before the presentation of another string of letters, and the participant's task is to make an LD; that is, to quickly determine if the presented string of letters is a word or is not a word. Stimuli for primes and for LD items are selected and organized in precise ways in order to examine semantic or other relationships between the two items. Reaction time (RT) data derived from tasks such as these inform our knowledge about the relative cognitive distance between items in the mental lexicon. Shorter RTs suggest closer associations/stronger representations; longer RTs suggest weaker associations/representations (see Harley, 1995, for a review). Carefully constructed sets of stimuli allow the researcher to test hypotheses about the organization of various items in the lexicon. Priming data have shown that semantically related items facilitate LDs, as evidenced by faster RTs, but other relationships may also be reflected in RT data (Perea & Rosa, 2002). The time course of lexical access has been explored in priming studies, suggesting that orthographic priming also facilitates word recognition, although more quickly than does semantic priming (Grainger, Kiyonaga & Holcomb, 2006). The paradigm can be used to explore numerous relationships between primes and LD items depending on how sets of stimuli are constructed. In this study, the stimuli were text messages (which served as primes) followed by LD items with various possible relationships to the text message primes.

Types of Text Messages and Psycholinguistic Inquiry

As in any communicative medium, in order for SMS communication to be effective, communicators must share context as well as coded representations (Murnan, 2005; Neviarouskaya et al., 2007). Text messaging is common among subgroups of individuals, suggesting that these users would be more familiar with SMS "vocabulary" items. However, differences in prevalence of the use of modality across a population do not obviate the linguistic and psycholinguistic reality of the modality and its vocabulary. As text messaging is used by many individuals on a daily basis to communicate effectively and instantly, and as it has potential to assist individuals with disabilities, study of the lexical organization of text messaging is warranted.

There are various types of SMS items described in the literature (Ling & Baron, 2007; Thompson & Cupples, 2008; Thurlow, 2003). Some text messages make use of single letters; others make use of multiple letters. Some text messages use numerals in a rebus fashion; others combine the rebus numeral with letters to create a unique item. This study used a priming paradigm to examine the lexical organization of various types of text messages among college students aged 20–24 years.

Research Questions

This study addressed the following research questions:

1. Do individuals store numerical/rebus text message/SMS items differently in their mental lexicon than they do text messages that are constructed from single letters and letter combinations?
2. Do individuals process these different types of text messages differently given the amount of processing time available to them?
3. For letter text messages, do individuals store text messages as a single semantic unit, as a set of component words, or as a set of component letters?
4. For numerical text messages, do individuals store text messages as a single semantic unit, as the numeral itself, or as a homophone of the numeral?
5. What differences in text message storage and access can be attributed to self-reported frequency of text message use?

METHOD

Development of Stimuli

An initial list of 25 text messages was developed via brainstorming by a group of students enrolled in an independent study psycholinguistics research course. This list was cross-referenced to and expanded by lists reported by others (Crystal, 2006; Thurlow, 2007). The preliminary list of 30 text messages was distributed to a group of 70 undergraduate students (none of whom served as participants in the priming study) who were asked to rate each item on a Likert scale to note frequency of use in either text or instant messaging, where 1 equaled *rarely* used and 5 equaled *frequently* used. The students were also invited to suggest additional text messages that they used frequently (no additional messages were offered). The top 20 most frequently used text messages were included in the study. The mean frequency scores for the most commonly used messages ranged from 2.16 to 3.63. A total of six single-letter messages, nine multiletter messages, two single-numeral messages, and three numeral + letter text messages were included. Table 1 shows the text message symbols and their agreement scores.

Development of prime/LD pairs. For each letter text message, several test and foil LD items were developed. LD items included a word that was the semantic interpretation of the text message, a word that was a component of the text message itself (for multiletter text messages), and a real word that was composed of the letters in the text message. Word frequency is an important variable to control as word frequency and familiarity impact RTs in LD tasks (Harley, 1995). The lowest frequency for any of the real words was 89 occurrences per million words in spoken and/or written English (Leech, Rayson, & Wilson, 2001). Foils included real words that were semantically unrelated to and included no letters from the text message, nonwords that included letters from the text message, and phonologically unrelated nonwords. Unrelated foils were presented to reduce participants' awareness of the specific intent of the task. Character length was balanced across real word and foil items. There was a total of 84 different prime-target combinations in the letter variable, with 54 real words and 30 nonword foils. Table 2 shows examples of stimuli and foils that were used in the study for letter primes.

Table 1. Text messages and their frequency of use scores.

Single letter	*Frequency score*	*Multiletter*	*Frequency score*	*Numerical*	*Frequency score*
U	3.51	LOL	3.63	2	3.02
UR[a]	3.47	IDK	3.31	4	2.71
Y	2.86	OMG	3.29	B4	2.55
R	2.81	JK	3.11	2NITE	2.43
B	2.22	CYA	2.61	2DAY	2.27
C	2.21	TTYL	2.59		
		ASAP	2.35		
		NM	2.16		
		BTW	2.16		

Note. 1 = never; 5 = very frequently.

[a]UR was treated as a single-letter message as it is used as a contracted "your" or "you're" and does not represent two conjoined words.

For each numeral text message, several test and foil LD items were developed. LD items included a word that was the semantic interpretation of the text, the numeral from the text message written orthographically, and two homophones of the numeral. Foils included real words that were semantically unrelated to the text message and unrelated nonwords. Character length was balanced across real word and foil items. Because several different text message constructions were used, and the specific text messages chosen were based on user-reported frequency, the numbers of stimuli are not uniform across types. There was a total of 27 different prime-target combinations in the numeral variable, with 22 real words and 5 nonword foils. Table 3 shows examples of stimuli and foils that were used in the study for numeral primes.

Participants

Sixty-eight students (mean age = 21.4, *SD* = 1.1, range = 20–24) received course credit for their participation in the study as part of an undergraduate course in psycholinguistics. Participants were excluded who had a history of speech, language, or learning disability; reported a history of head injury or other neurological condition; reported taking any medication that might impact performance on RT tasks; or for whom English was not the primary language. Because there was only 1 male among the 68 students, and the literature suggests gender differences in RT performance (Adam et al., 1999), the male participant's data were excluded. Participants provided demographic data that included an estimation of their daily use of text messaging. Participants who sent/received 10 or more messages a day were assigned to the high usage group (*n* = 30); those who reported fewer than 10 messages daily were assigned to the low usage group (*n* = 29). The experience criteria were arbitrarily determined based on the number of participants and their reported SMS use, which fairly equally divided the group. A total of 59 participants was included in the analysis.

