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Emotional load and the formation of illusory conjunctions in the time domain

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The effect of emotional load of the stimuli on its processing has been interpreted in terms of overautomaticity or as permanently lowered threshold for recognition. This special characteristic of emotional stimuli has been used to study how our cognitive system process information. In the present research the emotional/neutral manipulation has been used to test the model of Botella, Barriopedro & Suero (2001) for the formation of illusory conjunctions in the time domain. Results of three experiments are analyzed within this context. It is concluded that, in general, they support the general architecture of the model.

Carga emocional y formación de conjunciones ilusorias en el dominio del tiempo. El efecto de la carga emocional de los estímulos en su procesamiento ha sido interpretado en términos de la sobre-automaticidad o de un umbral permanente rebajado para su reconocimiento. Esta característica especial de los estímulos ha sido utilizada para estudiar cómo nuestro sistema cognitivo procesa la información. En la presente investigación la manipulación emocional/neutral ha sido utilizada para poner a prueba aspectos del modelo de Botella, Barriopedro y Suero (2001) para la formación de conjunciones ilusorias en el dominio del tiempo. Los resultados de tres experimentos son analizados a la luz del modelo y se concluye que, en general, apoyan su arquitectura.

Previous research has shown that emotional (E) stimuli are processed in a different in comparison to neutral stimuli (N) (Dalgleish, 1995; Wells & Mathews, 1994; Williams, Mathews & MacLeod, 1996). Such differential processing has been usually explained in terms of the overautomaticity of emotional words or a lowered perceptual threshold (Bargh, 1989). Moray (1959) tested predictions from the Broadbent's filter theory (Broadbent, 1958) by manipulating the emotional load of the stimuli. The findings were consistent with the idea that the differential salience of the words can be based in different thresholds for those words to reach awareness. Treisman's theory (1960) proposes that the filter is not an «all or nothing» mechanism but instead serves to attenuate rather than to block information from unattended channel. In her theory there is a node for a particular word which possesses a threshold that must be exceeded for that word to reach «awareness». Considering the filter theory words with very low thresholds can be activated by the unattended channel. For example, words with high salience, such as «fire» or an individual's name, have thresholds for activation that are permanently lower than those for other words and can reach awareness even when presented to the unattended channel.

Mogg, Mathews and Weinman (1989) studied the effect of emotional load on information processing by studying participants performance in a Stroop task. The effect has been called emotional Stroop effect. Williams, MacLeod and Mathews (1996) reviewed several studies in which the Stroop task was useful as an experimental paradigm to investigate the information processing in different psychopathologies.

Arend and Botella (2002) explored the differential processing of anxious participants by studying the effect of the emotionality of the words in the attentional blink effect. The attentional blink effect was attenuated when the first target was an emotional word compared with conditions where it was a neutral word, indicating that emotional stimuli require less attention resources for being fully processed than neutral words. Using a probe detection task MacLeod, Mathews and Tata (1986) found that generalized anxiety patients presented lower reaction time to respond to a dot when it was presented in the same location of a previous threating stimulus in comparision with trials with neutral stimulus.

The results described above allow two main conclusions. The first is that the information processing is sensitive to the emotional load of the stimuli and that the manipulations of this variable is a usefull tool to test theoretical predictions derived for a variety of experimental paradigms. The second conclusion is that automaticity to process emotional information can be verified both when such information is the target and when the emotional information is the distractor. When the emotional words are the target, a facilitatory effect is observed. When the emotional stimuli are the distractor an interference is produced.

In the present study we have used the emotinal load of stimuli to test some predictions derived from a model developed to account for the formation of the illusory conjunctions in the time do-

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main. The main purpose of the study was not to explore the emotionality itself. Instead of this, we used the emotional load as a way for manipulating the speed procesing.

