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Electrophysiological evidence of automatic early semantic processing☆

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Abstract

This study investigates the automatic-controlled nature of early semantic processing by means of the Recognition Potential (RP), an event-related potential response that reflects lexical selection processes. For this purpose tasks differing in their processing requirements were used. Half of the participants performed a physical task involving a lower–upper case discrimination judgement (shallow processing requirements), whereas the other half carried out a semantic task, consisting in detecting animal names (deep processing requirements). Stimuli were identical in the two tasks. Reaction time measures revealed that the physical task was easier to perform than the semantic task. However, RP effects elicited by the physical and semantic tasks did not differ in either latency, amplitude, or topographic distribution. Thus, the results from the present study suggest that early semantic processing is automatically triggered whenever a linguistic stimulus enters the language processor.

Keywords: Event-related potentials; Recognition potential; Semantic; Automatic; Controlled

1. Introduction

Cognitive psychology assumes that automatic processes are unconscious and do not use limited-capacity resources. In contrast, controlled processes are under strategic control and use limited capacity resources (Posner & Snyder, 1975). Psycholinguistics has considered the degree of automaticity of the different stages involved in syntactic and semantic processing. The ERP methodology has been of great utility when addressing this issue, since it allows the study of syntactic and semantic steps involved in language comprehension with a high temporal resolution.

Up to now, only two studies have dealt with the automatic-controlled processing nature of syntactic analyses by means of two ERP responses, an early left anterior negativity (ELAN) and a centroparietal positivity (P600), thought to reflect different steps of syntactic analyses (Gunter & Friederici, 1999; Hahne & Friederici, 1999). The ELAN is evoked by phrase structure violations in the form of word category errors. These syntactic anomalies have been found to elicit a frontal negativity in the 100–300 ms time interval with a left lateralization (Friederici, Pfeifer, & Hahne, 1993; Hahne & Friederici, 1999). This negativity is usually followed by a positivity, P600, that peaks around 600 ms after stimulus onset (Friederici, Hahne, & Mecklinger, 1996; Friederici, Steinhauer, & Frisch, 1999). In addition to word category errors, the P600 is elicited by a variety of syntactic anomalies such as agreement violations (Gunter, Stowe, & Mulder, 1997), subjacency violations (McKinnon & Osterhaut, 1996) or even syntactically correct sentences with infrequent structures and temporally ambiguous sentences (Friederici et al., 1996; Friederici, Mecklinger, Spencer, Steinhauer, & Donchin, 2001). The functional significance of ELAN and P600 responses is still

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controversial. However, the most accepted view is that ELAN reflects first-pass parsing processes when an initial structure is built on the basis of word category information (Friederici, 1995; Gunter & Friederici, 1999; but see King & Kutas, 1995), whereas the P600 has to do with sentence reanalyses and the cost of sentence reprocessing (Hagoort & Brown, 2000; Münte, Matzke, & Johannes, 1997; Osterhout & Holcomb, 1992; but see Coulson, King, & Kutas, 1998).

In the first of the studies that investigated the processing nature of the processes reflected by the P600 component, Gunter and Friederici (1999) compared the ERP patterns evoked by phrase structure errors and verb inflection violations. They asked their participants to perform either a physical task (upper–lower case discrimination) or a grammaticality judgement task. These authors found that verb inflection violations elicited a greatly attenuated P600 response in the physical task, which reflects a shallow level of processing, as compared to P600 elicited in the grammaticality judgement task. In contrast, the P600 elicited by phrase structure errors only showed slightly reduced amplitude in the physical task as compared to the grammaticality judgement. Gunter and Friederici concluded that syntactic repair processes appear to be relatively controlled, although they did not discard the possibility that under certain circumstances these processes might be triggered automatically. This issue was further investigated in an experiment by Hahne and Friederici (1999), who manipulated the proportion of correct sentences and sentences containing word category violations. Incorrect sentences were either of a low (20% violations) or a high (80%) proportion. These authors found that the two conditions elicited an equally pronounced ELAN, whereas the P600 was only noticeable for the low proportion condition. Hahne and Friederici concluded that the initial stages of syntactic processing are automatic, whereas the final stages are controlled.

