

Event-related potentials and illusory conjunctions in the time domain

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Features from stimuli presented at a high rate in a single spatial position (Rapid Serial Visual Presentation, RSVP) can migrate forming a wrong combination or illusory conjunction. Several serial and parallel models have been proposed to explain the generation of this type of errors. The behavioral results fit better the two-stage parallel model than other serial and parallel models. However, they have not been studied the psychophysiological correlates that distinguish successful bindings from Illusory Conjunctions. The goal here is to collect electrophysiological records during this task to determine the degree to which they converge with the evidence from behavioral results. One RSVP task required to identify the only uppercase word in a stream of lowercase words at a rate of 12 items/sec. As in previous experiments, more intrusions from post-target items than from pre-target items were observed. The results from event-related potentials are also more supportive for the two-stage parallel model than for the serial or other parallel models, as reflected in the differential waves associated to correct and wrong combinations.

There are a number of effects that reveal the important temporal limitations of our cognitive system to process stimuli (Marois, & Ivanoff, 2005). The Attentional Blink, Psychological Refractory Period, and Repetition Blindness, are some of the most salient. In all of them the rapid succession of stimuli impairs performance in some way. A similar impairment shows up in the process of building integrated perceptual representations of the stimuli under Rapid Serial Visual Presentation (RSVP) conditions, the phenomenon under the focus of the present study. As the building of a unitary percept needs time, when the procedure doesn't

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allow an exposure interval long enough for a proper binding some errors are produced. The features from different stimuli are incorrectly combined, producing percepts that are in fact “illusory conjunctions” of features actually presented, although in a different combination (e.g., reporting a T green after presenting a T red and an X green). The study of these errors is critical to understand the “binding problem”.

Generally speaking, the so-called “binding problem” refers to the way visual attributes are unitarily perceived despite our cognitive system functionally segregates the stimuli into a number of independent information channels (Livingstone & Hubel, 2003). As any other psychological process, the development of a percept after the presentation of a stimulus takes time. Although it is not tenable a strict hierarchical model in which features extraction structurally precedes attention and their combination, there is enough evidence that the features reach their own representations before they are combined to form objects. In conditions difficult for attention, as for example when the duration of the stimuli is too short to form a percept for each stimulus, the door is open for errors in which features of the several stimuli are miscombined. The study and systematic observation of this type of errors can shed light on the mechanisms involved in the building process.

Although the term illusory conjunction was first used to describe miscombinations of features coming from simultaneous stimuli presented briefly in different locations of the visual field (Treisman & Schmidt, 1982)¹, this type of errors had been previously reported within the time dimension. Thus, it was first found a significant number of illusory conjunctions when reporting the only uppercase word in a series of lowercase words in a RSVP (Lawrence, 1971). Specifically, the observer sometimes reports words actually presented in the series, but in lowercase and more probably in a position close to the target (for example, the word “*patata*” in the example of Figure 1), with a given distribution between

¹ The very existence of Illusory Conjunctions has been challenged by Donk (1999), at least for illusory conjunctions in the space domain, arguing that the distributions of responses observed are an artifact produced by mere guessing processes. However, several studies have shown that the feature reported is not randomly chosen (Ashby, Prinzmetal, Ivry, & Maddox, 1996). The features from certain spatial positions are more likely than others to be chosen; that is, the available features have associated with them certain partial information that makes them “better” or “worse” candidates for a response. Guesses based on this information certainly generate errors, but performance is better than making ‘blind’ guesses (Hazeltine, Prinzmetal, & Elliot, 1997). A “pure guessing” mechanism would generate a uniform distribution of the origin of intrusions around the target. But the results of the present experiment and of most previously published show non uniform distributions.

positions before and after it (pre target and post target intrusions, respectively).

Colored letters have also been extensively used to study the phenomenon (Botella & Eriksen, 1992; McLean, Broadbent, & Broadbent, 1983). For example, when asked to report the only letter in the series in a specific color (“red”, for example), a number of times the observer reports a letter presented in a different color (no red) but in positions close to the target. The same happens when the observer is asked to report the color of a specific letter (“T”, for example). Furthermore, high level representations can also be conjoined incorrectly, as they can be accessed in parallel (Potter, 1976; Quinlan, 2003; Rousselet, Fabre-Thorpe, & Thorpe, 2002; Thorpe, Fize, & Marlot, 1996; Vogel & Luck, 2002). In short, in RSVP tasks feature migrations between stimuli presented in close serial positions are frequently observed, even when the focus of the study is a different phenomenon, as the Attentional Blink (Botella, Arend, & Suero, 2004; Botella, Barriopedro, & Suero, 2001; Chun, 1997; Juola, Botella, & Palacios, 2004).

