

Priming illusory words: an ERP approach

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Abstract

Repetition blindness (RB) was used to investigate whether illusory words emerge at a lexical-perceptual or a semantic-reconstructional level. Illusory words were evoked by the rapid serial visual presentation (RSVP) of two real words and a word fragment. The initial words share the same string of letters (“CREEP”–“SHEEP”), producing a free-floating word fragment (“SH”). This fragment is likely to be linked to a subsequently presented fragment (“IFT”) if both combine to a meaningful word (“SHIFT”). The processing level of the illusions was probed by prime words preceding the RSVP sequence which were semantically related or unrelated to the second real word or to the illusion. Behavioural and electrophysiological correlates of the semantic priming effect were recorded in 14 subjects. Real words related to the prime were perceived more frequently, and evoked widespread N400-like effect in the event-related brain potentials (ERPs). An ERP effect of the same polarity was obtained for illusory words, however, its latency was delayed and the topographical distribution was restricted to left posterior electrode positions. These differences suggest that priming might affect real and illusory words at different levels of word processing: access to real words is facilitated at a semantic level, whereas lexical activation apparently accompanies the generation of illusory words.

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1. Introduction

Semantic priming has been extensively studied in psychological research. The processing of target words is facilitated if an associated item (prime) has been presented previously (Neely, 1991). The reliability of the effect suggests that priming relies on the automatic activation spread in networks of representation (Posner & Snyder, 1975; Collins & Loftus, 1975). This hypothesis is further supported by studies indicating that a priming effect does not necessarily require conscious access to the prime or the target word (Carr & Dagenbach, 1990; Fowler, Wolford, Slade, & Tassinari, 1981; Shapiro, Driver, Ward, & Sorensen, 1997; Marcel, 1998).

Semantic priming is accompanied by a unique electrophysiological correlate, the N400 effect (Kutas & Hillyard, 1980). A word evokes a negative-going event-related brain potential (ERP) component about 400 ms post-onset, mostly pronounced if the word is encountered for the first time. The

effect of priming is to attenuate the amplitude of the component. The mechanism was related to facilitation in contextual integration (Rugg & Doyle, 1994), or the attempt to activate semantic representations (Deacon, Mehta, Tinsley, & Nousak, 1995).

In the last years, the N400 effect has been used as a tool to track the status of stimulus processing, and has been especially useful in cases where the ability to report word targets is diminished or absent. For example, in clinical settings, the covert abilities of neurological patients have been examined (Swaab, Brown, & Hagoort, 1998). In normal observers, N400 effects were obtained even when backward masking, or attentional overload prevented stimulus awareness (Vogel, Luck, & Shapiro, 1998; Kiefer, 2002; Rolke, Heil, Streb, & Hennighausen, 2001).

This and other evidence of ‘automatic’ processing of semantic features prompts the question of how ‘illusions’ are treated by the visual word-recognition system. In general, illusions can be described as discrepancies between the physical stimulation and the perceptual state of an observer (Gregory, 1987). In the context of this paper, the ‘illusion’ is driven by a string of letters (physical input) which develop an independent semantic meaning (perceptual state). In

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other words, a specific semantic representation becomes activated although the corresponding sensory input is missing.

'Illusory words' are an example of this kind of activation pattern (Morris & Harris, 1999; Harris & Morris, 2001). Words and word fragments are displayed using the technique of rapid serial visual presentation (RSVP, Forster, 1970). If two succeeding words presented for approximately 100 ms, each, share an identical string of letters (e.g. CREEP–SHEEP), a partial repetition blindness (RB) (for the effect of repetition blindness, see Kanwisher, 1987) can be evoked, limited to the letters repeated. The free-floating word fragment not affected by partial repetition blindness (e.g. SH), is likely to be linked to a subsequently presented word fragment (IFT). Consequently, observers frequently report seeing the word sequence "CREEP–SHIFT" when in fact "CREEP–SHEEP–IFT" was presented.

The effect was first reported by Morris & Harris (1999), and provided evidence that RB in orthographically similar words has a lexical locus. According to the authors, cohorts of words containing the fragments "SH" and "IFT" are activated (Grainger, 1990), and the common entry "SHIFT" has some probability of passing the recognition threshold. Morris & Harris (1999) also emphasize that the phenomenology of perceiving the illusory word is comparable to the perception of a 'real' word displayed on the screen.