More work has been carried out on the processing nature of the N400, a negative response that reflects post-semantic processes related to lexical integration (Federmeier & Kutas, 1999; Kutas & Federmeier, 2000; Kutas, Federmeier, Coulson, King, & Münte, 2000). This component shows larger amplitudes for semantically incongruent words as compared to congruent words, and is especially sensitive to the predictability of a word in a given context. The N400 typically shows a right centroparietal distribution (Johnson & Hamm, 2000; Kutas & Hillyard, 1984; Weckerly & Kutas, 1999). Overall, research that has studied the processing nature of the N400 has concluded that this response reflects controlled processing (Bentin, Kutas, & Hillyard, 1993; Bentin, Kutas, & Hillyard, 1995; Brown & Hagoort, 1993; Chwilla, Brown, & Hagoort, 1995; Hahne & Jescheniak, 2001). Evidence comes from a variety of different tasks. Studies by Bentin et al. (1993) and by Chwilla et al. (1995) used the same approach as Gunter and Friederici's study (1999), and found N400 effects to be modulated by task variables that manipulate the depth of processing (memorizing vs counting in the Bentin et al. study; upper-lower case discrimination vs lexical decision in the Chwilla et al. study). Bentin et al. (1993) found N400 effects in a dichotic listening paradigm for attended, but not for ignored words. Hahne and Jescheniak (2001) presented their participants with correct and incorrect versions (the latter including word category errors) of regular and Jabberwocky sentences. These authors found that the detection of an error by first-pass parsing mechanisms blocks subsequent semantic processing, as revealed by the absence of N400 effects in the incorrect sentences. These findings were considered to support the controlled nature of the N400, since participants seem to discard lexical-integration processes when sentence context discourages such processes. Finally, Brown and Hagoort (1993), using the masking priming paradigm, reported that the N400 was modulated only by visible, and not by masked primes. However, recent work with the masked priming paradigm has reported that masked words also modulate the N400 at short SOAs, which suggests that the N400 is modulated by automatic processes also (Deacon, Hewitt, Yang, & Nagata, 2000; Kiefer & Spitzer, 2000). Thus, with the data currently available, the most reasonable position seems to assume that the N400 component reflects both automatic and controlled processes.

All the works mentioned above have studied the processing nature of a variety of processes involved in language comprehension. However, no previous study has explored the processing nature of early semantic processing. ERP methodology provides a useful tool for this purpose, in the form of an electrophysiological response, Recognition Potential (RP), which has repeatedly shown itself to be an index of early semantic processing. RP is a negative response that peaks around 250 ms after stimulus onset and displays a parieto-occipital distribution. Words elicit substantially larger RP amplitudes as compared to other non-meaningful stimuli, such as pseudowords or strings of random letters (Martín-Loeches, Hinojosa, Gómez-Jarabo, & Rubia, 1999, 2001a; Rudell & Hu, 2000). The type of semantic content modulates RP amplitude. In a study by Martín-Loeches et al. (2001a), the processing of words that belonged to the animal category elicited larger RP amplitudes than those from a heterogeneous pool of non-animal words. In another study, concrete words elicited larger RP responses than abstract words (Martín-Loeches, Hinojosa, Fernández-Frías, & Rubia, 2001b). The latency of the RP is also modulated by lexically related variables. Rudell and Hua (1997) showed that RP latency is a good predictor of reading ability, since skilled readers showed shorter latencies than less skilled readers. Finally, word frequency seems to affect RP latency, since frequent words show shorter latencies than infrequent words (Rudell, 1999).

The neural generators of the RP seem to be located within the fusiform/lingual gyri (Hinojosa, Martín-Loeches, Gómez-Jarabo, & Rubia, 2000; Martín-Loeches et al., 2001a; Martín-Loeches et al., 2001b). The areas that presumably generate RP are implicated in semantic processing, as suggested by the results of recent neuroimage studies (e.g., Kuriki, Takeuchi, & Hirata, 1998; Tan et al., 2000; Thompson-Schill, Aguirre, D'Esposito, & Farah, 1999). These findings, and considering the RP latency, make this component an appropriate candidate to be indexing the processes related to lexical selection (Martín-Loeches, Hinojosa, Casado, Muñoz, submitted).