Apparatus

The experiment was conducted on a Gateway computer running Windows XP using SuperLab experimental software (Cedrus, 2004). Stimuli were presented on a white background in black 60 point Times New Roman font. Each prime-LD trial was separated by one of 10 computer-generated colored faces; participants were told as part of the instructions for the experiment that the faces served only as placeholders to separate the stimuli and had no bearing on their performance on the task. These placeholders provided a period of untimed activity between stimulus items that permitted the participant time to focus adequately on the next experimental trial.

Two different experimental conditions were employed; each participant was randomly assigned to one of the two conditions. In both conditions, each text message prime was presented for 75 ms. In the *immediate* condition, there was no interstimulus interval before presentation of the LD item. In the *delayed* condition, the prime was followed by an interstimulus interval of 250 ms before presentation of the LD item. Participants pressed a key on a color-coded response pad (Model RB 530; Cedrus, 2004) to indicate their LD; RTs for each keypad press were measured, recorded, and saved in individual files by the SuperLab software. Each trial was coded for the variables of

Table 2. Examples of text message letter primes and lexical decision stimuli.

Type of prime	*Example*	*Semantic*[a]	*Component*	*Phonol real*[b]	*Real foil*	*Nonword foil*	*Phonol nonword*[c]
Letter	U	You		Us	Eye	Keln	Ul
Multiletter	LOL	Funny	Laugh	Lollipop	House	Paig	Olla

[a]Semantic = semantic interpretation, [b]Phonol real = phonologically related real word, [c]Phonol nonword = phonologically related nonword.

Table 3. Examples of text message numeral primes and lexical decision stimuli.

Type of prime	*Example*	*Semantic*[a]	*Written numeral*	*Homophone*	*Real foil*	*Nonword foil*
Numeral	4	For	Four	Fore	Flight	Sike
Num + let	2day	Today	Two	Too	Collie	Gilm

[a]Semantic = semantic interpretation.

association, prime construction, and word/nonword through SuperLab, with variables of experience and time (immediate/delayed) coded afterward.

Procedure

Each participant provided informed consent and completed a background demographic questionnaire. Participants were seated in front of the laptop at a distance of approximately 2½ feet from the screen. Each participant passed a computerized reading screening (derived from items in Shipley & McAfee, 1992) to ensure that they could read the size and style font that was presented. Participants were directed to orient the color-coded keypad as they wished, but to use both index fingers when pressing the keypad. They were directed to press the green key if the presented letter string was a word and the red key if it was not a word. For the study, the experimenter pressed a key on the keyboard to initiate the presentation of each prime-target combination; after the participant pressed the key for the word/nonword decision, one of the colored face placeholders appeared on the screen. The experimenter again pressed a key to advance to the next stimulus item. A practice block preceded presentation of the experimental stimuli and was repeated as needed to ensure the participants' understanding of the task. The stimulus items were randomized for presentation, and participants were given a break at the midpoint of the task. For each participant, the entire experimental task took approximately 15 min. RTs to the LD task were measured and automatically recorded by SuperLab and were saved in an individual file.

All procedures were approved by Bloomsburg University's Institutional Review Board.

ANALYSIS AND RESULTS

RT data were opened in Microsoft Excel and were grouped and sorted by the variables coded through SuperLab. Statistical analyses were completed using SPSS Version 15.0.1 (SPSS Inc., 2006) and the GraphPad QuickCalcs calculator (GraphPad Software Inc., 2005). Table 4 summarizes the self-reported text messaging data for the participants. The mean number of text messages sent/received per day for the low usage groups (immediate and delayed conditions) were 2.15 and 2.60; these were not significantly different, $t = 0.5190$; $df = 27$, $p = .608$: The mean number of text messages sent/received per day for the high usage groups were 27.15 and 27.31; these also were not significantly different, $t = 0.0312$; $df = 28$, $p = .925$.

Preliminary Analyses

Outlier management. Due to the variability of RT data, it is necessary to manage outliers so that extreme responses do not inappropriately skew the outcomes that are derived from the data. There are a number of methods of outlier management that can be employed, with no specific statistical advantage of one versus another (Ratcliff, 1993). For this study, initial means and standard deviations for words and nonwords for both letter primes and numeral primes were calculated before any further data management. In order to manage outliers, responses > 2 *SD*s from the mean were replaced with the value that was 2 *SD*s from the mean (Barnett & Lewis, 1978). A total of 112 outliers for responses to letter primes and 36 outliers for responses to numeral primes were replaced, representing approximately 2% of the data.

Item analysis. Although attempts were made to control for word frequency, the types of stimuli that could be used for this study were limited by the nature of the research questions that were proposed. An initial item analysis was conducted on a set of pilot data to determine if any single stimulus item appeared to be processed differently from the others; this would be indicated by a significant finding when RT data were analyzed by items. There was a significant effect noted in the item analysis, $F(1, 110) = 10.590$, $p < .0001$. The mean comparisons for RTs for

Table 4. Self-reported daily text message usage by research condition.

Time	*Usage frequency*	*N*	*Mean daily text messages sent and/or received*	*SD*	*Range*
Immediate	Low	15	2.15[a]	2.230	0–6
	High	15	27.14[b]	14.899	10–100
Delayed	Low	14	2.60[a]	2.354	0–5
	High	15	27.31[b]	13.325	10–50

[a]Low usage means comparison (immediate, delayed), $t = 0.5190$; $df = 27$, $p = .608$; [b]High usage means comparison (immediate, delayed), $t = 0.0312$; $df = 28$, $p = .925$.

items containing the homophone "fore" were significantly different from RTs for items concerning other homophones (*for* and *2/to/too*). RTs for items containing *fore* were not significantly different from items containing nonwords. Because *fore* is a less frequently occurring item (it was the least frequently occurring real word in the stimulus set), it was concluded that this RT difference was likely based on a word frequency effect, and items containing *fore* were excluded from further real word analysis.

Words/nonwords. In both conditions, participants responded more quickly to real words (M = 654.14; SD = 168.183) than to nonwords (M = 782.32; SD = 196.978) ($t = -25.764$; $df = 74$; $p < .0001$). The real word/nonword difference in response latency is consistent with prior priming research, which found that LD tasks are completed more quickly with real words, likely due to the strength of representations of the real words in the individual participant's lexicon and the resultant faster activation of these items (Meyer & Schvaneveldt, 1971). The presence of the real word/nonword difference in response latency suggests that other differences in RT will also likely reflect differences in lexical organization. For the remaining analyses, the nonword items were removed from the data set so that comparisons of only real words in the LD tasks would be made.

Error analysis. A set of pilot data was analyzed to see if there were any differences in correct versus incorrect responses in the LD task. Incorrect responses represented approximately 5.5% of the data in the analysis. RTs for incorrect responses (M = 742.211; SD = 195.55) were significantly different from RTs for correct responses (M = 587.36; SD = 154.58) ($t = 2.222$; $df = 449$; $p = .028$). All incorrect responses were eliminated from the data so that participants' incorrect responses would not skew the results.