Despite this preliminary evidence, the functional level at which illusory words are created in the information processing system is poorly understood. According to the lexical view, illusory words are experienced because the repeated letter sequence is inhibited, while the unique letters are detected and capable of activating words consistent with them (Morris & Harris, 1999; Harris & Morris, 2001). An implication of this view is that the activation of the illusory word in the visual input lexicon might differ minimally from activation of a physically presented word. We will refer to this as the "lexical activation account". This proposal of an early generation of illusory words is supported by prior ERP findings that repetition blindness operates at an early level of word processing (Schendan, Kanwisher, & Kutas, 1997). In contrast to this lexical view, some theorists have proposed that RB occurs when observers reconstruct the list during report. The degraded, fragmentary visual stimulus that accompanies RSVP leads observers to misattribute repeated letter segments (Masson, Caldwell, & Whittlesea, 1998; Whittlesea & Wai, 1997). Out of the effort to report degraded stimuli, high-level cognitive processes may work on the fragments perceived in order to generate a meaningful word. These top-down processes might result in the illusion being retrieved from semantic memory (or being guessed) as the best bet based on the fragments available. We will call this theoretical approach the "post-lexical reconstruction account". Of course, additional accounts in between these two extremes are possible.

To investigate illusory words with psychophysiological techniques, we designed stimuli that would allow us to capitalize on semantic priming and the N400 component. First,

in the case where an illusory word was perceived, we investigated whether ERP amplitudes differ as a function of semantic relatedness between the prime and the illusory word. A significant difference between 'primed' and 'unprimed' illusory target words would reflect an ERP priming effect which strongly contradicts the notion of a post-lexical reconstructional accounts. The reconstruction process is assumed to be a time-consuming process of variable onset and duration. Since the onset of word processing across trials would therefore not be time- and phase-locked to the presentation of the fragment, no ERP priming effect should be found if the post-lexical reconstruction account is valid. If the lexical activation account (or one of the intermediate accounts) is valid, however, the ERP effect should clearly be present.

Second, we compared ERP priming effects (unprimed–primed target words) on trials when the illusory word was reported with trials when the same word was physically presented with no illusion evoked. This comparison will tell us which steps in the chain of information processing differ between the two cases. According to the lexical activation account which predicts that illusory words are treated like real words at the level of semantic processing, ERP priming effects are expected to be comparable independently of the observers' perceptual state. In first line, the ERP amplitudes should not differ remarkably if semantic representations are activated in the same fashion by real and illusory words. If the same neural mechanisms contribute to the ERP priming effects in both perceptual states, their topography is expected to be comparable.

2. Methods

2.1. Subjects

EEG recordings and behavioural data were obtained from 18 persons who were naïve as to the purpose of the experiment. Data from four participants were excluded from analysis because low report of real and illusory words did not allow the averaging of ERP data. The remaining 14 subjects (9 female, 5 male, aged between 22 and 35) had no history of neurological disorders, their first language was German, and vision was normal or corrected-to-normal.

2.2. Stimuli and procedure

Each trial presented a prime word, two critical words (W1 and W2) that shared an orthographic string, and a fragment. All characters were presented in upper case format.

The item pool contained 100 different prime words that were semantically related to a real, or illusory word in 50% of the trials. For each 'related' prime, four different target events were constructed: for two events, the illusory word but none of the real words (W1, W2) were associated with the prime. Illusions were either due to an orthographic similarity

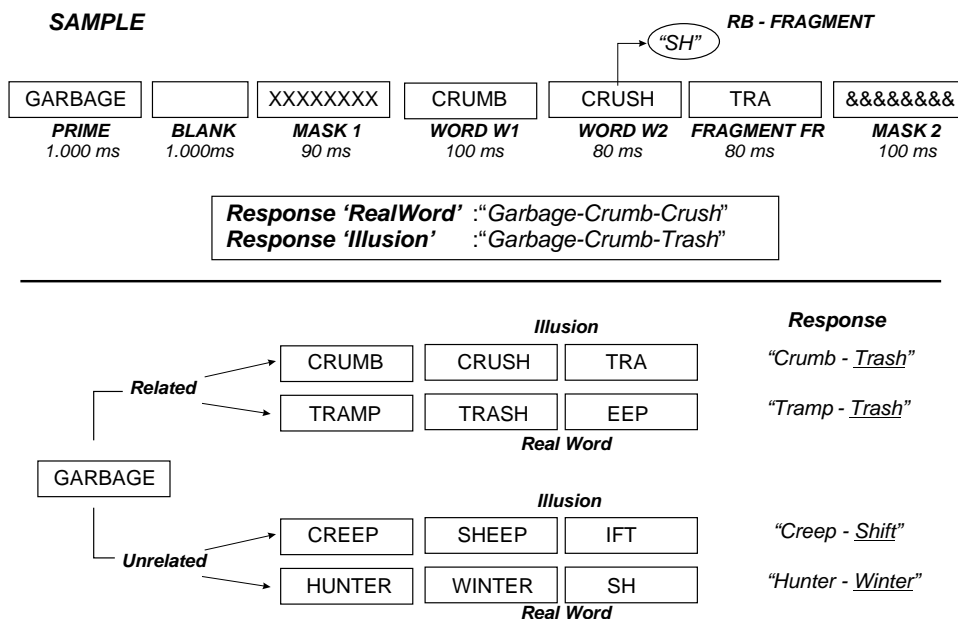


Fig. 1. Upper part: example of an RSVP stream (presentation duration indicated) and subject's verbal reports when either the real word or the illusion is perceived. Lower part: examples for the priming of real and illusory words. The initial prime was related to one item within the subsequently presented RSVP sequence in 50% of the trials, and unrelated in the remaining 50%. In the former case, prime words can be either related to the real word W2, or to the illusory word.