More interestingly, the distributions of these so-called *Illusory Conjunctions in the Time Domain* are predictable and can be modified by manipulating several parameters of the task (Botella et al., 2001; Botella, García, & Barriopedro, 1992). Most research about this phenomenon has been directed to reach an explanation of the behavior that determines the distribution of intrusions around the target. Especially relevant is the question of why the empirical distribution changes for different combinations of the target-defining feature and the to-be-reported feature.

The models proposed to explain how these migrations are produced have been traditionally classified as serial and parallel models. *Serial models* (e.g., Lawrence, 1971; McLean, Broadbent, & Broadbent, 1983) establish that at the beginning of each series the observer only processes the feature from the target-defining dimension. When the target-defining feature is detected, the system processes the to-be-reported dimension. The conjunction errors are produced because attention is applied at the wrong moment (too early in pre-target errors, too late in post target errors). *Parallel models* (e.g., Botella et al., 2001; Keele & Neill, 1978) establish that the features from the to-be-reported dimension are processed in parallel from the stimuli even before the target-defining feature has been detected. Those features are then available to form a unitary stimulus. The empirical evidence (see Botella et al., 2001, for a review) clearly favors parallel models. Furthermore, the recent results obtained by Botella, Narváez, Suero, and Juola (2007) with a double-response paradigm reinforce this

conclusion, essential for modeling the effect. In that paradigm, after giving their initial response the observers must report their “second candidate”. The distributions of second responses show that they are not given at random and that they are generated with the same rules as the first responses. The conclusion is that the response features: (a) are processed from the stimuli in parallel with a stable procedure; (b) all are chosen with similar criteria; and (c) are simultaneously available for the system to choose the responses.

However, the two main parallel models differ in an important way. On one side, in the codes coordination model of Keele and Neill (1978) the target-defining and the to-be-reported dimensions are processed in parallel for the stimuli in the series. Following their codes coordination view, features are in general combined according to spatio-temporal closeness; under RSVP conditions, where spatial location remains constant for all stimuli, temporal closeness is the key. Although the model is only roughly outlined, we understand that it assumes that the response feature selected is the one for which processing is completed in a moment closer to the moment the processing of the target-defining feature is completed (a more detailed version of this assumption has been explored by Suero & Botella, 2006). But what has to be highlighted here is that correct responses are produced in the same way as errors. In fact, they can be considered as no more than “fortunate conjunctions”.

On the other side, Botella et al. (2001) proposed a more complex two-stage model of the formation of this type of errors. Let’s outline briefly the general architecture of the model, to facilitate the following of the present report (for a more detailed description, see Botella et al., 2001).

The duration of the features binding process is a random variable, both in “natural” and laboratory conditions. When the Stimulus Onset Asynchrony (SOA) is fixed within a critical range only in some percentage of trials the percept will be developed before interference from the following items interrupt the process (probably by masking). But on the rest of the trials the system is still able of giving a response taking as a basis the representations of isolated features from the to-be-reported dimension. Thus, the empirical distributions of responses are a mixture of trials in which an effective binding process has been completed before masking, and ineffective trials in which the response is given only from isolated features. The study of the composition of those errors has allowed a better comprehension of the type of information they convey. We know these features are not “free-floating” nor are taken randomly, as proposed in the first version of the Feature-Integration Theory for illusory conjunctions in

the space domain (Treisman & Gelade, 1980). Partial and fragmented information on spatial location is the basis to make a better choice than pure guesses (Ashby, Prinzmetal, Ivry, & Maddox, 1996; Quinlan, 2003; see footnote 1). For the present task, where spatial location is not useful, the information conveyed is probably related to their levels of activation at the moment the target-defining feature is detected. As we have previously shown (Botella et al., 2001), a constant ratio Luce's rule² (Logan, 2004; Luce, 1959) applied to the levels of activation associated to the response features of the stimulus from each position around the target can account for the distributions of intrusions (see Botella et al., 2007).