In the field of visual attention there is a growing interest in studying how the salience of a given stimulus can improve subject's performance to report a stimulus presented by means of the Rapid Serial Visual Presentation procedure (RSVP). In this technique stimuli are presented successivelly in the same spatial location in a rapid rate (10 items/s). One of the errors that occur when this procedure is used is called illusory conjunctions in the time domain (Botella, Barriopedro & Suero, 2001). Such errors are characterized as failures to bind stimulus features. In the present research we used the same strategy used in other studies in which the emotionality of the words was used as the way to investigate the role of stimulus salience on our information processing system. More specifically our main interest was on studying if the emotional salience of stimuli change the pattern of illusory conjunctions. The predictions regarding the role of emotional salience and the pattern of illusory conjunctions follow the model formulated by Botella, Barriopedro and Suero (2001) to explain such errors.

Botella et al.s two-stage parallel model

The model accounts for the errors that are produced when subjects are asked to report one feature of the only stimulus from a RSVP stream that is characterized by a specific feature that belongs to another dimension. In this task stimuli have at least two relevant dimensions (relevant in the sense that they have a defined role in the task): the one that characterizes a stimulus as the target (key dimension, K) and the one that must be reported (response dimension, R). For example, reporting the identity of the only uppercase word, the color of the only letter «B» in a stream of letters, the identity of the only letter in red, etc. Among a majority of hits, subjects commit some errors that consist in that, instead of reporting the feature of the response dimension of the target, they report the feature from an item presented in positions that surround the target (between 2 before and 2 after it).

The model implies four mechanisms: two early processing modules for the dimensions involved in the task (module K and R), the mechanism of focal attention, and a sophisticated guessing mechanism. Two indexes are employed to assess subejcts' performance. The first is the hit rate, that indicates the general performance. The second one is the average position of intrusions (API). This index was defined by Botella et al. (2001) and consists in averaging the ordinal position of the features of the response dimension that have been miscombined with the key feature. Since this index is used to assess the pattern of errors, the hits are not considered on it. Sometimes the intrusions come mostly from positions before the target, other times they come from positions after the target, and sometimes they are balanced. When there is a higher number of pre-target intrusions, negative values are observed; when there is a higher proportion of post-target intrusions, a positive value is observed; when they are equilibrated, an API value around zero is observed.

According to the model, subjects' performance can be described in the following way. As each stimulus is presented, a process begins on each module K and R (pre-attentional) to extract the key and the response features of the stimuli in parallel. When the module K emits a positive output, an attempt to apply focal attention on it is triggered. This focusing mechanism is responsible for generating a unique percept of the target. However, when the focusing mechanism fails (given that time is needed to bind stimulus features and that stimuli are presented at a very rapid rate) a second attempt is produced by means of a sophisticated guessing mechanism. The responses that are solved by the sophisticated guessing mechanism are based on the level of activation of each stimulus features at the time the key feature is detected. Therefore, this second mechanism is reponsable for the intrusions and also for some hits that can be called «fortunate conjunctions».

Botella et al. (2001) have demonstrated empirically that some predictions can be made considering the mechanisms within the model. For doing so, the authors analized the consequences that could have experimental manipulations of isolated elements of the model (see the justification for such predictions in Botella et al., 2001). For example: (a) if the processing time of module R is reduced, the hit rate should not change, whereas the API should be later, (b) if the processing time in the module K is reduced, the hit rate should increase, whereas the API should be earlier, (c) if the mean time needed for focusing attention is reduced, the hit rate should increase whereas the API should not change.

Given that the authors have demonstrated that these predictions are verified with a variety of experimental manipulations, now we can pose things in the opposite way. Assuming that the model represents a correct description of what happens when participants face the task, observing the changes produced on the hits rate and in the API when an experimental manipulation is done, it can be inferred the element of the model that such experimental manipulation is influencing. Specifically, the difference between the words considered as emotional and the words considered as neutral has been characterized by an increased automaticity to process the former, that facilitates the cognitive processes associated with them. As a consequence, the use of emotional and neutral stimuli could be considered as a manipulation of the processing time on the mechanism described in the model (module K, module R and the focusing mechanism) depending on whether this manipulation is done in the key dimension, in the response dimension, or in a no-relevant dimension for the task.

