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An Investigation into the Processing of Lexicalized English Blend Words: Evidence from Lexical Decisions and Eye Movements During Reading

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Abstract New words enter the language through several word formation processes [see Simonini (Engl J 55:752–757, 1966)]. One such process, blending, occurs when two source words are combined to represent a new concept (e.g., SMOG, BRUNCH, BLOG, and INFOMERCIAL). While there have been examinations of the structure of blends [see Gries (Linguistics 42:639–667, 2004) and Lehrer (Am Speech 73:3–28, 1998)], relatively little attention has been given to how lexicalized blends are recognized and if this process differs from other types of words. In the present study, blend words were matched to non-blend control words on length, familiarity, and frequency. Two tasks were used to examine blend processing: lexical decision and sentence reading. The results demonstrated that blend words were processed differently than non-blend control words. However, the nature of the effect varied as a function of task demands. Blends were recognized slower than control words in the lexical decision task but received shorter fixation durations when embedded in sentences.

Keywords Blends · Word formation processes · Visual word recognition · Eye movements · Lexical decision

Introduction

Blending is a word formation process where a novel word is created from two source words. Blend words are lexicalized when they continue to be used in the language. Some examples

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of common blends that should be familiar to most English speakers are SMOG (smoke + fog), BRUNCH (breakfast + lunch), MOTEL (motor + hotel) and the relatively recent blend, BLOG (web + log). While blends and compound words (e.g., farmhouse, airport) share some similarities, they differ in that at least one of the source words is shortened in blends (see Gries 2004; Lehrer 1998). While blends can be created through a speech error, where two competing words are accidentally spliced together (see e.g., Laubstein 1999), word formation blends are often created purposefully to convey a new meaning. Analyses suggest that word formation blends differ from speech error blends on a number of characteristics (see Lehrer 1996).

Blends have been of interest to linguists for some time. One reason for this interest may be that blends are ubiquitous. Cannon (1986) suggests that blending is a universal word formation process found in all languages. In terms of prevalence in the English language, Simonini (1966) identified blending as one of fifteen methods for word formation and suggested that blend words comprised approximately 3 % of new English words. Blend words are also used as a marketing technique and may be particularly common today on the internet where words are often formed to express new ideas (see Thelwall and Price 2006).

Several papers have explored the structure of existing blend words (e.g., Algeo 1977; Cannon 1986; López Rúa 2004; Gries 2004; Kelly 1998; Ronneberger-Sibold 2006; Tomaszewicz 2008). Structural regularities in the creation of blends are typically assessed through examination of corpora of existing blends gathered from various sources. For example, in an early investigation into blending, Algeo (1977) identified five structural categories of blend words such as those with clipping of both source words (e.g., SMOG) and those with both clipping and letter overlap (e.g., MOTEL). Kelly (1998) examined a corpus of 320 English blends and identified the source words of each blend. The number of syllables and frequency of the source words was measured. Kelly observed that the first word in the blend is significantly shorter and more frequent than the second word on average, suggesting there are linguistic constraints operating on the ordering of source words within a blend. An additional analysis by Kelly (1998) examined the breakpoint in 165 blends that did not have any overlap between source words. This analysis showed that the breakpoints most often preserve phonological units such as syllables and rimes. Gries (2004) provided a quantitative analysis of 585 blends in terms of the contribution of each source word. Results showed that, on average, the second source word is significantly longer and contributes more to the blend. Taken together, the results of Kelly (1998) and Gries (2004) suggest that although there is considerable variability in blends, orthographic and phonological constraints do impact blend formation.

Linguists have assessed the similarity of blends to other forms of words such as acronyms, compounds, and abbreviations (e.g., Bauer 1998; López Rúa 2004; Ronneberger-Sibold 2006; Tomaszewicz 2008). These studies have highlighted the fact that the boundaries between the various word formation processes are not always clear. In fact, blending can create productive components that are then used in other words (e.g., -thon, -scape, -burger). Lehrer (1998) uses the term "combining forms" to describe these components and suggests that blends containing combining forms are quite similar to compound words (see also Bauer 1998; Tomaszewicz 2008). Relatedly, Ronneberger-Sibold (2006) also suggest that blending shares similarities with compounding and specifically refers to blending as a type of "extragrammatical compounding". Thus, this view suggests that blends are formed via an extragrammatical morphological process that does not conform to the standard morphological rules of the language.