The present experiment aims to study the automatic-controlled nature of the processes reflected by RP. For this purpose, we follow the levels of processing approach. According to this view, different task demands are assumed to result in different levels of processing (Craik & Lockhart, 1972). Results from several studies have demonstrated that this is a useful approach (Bentin et al., 1995; Gunter & Friederici, 1999). Therefore, we presented half of our participants with a physical task in which they had to identify words in lower-case letters. This task is assumed to trigger a shallow level of processing, since participants do not have to perform an explicit semantic analysis. The other half of the participants were confronted with a semantic task that consisted in detecting animal names, which forced them to perform an explicit semantic analysis. This task is assumed to trigger a deep level of processing. In order to further confirm that the two tasks trigger different levels of processing, we measured reaction times to targets in both the semantic and the physical tasks. Shorter reaction times were expected for the physical task compared to the search for animal names. Predictions for RP depend on the particular pattern of results. If similar RP responses are elicited by the stimuli in the physical and the semantic tasks, it should be concluded that early semantic processes reflected by RP are automatic. In contrast, if RP is smaller or even absent in the physical task condition, this should be considered as reflecting a controlled nature of the processes indexed by RP.

2. Materials and methods

2.1. Participants

Twenty eight participants (16 females) whose native language was Spanish were paid for taking part in the experiment. Their ages ranged from 17 to 32 years (mean 24.7 years). All were right-handed, with an average handedness score of 75.4, ranging from 6.7 to 100 according to the Edinburgh Handedness Inventory (Oldfield, 1971). All participants had normal or corrected-to-normal vision.

2.2. Stimuli

There were three types of stimulus, 40 animal names, 40 non-animal nouns, and 160 background stimuli. Animal names and non-animal nouns were used in a previous experiment (Martín-Loeches et al., 2002) and had a comparable word frequency according to the Alameda and Cuetos (1995) dictionary of frequencies for Spanish (mean 19.9 for animal names and 23.5 for non-animal words, $t_{78} = -0.45$; $p > .1$).

Animal and non-animal words were two-syllable words that could be formed of five (80%), four (10%), or six (10%) letters. Words could be presented in either lower or upper-case letters. Thus, there were 40 upper-case animal names, the same 40 animal names in lower-case letters, 40 upper-case non-animal nouns, and the same 40 non-animal nouns in lower-case letters. Background stimuli were formed by cutting lower and upper-case versions of animal and non-animal words into a random number of fragments. These fragments were put back in such a way that the resulting non-words resembled the words with either lower or upper-case letters. Special care was taken to guarantee that the background stimuli could never be identified as linguistic stimuli.

All stimuli were 3 cm in width. Upper-case versions of both animal and non-animal words, as well as the background stimuli made by cutting up these words, were 1 cm in height. Lower-case versions of all stimuli ranged in height from 0.6 to 1.5 cm. Examples of each type of stimulus are shown in Fig. 1.

Participants' eyes were 65 cm from the screen. All stimuli were presented white-on-black on an NEC computer MultiSync monitor, controlled by the Gentask module of the STIM package (NeuroScan).

2.3. Procedure

Stimuli were presented according to the rapid stream stimulation paradigm (Hinojosa et al., 2001a, 2001b; Rudell, 1992), with a stimulus onset asynchrony (SOA)

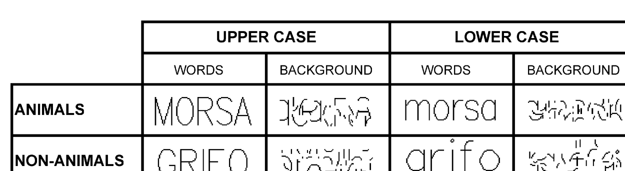

Fig. 1. Examples of the stimulus presented to participants.

of 257 ms. The computer displayed mostly background stimuli, and after either six or seven of these (this number being randomized) a test stimulus was presented. Test stimuli could be either an upper-case animal name, a lower-case animal name, an upper-case non-animal noun, or a lower-case non-animal noun.