In short, in the two-stage model the first stage is an attempt to generate an integrated percept by focal attention. The second stage, in which the response is given only from isolated features, only happens when the first stage doesn't succeed. However, it is a parallel model in the sense that both features (the target-defining one and the response one) are simultaneous and automatically processed for all items, even before the target-defining feature is detected.

The present research

A number of studies have focused on errors produced in binding features in RSVP conditions, or on electrocortical activity during other phenomena associated to RSVP conditions (Marois, Chun, & Gore, 2000; Sergent, Baillet, & Dehaene, 2005; Vogel & Luck, 2002; Vogel, Luck, & Shapiro, 1998). However, as far as we know they have not been reported the psychophysiological correlates that distinguish successful bindings from Illusory Conjunctions. The main goal of the present research is to collect electrophysiological records during this task and to determine the degree of convergence of the results with the models mentioned above. Although behavioral evidence supporting Botella et al.'s (2001) model is overwhelming, Event-Related Potentials (ERP) associated to hits and both types of errors (pre and post target intrusions) can help us to more convincingly corroborate the model, disproving some ideas and supporting

² The constant ratio rule specifies the relationship between the probabilities of two alternatives for being selected in a choice setting. Applied to the levels of activation of the k different features available for selecting a response, A_i , the constant ratio rule states that the probabilities of choosing alternative j is,

$$p(X_j) = \frac{A_j}{\sum_{i=1}^k A_i}$$

others. We are aware that some psychophysiological predictions are shared by other models. However, if our results are compatible with the two-stage model they will add to the bulk of the behavioral evidence, giving to the model a broader range of sources of convergent empirical evidence. Nevertheless, let's be as specific as possible in the differential predictions derived from those alternative ideas.

Two main ideas among those to be disproved deserve special attention. The first one is the idea that those errors are produced because attention is focused on the wrong stimulus, from which the to-be-reported feature is extracted after the target-defining feature is detected. This is the early selection view involved in serial models, as response features are not processed (they are excluded by filtering) until the key feature is detected. The prediction from those serial models is that the waves associated to hits and errors should be indistinguishable in their amplitude, but pre-target errors should reach their peak earlier than hits, whereas post target errors should reach it later than hits.

The second idea to be disproved is that involved in Keele and Neill's (1978) parallel model that correct responses are produced in the same way as errors. The prediction from that model is that the waves associated to hits and errors should be clearly indistinguishable, as hits are no more than "fortunate conjunctions" instead of the consequence of a more efficient processing.

On the other side, among the ideas to be supported is that, in general, correct combinations are not formed in the same way as errors, although of course the mechanism that produces errors also generates some "fortunate conjunctions". From Botella et al.'s (2001) model the bindings yielded within Focal Attention are to be expected in the maximum efficiency trials. As a consequence, the prediction is that a larger wave amplitude associated to hits than to errors will be observed. However, the waves for both types of errors should be indistinguishable. To pre-empt the results, the waves fit better the prediction from Botella et al.'s model than those from the serial model or from the code coordination parallel model.

METHOD

Participants. Ten healthy undergraduate and graduate students from the Universidad of Coruña volunteered as subjects. All had normal or corrected-to-normal vision, by self-report.

Stimuli and materials. Four-hundred series of 13 Spanish words of 4-7 letters length in lowercase were firstly prepared. The words were taken from a pool of 300 Spanish words. A word was never repeated within a trial. Then, in 80% of the trials the word in the 6th, 7th or 8th position (one third each) was changed to uppercase to serve as the target word. In the other 20% of trials (catch), no target was included. A word was never employed as the target in more than one trial. The stimuli were presented on a NEC Multisync Ila monitor controlled by a desk-top computer, in a darkened, sound attenuated chamber. At a viewing distance of about 60 cm, each character subtended .5 deg or less in horizontal and vertical extension. The experimental program was written and run using MEL (Schneider, 1988).