Although linguists have provided many descriptions of the structure of blends, there has been relatively little attention given to how blends are recognized during language processing tasks. Only Lehrer (1996, 1998, 2003) has reported a small number of psycholinguistic studies on blends. Most of Lehrer's research is focused on what factors affect the ease with which source words can be identified in a blend. For example, Lehrer (1996) presented participants with a set of blend words mostly selected from existing sources. Participants were asked to provide the source words, give a definition, and rate the blend on a scale of 1–5 to indicate whether they thought the word was a good one (1) or a poor one (5). One group of participants was given the blends in isolation and a second group was given them in a supportive sentence context. The source words were identified better in context for 11 out of 26 of the blends (1 was identified better in isolation and for 14 there was no significant difference). Lehrer (1996) examined the percentage of correct identifications of source words as a function of the number of letters present in the blends and found that for blends where both source words are clipped, there was a strong positive correlation between the number of letters in the source words and accuracy in identifying the blends. Lehrer (1996) also examined the frequency of the source words in the blend to assess whether frequency would impact identification. The results suggested that more frequent words are easier to identify in the blend. However, the examination was purely descriptive with no inferential statistics provided. Lehrer (1998) examined the relative productivity and characteristics of combining forms derived from blends (e.g., -scape, -rama). A series of studies was described where participants were asked to provide as many words containing a combining form, rate the familiarity of words, rate the semantic contribution of the various components of blends, or rate the suitability of the definitions of blends. The results of these studies were presented for each item in an appendix to support further investigation into blending processes.

In a more recent study, Lehrer (2003) explored how blends are processed on-line. Participants were presented with blends on a computer screen and were told to press a button when they could identify the two source words. They were then asked to speak the source words into a microphone. Two lists of 40 blends each were given to separate groups of participants. Reaction times were quite long, almost 3000 ms on average. Lehrer analyzed reaction times as a function of blend structure but found no significant differences between blend types. In a second experiment, a lexical decision task was conducted using the masked priming paradigm. The target word was always a source word from a blend. The 100 ms prime was either the blend word, an identical prime, or an unrelated word matched in length to the blend word. There were no significant differences between conditions. While the Lehrer (1996, 1998, 2003) studies make an important contribution to the literature on blends by examining how adults process them, they are somewhat difficult to interpret. Many times, the results are not analyzed with inferential statistical techniques and, when they are, the effects often do not reach significance. Participants in Lehrer's studies were usually undergraduates in linguistics or English classes and presumably had a working knowledge of blending as a linguistic construct. It is therefore still an open question as to how blend words are recognized during skilled reading.

Recent research on blending has taken more of a computational approach to understanding blending. Thelwall and Price (2006) developed a method to track the use of what they term "hybrid word families". Specifically, they examined the "Franken" word family, which is related to the concept of genetically modified food (e.g., Frankenfood, Frankenfish). The prevalence of this combining word form was assessed through examination of page counts in search engines such as Google. In this way, they were able to track the creation of new words and concepts using this combining word form. Most recently, Cook and Stevenson (2010) developed a statistical model for source word identification for blends.

While the research on blends to date provides insight into how blends are structured and some information on how source words are identified in blends, it cannot answer the question of how blends are stored in the mental lexicon or processed during silent reading. Are lexicalized blends stored and processed the same as monomorphemic words? Or, are blend words recognized more similarly to morphologically complex words such as compound words? As discussed above, linguists have noted the similarities between blend words and compounds. There is a large literature examining how familiar compound words are recognized and processed during reading and visual word recognition (e.g., Andrews 1986; Andrews et al. 2004; Bertram and Hyönä 2003; de Jong et al. 2002; Duñabeitia et al. 2007; Fiorentino and Fund-Reznicek 2009; Hyönä and Pollatsek 1998; Inhoff et al. 2008; Juhasz 2007, 2008, 2012; Juhasz and Berkowitz 2011; Juhasz et al. 2003; Kuperman et al. 2008, 2009; Libben et al. 2003; Pollatsek et al. 2000; Shoolman and Andrews 2003; Taft and Forster 1976). Much of this research supports the view that compound words are decomposed during their recognition into their constituent lexemes.