The present study

Botella et al.s model states that when the sophisticated guessing mechanism is accessed for making a reponse, the system takes one of the active representations at the moment the key feature is detected, and that the probability that any one of them is selected is proportional to its activation level in that moment. This produces a distribution of probabilities that the key feature will be combined with the response feature of the different elements presented in positions close to the target. The model allows specific predictions regarding the processing time of the response dimension. The first is that a «more post» pattern of intrusion should be found when the time of processing the response dimension is reduced and a «more pre» pattern of intrusion should be found when the time of processing the response dimensions is increased. In the present experiments we used the paradigm employed by Botella et al. (2001) to investigate illusory conjuntions using words as stimuli. In a first experiment the response dimension was the word identity, therefore the identity was a relevant feature for the task.

The word could be negative or neutral in content («*identify which word appeared in this color_____*»). In a second experiment the identity of the word was neither the response feature nor the key feature («*identify the color of the only uppercase word of the stream*»). Again the target could be a neutral or an emotional word, but now the identity was not relevant for the task. The third experiment was designed to test for response biases on the hit rate. We will explain our predictions on each experiment.

Experiment 1

Method

Participants

Twenty nine undergraduate students from the Universidad Autónoma de Madrid participated as volunteers in the experiment. All of them had normal or corrected-to-normal vision and were Spanish native speakers.

Apparatus

Stimuli were presented by means of an Inves monitor controlled by an Inves PC-compatible computer. The experimental programming was made using the MEL program (Schneider, 1988).

Stimuli and materials

180 series of 13 words of 4-7 letters were constructed, all written in lowercase, each of which contained the name of a neutral or a emotional word, occupying, equiprobably, positions 6 to 8. All of them were Spanish words. We will call the «critical set» the five items composed by the target stimulus plus the two items prior to it and subsequent to it. Thus, the critical set could occupy positions 4-8, 5-9 or 6-10. We selected 50 emotional and 50 neutral words pair matched according to their frequency of use and length (Alameda & Cuetos, 1995). The rest of the words were included in each serie without repetitions in random order, but a same filler word could be repeated in different series. The words were presented in five different colors (red, green, white, yellow and blue), and the background of the screen remained grey throughout the experiment. For the rest of the series the four colors not used for the target in that particular series were employed, randomly, with the only restriction that there were never two consecutive stimuli with the same color. The words subtended 0.64º in height, while their width depended on the number of letters in each word. Each letter subtended 0.29º in terms of width. There were two kinds of series, depending on the emotinality of the target word: series with a neutral word or series with an emotional word (an example of a neutral trial is given in figure 1). Positions 6 to 8 were selected for the target in order to maintain the critical set away from the ends by at least 3 items before and after. In that way the data are kept uncontaminated from the well-known trend for participants to report the first and last items from the series (Lawrence, 1971). The response menu was contructed with the five words from the critical set (presented in random order), plus the alternative «don't know». Although the participants could be able to use the serial position as a cue to select the response item, this could not explain any eventual difference between the experimental conditions.

Procedure

Participants sat with their eyes at about 40 cm from the screen. At the beginning of each trial a horizontal string of 6 X letters appeared on the center of the screen, in the position where the words would appear. Participants began each trial by pressing the space bar. After 500 ms the first word of the series appeared, remained for 150 ms, was immediately replaced by the following one and so on until the end of the trial. On completion of the presentation a response menu appeared, containing the words that formed the critical set, but presented in a random order plus the option «don't know.» Participants were required to report which word appeared in a color that was specified before beginning each trial («*Which word appeared in this color___?*»), by a string of six Xs. Participants were asked to choose their response by pressing the number of the corresponding alternative. Then, the display for the beginning of the following trial appeared. Before beginning the experimental block, by way of practice, a random sample of 40 of the experimental series, 20 of each condition, was administered.