Procedure. During a single session of about one hour evoked potentials were recorded while performing an identification task of the target word, defined as the only one presented in uppercase. Figure 1 shows the experimental procedure. The observer began each trial pressing the spacebar. A row of six asterisks remained as fixation for 500 msec. Then, the words series was presented with an SOA of 83 msec., each word replacing the previous one without any blank gap between them. At the end of each series a five words menu was presented, including the target word, plus the two items before and after it in the series, all in uppercase and in random order, plus the option "Don't know". The observers chose the response by pressing the number of the corresponding alternative. Previous research has shown, by including in the menu words not presented in the series, that the words are not taken at random from the menu, as those new words are seldom selected (Botella & Eriksen, 1992).

The observers never had feedback of the correctness of the responses given.

Electrophysiological activity in the brain was continuously recorded from 13 scalp electrodes mounted in an elastic cap (Electrocap) and located at standard positions (International 10/20 System). They were referenced to A1 (left ear's lobe). Bipolar recordings of vertical and horizontal EOG were made from sites above and below the right eye and 2 cm external to the outer canthus of each eye. The EEG and EOG were amplified online using Grass amplifiers (model 12) with a band-pass filter of 0.01-20 Hz. Electrode impedances were below 5 kohm. They were digitized online at 250 Hz. Ocular artefacts were removed with Gratton, Coles and Donchin's (1983) program; this program allows keeping all trials in an ERP recording, irrespective of ocular artefacts.

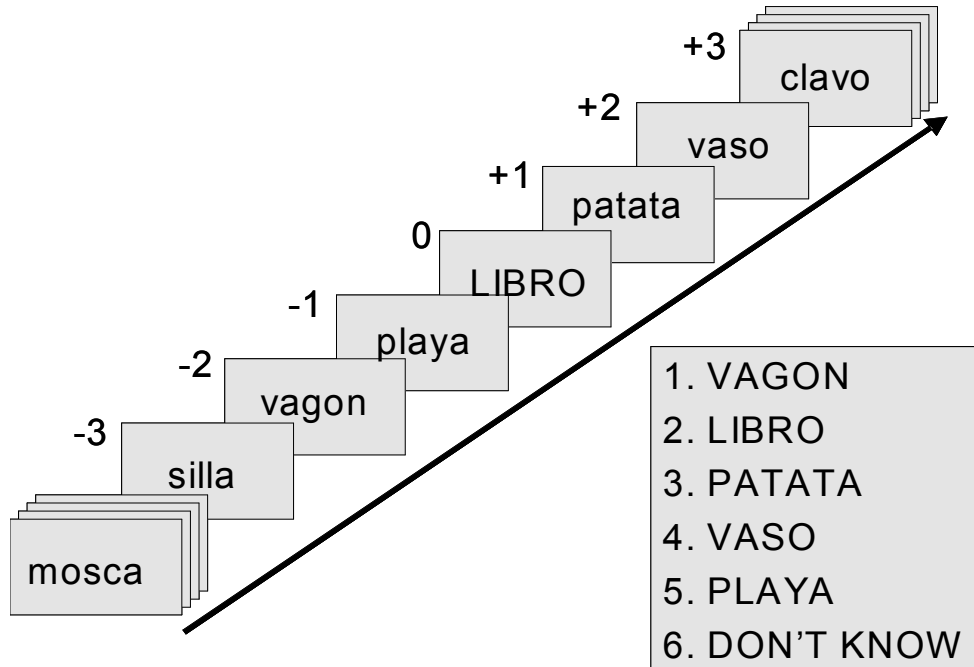


Figure 1. Scheme of the procedure. After the series has finished, a menu with the words from the critical set (the target plus the two words before and after it) is presented to collect the response.

For analysis purposes the EEG was transformed into stimulus-triggered epochs between -850 ms to +1000 ms referenced to the presentation of the target stimulus. Epochs with values outside $\pm 100 \mu\text{V}$ at any electrode or with values outside $\pm 50 \mu\text{V}$ in EOG recordings were excluded from the analysis. Baseline subtraction was done using the average of the 150 ms prior to the stimulus. As a potential amplitude measure it was taken the maximum value in the temporal window and as a measure of latency the momentum of that maximum. The temporal windows employed were: N2 [100 - 300] (ms); P3 [304 - 760] (ms); a low-pass filter of 20 Hz was employed.

Event-related potentials from each subject were averaged based on trial type (target correctly identified, pre-target errors, post-target errors, catch trials with an "I don't know" response).