Research comparing compound words to monomorphemic words that are matched on length and frequency has provided insight into how morphologically complex words are stored and accessed in the mental lexicon. Fiorentino and Poeppel (2007) compared the processing of English compound words (e.g., flagship) with length and frequency matched monomorphemic words (e.g., crescent) in a lexical decision task combined with MEG recordings. Compound words were responded to significantly faster and more accurately compared to the monomorphemic words. The results support an early morphological decomposition process for the compound words. Drieghe et al. (2010) also compared the processing of compound words to monomorphemic words. This study recorded eye movements during reading where compounds and monomorphemic words (matched for length and frequency) were embedded in sentences. There was a main effect of word type such that compound words received shorter gaze durations (a measure that sums together all first pass fixations on a word and is therefore thought to be a good measure of word recognition). This effect suggests that the decomposition of compound words with relatively high frequency lexemes results in faster reading time overall compared to matched monomorphemic words (but see Inhoff et al. 1996 for a different pattern of results).

While much research has focused on how morphologically complex words are recognized, very little is known about the recognition of blend words. The purpose of the present study was to examine how lexicalized blend words are processed. Similar to past studies examining English compound words, we selected blend words that are relatively familiar to skilled adult readers and matched these on length, familiarity, and frequency to non-blend control words. In addition, two tasks were employed: lexical decision and recording eye movements during sentence reading. In the lexical decision task, participants were asked to discriminate real words from made-up nonwords. Although this is a standard task in the field of visual word recognition, it imposes demands on the participant that are not typical of reading for comprehension. Therefore, in the second experiment, the words were embedded in non-predictable, but meaningful, sentences. Eye movements were then recorded and compared to sentences containing the non-blend control words. Recording eye movements during reading provides insight into the time-course of visual word recognition (Rayner 2009) through the various fixation duration measures that can be examined. Examination of how blend words are processed in these two tasks should provide insight into how lexicalized blends are recognized by skilled adult readers and whether this recognition process differs from non-blend control words.

Experiment 1: Lexical Decision

Method

Participants

A total of 52 undergraduates at Wesleyan University participated for partial course credit for their Introductory Psychology course. All participants reported English to be their primary language.

Apparatus

Stimuli were displayed on a computer screen using the E-Prime software (version 1.1, Psychology Software Tools, Inc). The stimuli were presented in black text on a white background. Participants were instructed to press the "z" key if the letter string was a word and the "m" key if the letter string was not a word in the English language. These keys were labeled with a "W" and "NW" respectively. Participants sat at a comfortable distance from the computer screen.

Materials

Potential blend words were compiled from a variety of sources including published articles and online searches. A questionnaire containing 82 blend words was created to assess participants' familiarity with the words. Twenty-five Wesleyan University undergraduates were administered the questionnaire. They were asked to rate their familiarity with the blend words on a 1–7 scale and to provide the two source words, if possible. Sixteen blend words were selected from the questionnaire. For these blends, at least 50 % of the participants were able to provide the two source words (average completion for first source word = 92.5 %, range = 68–100 %; average completion for second source word = 84.25 %, range = 52–100 %).

Many blend words are relatively recent neologisms which do not appear in published corpora. This makes selecting frequency-matched control words challenging. We therefore matched control items on rated familiarity (i.e., a measure of subjective frequency of occurrence). In addition, we also recorded the number of Google™ Hits the words received as a measure of how frequently the word is used. A natural log transformation was applied to the Google™ Hits measure. In order to select the control words, low frequency words matching the length of the 16 blend words were extracted from the Educator's Word Frequency Guide (Zeno et al. 1995). A total of 152 low frequency words were included on a familiarity questionnaire. Nine Wesleyan University Undergraduates were asked to rate their familiarity with these items on a 1–7 scale. Sixteen control words were then selected that matched the blend words in length, rated familiarity, and the natural log of Google™ Hits (see Table 1). Blend words and the controls are presented in the Appendix. For the lexical decision study, the 32 critical items were included in a list containing 88 filler words (some from an unrelated study) and 120 length matched nonwords that were selected from the English Lexicon Project (Balota et al. 2007). All stimuli were presented in a random order.