Stimulation was organized in sequences. An experimental session consisted of eight sequences with a duration of approximately 1 min each. A practice sequence was carried out before the experiment began. Sequences began with six or seven background stimuli, followed by the first test stimulus. A sequence included 20 test stimuli: 5 upper-case animal names, 5 lower-case animal names, 5 upper-case non-animal nouns, and 5 lower-case non-animal nouns. A random process determined the type of test stimulus applied, with the constraint of no more than two of the same type occurring consecutively. Special care was taken to prevent the presentation of an upper-case word and its lower-case version in the same sequence. Each of the test stimuli appeared once during an experimental session. At the beginning of each sequence, participants pushed a button, and a message appeared on the screen telling them to blink as much as they wanted (they were told to avoid blinking as much as possible during stimulus presentation) and push again to start the sequence. At the end of each sequence, participants were provided with feedback about their performance.

Although all participants were presented with the same sequences, task instructions differed between subgroups, with the intention of manipulating task processing requirements. Participants were explicitly instructed to respond as rapidly as possible every time they detected a target stimulus. Half of them were presented with a semantic task that consisted in pushing a button every time they detected an animal name (semantic task subgroup), while the other half were instructed to perform a physical task and to press a button when they detected a lower-case word (physical task subgroup). Lower-case animal names were the critical stimuli in our experiment, since they were the only test stimuli that were targets in both tasks.

2.4. Electrophysiological recordings

The electroencephalogram (EEG) was recorded with 58 tin electrodes embedded in an electrode cap (ElectroCap International). Scalp locations were: Fp1, Fpz, Fp2, AF3, AF4, F7, F5, F3, F1, Fz, F2, F4, F6, F8, FC5, FC3, FC1, FCz, FC2, FC4, FC6, T7, C5, C3, C1, Cz, C2, C4, C6, T8, TP7, CP5, CP3, CP1, CPz, CP2, CP4, CP6, TP8, P7, P5, P3, P1, Pz, P2, P4, P6, P8, PO7, PO3, PO1, POz, PO2, PO4, PO8, O1, Oz, and O2. These labels correspond to the revised 10/20 International System (American Electroencephalographic Society, 1991), plus two additional electrodes, PO1 and PO2, located halfway between POz and PO3 and between POz and PO4, respectively. All scalp electrodes, as well as one electrode at the left mastoid (M1), were originally referenced to one electrode at the right mastoid (M2). The electrooculogram (EOG) was recorded from below versus above the left eye (vertical EOG) and the left versus right lateral orbital rim (horizontal EOG). Electrode impedances were kept below 3 KΩ. The signals were recorded continuously with a bandpass from 0.3 to 100 Hz (3 dB points for −6 dB/octave roll-off).

2.5. Data analysis

EEG epochs were extracted lasting 1024 ms after the presentation of lower-case animal names in both physical and semantic tasks. Artifacts were automatically rejected by eliminating those epochs that exceeded ±65 μV and those with amplifier saturation artifacts. Additionally, a visual inspection was performed, and trials in which there were no responses, or the reaction time was not between 200 and 800 ms, were excluded. Those epochs with false alarms and omissions were also rejected. Offline correction of small eye movements artifacts was also made, using the method described by Semlitsch, Anderer, Schuster, and Preelich (1986). ERP averages were computed for lower-case animal names.

For the entire sample of electrodes, originally M2-referenced data were re-referenced off-line using the common average reference method (Lehmann, 1987), which has proved to be the best way to obtain the RP (Martín-Loeches et al., 2001a).

Repeated-measures analyses of variance (ANOVAs) were carried out with the purpose of comparing latency and amplitude of the RP elicited by lower-case animal names in the physical and the semantic task. Statistical analyses were conducted on these stimuli, since they were the only stimuli that differed in nothing but the processing demands imposed by the physical and semantic tasks, as pointed out above. Latencies were measured and compared for the electrode showing the highest RP amplitude. This analysis determined the time interval in which the mean amplitude for the RP was computed. Repeated-measures ANOVAs were then conducted on these data. To avoid a loss of statistical power when repeated-measures ANOVAs are used to quantify large numbers of electrodes (Oken & Chiappa, 1986), analyses on amplitude were conducted on a selected sample of 30 electrodes: Fp1, Fp2, AF3, AF4, F5, F1, F2, F6, FC5, FC1, FC2, FC6, C5, C1, C2, C6, CP5, CP1, CP2, CP6, P5, P1, P2, P6, PO7, PO1, PO2, PO8, O1, and O2. These ANOVAs included two within-subjects factors, electrode (15 levels) and hemisphere (2 levels), and one between-subjects factor, task (2 levels, physical/semantic). The Geisser–Greenhouse correction was always applied.