RESULTS

The mean percentage of correctly reported features is 62.6%. As is usual for this particular combination of target-defining feature and to-be-reported dimension, significantly more errors come from post-target positions than from pre-target positions (23.1% vs. 14.3% in the average; $t(9) = 3.439, p = 0.007$). It is also clear that the subjects did not take blindly a feature from a temporal window tied to the beginning of the series, as in 91% of the catch trials responded “Don’t know”.

The ERPs associated to the different types of responses allow distinguishing very clearly between them, even though the observers could not be confident as to whether their responses were correct. Figure 2a shows the average wave associated to correct detections, errors, and catch trials with a “Don’t know” response. The absence of a positive component associated to the catch trials after the first 150 ms demonstrates that the components after then reflect the processes triggered by the detection of the target-defining feature.

More importantly, correct responses show a wave with distinctive characteristics from errors, thus supporting the view that most hits are not just “fortunate conjunctions”. After observing a peak at 450 ms we have averaged the voltage in a window of 40 ms around it and carried out within-subjects ANOVA for each electrode with three trial type conditions: hits, pre-target intrusions, and post-target intrusions. In 8 from 13 electrodes the ANOVA shows the same pattern of results:

(1) A significant main effect of trial type: $F3$ ($F(2,8) = 5.721, p = 0.012$); Fz ($F(2,8) = 6.181, p = 0.009$); $F4$ ($F(2,8) = 7.276, p = 0.005$); $C3$ ($F(2,8) = 4.337, p = 0.029$); $C4$ ($F(2,8) = 6.430, p = 0.008$); $P7$ ($F(2,8) = 8.521, p = 0.002$); $P3$ ($F(2,8) = 7.710, p = 0.004$); Pz ($F(2,8) = 8.447, p = 0.003$).

(2) In post-hoc Bonferroni comparisons, significant larger magnitudes associated to hits than to both types of intrusions ($p < .05$ in all cases), but no differences between pre- and post-target errors ($p > .05$ in all cases).

In order to analyze the distributions of the electrocortical activity of the three types of trials, we carried out a within-subjects 3×13 ANOVA (3 trial type, 13 electrodes), after normalizing the values to compensate the different amplitudes. As a result, a statistically significant main effect of the trial type was observed [$F(2,18)=7.848; p<.005$], but also of the interaction [$F(24,216)=2.426; p<.001$]. The significant effect of the interaction is not only due to different distributions of correct responses and errors, as in a similar analysis with only the two types of errors the interaction is still

significant [$F(12,108)=2.172$; $p<.02$]. Interestingly, it doesn't show a main effect of the trial type [$F(1,9)=1.836$; $p>.20$].

As can be observed in figure 3, the amplitude associated to hits is always larger than that associated to errors. Both types of errors are indistinguishable in frontal and most central electrodes. However, there are some areas (mostly showed by medial and right parietal electrodes) where the amplitude associated to pre-target errors is larger than that associated to post-target errors (as reflected in the statistical interaction). There are also some cues (not statistically significant) for an earlier appearance of the positive component for pre-target than for post-target errors (figure 2b).

No other remarkable comparison yield statistically significant effects.

DISCUSSION

Several models have been proposed to account for the formation of illusory conjunctions in the time domain. The goal of the present research is to collect psychophysiological evidence and to assess the degree to which that evidence converges with the behavioral results from previously published experiments. Differential predictions can be derived from the serial model (Lawrence, 1971; McLean, Broadbent, & Broadbent, 1983), the code coordination parallel model (Keele & Neill, 1978), and the two-stage parallel model (Botella et al., 2001).

The pattern of evoked potentials observed supports the parallel, late selection view, embodied in the two-stage model (Botella et al., 2001) in explaining the observers' responses when identifying the only feature-defined target presented in a RSVP paradigm. When the target defining feature is detected, a focal attention process is triggered to build an integrated percept (Paul & Schyns, 2003). Different electrocortical response patterns were obtained with target present and catch trials, suggesting specific processes triggered by the target-defining feature detection.

Correctly reported and illusory conjoined trials show different patterns of electrical activity, reflecting the higher effectiveness of neural activity in trials succeeded. The larger amplitude associated to the correct responses, as compared to pre- and post-target errors, reflects enhanced central processes for hits. According to the two-stage model, in more efficient trials (larger positive amplitude) a correct response is generated. In less efficient trials (smaller amplitude) focal attention fails, but a response based on isolated features is yet possible.