at the beginning of W1 and W2 (**CRUMB**–**CRUSH**), or at the end of W1 and W2 (**CREEP**–**SHEEP**). In the remaining two events, the real word presented at the second position (W2) was related to the prime, whereas the illusory word was semantically unrelated. For each ‘unrelated’ prime, four targets events were constructed, in which neither the illusory words, nor the real words were associated with the prime. Free-floating fragments were induced by an orthographic similarity either at the beginning or at the end of W1 and W2. To control for differences in word frequency, and degree of semantic association a target word was presented both, as a real word and as an illusory word. In sum, 400 trials were presented. With a probability of 25% (100 trials) each, the prime word was semantically related to the ‘real’ word (W2), or the illusory word. With a probability of 50% (200 trials), the prime was unrelated to the subsequently presented word stream. Fig. 1 provides a sample of a trial and illustrates the experimental conditions.

Words were presented at a centered position on a 21 in. PC monitor controlled by a VSG 2/5 system (Cambridge Research Systems, Cambridge, UK). Length of prime words, W1 and W2 varied from four to seven letters, and word fragments contained two to four letters. The corresponding retinal size of the stimuli varied between $0.6^\circ \times 0.35^\circ$ (two letters) and $2.1^\circ \times 0.35^\circ$ (seven letters) at a viewing distance of 200 cm. Single letters were printed in white, and presented on a grey background resulting in a contrast of 90%.

Each trial was started with the presentation of the prime word for 1000 ms, released by a fixation presented for another 1000 ms. The RSVP sequence was initiated by the string of identical letters (“XXXXXXXX”) presented for

90 ms, followed by W1 displayed for 100 ms. W2 and the word fragment (FR) were presented subsequently for 80 ms, each, and the RSVP trials was concluded by a string of symbols (“&&&&&&&&”) presented for 100 ms. The inter stimulus interval between the succeeding words in the RSVP sequence was 0 ms, meaning that words were not separated by a blank. The exposure durations were determined in a pre-study. The longer presentation time was selected in order to ensure that W1 was reported with a mean probability of 80%. Presentation duration of W2 and FR were reduced to ensure that in most cases at least one word but not both, W2 and the illusion, were reported.

A question mark appeared on the screen 1000 ms following the offset of the RSVP sequence. Subjects' task was to report verbally what words has been detected. Feedback provided in the training procedure (at least 40 trials) as well as the instructions for the experimental trials encouraged guessing.

2.3. EEG recording and analysis

Thirty Ag/AgCl electrodes were referenced to linked mastoids, with impedance kept below 5 k Ω . Vertical and horizontal EOGs (vEOG, hEOG) were recorded to control for ocular artefacts. Biosignals were recorded continuously (EEG-8 amplifiers, Contact Precision Instruments, London, UK), sampled at 250 Hz, and online band pass-filtered (0.03–200 Hz). Offline, EEG data were segmented to epoch extending from –100 to 1000 ms, with the onset determined by what stimulus the subject reported: EEG segments were aligned to the onset of W2, if the real word, but not the

Table 1

Distribution of the verbal reports following the RSVP stream, separated for the three priming conditions

	Prime unrelated ($n = 200$ trials)	Real word primed ($n = 100$ trials)	Illusory word primed ($n = 100$ trials)
Real word reported (%)	24.2 (6.1)	43.7 (14.1)	10.3 (6.8)
Illusory word reported (%)	51.8 (7.2)	34.7 (8.9)	69.7 (8.9)
Both target words reported (%)	0.3 (0.5)	0.7 (1.1)	0.5 (1.4)
Both target words missed (%)	23.7 (6.6)	20.9 (8.2)	19.6 (6.5)

In each cell, the mean frequency of reports is given. Standard deviations are given in parentheses.

word illusion was reported. In case that the illusory words has been reported, but not W2, onset of EEG segments was determined by the onset of presentation of the word fragment FR.¹ Each segment was filtered (0.5–40 Hz, –48 dB cut-offs), and baseline corrected (–100 to 0 ms). Single EEG sweeps were excluded from analysis if they contained muscular or ocular (vEOG, hEOG) artefacts. The remaining sweeps were averaged according to the perceptual state (real word versus illusory word), priming condition (related versus unrelated), and electrode position. To extract semantic priming effect, difference waves (unrelated–related) were computed for each subject.