Procedure

Participants were tested individually in a quiet room. Letter strings were presented in the center of the computer screen in upper-case letters in 18pt Courier New font. There were 15

Table 1 Average length, rated familiarity and the natural log of Google^{TM} hits as a function of word type

	Blend words	Non-blend controls
Length	7.31 (0.60)	7.25 (0.58)
Familiarity	5.56 (0.78)	5.52 (0.83)
lnGooglehits	17.46 (0.62)	17.40 (0.35)

There were no significant differences between blend words and non-blend control words (all ts < 1). Numbers in parentheses are the standard error of the mean

practice items (8 words, 7 nonwords). Prior to each letter string, a fixation cross appeared in the center of the screen for 1000 ms. Letter strings stayed on the screen until a response was recorded.

Results

Lexical decision times were analyzed with a linear mixed effects regression model (lmer) that included random intercepts for subjects and items as well as a random by-subject slope for the blend condition variable. A random by-item slope for the blend condition was not possible since blend condition was manipulated between items. While the two conditions were matched on average for word length, rated familiarity, and the natural log of Google^{TM} hits, there was still considerable variability within each condition on these measures. Therefore, these variables were included as continuous covariates into the models. All predictor variables were centered on their means. Since accuracy is a binary response, and requires a logistic regression, accuracy rates were analyzed via general linear mixed effects models. The lme4 package (Bates et al. 2011) was used within the R environment for statistical computing (version 2.14.1 R-Core Development Team, 2011). For the reaction time measure, only correct responses were included in the analysis. In addition, outliers (2.5 standard deviations above the condition means) were removed (3.10 % of the data). For the lexical decision times, an effect was considered statistically significant at the 0.05 level if the absolute value of the t value was greater than 2.00 (Baayen et al. 2008). For the accuracy measure, z tests and p values are provided.

Lexical decision times for blend words ($M = 892$ ms, $SE = 14.86$) were longer than those to non-blend control words ($M = 841$ ms, $SE = 10.65$). The effect of blend status was significant ($\beta = -87.78$, $SE = 40.23$, $t = -2.18$). With respect to the continuous covariates included in the model, words with a higher rated familiarity were responded to significantly faster ($\beta = -89.08$, $SE = 30.85$, $t = -2.89$), longer words received significantly longer reaction times ($\beta = 22.98$, $SE = 8.63$, $t = 2.67$) and there was a trend such that words with more Google^{TM} hits received shorter reaction times ($\beta = -20.32$, $SE = 12.94$, $t = -1.57$).

The accuracy rate for blend words ($M = 75.59\,\%$, $SE = 1.48$) was numerically lower than for non-blend words ($M = 84.20\,\%$, $SE = 1.25$), although this effect did not reach significance in the model ($\beta = 0.77$, $SE = 0.44$, $z = 1.76$, $p = 0.079$). Both the number of Google^{TM} Hits ($\beta = 0.35$, $SE = 0.15$, $z = 2.43$, $p = 0.015$) and the rated familiarity ($\beta = 1.42$, $SE = 0.35$, $z = 4.05$, $p < 0.001$) significantly influenced accuracy rates such that greater frequency and greater familiarity led to higher accuracy rates. The effect of word length did not reach significance on the accuracy measure ($\beta = 0.17$, $SE = 0.09$, $z = 1.80$, $p = 0.072$).

Discussion

Blend words that are relatively familiar to college undergraduates took longer to identify as words in the lexical decision task when compared to non-blend words matched in length, rated familiarity, and Google™ Hits. This may indicate that lexicalized blend words are stored and/or accessed in a different manner compared to non-blend words. However, the results do not support the position that blend words are processed similarly to traditional compound words. Recall that Fiorentino and Poeppel (2007) demonstrated that compound words are responded to faster in the lexical decision task relative to length and frequency matched monomorphemic words, the opposite effect to what was found currently with blend words.