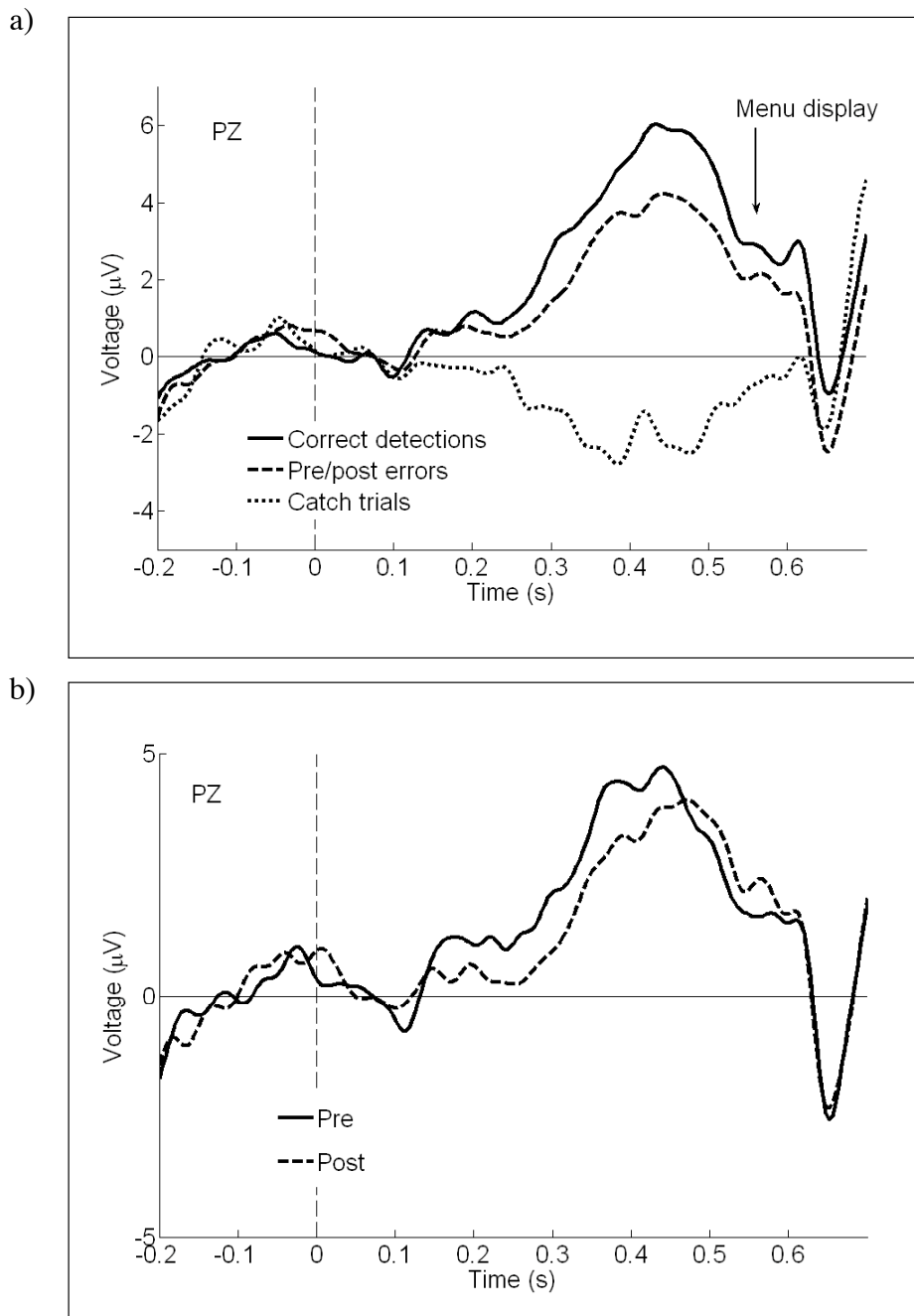


Figure 2. Grand average ERPs associated to different responses at the parietal area. Panel (a) shows waves at Pz for correct responses, errors, and catch trials with a “don’t know” response. Panel (b) shows the earlier appearance of the same component for pre- than for post-target intrusions.