Results

Three dependent variables were considered: the number of hits, the average position of the intrusions (API) and the don't know answers. As mentioned above, the average positions of intrusion (API) is an index to assess the type of intrusion pattern by means of averaging the –2, –1, + 1 and + 2 answers.

Table 1 (first row) shows the descriptive results for the type of word used (emotional or neutral) and for all dependent variables. Regarding the pattern of intrusions we can see that the API is more post for emotional in comparison to neutral words, the difference being statistically significant [t(28)= -10.161, p<.001]. Regarding the number of hits we found a higher proportion of hits when the word was an emotional one than when it was neutral. This result was also statistically significant [t(28)= -17.58, p<.001]. Finally, participants gave a higher proportion of don't know answers when the word was emotional than when it was neutral [t (28) = 5.169, p<.001].

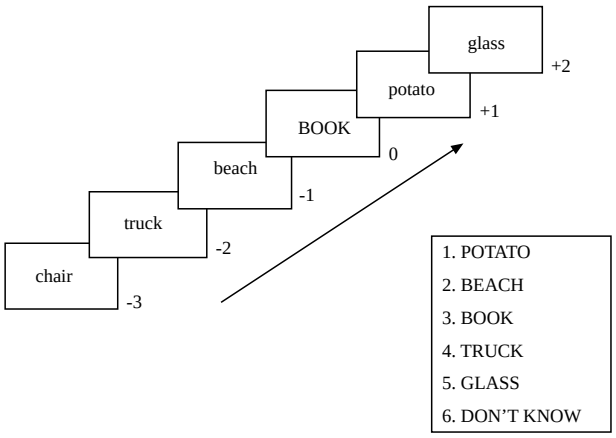

Figure 1. *Example of a Rapid Serial Visual Presentation stream and the respective menu. In this case the target could be a neutral or an emotional word*

Table 1
Proportion of Hits, Average Position of Intrusions (API) and the Don't know answers for the three experiments

	Hits		API		Don't'know	
	E	N	E	N	E	N
Experiment1 (N= 29)	.79	.54	.38	-.29	0.38	.08
Experiment 2 (N= 24)	.90	.77	.-14	.38	.02	.12
Experiment 3 (N= 9)	.67	.47	.29	-.04	.05	.15

Discussion

In this experiment the identity of the words plays the role of the response dimension, and therefore, they should receive an important highlight in its processing. Considering the results from other experimental paradigms in which the emotionality of the word was manipulated, it is reasonable to predict that the number of trials solved by means of a successful focalization of attention would be higher when the target word is an emotional *versus* when it is a neutral word. Thus, we predicted a higher number of hits for the E condition considering that according to the model the probability to complete the focalization process is increased by the emotionality (automaticity) of the target word.

Regarding the API the model does not allow a specific prediction. If all the words in the list were emotional in content, we would expect a reduced processing time for the response dimension, resulting in a «more post» pattern of intrusions for the E condition with respect to the N condition. However, in the present experiment the only word that could be emotional in content was the target word. Considering the model we do not have a prediction for the API when the processing time of a single stimulus (the target) is manipulated. We can propose a possible explanation for the effect found on the API, despite a *post hoc* one. The emotional load of the target words could have produced an acceleration to process the word identity when the target word appeared. That is, in 3 of the 5 items of the critical set (0, +1, +2).

Regarding the don't know answers we found that the emotionality of the words did not reduce its ocurrence. The model does not predict a specific pattern for don't know answers, but they can be informative about the way participants face the task. We could discuss that the high hit rate is due to the reduction of the don't know answers, while in both conditions (E and N) the number of trials that are solved by the guessing route are the same. This idea seems not right considering that the reduction of don't know answers is smaller than the reduction of the number of hits.

These results taken together suggest that: 1) the emotional load of the target serves to facilitate the focal attention on it, leading to a higher hit rate for emotional words than for the neutral ones, 2) the emotional load of the stimuli affected the pattern of illusory conjuntions even when the speed in processing the key feature is not manipulated, 3) as observed with other experimental paradimgs we also found a faciliatory processing of the emotional information when it plays the role of target.