It is important to note that both the blend words and the non-blend control words received fairly long lexical decision times in the current study. This may reflect the low frequency of occurrence of the items. In fact, many blend words do not occur in published corpora, which is why rated familiarity and Google™ Hits were used in the present study. Participants may have found both types of words particularly difficult to discriminate from nonwords. Nonwords in this study were responded to with a mean accuracy of 92 % ($SE = 0.35$) and a response time of 954 ms ($SE = 6.7$). The low accuracy rates for both the blend and non-blend items also support the idea that these items are difficult to discriminate from non-words. In further examining the accuracy patterns on the blend items, it is clear that some blend items such as dramedy (Accuracy = 18.87 %) and ebook (Accuracy = 30.19 %) were very rarely endorsed as words in this task. Thus, the nature of the task itself may make participants question whether blend items should, in fact, be considered words. Therefore, the effect of blend status on the reaction times in this study may be due to the decision component in the lexical decision task.

As noted in the Introduction, Lehrer (1996) found that source words for several blends were identified better when they were presented in a supportive context compared to when they were presented in isolation. The purpose of Experiment 2 was therefore to examine whether blends would similarly be processed slower than their matched non-blend controls when they were presented in a sentence context where the decision component is removed from the task. To this end, both blends and non-blend items were embedded in a supportive, but non-predictable, sentence context and eye movements were recorded while participants read the sentences for comprehension. Recording eye movements also allows an examination of the time-course of blend processing during reading.

Experiment 2: Sentence Reading

Method

Participants

Forty-three Wesleyan Undergraduates participated for partial course credit for their Introductory Psychology course. All participants reported that English was their primary language and had normal or corrected vision.

Table 2 Example sentences from Experiment 2 for blend words and non-blend controls

Example sentences
Blend words
Jane was a compulsive **workaholic** and always worked on the weekends.
There are four factors necessary for **smog** formation on a hot summer day.
Brad was trying to speak **Spanglish** to his friend at the international seminar.
Non-blend control words
Drew had very high **cholesterol** and decided to stop eating doughnuts.
Peggy bought a redesigned **nozzle** for her shower because she broke the last one.
Bob dropped the last **cookie** on the floor of his house and still ate it.

Apparatus

An Eyelink 1000 (SR Research, Ltd) eye-tracker was used to record eye movements every millisecond. Participants viewed the sentences binocularly, however eye movements were only recorded from the right eye. Participants were seated 83 cm from a computer monitor where the sentences were displayed in black Courier New 14 point font on a white background. The sentence display was controlled by the EyeTrack software (http://www.psych.umass.edu/eyelab/software/).

Materials

Non-predictable sentence contexts were written for the 16 blend and 16 non-blend target words used in Experiment 1. Sentences were constructed such that the target word was never the first two or last two words in the sentence. Target words were written in lowercase letters except where uppercase was required (FedEx, Medicare, Spanglish). Since the target words from the two conditions were fit into separate sentences, it is critical to make sure that the words fit equally well into their sentence frames (i.e., that understandability did not differ as a function of condition). Therefore, a rating was conducted with ten Wesleyan University students. They were asked to rate on a 1–7 scale how well the target word fit into the sentence frame. Average ratings did not significantly differ as a function of blend condition (blend = 5.88, non-blend = 5.84, $t < 1$). In order to confirm that the sentence frames were not predictable, ten additional Wesleyan University undergraduates were given the beginning sentence context and asked to provide a word that could come next in the sentence. Target words were never used in the blend condition (0 %) and only one non-blend response was given (0.60 %). Example sentences for each condition are displayed in Table 2. In addition to the 32 sentences containing target words, an additional 68 filler sentences were created, so that each participant read 100 sentences. Ten of the filler sentences served as practice.