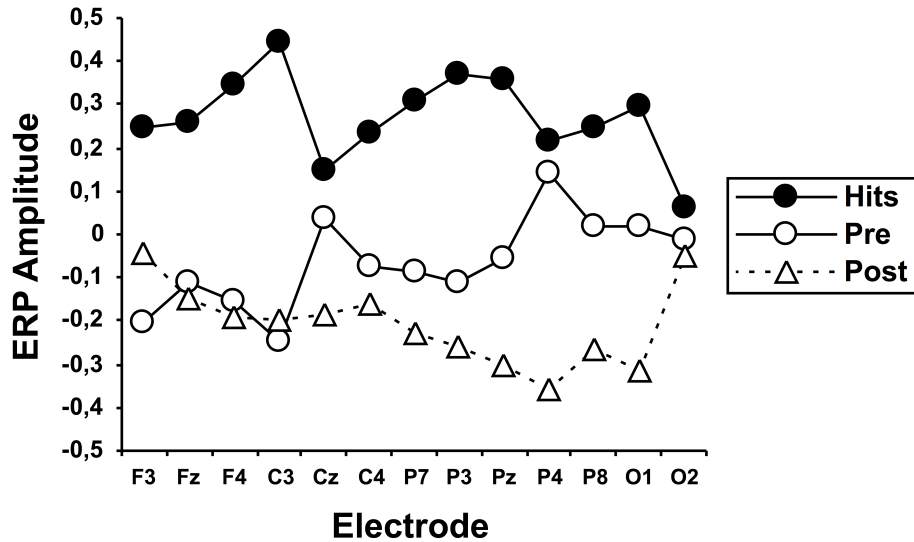


Figure 3. Mean amplitude at the 40 msec window around 450 in the 13 electrodes recorded, for three trial types: hits, pre-target errors and post-target errors.

It is especially important that both types of errors are indistinguishable in frontal areas, as the model specifies an impaired performance in focalizing attention, a process often linked to working memory and with the functioning of frontal areas (Kane & Engle, 2002). Apparently, the functioning of the neural generators in trials with correct and incorrect responses is different just in those areas. Nevertheless, the activity associated with both types of errors differs only slightly and in more posterior areas, especially the right parietal. We still do not know if this is an enduring difference between pre and post-target errors or is associated to the specific features used here to define the target and to be reported. Thus, in this particular experiment the target-defining feature is the lower/uppercase category, a distinction probably related with the activity in right parietal (Burgond & Marsolek, 1997; Marsolek, Nicholas, & Andresen, 2002); P4 is just the electrode that shows the maximum difference between pre- and post-target errors. Experiments with different combinations of target-defining features and to-be-reported features are needed to address this issue. Of course, the “hits higher” and “both errors

equal” results should appear with any target-defining and to-be-reported features.

In general, the fact that the amplitudes of pre- and post-target errors in almost all locations and latencies are indistinguishable supports the view that they are generated in the same way. However, there are also some cues for an earlier appearance of that positive component for pre-target than for post-target errors. Of course, following the model (Botella et al., 2001) there must be some difference in the functioning of the neural generators associated to pre-target and post-target errors, although it should not be in the frontal areas. At a speculative level, earlier triggering (shorter latency) of the small amplitude attentional process is more probably associated to pre-target intrusions, whereas later triggering is more probably associated to migrations from post-target items.

Along the last decade a growing body of research has shown how selective attention can be modulated according to temporal cues. As a consequence, a peak of efficiency can be reached in the temporal window when the target will be displayed more probably (e.g., Correa, Sanabria, Spence, Tudela, & Lupiañez, 2005; Jones, Moynihan, MacKenzie, & Puente, 2002; Nobre, 2001). This notable ability and the well known effects of predictable foreperiods, can be a problem in the present context. Specifically, it could be suggested that the post-target predominance of errors could be due to enhanced preparation within that part of the temporal window. Many aspects of our design are directed to avoid such effects, as for example the fact that the target is not always presented in the same serial position or the inclusion of a number of “catch” trials with no target to prevent “blind” responses. In the present and most previous experiments with this experimental paradigm we have checked that the distributions of responses do not change as a function of the serial position of the target and that in the trials with no target the responses are “no target presented” in almost 100%. Those results, together with the fact that we have been able to shift the distributions of responses by manipulating several experimental factors (e.g., Botella et al., 2001; Botella et al, 1992), make us confident in that the results are not produced by any selective attention in the time domain. Rather, attention is uniformly enhanced along the temporal window where the target can be presented. Within that window, selective attention works as described in Botella et al’s model.