Based on the grand-averaged ERPs, three time windows were determined (100–300, 300–500, 500–700 ms) which were characterized by distinct topographical distribution. Mean amplitudes within these windows were computed for each subject, experimental condition, and electrode. In order to consider topographical effects, electrodes were pooled on the basis of their spatial position. The resulting nine electrode clusters refer to the factorial combination of the spatial factors ‘caudality’ (anterior, central, posterior), and ‘laterality’ (left, middle, right).

2.4. Design and statistical analysis

Effect of semantic priming was tested for real and illusory words independently. The corresponding repeated measure analysis of variance (ANOVA) used for within-subject comparisons therefore included the factors ‘priming’ (related versus unrelated), ‘caudality’ (anterior versus posterior), and ‘laterality’ (left versus middle versus right). Effects of the perceptual state were tested using ERP difference waves (unrelated–related). The ANOVA included the factor perceptual state (real versus illusory word), and the factors ‘caudality’ and ‘laterality’. Following the recommendations of McCarthy and Wood (1985), reference-independent ERP amplitudes (z -standardized) were computed for the analysis of topographical differences. All tests used Greenhouse–Geisser epsilon estimate to compensate for sphericity violations.

¹ The different alignment was necessary because the RSVP sequence evoked a steady-state-like rhythm in the ERP time course. Therefore, ERPs related to the onset of a word can hardly be compared with ERPs related to the subsequent onset of the fragment. However, ERPs aligned to the same temporal onset (e.g. real word W2: related versus unrelated) can be superimposed, and differentiated.

3. Results

In 75.25% of the trials, subjects correctly reported both the prime word and W1 at the end of the stream. The remaining trials were excluded from all further analyses.

3.1. Behavioural data

Table 1 lists the probabilities for the four different perceptual states, defined by the word(s) reported by the subjects.

Subjects very rarely reported both, W2 and the illusory word. Considering the ‘unrelated prime’ as a baseline condition, the frequency for reporting the illusory word, but not real word was higher than the probability of reporting the real word, but not the illusion. The frequency for the former perceptual state was also affected by the position of the word fragment FR within the illusory word. Illusory words were reported more frequently when the FR defined its beginning ($TRA \rightarrow$ ‘TRAMP’, $M = 62.32\%$, $S.D. = 8.71$), and less frequently when the FR defined its end ($EEP \rightarrow$ ‘SHEEP’, $M = 43.63\%$, $S.D. = 8.10$). Unfortunately, the number of trials in each condition were insufficient for a reliable ERP analysis. Because of the electrophysiological framework of this paper, the position effect will not be discussed in detail.

Semantic priming affected the perceptual states by increasing the probability to report the prime-related word. The effects of the prime word (related versus unrelated) on the perceptual state (illusory word versus real word) was

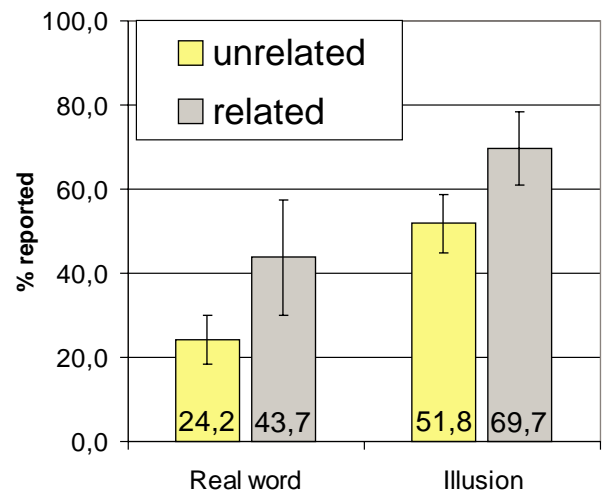


Fig. 2. Mean percentage of verbal reports for real and illusory words separated for the priming conditions. Error bars indicate standard deviations.

analysed using a 2×2 repeated measure analysis of variance. As indicated in Fig. 2, the overall probability for perceiving an illusory word was significantly higher than the probability of reporting the real word W2 (61.73% versus 34.16%, $F(1, 13) = 88.44$, $P < 0.001$). If the prime word was semantically related to a word presented in the RSVP stream, the probability to report it was also significantly increased (related versus unrelated: 57.79% versus 38.11%, $F(1, 13) = 65.45$, $P < 0.001$). However, we did not find

evidence that the aforementioned priming effect was more pronounced for the real word W2 or the illusory word, respectively.