3. Results

3.1. Behavioral data

Mean reaction time was 525 ms for lower-case animal names in the semantic task, whereas it was 449 ms in the physical task. This difference reached statistical significance ($F_{1,26} = 27.4$; $p < .0001$). Omissions and delayed responses means for lower-case animal names were also smaller in the physical task (0.4 omissions and 0 delayed responses) as compared to the semantic task (1.27 omissions and 1.1 delayed responses). False alarms means were 2 in the physical task and 2.5 in the semantic task. Overall, results from behavioral measures seem to indicate that the physical task was easier to perform than the semantic task.

3.2. Electrophysiological data

A visual inspection of the waveform averages revealed the presence of a parieto-occipital negativity, RP, for lower-case animal names, regardless of task demands, and peaking at the PO7 electrode. The peak latencies of the RP elicited by lower-case animal names in both the physical and semantic tasks were measured at this electrode from average waveforms in the 160–417 ms time interval after stimulus onset, following criteria outlined elsewhere (Rudell & Hua, 1997). Peak latencies and amplitudes were 220 ms and $-7\,\mu V$ in the semantic task, and 232 ms and $-7.4\,\mu V$ in the physical task. It can be observed that at the PO8 electrode, RP elicited by the lower-case animal names in the physical task displays a lower amplitude than RP elicited by stimuli in the semantic task. Grand-mean average waveforms corresponding to lower-case animal names in the physical task and the semantic task are shown in Fig. 2.

The results of an ANOVA comparing RP latencies did not reach statistical significance ($F_{1,26} = 2.3$; $p > .1$). Therefore, the same peak latency could be assumed for the RP elicited by stimuli in both the physical and semantic tasks, with an overall mean latency of 226 ms. The area within a single time-window was therefore calculated for amplitude analyses. This window ranged from 196 to 256 ms (around latency mean ± 30 ms) after stimulus onset. Statistical analyses on RP amplitude revealed significant main effects of electrode ($F_{14,364} = 83.6$; $p < .0001$), as well as the interaction electrode × hemisphere ($F_{14,364} = 77.3$; $p < .0001$). There were no significant effects for hemisphere ($F_{1,26} = 0.7$; $p > .1$), or for the interactions electrode × task ($F_{14,364} = 1$; $p > .1$), hemisphere × task ($F_{1,26} = 1.7$; $p > .1$), and electrode × hemisphere × task ($F_{14,364} = 0.8$; $p > .1$). In order to further confirm the absence of task effects suggested by the ANOVA, post hoc analyses were performed for the PO8 electrode, which showed the largest difference between tasks in RP amplitude. These analyses compared

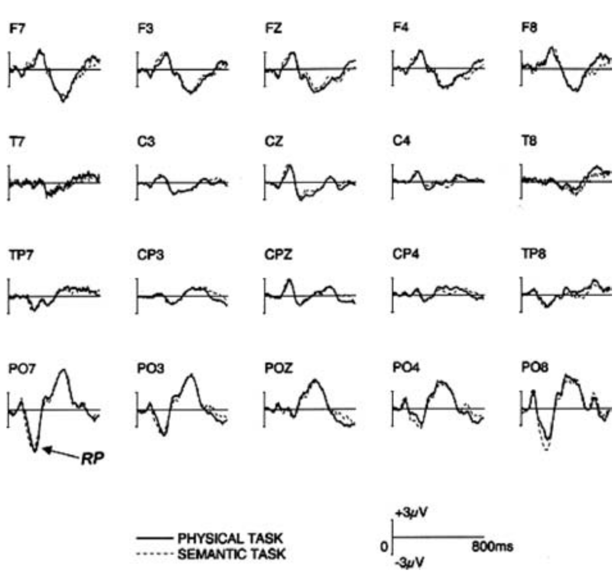

Fig. 2. Grand average waveforms elicited by lower-case animal names in the physical and semantic tasks at a selected sample on electrodes. A Recognition Potential with a similar latency and amplitude can be identified for the two types of stimulus.