The present research adds to an increasing body of results looking for correlates of neural activity that reflect the differential cascade of events accompanying trials that finish with different behavioral results in highly demanding tasks. When the task arrangements induce to work beyond the

limits of the temporal resolution of the system, impairments of different types arise. The way those impairments manifest is relevant to understand how the system works. Thus, when the task requires a response to two stimuli presented within an interval of about 300 ms, detection of the second target is impaired (Attentional Blink; Raymond, Shapiro, & Arnell, 1992). Differential electrocortical activity accompanying trials succeeded and failed can help to understand the mechanisms involved and to elucidate the neural basis of those mechanisms. Even more, it can help to study the fate of stimuli with different behavioral manifestations, including the absence of a response (Fell, Klaver, Elger, & Fernández, 2002; Marois, 2005; Martens, Elmallah, London, & Johnson, 2006; McArthur, Budd, & Michie, 1999; Sergent, Baillet, & Dehaene, 2005). Similarly, speeded responses to the second of two consecutive stimuli within a short SOA are delayed (Psychological Refractory Period; e.g., Pashler, 1994). Neuroimaging has been also employed to investigate the nature of the impairment in this task, assessing the correlations between the neural activity in several cortex areas and the size of the behavioral effect (Jiang, 2004).

Similarly, we have shown different patterns of ERPs associated to hits and the two types of errors when reporting a feature from the only target presented under RSVP conditions. Our main conclusion is that the psychophysiological results obtained converge with a large body of behavioral results that support the two-stage model (Botella et al., 2001) developed to account for the formation of illusory conjunctions in the time domain.

The larger amplitude associated to correct responses can be interpreted also as the result of other factors³. Among them are different levels of uncertainty about the responses, or different levels of awareness. However, our interpretation in terms of Focal Attention converges with many other experimental results, besides the fact that phenomenological certainty and awareness probably overlap with Focal Attention.

The picture that emerges is that when the temporal limit is approached the probability that focal attention builds a correct integrated percept decreases. Correspondingly, it increases the probability of a scenario of uncertainty in which the system only has available floating features with some cues associated that can be used to make “sophisticated guesses”. Those cues are probably linked to the level of activation of the representations of the features when the target-defining feature is detected. If the observers are pressed to give a response even in those trials in which

³ Thanks are due to an anonymous reviewer for rising this point.

they do not feel confident on it, this paradigm and the distributions of responses can be very useful. They allow investigating the nature of the partial and fragmented information available for the system when working beyond the comfortable temporal resolution limits within which we reach ceiling performance levels.

RESUMEN

Potenciales evocados y conjunciones ilusorias en el dominio del tiempo.

Los rasgos procedentes de estímulos presentados a una tasa alta en una única posición espacial (Presentación Rápida de Series Visuales, PRSV) pueden migrar formando combinaciones incorrectas o conjunciones ilusorias. Se han propuesto diversos modelos seriales y paralelos para explicar la generación de este tipo de errores. Los resultados conductuales se ajustan mejor al modelo paralelo bifásico que a otros modelos seriales y paralelos. Sin embargo, no se han estudiado los correlatos psicofisiológicos que distinguen las combinaciones correctas de las conjunciones ilusorias. Nuestro objetivo aquí es recoger registros electrofisiológicos durante esta tarea para determinar el grado en que convergen con la evidencia procedente de los resultados conductuales. En una tarea de PRSV se pedía identificar la única palabra que aparecía en mayúsculas en una serie de palabras en minúsculas presentadas a una tasa de 12 ítems por segundo. Como en experimentos anteriores, se observaron más intrusiones desde ítems post-target que desde ítems pre-target. Los resultados de potenciales evocados apoyan también más al modelo paralelo bifásico que al serial o a otros modelos paralelos, tal y como se refleja en la ondas diferenciales asociadas a las combinaciones correctas e incorrectas.

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