Further analysis proceeded after the management of outliers, nonword foils, and errors. Data were analyzed in a three-factor analysis of variance (ANOVA) with two levels of time (immediate, delayed), two levels of prime construction (letter, numeral), and two levels of experience (high, low). Following each ANOVA result, the means and the standard error of the mean (SEM) are reported in parentheses.

Time: Immediate/Delayed. There was a significant main effect for time, $F(1, 75) = 291.348$; $p < .0001$. Participants responded faster in the delayed condition (M = 588.895; SEM = 4.764) than in the immediate condition (M = 695.676; SEM = 4.055).

Prime construction. There was a significant main effect for prime, $F(1, 75) = 60.448$; $p < .0001$. RTs across all items in the LD task were faster for primes that included numerals (M = 617.966; SEM = 5.611) than for primes that were composed of single or multiple letters without numerals (M = 666.605; SEM = 2.2.767).

Experience: High/Low. Across all conditions for real words, there was a significant main effect for experience, $F(1, 75) = 10.413$; $p < .0001$. Individuals who reported higher use of text messaging had overall slower RTs to the LD task (M = 647.714; SEM = 3.915) than did individuals who reported use of < 10 text messages per day (629.195; SEM = 4.196).

Interaction effects. There was an interaction effect for Time × Prime Construction, $F(1, 75) = 13.326$; $p < .0001$, and for Time × Experience, $F(1, 75) = 6.196$; $p = .013$. Figure 1 displays the RTs for numeral and letter primes in both time conditions by experience. The difference in RTs between numeral and letter text messages, by experience, were greater in the delayed condition than in the immediate condition.

Associations: Letter text message primes. Separate ANOVAs were completed for the LD tasks with the letter and numerical text message primes. For the letter primes, an ANOVA was completed with four levels of association (semantic, component, word, foil), two levels of prime construction (single letter, multiletter), two levels of time (immediate, delayed), and two levels of experience (high, low).

There was a significant main effect for association, $F(3, 53) = 43.541$; $p < .0001$. Post hoc testing was conducted using Fisher's LSD (multiple comparisons). RTs were fastest for LD tasks that used component words (M = 619.007; SEM = 7.359) and that used the semantic interpretation of the text message (M = 630.451; SEM = 6.013). RTs for unrelated foils (M = 670.359; SEM = 5.035) were significantly slower than RTs for words that were either component or semantic units, but they were faster than RTs for unrelated words composed of the letters of the text message prime (M = 690.447; SEM = 5.142). There was also a main effect for prime construction, $F(1, 53) = 54.541$; $p < .0001$). RTs for single-letter primes were faster (M = 640.666; SEM = 4.950) than RTs for multiletter primes (M = 669.880; SEM = 3.404).

There was an interaction effect noted for Association × Prime Construction, $F(2, 53) = 6.291$, $p = .002$. The interaction effect is illustrated in Figure 2. Because there could be no separate "component" measure for the single-letter prime, the single-letter text message is represented with the same value as "semantic" in this figure, for illustrative purposes only, as it represents the same concept. RTs for the semantic interpretation of the single-letter prime were faster

Figure 1. Reaction times (RTs) by prime construction, time, and experience.

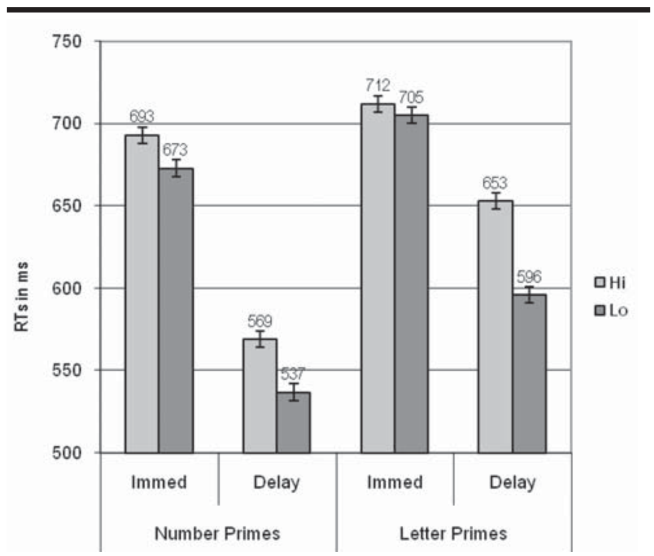
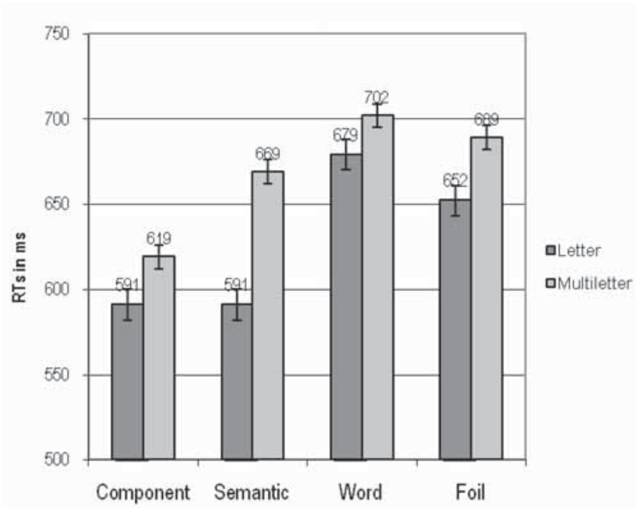


Figure 2. Letter lexical decision interaction: Association × Prime Construction.



in comparison to RTs for the semantic interpretation of the multiletter primes than was the single/multiletter difference in either the graphically related word or the unrelated foil.

There was also an interaction effect for Association × Time, $F(3, 53) = 5.546$; $p = .001$, which is illustrated in Figure 3. The fastest RTs were seen in the component LD task in the delayed condition, a difference that was not seen across the immediate condition.

In the letter LD task, there was also an interaction effect for Time × Experience, $F(1, 53) = 12.795$; $p < .0001$. The experience effect, where users with high experience had slower RTs, was only seen in the delayed condition (High $M = 634.019$; SEM = 5.059; Low $M = 585.254$; SEM = 6.453), not in the immediate condition (High $M = 707.774$; SEM = 5.730; Low $M = 702.394$; SEM = 5.700).

Associations: Numerical text message primes. A separate ANOVA was completed for the numerical text message primes, with four levels of association (semantic, written, homophone, foil), two levels of prime construction (numeral, numeral + letter), two levels of time (immediate, delayed), and two levels of experience (high, low).