Experiment 2

In order to study the illusory conjunctions pattern when emotional stimuli are involved we designed the Experiment 2, in which the identity of the word was neither the response feature nor the key feature. In the following experiment participants were required to «*identify the color of the only uppercase word of the stream*». The target could be either an emotional or a neutral word. Considering that the focusing mechanism is not restricted to the dimensions relevant for the task, but instead it includes the creation of integrated percepts as an episodic representation for all stimuli dimensions, we expected to find a higher number of hits for the E condition (Botella & Ericksen, 1992). Considering the API, if our *post hoc* explanation for the results in Experiment 1 is right, in the present experiment we should find the opposite. The intrusion pattern should be «more pre» for the emotional targets condition. The reason for this is that the emotionality captures procesing resources from other stimulus dimenions. Thus, as processing resources are withdrawn from the response dimension, the time for processing it increases. The increasing of processing time in the response dimension produces «more pre» patterns of intrusions (Botella et al., 2001).

Method

Participants

Twenty four undergraduate students from the Universidad Autónoma de Madrid participated as volunteers in the experiment. All of them had normal or corrected-to-normal vision and were Spanish native speakers. None of them had participated in the previous experiment.

Apparatus

Stimuli were presented by means of an Inves monitor controlled by an Inves PC-compatible computer. The experimental programming was made using the MEL program (Schneider, 1988).

Stimuli and materials

They were the same used in Experiment 1 with a few changes. The words were written in lowercase and the target word (that could be emotional or neutral) was written in uppercase. As the response dimension was the color, the response menu contained the five possible colors used in the experiment (red, green, white, yellow and blue), plus the alternative «don't know».

Procedure

The procedure was the same used in experiment 1, the only difference was that participants were asked to «*detect the color of the only uppercase word presented in the list*».

Results

The dependent variables were the same as in the first experiment. As reflected in the second row of table 1, we found a significant difference between the API for neutral and for emotional words [t (23)= 4.103, p<.001], with a more pre pattern for the emotional ones. Regarding the number of hits, we found the same pattern then in Experiment 1. There was a higher proportion of hits for emotional than for neutral words. This result was also statistically significant [t (23)= -11.786, p<.001]. Regarding the «don't know» answers, we found significantly more don't know answers for neutral than for emotional hits [t (23)= 5212, p<.001].

Discussion

As we predicted, the use of emotional stimuli increased the number of hits even thought the identity of the word was not relevant to the task. This result indicate that the mechanismn proposed within the model that act in parallel in order to extract stimuli features are sensitive to stimuli characteristics that were not stablished as relevant for the task. As well as in the first experiment this result can not be due to a reduction of the don't know answers. The number of don't know aswers were not proportionaly reduced to consider the increment of the hits as a result of it.

Regarding the intrusion pattern, we found a «more pre» pattern of intrusions for the E condition than for the N condition. Considering the processes described within the model, a «more pre» target intrusion is expected when the time of processing in module K is reduced. In this case the key feature was the dimension «uppercase». When the target was an emotional word the key feature was accelerated by its content. The model states that when the processing of the key feature is accelerated the stimuli that receive more activation are those presented before the target. Therefore, when the focusing mechanism fails, responses are based on stimulus representation that is more activated. In this case such stimuli are those presented before the target.

We also have to mention the possibility of response biases in the present paradigm associated to offline processes, when the response menu is presented. We can think in terms of an increased tendency to choose from the menu the word that is emotional in content basically by two reasons: first, because its semantic category is different from the others in the menu, making more likely to be chosen as a second candidate; second, because of its salience which can make participants to direct more attention to it. We designed the last experiment to check this out.

Experiment 3

Experiment 3 was designed to test the possible effect of response biases in our experimental paradigm. In experiment 1 there was always an emotional word in the menu in the E condition, but not in the N condition. Here we have included an emotional word in the response menu of the neutral trials as well. If there is a response bias favoring the emotional words we should find that participants would opt for the emotional words even when they were not presented in the series.