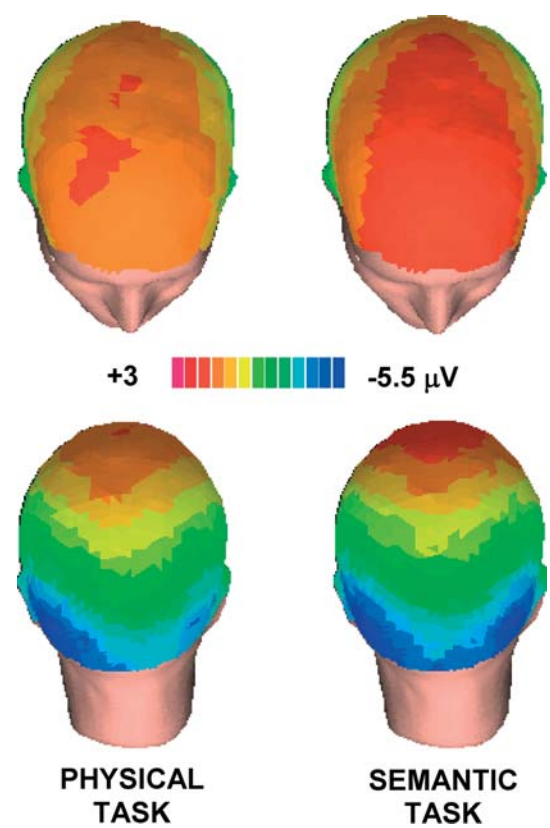

Fig. 3. Topographic distribution of the Recognition Potential elicited by lowercase animal names in the physical and semantic tasks across the total array of 58 cephalic electrodes. Mean values for the 196–256 ms time interval are represented.

the RP amplitude elicited by lower-case animal names in the physical and the semantic tasks and did not reach significance ($F_{1,26} = 2.7$; $p > .1$). Thus, no differences in RP effects elicited by lower-case animal names due to task demands could be assumed.

The topographic maps in the 196–256 ms time interval are shown in Fig. 3 for lower-case animal names in the physical and semantic tasks. The two maps show similar topography, with a parieto-occipital negativity. Data are represented using the common average-reference method.

Although Fig. 3 indicates that the topographic distribution of the RP was fairly similar for lower-case animal names in the physical and semantic tasks, a Profile Analysis (McCarthy & Wood, 1985) was performed in order to statistically validate this assumption. Accordingly, mean amplitudes in the 196–256 ms interval were scaled for each participant. An ANOVA was then performed with electrode (30 levels) as within-subjects factor and task (2 levels) as between-subjects factor. Results revealed no differences in the electrode × task interaction ($F_{29,754} = 1$; $p > .1$). Thus, the same neural origin can be assumed for the RP elicited in the physical and semantic tasks.

4. Discussion

The goal of this study was to examine the automatic-controlled processing nature of early semantic analysis as reflected by the RP component. This issue was addressed by comparing tasks in which semantic information was either relevant or irrelevant for the task. Reaction-time measures clearly show that the physical task is easier to perform than the semantic task, which places higher demands on the processor. The results from electrophysiological measures show a negative response, RP, peaking at about 226 ms after stimulus onset, with a parieto-occipital distribution. Task manipulations did not yield any significant difference in latency, amplitude, or topographical distribution between the RP elicited by lower-case animal names in the semantic and physical tasks. This absence of differences in the RP response could not be attributed to factors other than task processing requirements, since RP effects elicited by exactly the same stimuli (i.e., lower-case animal names) were compared. It seems, therefore, that early semantic processing is independent of depth of processing, and is automatically triggered whenever a word is presented to participants. The presence of a notable RP elicited by stimuli in the physical task could be attributable to automatic spreading of activation within the semantic system (Bentin et al., 1993).