There was a significant main effect for association, $F(3, 21) = 9.893$, $p < .0001$. There were no significant differences in response to text message primes paired with the semantic interpretation ($M = 595.320$; SEM = 12.846), the numeral written graphically ($M = 595.049$; SEM = 10.118), or the homophone ($M = 608.144$; SEM = 10.118), but these were all faster than the RT to an unrelated foil ($M = 660.622$; SEM = 10.325).

There was an interaction effect noted for Association × Prime Construction, $F(2, 21) = 7.880$; $p < .0001$. This interaction is shown in Figure 4. Longer prime length increased RTs for unrelated words, but not for items with either a semantic relationship, a graphic representation of the numeral, or a homophone. For single-numeral primes, RTs did not vary with the relationship of the LD task to the prime.

No other interaction effects were noted.

Planned comparisons. A series of planned comparisons was completed for items that were not directly evaluated within the ANOVA.

Planned comparisons: Homophone. Single-letter text message primes paired with semantic LD items (e.g., *C – SEE*; $M = 590.702$; SEM = 8.884) were compared to single-numeral primes paired with homophone LD items (e.g., *4 – FOR*; $M = 616.378$; SEM = 15.419) because in both cases, the LD item was essentially a homophone. There was no significant difference in RTs between these two types of items, $t = 1.4137$; $df = 622$; $p = .158$.

Planned comparisons: Semantic. Responses to semantic interpretations of both multiletter text message primes (e.g., *LOL – FUNNY*) and numeral + letter text message primes (e.g., *2day – TODAY*) were compared across the two experience conditions. For the high experience group, there was a significant difference between the multiletter ($M = 672.322$; SEM = 9.641) and the numeral + letter (M

Figure 3. Letter lexical decision interaction: Association × Time.

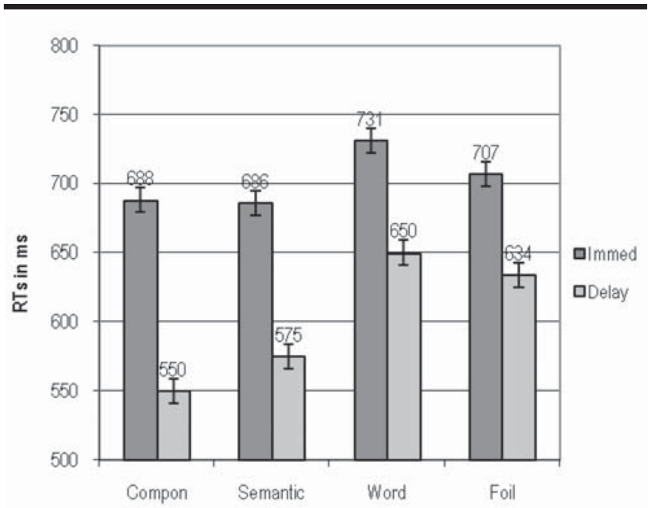
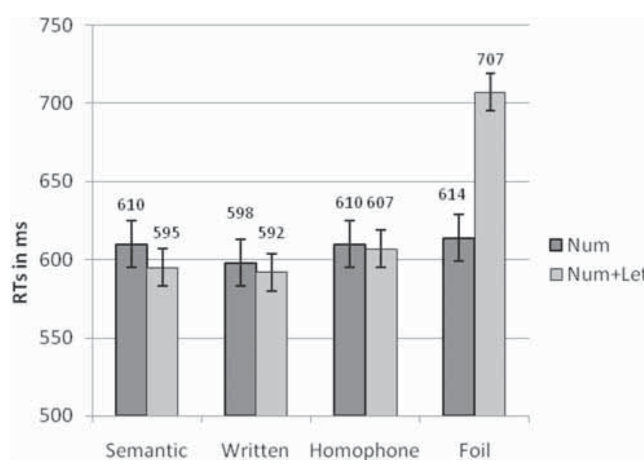


Figure 4. Numeral lexical decision interaction: Association × Prime Construction.



= 601.646; SEM = 16.737) conditions, $t = 3.928$; $df = 648$; $p < .0001$. For the low experience group, there was also a significant difference between the multiletter ($M = 666.714$; SEM = 11.170) and the numeral + letter ($M = 588.994$; SEM = 19.492) conditions, $t = 3.718$; $df = 648$; $p = .0002$.

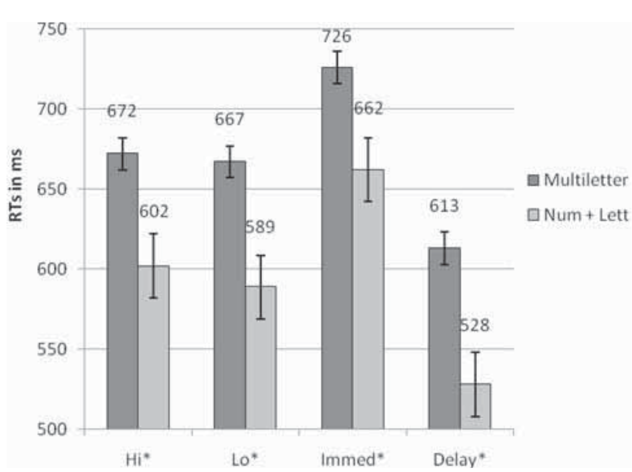
Responses to semantic interpretations of both multiletter text message primes (e.g., *LOL – FUNNY*) and numeral + letter text message primes (e.g., *2day – TODAY*) were also compared across the two time conditions. In the immediate condition, there was a significant difference between the multiletter ($M = 726.033$; SEM = 9.304) and the numeral + letter ($M = 662.378$; SEM = 16.314) conditions, $t = 3.643$; $df = 648$; $p = .0003$. In the delayed condition, there was also a significant difference between the multiletter (613.004; SEM = 11.453) and the numeral + letter ($M = 528.263$; SEM = 19.847) conditions, $t = 3.396$; $df = 648$; $p = .0001$. The above planned comparisons, which are shown in Figure 5, reflect the longer RTs observed for the responses to the letter versus numeral text message primes as noted in main effects.

Planned comparisons: Components. Responses to components of multiletter text message primes (e.g., *LOL – LAUGH*) and graphic with numeral + letter (e.g., *2day – TWO*) text message primes were compared across the experience and time conditions. These two variables were compared because the graphic representation of the numeral + letter condition (*2day – TWO*) could be considered analogous to the component variable in the letter condition (*LOL – LAUGH*). These comparisons are illustrated in Figure 6.

For the experience variable, there was no significant difference in RTs between multiletter/component and numeral + letter/graphic conditions across high ($p = .243$) and low ($p = .108$) users.