3.2. ERP data

Grand-averaged ERPs evoked in the RSVP stream are depicted in Fig. 3. At posterior leads, a series of visually evoked components was prominent which accompanied the

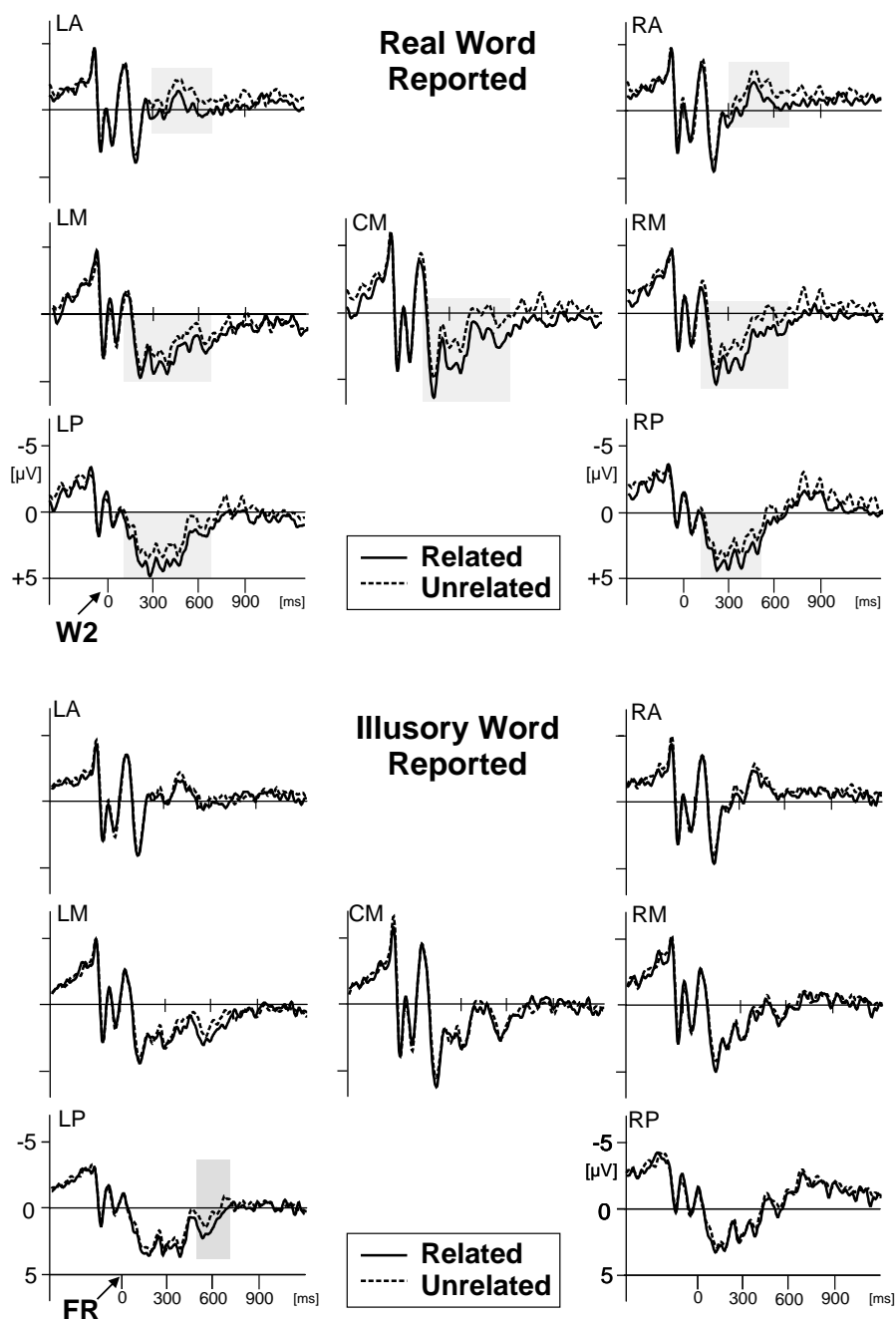


Fig. 3. Grand-averaged ERPs to real words (upper part) and illusory words (bottom part) reported. Responses to words semantically related and unrelated to the prime are superimposed. Time point '0' refers to the onset of the real word W2 in the RSVP stream in the upper part, and to the onset of the word fragments FR in the lower part. In each block, the averaged potentials are shown for seven selected electrode clusters (LA: left anterior, RA: right anterior, LM: left medial, CM: central medial; RM: right medial, LP: left posterior, RP: right posterior).

transients (on- and offsets) of the individually presented letter strings. The rapid sequence of transient components was terminated by a fronto-central positive component peaking at about 150 ms following the onset of the word fragment (FR). At posterior positions, the positive shift remained for another 400 ms. At frontal leads, it returned to baseline and was followed by a negative component extending from 400 to 600 ms (aligned to the onset of FR).