The possible existence of automatic semantic activation prior to post-lexical integration was pointed out by Chwilla et al. (1995). Although in their study a lower–upper case discrimination task did not elicit an N400 effect, the authors did not rule out the possibility that some access to word meaning occurred under shallow processing requirements. This conclusion was drawn on the basis of their P300 effects findings, which demonstrated that participants assigned related and unrelated word pairs to different categories. Chwilla et al. noted that this assignment presupposes that even in the absence of N400 effects in the physical task, participants accessed words meanings. It seems not implausible to assume that such processes should have been triggered earlier in time, since they were not noticeable due to the absence of N400 responses. Our proposal is that such word meaning activation occurs around the time the RP peaks, as the results from the present experiment would support. If this were the case, categorization processes reflected by the P300 effect reported in Chwilla et al.'s experiment would rely on the previous and automatic processes of word meaning activation, indexed by the RP.

This is the first time, to our knowledge, that the processing nature of early semantic analysis has been explicitly studied with ERP methodology. In a previous study, Rudell and Hua (1996) tried to clarify the effects of conscious awareness on RP—an aspect that might have some implications for the processing nature of the RP. In that study participants who spoke Chinese and English were presented with English words, Chinese ideograms, or superimposed English and Chinese stimuli. Participants were instructed to press a button every time they detected a word belonging to one of the two languages. Results showed that words from the attended language elicited an RP, whereas words from the unattended language did not. The amplitude of the RP was about the same whether the participants looked for Chinese or English words, and Rudell and Hua concluded that selective attention is a prerequisite for eliciting RP. Although the authors did not express any opinion with regard to the processing nature of the RP, their findings might be taken as supporting a controlled nature of the early semantic processes reflected by the RP.

Several considerations, however, lead us to be cautious about this possible interpretation. First, words belonging to either Chinese or English could be easily detected exclusively on the basis of perceptual parameters, since Chinese and English words obviously differ greatly in their physical appearance. There were also other sources of perceptual discrepancies. In this regard, whereas Chinese words were in blue, English words were in white, so it seems plausible to assume that participants could easily search for a particular color instead of a word belonging to a particular language. Thus, no semantic analysis, either controlled or automatic (as reflected by RP), would take place if previous perceptual features analysis ruled out a given stimulus.

The results from the present study may enhance the overall view of processing nature of language comprehension. On the basis of the results from the literature and those from this study, it would appear that early language processes are automatic in nature. In this regard, both first-pass parsing processes and lexical selection processes, which constitute the first steps of syntactic and semantic processing, respectively, seem to be automatically performed by the language processor, as reflected by the automatic nature of ELAN (Hahne & Friederici, 1999) and RP responses (present study). This might be related to a question of *cognitive economy*, since early stages of language processing seem to be mandatory for the language processor in order to recognize an input as belonging to a specific linguistic entity that deserves further processing. As the processing goes further and becomes more elaborate, the strategies used by the processor become more controlled, although automatic processes still exert some influence. Results related to the processing nature of the N400 would support this view. Although the data are far from conclusive, the divergent pattern of results from these studies rather suggests that both automatic and controlled aspects modulate post-lexical integration processes (Bentin et al., 1993, 1995; Brown & Hagoort, 1993; Chwilla et al., 1995; Deacon et al., 2000; Kiefer & Spitzer, 2000). As suggested by Chwilla et al. (1995), lexical integration may be guided by the participant's awareness of the informational context of the discourse, and such awareness requires more processing resources. At the same time, lexical integration seems to be a mandatory process in order to integrate individual word meaning into message-level representations, and this would involve the use of automatic processes. Whatever the case, it seems that it is not until a final stage of language processing that the processes become totally controlled, as reflected by the P600 response, which has shown to be modulated by controlled strategies (Gunter & Friederici, 1999; Hahne & Friederici, 1999). P600 would indicate, therefore, that the processor has to integrate several sources of information (semantic, syntactic, morphological, etc.) in order to perform sentence re-analysis and to trigger repair strategies whenever they are needed (Münte et al., 1997).

In conclusion, this study provides evidence that an early stage of semantic analysis is automatic in its processing nature, as reflected by an ERP response, RP, which indexes lexical selection aspects. It would be of great interest for future research to further confirm these findings with the use of other methodological approaches, such as the masked priming paradigm, which has shown itself to be useful when addressing the processing nature of the many aspects involved in language comprehension.

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