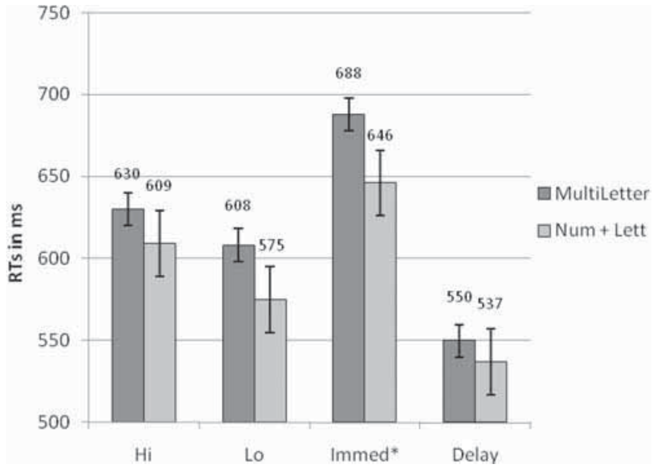
Similar planned comparisons were conducted for the time variable. In the immediate condition, there was a significant difference between multiletter text message/component

Figure 5. Planned comparisons – semantic association: RTs by experience and time for multiletter and numeral + letter primes.



*Comparison is significant.

Figure 6. Planned comparisons – component association: RTs by experience and time for multiletter and numeral + letter primes.



*Comparison is significant.

LD items (*LOL – LAUGH*; $M = 687.666$; SEM = 9.320) and numeral + letter/graphic LD items (*2day – TWO*; $M = 646.410$; SEM = 16.219), $t = 2.369$; $df = 648$; $p = .018$. In the delayed condition, the differences between items in these variables were not significant ($p = .647$). With increased processing time, the significant differences between processing text message components as either letters or numerals disappeared.

DISCUSSION

In this study, we examined the lexical organization of text messages through the use of a priming paradigm. We analyzed RT data in response to an LD task after presentation of text message primes to examine the associations between primes and various LD items. Several specific research questions were addressed.

Research Question 1

Do individuals store numerical/rebus text message/SMS items differently in their mental lexicon than they do text messages that are constructed from letters and letter combinations?

There is evidence that numerical text messages are processed differently than are letter text messages, but the relationships appear complex. First, overall RTs across all conditions were faster for primes that contained numerals versus primes that consisted of letters only. For single letters and single numerals (semantic LD), however, planned comparisons revealed no difference in RT by experience or time conditions. This suggests that for single character primes, letters and numerals were similarly associated with their semantic interpretations; for letters and numerals, both are homophones. When the primes/text messages became longer, the relationships changed.

In comparing RTs for semantic LD for multiletter and numeral + letter primes, numeral primes resulted in faster RTs across both experience and time conditions. For semantic associations, the pairing of the numeral plus the letter may have increased the semantic content of the prime to a greater degree than did a combination of letters. Thus, when comparing singleton primes to complex primes (semantic LD), singleton numerals and letters were processed similarly, but differences in RTs to semantic associations were seen in primes composed of numerals paired with letters, not letter combinations. Perhaps numeral + letter text messages either carry more semantic information themselves or otherwise activate more relationships, more quickly, than letters alone. Because there was little difference in RTs across the numeral prime conditions themselves (except for the slower RT to unrelated LD foils; Figure 4), but differences in RTs across the letter conditions (Figure 2), more time was required for participants to link multiletter primes with their possible associations than to link numeral primes with theirs.

With regard to homophones, this study found similar RTs to singleton primes for letter and numeral homophones. It also found no difference in RTs to numerical primes between homophones, written numerals, and semantic LDs. It will be recalled that after the item analysis, the less frequently occurring *fore* homophone was removed from the analysis; this homophone was associated with significantly slower RTs and was, in fact, processed by the participants similarly to the nonwords. There is a body of research addressing the visual processing of homophones in LDs. Edwards, Pexman, and Hudson (2004) found that homophones, which normally are processed more slowly than nonhomophones, may not necessarily be processed more slowly when they are combined with other items in morphologically varied sets (i.e., *BILLED – BUILD*). This study had relatively few homophone items and only two primes that were singleton numerals (2 and 4); stimuli for 8 (e.g., *L8TER*) did not reach the frequency criterion for inclusion in the study. Paired with the findings of Edwards et al., and considering the very small number of items in that condition, the evidence suggests that visual representations of homophones may be processed differently based on the concept of "morphology" in text messaging. In that context, numeral + letter primes may have facilitated RTs for semantic, written, and homophone LD tasks; there was a significant slowing in RTs to foils after the numeral + letter prime. Perhaps the pairing of prime and any type of related LD item may have, together, facilitated RT speed.

These results can also be related to the findings of Perea et al. (2008), who suggested that numerals could potentially have different levels of representation that would enable them to activate different types of associations. They found that numerals that were visually similar to letters and were used in that capacity were processed similarly to letters in an LD task (e.g., *M4T3R14L – MATERIAL*). In text messaging, numerals are not used in this same fashion (to represent letters); however, Perea et al. provided evidence that numerals could be processed in a different manner than simply as their typical numerical concept. Numerals do appear to carry multiple levels of representation, not just numerical, but visual and homophone/semantic as well.

Research Question 2

Do individuals process these different types of text messages differently given the amount of processing time available to them?

Across all conditions, RT was faster in the delayed condition. This increase in processing time did not selectively affect the processing in terms of any of the primary variables examined in this study, as there were no interaction effects noted with the time variable, with the exception of Time × Experience in letter LD only, where RTs were slower for letter LD for the high users as opposed to the low users—a difference that was not seen in the immediate condition. However, in planned comparisons, multiletter and numeral + letter primes were processed differently in response to component LD tasks in the immediate condition only, suggesting that the time variable could selectively affect processing of more complex symbolic text messages.

Research Question 3

For letter text messages, do individuals store text messages as a single semantic unit, as a set of component words, or as a set of component letters?

For single-letter text messages, RTs were fastest for semantic interpretations (e.g., *C – SEE*), suggesting that individuals stored these representations as a semantic unit. For multiletter text messages, RTs were fastest for components of the text message (e.g., *LOL – LAUGH*), suggesting that individuals did not store these items (e.g., *LOL*) more exclusively as an entire semantic unit (*funny*), but as the individual words. In fact, RTs for phonologically similar words (e.g., *LOL – LOLLIPOP*) were not significantly different from RTs for the semantic interpretation of the text message (e.g., *LOL – FUNNY*), and an unrelated foil showed a faster RT than a phonologically similar word did.