Method

Participants

Nine undergraduate students, from the same University, that did not participated in the previous experiments took part in the present one. All of them had normal or corrected-to-normal vision and had Spanish as their first lenguage.

Apparatus

The same than the other experiments.

Stimuli and materials

The same than in experiment 1.

Procedure

The procedure was the same used in experiment 1. Participants were required to «*identify which word appeared in this color____*». The only change regarded the structure of the response menu. We included in the menu of the N condition an emotional word and in the menu of the E condition a neutral word. Therefore, the menu was constructed with the five words that pertained to the critical set (the same as in previous experiments), a no presented word that was, for neutral conditions an emotional word and for the emotional condition a neutral word, plus the option «Don't know». The six options were presented in random order, plus the option don't know, for preventing subjects to find the target by following its order of presentation in the series.

Results and discussion

The dependent variables were the same used in previous experiments, plus the sixth menu item. As reflected in the third row of table 1, we found a later API value for the emotional condition than for the neutral condition. The *t* test revealed that this difference is statistically signitificant [t (8)= -3,073, p= .015]. Regarding the number of hits, we found more for emotional than for neutral words. This result was also statistically significant [t (8)= -11,275, p<.001] . Regarding the don't know answers, participants gave more when neutral words were used than when emotional words were used [t (8)= 2,639, p = .03]. In short, the results replicate those of Experiment 1. In order to verify if the difference in the hits rate between emotional and neutral words was due to a response bias we compared the sixth alternative (the word that was not present in the series) between emotional and neutral condition. The frecuency of times participants chose the item not presented in the series was about the same when it was an emotional word than when it was an neutral word [t (8), 1,537, p= .163], the difference was not statistically significant. Thus, results show that the percentage of times participants choose the item not presented in the series in the two conditions can not explain the difference between hits for emotional and neutral words. Two conclusions arise: 1) results of the present experiment replicate those found in experiment 1, 2) the data indicate that the higher number of hits for the emotional condition can not be explained in terms of a response bias toward the emotional loaded words.

General discussion

The three experiments presented here were designed to test predictions derived from Botella et al.s model (2001) for the formation of illusory conjunctions in the time domain. More especifically we investigated if the salience of the stimuli (operationalized by its emotional load) would have any effect on the patterns of illusory conjunctions. Botella et al.s model allows specific predictions regarding the function of two parallel modules that are responsible for extracting the features relevant for the task and the two mechanisms responsible for the responses: a focusing mechanism (whose output, if generated, is a hit) and a sophisticated guessing mechanism (responsible for the intrusions and also for the fortunate conjunctions). Our main conclusion, based on the pattern of results found for the emotional condition is that the emotional load of the stimuli acts to facilitate the mechanism of focal attention in the target item. The focal attention that is required to bind features of sti-

muli presented in rapid rate is improved by the salience of the emotional stimuli. That is, the higher stimulus salience is, the faster and stronger the process responsable for binding its features is. This result is also consistent with results from other experimental paradigms mentioned in the introduction section.

This conclusion is based on the pattern of results found in three experiments. In the first one the response feature was the identity of the word that could be emotional or neutral. In this experiment we found a more «post target» pattern of intrusions for emotional than for neutral words. This result can be explained by Botella's et. al model if we consider that the emotional load captures subjects attention and therefore speeds the processing on the module R.

The results of experiment 1 were replicated in experiment 3. Besides of observing that the pattern found in the first experiment is consistent we found, as well, that the high hit rate for the emotional condition was not due to a response bias.

In summary, the results of the present study corroborate the idea that the emotional stimuli are processed in a different way and therefore such differential processing can be taken as a strategy to study the arquitecture of our attentional system. When applied to the Botella et al.s model (2001) to account for the illusory conjunctions in the time domain, it supplies convergent evidence that increases the credibility of its general architecture.

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