Procedure

Participants were tested individually in a quiet room. After initial instructions, the eye-tracker was adjusted and a single-line calibration and validation was completed. The experiment was only started if the average calibration error was less than 0.4° of visual angle (with a maximum error of less than 0.5°). Participants were told to read silently, for comprehension, at their

Table 3 Mean fixation durations for the blend and non-blend control words in Experiment 2

Duration	Blend words	Non-blend controls
First fixation duration	254 (3.94)	263 (3.82)
Single fixation duration	265 (4.59)	281 (4.72)
Gaze duration	291 (5.10)	321 (5.57)
Total fixation duration	338 (7.50)	376 (7.60)

All fixation durations are in milliseconds. Numbers in parentheses are the standard error of the mean

usual reading rate. Prior to the start of each sentence, they fixated on a black box on the left side of the screen. A fixation in this box triggered the display of each sentence. The experimenter was in the room with the participant during the experimental session and re-calibrations were conducted if the sentence failed to trigger or when deemed necessary by the experimenter. Once participants were done reading a sentence, they were told to look to the right of the sentence and press a button on a gamepad they were holding. Participants were allowed to take breaks as needed. After the ten practice sentences, target sentences and filler sentences were presented randomly for each participant. Yes-or-no comprehension questions were asked on 25 % of all sentences and participants could answer by pressing one of two buttons on a gamepad (Average Percent Correct = 94.73 %).

Results

Trials were removed if there was a blink or track-loss on the pre-target, target, or post-target word, if the first fixation was on the pre-target word or further into the sentence, or if the participant did not finish reading the sentence. Twelve participants did not contribute to the analysis due to having more than 25 % of their data removed for these reasons. For the remaining 31 participants, approximately 9.78 % of trials were removed from analysis. In addition, as is standard with eye movement studies, the data analysis program combined fixations that were shorter than 80 ms and on adjacent characters. Remaining fixations shorter than 80 ms or longer than 1000 ms were removed from analysis.

In order to assess the time course of processing, four fixation duration measures were examined: first fixation duration, single fixation duration, gaze duration, and total fixation duration. First fixation duration is the duration of the first fixation on the target word irrespective of how many fixations the words receives, single fixation duration is the duration of the first fixation on the target word if the word receives only a single fixation, gaze duration is the sum of fixations on the target word before the reader moves their eyes off of the word, and total fixation duration is the duration of all fixations on the target word. The target word region was defined as the word itself and the space preceding it. Fixation durations were analyzed in the same manner as in Experiment 1, using a linear mixed effects regression model (lmer) that included random intercepts for subjects and items as well as a random by-subject slope for the blend condition variable. Word length, rated familiarity, and the natural log of Google™ hits were included in all models as continuous covariates. All predictor variables were centered on their means. The lme4 package (Bates et al. 2011) was used within the R environment for statistical computing (version 2.14.1 R-Core Development Team, 2011). Outliers (2.5 standard deviations above the condition means) were removed from each fixation duration measure (2.97, 2.98, 2.02, 2.56 % from first fixation, single fixation, gaze duration, and total fixation duration respectively). An effect was considered statistically significant at the 0.05 level if the absolute value of the *t* value was greater than 2.00.

Table 3 displays the fixation duration means as a function of blend condition. As is evident from the means, when items were presented in a sentence context, fixation durations were shorter on blend words compared to the non-blend control words. This effect amounted to 9 ms in first fixation durations, 16 ms in single fixation durations, 30 ms in gaze durations, and 38 ms in total fixation durations. The effect of blend did not reach significance in first fixation durations ($\beta = 8.52$, $SE = 7.67$, $t = 1.11$) or single fixation durations ($\beta = 14.76$, $SE = 10.81$, $t = 1.37$). However, the effect was significant in both gaze duration ($\beta = 28.43$, $SE = 11.86$, $t = 2.40$) and total fixation duration ($\beta = 37.97$, $SE = 15.70$, $t = 2.42$).

In terms of the continuous covariates included in the models, familiarity had a significant influence on both single fixation durations ($\beta = -18.09$, $SE = 8.95$, $t = -2.02$) and total fixation durations ($\beta = -31.75$, $SE = 12.45$, $t = -2.55$) such that words with a higher rated familiarity received shorter reading times. There was a similar trend in both first fixation durations ($\beta = -9.84$, $SE = 6.34$, $t = -1.55$) and gaze durations ($\beta = -17.37$, $SE = 9.72$, $t = -1.79$). Longer words received significantly longer gaze durations ($\beta = 6.71$, $SE = 2.71$, $t = 2.48$) with a trend in the same direction for total fixation durations ($\beta = 5.76$, $SE = 3.46$, $t = 1.66$). No other effects of the covariates were significant in the models (all ts < 1).