Recognition of and access to semantics by acronyms have been discussed elsewhere. Laszlo and Federmeier (2007) found in a gating task that individuals recognized acronyms based largely on familiarity rather than on legal/illegal letter combinations. In an event-related potential study where participants attended to cloze sentences with illegal and legal strings, Laszlo and Federmeier (2008) found that semantics also could be activated through the visual presentation of either legal or illegal acronyms. It appears that acronym recognition and access to semantic information through acronyms is quite possible but might be mediated through several co-occurring mechanisms. In this study, acronym primes did not facilitate faster RTs to semantic LD tasks but did facilitate faster RTs to component LDs. Despite attempts to control for familiarity, these effects are still likely to be present, but they would be specific to each item, as there were no interactions related to experience in this variable. The pragmatic content of these primes was not addressed in this study, and it may be the case that in actual social use of the text messages, associations related to pragmatics activate a more semantic relationship than these data suggest. Further study with the lexical representations of acronyms in the text messaging seems warranted.

Research Question 4

For numerical text messages, do individuals store text messages as a single semantic unit, as the numeral itself, or as a homophone of the numeral?

For single-numeral text messages, there was little difference in RT across the conditions of graphic representation, semantic interpretation/homophone, or unrelated foil. For numeral + letter primes, RTs were similar to the single-numeral primes for the semantic, written, and homophone conditions, becoming significantly slower for the foil condition. The longer RT to the unrelated foil in only the numeral + letter combination suggests that for the single-numeral prime, multiple relationships were activated. Participants had similar RTs to the single-numeral primes no matter the relationship of the text message to that prime, whereas for the numeral + letter primes, similar RTs were seen if there was any kind of relationship between the prime and the target. Differences were seen in RT by LD task for numeral + letter primes when there was no semantic relationship. It may be that the numeral + letter prime carried sufficiently targeted semantics to affect the RT for the unrelated foil, whereas the single-numeral prime carried a wider range of semantic content so that multiple associations were primed.

Research Question 5

What differences in text message storage and access can be attributed to self-reported frequency of text message use?

In this sample, participants who reported a higher frequency of text message use showed overall slower RTs in the LD task. This was an unexpected finding, as it was predicted that experienced users of SMS would have stronger representations in their lexicon for the items used when text messaging. There was no significant difference between high and low users within letter or numeral prime conditions in the immediate condition, but for letter primes, participants with more experience had significantly slower RTs in the delayed condition (M = 592.323; SEM = 5.656) than did participants with less experience (M = 569.821; SEM = 7.213), t = 2.4549; df = 57; p = .0141. Explanations for the slower RT among more experienced text message users in the delayed condition can be speculated. First, the experience threshold of 10 text messages per day, which was arbitrarily determined, may have been too lenient in identifying lexical organization patterns with stronger representations. Perhaps a higher threshold, such as 50 messages daily, would have revealed a different pattern based on experience. In addition, experience could be defined not only as a number of messages sent per day, but also as a level of familiarity with the symbols in question. The lack of an interaction between experience and any other main variable suggests either that the representations used in text messaging already existed in an individual user's lexicon, or that users make use of other pre-existing representations when text messaging. An individual may not text message often but may still be familiar with the acronyms as they emerge in popular culture, or may be exposed through e-mail communication. The use of numerals as a rebus/homophone is perhaps more universally known across both users and nonusers of text messaging, making experience less of an issue.

Limitations and Future Directions

Several observations may be made that should impact future study in this area. First, some of the participants indicated (after the results were shared with their class) that they were not aware of the presence of the prime, whereas others were aware. A level of awareness of the presence of the prime was expected given the length of time it was presented. However, on reflection of the results, particularly the results related to the experience variable, awareness of the prime may have invoked higher level cognitive processes, such as problem solving, whereby participants may be cognitively seeking a relationship between the items that were presented. Awareness of the prime has been studied elsewhere, and the contribution of conscious awareness to models of lexical organization and processing is controversial. Different types of word recognition strategies were used in an LD task depending on the time available to them for each stimulus, suggesting a contribution of conscious awareness (Cheesman & Merikle, 1986). Other studies have supported that awareness of the prime did not influence otherwise variable RTs in an LD task (Bodner & Masson, 2003), but that emotionally charged words in particular could be processed without conscious awareness (Gaillard et al., 2006). In another study, functional magnetic resonance imaging revealed differentiated brain activations to masked word and nonword priming stimuli, where the masking limited participant conscious awareness (Diaz & McCarthy, 2007). There is evidence that semantic processing occurs without conscious awareness, although the contributions of awareness and its impact on models of processing are unclear.

In this study, familiarity with the priming task could also have contributed to the awareness variable. Although the participants in this study were students in a psycholinguistics course, this testing was completed before their study of priming as an experimental method. However, there were no controls of their knowledge of psycholinguistic experimental methods beyond that, and a more naïve group might present different results.

In future work, the use of masked priming, where the presentation of the prime is preceded by a visual distractor such as ######, and/or reducing the length of presentation of the prime, might help to control for awareness of the prime, minimizing it and thereby reducing the conscious cognitive processing that participants may have employed. Participants would then use more automatic as opposed to controlled postlexical processes. If the task were modified to invoke more automatic processes, the results would more likely reflect differences in lexical organization rather than cognitive problem solving. Differing degrees of cognitive resources may be involved in processing text messages, depending on users' experience with the modality. The effect of cognitive processing and resource allocation for processing text messages could be further explored by otherwise increasing the cognitive demand of the task through such manipulations as auditory distraction.

The phenomena of backward priming and other priming relationships may also have impacted these results. This study examined potential associations between the primes and targets and compared relationships based on RT differences. Chwilla, Hagoort, and Brown (1998) reported that the relationship between the target and the prime, separate from the anticipated relationship between the prime and the target, may also impact RTs. In priming/LD tasks, RTs may be dependent on multiple factors such as semantic matching, spreading activation, and expectancy. Perea and Rosa (2002) have also discussed different types of relationships between primes and targets, specifically, semantic and associative relationships. Whereas text message primes may be semantically related to the LD targets, it is not likely that they would be associatively related; that is, users are not likely to use *LOL* at the same time as they would use either *funny* or *laugh*. The items may share conceptual features but would not share contextual features during actual use. However, in a spreading activation model, any of these relationships may have an additive effect so that an item that was activated by a prime could be further activated by a related LD target (Neely, Keefe, & Ross, 1989). In addition, activation could persist across the next trial so that various items remain activated beyond their initial presentation, potentially confounding results. Chwilla et al. found through an evoked response potential study that backward priming was primarily a result of semantic matching/integration—processes that seem postlexical in nature. Semantic integrative effects might not occur equally for the letter primes as for the numeral primes, given the different representations noted for numerical primes, or if the participant has less conscious awareness of the prime itself. Future work should examine the use of masked priming and shorter presentations of the primes to see if this helps obviate at least part of the higher level processes that may be involved in processing text messages.