The effects of semantic priming if the subject reported the real word W2 is shown in the upper part of Fig. 3. In order to visualize the spatial distribution of the effect, the topographical distribution of the difference waves (unrelated–related) for the three time windows is presented in Fig. 4b. Please note that the onset of the time windows refers to the onset of W2. A significant effect of semantic priming was already present in the first window of analysis extending from 100 to 300 ms. Mean ERP amplitudes were significantly more negative if W2 was not preceded by a related prime word ($F(1, 13) = 8.29, P = 0.013$). As indicated in Fig. 4b, the difference was more pronounced at central electrode clus-

ters, and was also shifted to right-hemispheric leads (interaction with ‘caudality’ and ‘laterality’: $F(4, 52) = 3.22, P = 0.042$). The significant main effect persisted in the two subsequent time windows (300–500 ms: $F(1, 13) = 16.29, P < 0.001$; 500–700 ms: $F(1, 13) = 11.906, P = 0.004$), and consistently reflected a more negative-going wave if W2 was unrelated to the prime. However, the spatial distribution changed significantly over time: in the time window from 300 to 500 ms, the effect extended to left fronto-central leads (interaction with ‘caudality’ and ‘laterality’: $F(4, 52) = 4.26, P = 0.011$), and was focused at frontal leads in the third time window from 500 to 700 ms (interaction with ‘caudality’ and ‘laterality’: $F(4, 52) = 3.9926, P = 0.021$). A direct comparison of the topographical distribution confirmed a significant frontal shift in the negative activity from the second to the third temporal epoch (‘time’ \times ‘caudality’: $F(2, 26) = 9.88, P = 0.001$).

The lower part of Fig. 3 shows the ERP correlates of semantic priming when the illusory word was reported. The topographical distribution of amplitude effects in the three