Discussion

Across all fixation measures, blend words were read faster than non-blend control words. This effect reached statistical significance in the gaze duration measure and total fixation duration. Gaze duration is often considered to be an ideal measure of word recognition time as it sums together all fixations on the word before the reader has moved their eyes to another word. Thus, this measure demonstrates that blend words were recognized faster than non-blend words when embedded in a non-predictable but supportive sentence context. The direction of the blend word effect is opposite from that reported in Experiment 1 when the task was to discriminate words from non-words. Taken together, the results of the two experiments suggest that blend words may be processed differently than non-blend controls in skilled readers. However, the nature of the blend word effect seems to be very sensitive to the demands associated with various psycholinguistic tasks. This issue will be discussed further in the General Discussion.

General Discussion

The purpose of the present study was to provide a preliminary investigation into how lexicalized English blend words are processed by skilled adult readers. As such, the processing of blend words was compared to non-blend control words that were matched on length, familiarity, and frequency to the blends. The results suggest that blend words are processed differently from the matched control words, but that the nature of the effect differs as a function of task demands. Specifically, when the lexical decision task was employed and participants were required to discriminate both the blend words and the control words from made-up nonwords, blend words resulted in significantly longer reaction times compared to the control words. In contrast, when the blend words and control words were embedded in supportive but non-predictable sentences and eye movements were recorded, the blend words were processed faster than the control words, an effect that reached significance in the gaze duration and total fixation duration measures.

In order to understand the nature of these task effects, it will be informative to focus on research that has directly compared responses in lexical decision and eye-tracking. Schilling et al. (1998) compared word naming, lexical decision, and eye-tracking data for high frequency and low frequency English words matched on word length. The word frequency effect is a robust finding where words that occur with a high frequency in written language are processed faster than words that occur with a low frequency. While Schilling et al. (1998) observed significant correlations between lexical decision time (LDT) and both first fixation duration and gaze duration to the same target items, the word frequency effect was significantly larger in the lexical decision task relative to fixation durations, suggesting that the decision component of the lexical decision task magnifies the role of word frequency. A recent investigation by Kuperman et al. (2013) examined reaction times in word naming, lexical decision, and eye movements from a number of available corpora in both English and Dutch. Their results suggested that once the effects of word frequency and word length are partialled out of the analyses, the amount of variance shared by lexical decision and gaze durations is only between 5 and 17 %. This suggests that both tasks are assessing different aspects of word recognition performance and that task demands, as well as presentation format in eye movement studies (i.e., whether sentences are displayed one at a time or paragraphs are used), have a strong influence on response latencies.

As discussed in the Introduction, there are some similarities between blending and compounding (e.g., Bauer 1998; Lehrer 1998; López Rúa 2004; Ronneberger-Sibold 2006; Tomaszewicz 2008). Psycholinguistic studies have directly compared the processing of English compound words in both the lexical decision task and in eye-tracking using the same items (e.g., Inhoff et al. 2008; Juhasz and Berkowitz 2011; Juhasz et al. 2003, 2005). In general, the differences between tasks have been relatively minor with respect to compound processing. However, Juhasz et al. (2005) did observe a reversal in the effects of compound word spacing in lexical decisions and fixation durations. This pattern of results was interpreted as indicating that the interword spaces in compounds facilitated lexical decision making in the lexical decision task and was based on strategies participants developed in this task for assessing the lexicality of both compound constituents.

In the present study, the finding that blend words took longer than non-blend controls in lexical decision may also be due to the specifics of this task. No instructions were given to the participants regarding blend words and participants may have been reluctant to endorse blend words as being real words in the English language. In addition, both the blend words and the non-blend controls were very low in frequency in the present study, with many of the blends not occurring in available frequency corpora. Thus, both categories of items were most likely challenging to discriminate from nonwords since word frequency effects are magnified in the lexical decision task relative to other tasks (e.g., Schilling et al. 1998). In contrast, the eye movement study presented all words in a non-predictable supportive context which removed any uncertainty about whether the target items should be considered to be words. In this situation, blend words showed a clear advantage relative to the non-blend control words. Note that the reversal in the pattern of effects in lexical decision and eye-tracking suggests that the effects we did observe are not merely due to issues of uncontrolled familiarity or frequency between the items. If it were the case that items were not appropriately matched on some measure of word frequency, we would expect the pattern of effects to be similar across the tasks (with blend items always being processed more slowly than controls or vice versa). Instead, the reversal in the effect of blend items points to task demands influencing the processing of these items and suggests that blend words may be recognized in a different manner than non-blend words.