Design and apparatus issues should also be addressed in future studies. As previously noted, the thresholds for the experience variable were arbitrary, and further work examining experience with text messaging might stipulate a higher mean difference between the two groups examined or characterize experience in some other way, perhaps including length of time and/or comfort level with text messaging. The study also is limited by its use of foil items only in the LD stimulus sets. All of the primes that were presented were text message items, and this may have contributed to any effects of either expectancy or semantic matching, especially among those participants who were aware of the presence of the primes and may have used higher level cognitive skills during the tasks. Several participants commented that they "saw some text messages, but weren't sure what they were for." Future work should include foil primes as well as foil LD items in order to further minimize participant awareness of the nature of the inquiry. The placeholder faces also were a distraction to some participants, who sometimes, despite being told that the placeholders had no impact on their performance and were merely between items, stated that they were "distracted" by the presence of the faces and that these caused them to "question themselves." Although at first glance this might be interpreted as a weakness, it could also be considered a positive if in fact it helped to reduce the additive effect of semantic, integration, and expectancy variables in the priming task. Future work might employ some type of simple interstimulus cognitive task to further help reduce the additive effects of these lexical variables on participants' RTs.

Factors related to problem solving, familiarity, and multiple representations are likely to be important when considering the use of CMC/SMS with individuals who use augmentative communication systems. This study did not provide sufficient information to conclude that experience with text messaging resulted in stronger representations, because the factors contributing to familiarity, the effect of cognitive processing, and the relative impacts of each on RT remain unclear. The use of numerals adds the notion of multiple representations that seem to become available for use in a rebus fashion. Further work with individuals with little to no familiarity with text messaging and with individuals with cognitive and/or sensory impairments might help determine the best way to use SMS with individuals with disabilities.

Overall Conclusions

This study demonstrated that letter and numeral text messages appear to be processed differently from one another, but that representations do seem to exist for these messages. The specific mechanisms for storing these representations are likely affected by familiarity as well as specific semantic and component relationships. Singleton numeral and letter text messages were processed similarly, whereas complex text messages containing numerals were processed more quickly than complex messages containing only letters. Singleton text messages were processed most quickly as semantic/homophone interpretations. Complex letter primes were most closely associated with items that were components of the message, and complex numeral + letter primes were equally associated with semantic, written, and homophone LD items. Experience and time did not selectively affect RTs for main variables of prime construction except within very limited contexts.

Future work should focus on reducing the additive effect of semantic relationships by minimizing participant awareness of the prime through the use of masked priming and/or reduction of the time of presentation of the prime. In addition, modifying cognitive demands through either simple cognitive tasks between trials or providing auditory distraction might affect the cognitive resources that participants use in processing text messages.

REFERENCES

Abascal, J., & Civit, A. (2000). Mobile communication for people with disabilities and older people: New opportunities for autonomous life. *Proceedings from the 6th ERCIM Workshop "User Interface for All."* Retrieved from http://ui4all.ics.forth.gr/UI4ALL-2000/files/Position_Papers/Abascal.pdf.

Adam, J. J., Paas, F. G. W. C., Buekers, M. J., Wuyts, I. J., Spijkers, W. A. C., & Wallmeyer, P. (1999). Gender differences in choice reaction time: Evidence for differential strategies. *Ergonomics, 42*(2), 327–335.

Balabanis, G., Mitchell, V., & Heinonen-Mavrovouniotis, S. (2007). SMS-based surveys: Strategies to improve participation. *International Journal of Advertising, 26*(3), 369–385.

Barnett, V., & Lewis, T. (1978). *Outliers in statistical data.* New York, NY: Wiley.

Baron, N. (2004). See you online: Gender issues in college student use of instant messaging. *Journal of Language and Social Psychology, 23,* 397–422.

Baron, N. (2005a). Instant messaging and the future of language. *Communication of the ACM, 48,* 29–31.

Baron, N. (2005b). Who wants to be a discipline? *The Information Society, 21,* 269–271.

Bodner, G., & Masson, M. (2003). Beyond spreading activation: An influence of relatedness proportion on masked semantic priming. *Psychonomic Bulletin & Review, 10,* 645–652.

Cedrus Corporation. (2004). SuperLab 4.0 [Computer software]. San Pedro, CA: Author.

Charness, N., & Holley, P. (2004). The new media and older adults: Usable and useful? *American Behavioral Scientist, 48,* 416.

Cheesman, J., & Merikle, P. (1986). Distinguishing conscious from unconscious perceptual processes. *Canadian Journal of Psychology, 40,* 343–367.

Chwilla, D., Hagoort, P., & Brown, C. (1998). The mechanism underlying backward priming in a lexical decision task: Spreading activation versus semantic matching. *Quarterly Journal of Experimental Psychology, 51A*(3), 531–560.

Collins, A., & Loftus, E. (1975). A spreading-activation theory of semantic processing. *Psychological Review, 82,* 407–428.

Constantiou, I., Damsgaard, J., & Knutsen, A. (2007). Exploring mobile device user adoption patterns and market segmentation. The four incremental steps toward advanced mobile service adoption. *Communications of the ACM, 50,* 51–55.

Crystal, D. (2006). *Language and the Internet* (2nd ed.). New York, NY: Cambridge University Press.

CTIA: The Wireless Association. (2008). *US Wireless quick facts and figures*. Retrieved from www.ctia.org.

Diaz, M., & McCarthy, G. (2007). Unconscious word processing engages a distributed network of brain regions. *Journal of Cognitive Neuroscience, 19,* 1768–1775.

Edwards, J., Pexman, P., & Hudson, C. (2004). Exploring the dynamics of the visual word recognition system: Homophone effects in LDT and naming. *Language and Cognitive Processes*, *10*(4), 503–532.

Fox, A., Bukatiko, D., Hallahan, M., & Crawford, M. (2007). The medium makes a difference: Gender similarities and differences in instant messaging. *Journal of Language and Social Psychology, 26,* 389–397.

Gaillard, R., Del Cul, A., Naccache, L., Vinckier, F., Cohen, L., & Dehaene, S. (2006). Nonconscious semantic processing of emotional words modulates conscious access. In E. Smith (Ed.), *Proceedings of the National Academy of Sciences, 103,* 7524–7529. Retrieved from http://acces.inrp.fr/acces/ressources/neurosciences/neuro_apprentiss_2/ateliers/tilquin/7524.pdf.

Grainger, J., Kiyonaga, K., & Holcomb, P. (2006). The time course of orthographic and phonological code activation. *Psychological Science, 17,* 1021–1026.

GraphPad Software Inc. (2005). GraphPad Quickcalcs T-test calculator [Computer software]. Retrieved from http://www.graphpad.com/quickcalcs/ttest1.cfm.