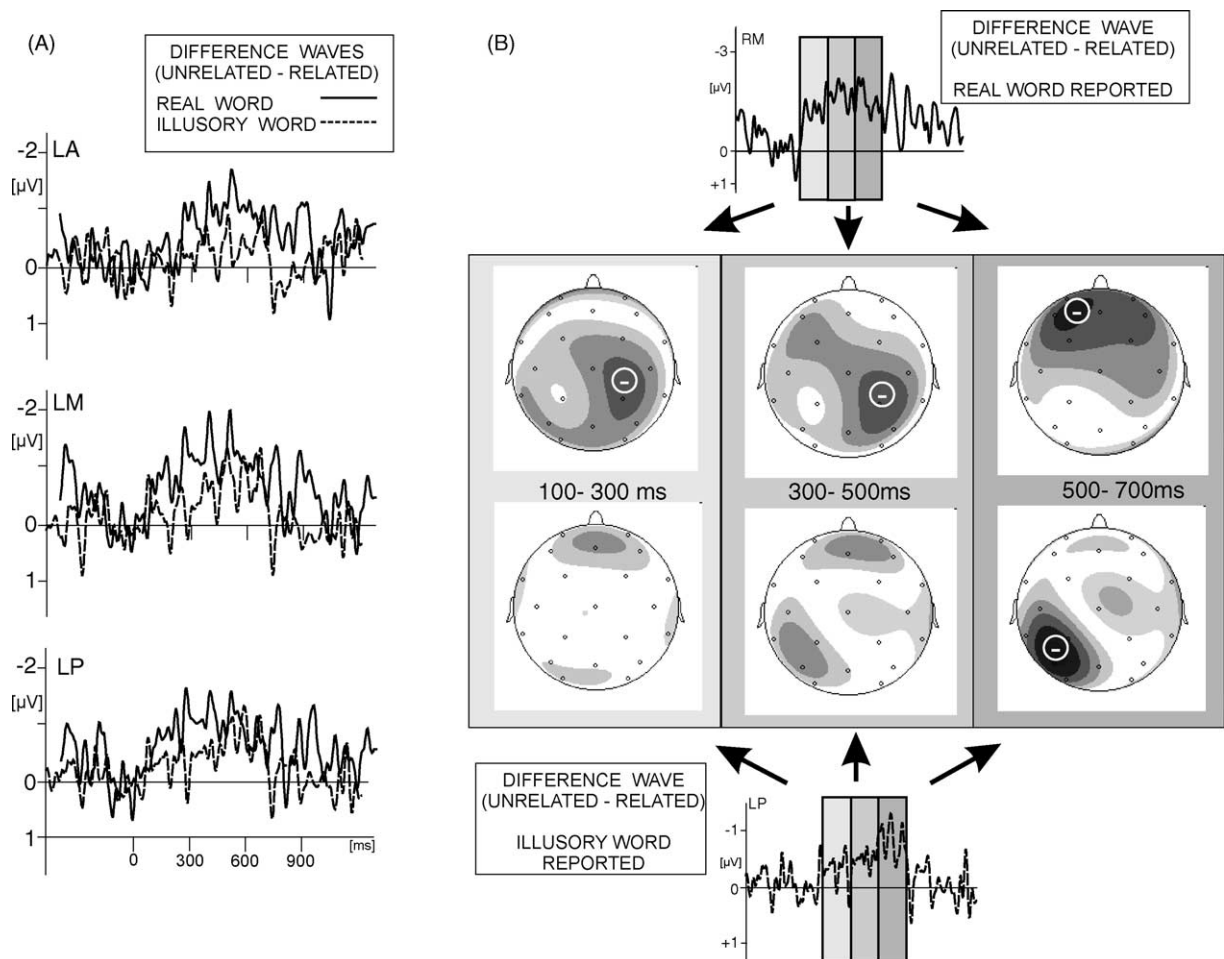


Fig. 4. The left hand figure (A) shows the grand-averaged difference waves (unrelated–related) recorded at left anterior, left medial, and left posterior clusters. The responses to real words and illusory words are superimposed, and corrected for the onset of the real word W2 and the word fragment FR. The topographic distribution of the amplitudes of the difference waves is shown in the right hand figure (B) for three pre-selected temporal windows (100–300, 300–500, and 500–700 ms). The amplitude values plotted in the maps are average-referenced.

subsequent time windows—aligned to the onset of the word fragment FR—is shown in Fig. 4b. Semantic priming did not affect ERP amplitudes prior to the onset of the third time window (500–700 ms). In this temporal epoch, illusory words not related to the prime word evoked a significantly enhanced negativity. As indicated by the interaction with the spatial electrode position ('priming' \times 'laterality': $F(2, 26) = 8.64, P = 0.002$) the effect was focused at the left hemispheric electrode clusters, and was primarily focused at left-posterior leads ('priming' \times 'laterality' \times 'laterality': $F(4, 52) = 3.34, P = 0.039$). Post-hoc comparisons confirmed that the effect was significantly expressed at this location (paired t -test $t(13) = 4.33, P = 0.001$, see Fig. 4b).

In a final analysis, the expression of the semantic priming as reflected in the difference waves was compared between the perceptual states. As shown in Fig. 4a, the negative difference wave was significantly more pronounced when the real word W2 was reported as compared to the illusory word in the first two segments: from 100 to 300 ms, the effect was expressed at central leads ('percept' \times 'caudality': $F(2, 26) = 4.299, P = 0.039$), and extended to a main effect in the following epoch (300–500 ms: $F(1, 13) = 6.69, P = 0.023$). In the terminal time window extending from 500 to 700 ms, the negative wave was significantly more pronounced at frontal leads if W2 was reported, the effect reversed at posterior leads, if the word illusion was perceived ('percept' \times 'caudality': $F(2, 26) = 4.62, P = 0.034$). This difference in the distribution was also confirmed when then z-standardized brain maps (see Fig. 4b) were compared ('percept' \times 'caudality' \times 'laterality': $F(4, 52) = 2.95, P = 0.035$).

4. Discussion

The results of the experiment can be summarized as follows: (1) semantic priming facilitates the processing of both real and illusory words. The probability of reporting the word related to the preceding prime was increased irrespective of whether it was physically presented or mentally constructed. The processing of primed target words was characterized by a significantly attenuated ERP negativity when compared to its unprimed counterpart. (2) Although the behavioural priming effect did not differ for real versus illusory words,² the ERP correlate of priming differentiated between the two perceptual states. For illusory words, the onset of the effect was delayed, its temporal characteristic

more transient, and its spatial distribution was different and also more focused.

The first finding emphasizes the role of ERPs in cognitive sciences. A behavioural priming effect alone would not allow us to conclude whether illusory words are generated at a lexical level (Harris & Morris, 2001), or result from a post-lexical reconstruction process. According to the latter account, the priming effects on illusory words would be traced back to a bias in the combination of word fragments, or to the activation of the semantic representation of the illusion by routing the top-down activation.

However, the time course of the ERP components is most consistent with activation of the illusory word during initial perceptual intake, not with post-lexical reconstructive processes. Irrespective of the differences to the priming effects on real words—which will be discussed in detail below—primed illusory words can be clearly distinguished from illusory words not pre-activated by a related prime word. Here, the time course of the ERP activation pattern is most important, namely its transient activation pattern with a maximum about 550 ms, and an abrupt offset at 700 ms (see Fig. 3). This temporal ERP pattern is likely to be induced by processes activated phase- and time-locked to the onset of the presentation of the fragment. This result is compatible with the idea of a lexical activation account. In contrast, the post-lexical reconstruction process triggered by the effort to generate a meaningful word will vary considerably across trials, both in onset and duration. Consequently, such a variable on- and offset would rather induce a late sustained ERP effect—if any (Ford, White, Lim, & Pfefferbaum, 1994).