Much research supports the idea that familiar compound words are decomposed into their two lexemes during processing. Are lexicalized blend words similarly decomposed into their source words during recognition? Since this is a very preliminary examination of blend word processing, it is beyond the scope of the present study to offer suggestions for how blends are stored and accessed in the mental lexicon. However, a masked priming study by Taft and Kougious (2004) provided evidence that readers access components of words that are not traditional morphemes, such as the vir- in virus and viral. Taft and Kougious further suggested that these components, if associated with a certain meaning over time and in a number of contexts, could form a sublexical lemma that could then be used to activate a whole-word lemma in the mental lexicon. It is therefore possible that the productive combining forms that are part of certain blend words could also function as a "sublexical lemma" and be used to activate corresponding blend words from the mental lexicon. Of course, there are a variety of blend word structures, and not all blends contain a productive combining form. In order to include enough blend words that were familiar to adults, blend structure was not specifically manipulated or controlled in the present study. Lehrer (2003) specifically addressed whether blend structure influenced reaction times in a task where participants were asked to provide the source words for blends and saw no significant differences. Future research should address this using more sensitive measures of word recognition performance, such as by recording eye movements during reading.

There were some limitations in the present study that could be addressed with future research. Ideally, a larger number of blend words and controls could be identified. It would also be useful to examine the impact of blend words on word naming latency. While word naming is very sensitive to properties of the initial phoneme, the analysis by Kuperman et al. (2013) found stronger correlations between word naming and lexical decision than between lexical decision and fixation durations. Since word naming removes demands of discriminating blend items from nonwords, it would be interesting to examine whether blends would be processed faster (as in the eye movement study) or slower (as in the lexical decision task) relative to non-blends. In addition, due to the nature of the present set of items, the blends and non-blend controls were embedded in entirely different sentence contexts that were equated on predictability and goodness-of-fit. While different but controlled sentence contexts have been used in past studies examining morphological processing (e.g., Inhoff et al. 1996, 2008; Juhasz et al. 2003), a more sensitive design would include both a blend word and a matched control word in the same sentence frame. Ideally, an eye movement study could be conducted with a larger set of blend and non-blend control words and provide completely matched sentence frames.

While we acknowledge that the results of the present study are preliminary, they also provide a completely novel investigation into the processing of lexicalized blend words. The results suggest that blends are in fact processed differently than non-blend control words and that the nature of the effect is very sensitive to various demands associated with word recognition tasks. This initial research will hopefully pave the way for future investigations into how blend word structure influences word recognition processes and how blends are stored and accessed in the mental lexicon. Additional psycholinguistic research could also focus on directly comparing blending to other word formation processes such as compounding. Thus, the current study will hopefully motivate further psycholinguistic research on English word formation processes.

Compliance with Ethical Standards

Conflict of interest Barbara J. Juhasz, Rebecca L. Johnson and Jennifer Brewer declare that they have no conflict of interest.

Appendix

Blend and Non-Blend control words. Items were displayed in uppercase in Experiment 1 and in lowercase in Experiment 2 except where uppercase was warranted.

Blend Words

ALPHABET, BRUNCH, CARJACK, DRAMEDY, EBOOK, EMAIL, FEDEX, FRAPPUCCINO, INFOMERCIAL, MEDICARE, MULTIPLEX, SMOG, SPANGLISH, TWEEN, WEBCAM, WORKAHOLIC.

Non-Blend Control Words

COOKIE, COSMETIC, CHOLESTEROL, DINGO, DOPE, FILAMENT, FRONTIER, GERANIUM, GUAVA, LEMON, MAGISTRATE, MAIZE, NOZZLE, SCAFFOLD, TUBERCULOSIS, VERANDA.

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