Grinter, R., & Eldridge, M. (2003). Wan2tlk?: Everyday text messaging. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 441-448). New York, NY: ACM Press. Retrieved from http://reference.kfupm.edu.sa/content/w/a/wan2tlk___everyday_text_messaging_91784.pdf.

Harley, T. (1995). *The psychology of language: From data to theory*. East Sussex, UK: Erlbaum Taylor & Francis.

Herring, S. (1996). Linguistic and critical research on computer-mediated communication: Some ethical and scholarly considerations. *The Information Society, 12*(2), 153–168.

Herring, S. (1999). Interactional coherence in CMC. *Journal of Computer-Mediated Communication, 4*(4). Retrieved from http://jcmc.indiana.edu/vol4/issue4/herring.html.

Herring, S. (2004). Slouching toward the ordinary: Current trends in computer-mediated communication. *New Media & Society*, *6*(1), 26–36.

Johansen, A., & Hansen, J. (2006). Augmentative and alternative communication: The future of text on the move. *Universal Access in the Information Society, 5,* 125–149.

Laszlo, S., & Federmeier, K. (2007). The acronym superiority effect. *Psychonomic Bulletin & Review, 14*(6), 1158–1163.

Laszlo, S., & Federmeier, K. (2008). Minding the Ps, queues, and PXQs: Uniformity of semantic processing across multiple stimulus types. *Psychophysiology, 45,* 458–466.

Leech, G., Rayson, P., & Wilson, A. (2001). *Word frequencies in written and spoken English*. London, England: Longman.

Ling, R., & Baron, N. (2007). Text messaging and IM: Linguistic comparison of American college data. *Journal of Language and Social Psychology, 26*(3), 291–298.

Mann, W., Helal, S., Davenport, M., Justiss, M., Tomita, M., & Kemp, B. (2004). Use of cell phones by elders with impairments: Overall appraisal, satisfaction and suggestions. *Technology and Disability, 16,* 49–57.

McClelland, J. L., & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: Part I. An account of basic findings. *Psychological Review, 88,* 375–407.

McNamara, T. (1992). Priming and constraints it places on theories of memory and retrieval. *Psychological Review, 99*(4), 650–662.

Meyer, D., & Schvaneveldt, R. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology, 90,* 227–234.

Murnan, C. (2005). Expanding communication mechanisms: They're not just e-mailing anymore. *Proceedings of the 34th Annual ACM SIGUCCS Conference on User Services*. Association of Computing Machinery, 267–272. Retrieved from http://portal.acm.org/citation.cfm?doid=1181216.1181275.

Neely, J., Keefe, D., & Ross, K. (1989). Semantic priming in the lexical decision task: Roles of prospective prime-generated expectancies and retrospective semantic matching. *Journal of Experimental Psychology: Learning, Memory and Cognition, 15,* 1003–1019.

Neviarouskaya, A., Prendinger, H., & Ishizuka, M. (2007). Analysis of affect expressed through the evolving language of online communication. *Proceedings of the 2007 International Conference on Intelligent User Interfaces,* Association of Computing Machinery, 278–281. Retrieved from http://portal.acm.org/citation.cfm?id=1216346.

Noice, H., & Hock, H. S. (1987). A word superiority effect with nonorthographic acronyms: Testing for unitized visual codes. *Perception & Psychophysics, 42,* 485–490.

Perea, M., Dun, J., & Carreiras, M. (2008). OBSERVATIONS: R34D1NG W0RD5 W1TH NUMB3R5. *Journal of Experimental Psychology: Human Perception and Performance, 34,* 237–241.

Perea, M., & Rosa, E. (2002). The effects of associative and semantic priming in the lexical decision task. *Psychological Research, 66,* 180–194.

Power, D., Power, M., & Rehling, B. (2007). German deaf people using text communication: Short message service, TTY, relay services, fax, and email. *American Annals of the Deaf, 152,* 291–301.

Rajendran, G., & Mitchell, P. (2006). Text chat as a tool for referential questioning in Asperger syndrome. *Journal of Speech, Language, and Hearing Research, 49,* 102–112.

Ratcliff, R. (1993). Methods for dealing with reaction time outliers. *Psychological Bulletin, 114,* 510–532.

Ray, S. (2008). An investigation of time course of category and semantic priming. *The Journal of General Psychology, 135*(2), 133–148.

Ray, S., & Bly, B. (2008). Two routes for activation in the priming of categorical coordinates. *The Journal of General Psychology, 135*(1), 65–83.

Schindler, C. (2003). *Text messaging: More than just an add-on to cell phone plans*. Retrieved from http://www.tcnj.edu/~technj/2003/testmessaging.htm.

Seidenberg, M., & McClelland, J. (1989). A distributed, developmental model of word recognition and naming. *Psychological Review, 96,* 523–568.

Shipley, K., & McAfee, J. (1992). *Assessment in speech-language pathology* (2nd ed.). San Diego, CA: Singular.

SPSS Inc. (2006). *SPSS Base 15.0.1 for Windows user's guide*. Chicago IL: Author.

Stone, A. (2007, October 3). Campus alert systems take hold. *USA Today*, p. 3a.

Subrahmanyam, K., & Greenfield, P. (2008). Online communication and adolescent relationships. *Children and Electronic Media, 18,* 119–146.

Sutherland, J. (2002, November 11). Can u txt? John Sutherland asks what texting is doing to the English language—and finds it all a bit :-(. *The Guardian Newspaper*. Retrieved from http://www.guardian.co.uk/technology/2002/nov/11/mobilephones2.

Taft, M. (1984). Evidence for an abstract lexical representation of word structure. *Memory and Cognition, 12,* 264–269.

Thompson, L., & Cupples, J. (2008). Seen and not heard? Text messaging and digital sociality. *Social & Cultural Geography, 9,* 95–108.

Thurlow, C. (2003). Generation Txt? Exposing the sociolinguistics of young people's text-messaging. *Discourse Analysis Online*, *1*(1). Retrieved from http://extra.shu.ac.uk/daol/articles/v1/n1/a3/thurlow2002003-paper.html.

Thurlow, C. (2007). Fabricating youth: New-media discourse and the technologization of young people. In S. Johnson & A. Ensslin (Eds.), *Language in the media: Representations, identities, ideologies* (pp. 213–233). London, England: Continuum.

Whittaker, R. (2008). Can cell phone messages help workers quit smoking? *Occupational Health Management, 18,* 25–26.

Young, J. (2008). Forget e-mail: New messaging service has students and professors atwitter. *Chronicle of Higher Education*, *54*. Retrieved from http://chronicle.com/free/v54/i25/25a01501.htm.

Contact author: Pamela A. Smith, Bloomsburg University, Bloomsburg, PA 17815. E-mail: psmith@bloomu.edu.