Even if we exclude that a post-lexical reconstruction mechanism contributes to the generation of illusory words, three questions remain: are differences in the ERP priming effects between real and illusory words due to the sequencing of letter strings in the RSVP? Which stage of word processing benefits from semantic priming when the real or the illusory word has been reported? Does the ERP priming effect confirm that illusory words are treated like 'real' words at a semantic level of processing? In the following, we will address these three questions one after another.

Our data clearly show (a) an amplitude modulation as a function of relatedness both for real and for illusory words and (b) that these amplitude modulations differ from each other substantially, i.e. they differ according to their amplitude, latency and topography, respectively. One might argue, however, that the experimental situations creating the two perceptual states differ also differ substantially. While this is true, one has to realise, however, that (a) the two situations are based on physically comparable stimulus presentations, and (b) that we compare the effects of relatedness, i.e. the difference potentials between unassociated and associated conditions. Therefore, even if the baseline activities differ according to the position in the RSVP stream, this should not affect the difference potential itself. Moreover, because the difference amplitudes of the two perceptual

² The significantly enhanced probability reporting an illusory word as compared to the probability to report a real word was not obtained in earlier studies (Harris & Morris, 2001). We assume that the increase in probability is partially due to the lack of an inter-stimulus interval between the single items presented in the RSVP stream. This change in experimental setup did probably challenge the token individuation (Kanwisher, 1987), and therefore supports the partial repetition blindness effect.

states differ so substantially from each other on the basis of amplitude, latency, and topography, the claim that different cognitive processes are involved in these two situations is quite convincing.

As mentioned, the priming effect on real words was expected to reflect itself in an N400 effect (Kutas & Hillyard, 1980). Numerous findings indicated that the N400 effect signals the activation necessary to access a semantic representation. For example, the cloze probability of a semantic prime is inversely related to the activation (van Petten, 1995). The ERP priming effect obtained for real words which were later reported shares a number of characteristics of the N400 effect: the unrelated target word evoked a negative-going wave when compared to the related target word, and the early part of the difference wave (100–300 ms) showed a distinct centro-parietal maximum lateralized to right hemispheric leads (Curran, Tucker, Kutas, & Posner, 1993; Niedeggen, Roesler, & Jost, 1999). We propose that this early activation pattern signals the activation of lexical units.

However, the sustained time course of activation and its shift to frontal leads (see Fig. 4) does not fit the typical N400 effect. Both effects can be hardly related to the presentation technique (RSVP stream) because earlier findings already demonstrated that a transient N400 effect could be also evoked if words are presented in a rapid sequence (Vogel et al., 1998; Rolke et al., 2001). It is more likely that the temporal extension of the ERP effect is due to the difficulty in decoding the target word W2 that was orthographically similar to the preceding words (W1) in each trial. The effort to overcome the partial repetition blindness as well as the extended temporal interval between prime and target (SOA 1710 ms) might contribute to the frontal shift. A comparable effect has been previously reported by Kiefer & Spitzer (2000), and attributed to controlled aspects of words processing. Up to now, these explanations cannot be entirely sufficient and require further experiments.

In contrast, the ERP correlate of semantic priming obtained for illusory words showed a different temporal and topographic pattern. As stated before, we assume that right centro-parietal ERP effects between 100 and 300 ms signals the early activation of lexical units. A corresponding process is obviously not triggered if an illusory word has been perceived. The ERP priming effect obtained for illusions is unique with respect to its onset (approximately 500 ms), and its focal activation at left posterior electrodes. Both findings indicate that priming of illusory words operates at a different level of word processing, apparently related to visual areas in the language-dominant hemisphere. One probable candidate is a “visual word form area” responding to familiar visual forms regardless of the format that has been localized in the left medial extrastriate cortex (Petersen, Fox, Synder, & Raichle, 1990; Bookheimer, Zeffiro, Blaxton, Gaillard, & Theodore, 1995; Nobre, Allison, & McCarthy, 1994). A priming effect at the level of a “visual word form area” would indicate that the prime word supports the binding of the free-floating word fragment evoked by partial repeti-

tion blindness, and the fragment presented within the RSVP stream. In line with the idea of a cohort activation of words triggered by both fragments (Harris & Morris, 2001), the prime word reduces the activation threshold for the common entry, and therefore the probability to report the illusory word. The question why this lexical priming effect does not evoke the electrophysiological correlates of higher levels of processing that were identified for the real word must remain open at the moment. The restriction is probably due to the competition between word candidates during cohort activation that reduces the activation level of the illusory word.

In sum, we like to conclude that illusory words not only share the vividness of real words, but also are available as a lexical entity. This notion is strongly supported by the generation of an ERP priming effect that seems to operate at an early level of processing. Therefore, our first ERP approach confirmed that illusory words created by repetition blindness could be used as a tool for probing the perceptual units underlying visual word recognition.

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