Psicothema 2007. Vol. 19, nº 3, pp. 375-380
www.psicothema.com

ISSN 0214 - 9915 CODEN PSOTEG

Recognition memory for pictorial stimuli: Biasing effects of stimulus emotionality

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The possibility that stimulus emotionality might influence recognition bias in a long-term memory task was studied with respect to both the valence and arousal dimensions of emotion. For this purpose, we used 108 International Affective Picture System pictures that were representative of all regions of this two-dimensional space. Signal detection theory analysis was applied using A' and B''_D as discrimination and bias measures, respectively. In general, the results showed that greater discrimination was accompanied by a response bias that was more conservative for pleasant and for unarousing pictures than for unpleasant and for arousing ones. These results provide new evidence in connection with the emotion-induced recognition bias in long-term memory performance.

Memoria de reconocimiento para estímulos pictóricos: sesgos inducidos por la emocionalidad del estímulo. En la presente investigación se estudió la posibilidad de que la emocionalidad del estímulo, tanto en la dimensión de valencia como en la de arousal, pudiera afectar al sesgo de reconocimiento en una tarea de memoria a largo plazo. Para ello se emplearon 108 imágenes del IAPS (*International Affective Picture System*) representativas de todas las regiones del espacio afectivo bidimensional. Los análisis basados en la teoría de detección de señales, utilizando A' y B''_D como medidas de discriminación y sesgo, respectivamente, mostraron una mayor discriminación y un sesgo de respuesta más conservador para las imágenes agradables y las desactivadoras en comparación con las desagradables y las activadoras. Estos resultados proporcionan nueva evidencia con respecto al sesgo de reconocimiento inducido por la emoción en el rendimiento de memoria a largo plazo.

There is empirical evidence that emotion can enhance long-term memory under certain conditions and impair or distort it under others (for review, see Bradley, 1994; Christianson, 1992). Free recall of words or images tends to be easier if they have negative or sometimes positive emotional content than if they are emotionally neutral (e.g., Bradley & Baddeley, 1990; Bradley, Greenwald, Petry, & Lang, 1992; Doerksen & Shimanura, 2001). Similarly, studies of autobiographical memories have often revealed a memory-enhancing effect of emotion, reporting that emotionally relevant personal experiences are easier to recall than experiences without emotional import (e.g., Conway, 1995; Thompson, Skowronski, Larsen, & Betz, 1996). In the case of recognition memory, however, experimental results have not been so consistent: some authors, such as Ochsner (2000), have reported better recognition of images with emotional content than of those without, while others, such as Maratos, Allen, & Rugg (2000), have observed the reverse. This issue has considerable practical implications: for example, it has been reported that eyewitnesses to emotive events tend to exhibit uncritical acceptance of assertions that are compatible with what they have seen but are in fact false (García-Bajos & Migueles, 1999; Migueles & García-Bajos, 1999).

Most research on recognition of emotive stimuli has focused on the accuracy or discrimination of recognition, but the influence of emotion on the individual's general tendency to deem that recognition has occurred (bias) is also of interest. There is evidence that emotion may increase the likelihood that a participant will indicate that he or she recognizes a stimulus as indicated by the fact that the percentages of true and false positives in word recognition are both being larger for words with emotive content than for those without. In particular, it has been reported that participants are considerably more likely to claim recognition of words inducing negative emotions than of emotionally neutral words (e.g., Maratos et al., 2000; Windmann & Kruger, 1998; Windmann & Kutas, 2001). One hypothesis put forward to explain this relative bias is that negative emotionality defines a coherent semantic category, whereas emotionally neutral words are not interrelated in this way (Maratos et al., 2000). Based on this hypothesis, false recognition of negative emotional words could be due to the same cognitive processes as give rise to false recognition of neutral words that are semantically related to words that have genuinely been seen before (Roediger & Gallo, 2004; Roediger & McDermott, 1995). By contrast, Windmann & Kutas (2001) have suggested that it is the emotional response to negatively emotive stimuli, rather than their semantic properties, that is responsible for recognition bias, at least in the case of negatively emotive words. They also claimed that this relaxation

Fecha recepción: 7-6-06 • Fecha aceptación: 16-1-07
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of the participant's internal criterion of recognition fulfils the potentially useful function of preventing stimuli inducing negative emotions from going unheeded.

To decide between the above two hypotheses, McNeely, Dywan, & Segalowitz (2004) recently carried out recognition experiments using three word groups: emotionally neutral words, negatively emotive words, and animal names. The latter group was regarded as emotionally neutral but more semantically homogeneous than the other two. Their results led them to conclude that it is the emotional response to negatively emotive words, rather than their possible semantic coherence, that is responsible for their greater probability of false recognition. The results of recent recognition experiments in which face pictures were used instead of words have also been interpreted as weighing against the semantic coherence theory (Johansson, Mecklinger, & Treese, 2004).

In the studies mentioned above, stimuli were distinguished on the basis of their emotional valence, that is, as to whether they aroused pleasant emotions, or unpleasant emotions, or were emotionally neutral. They were, however, not distinguished with regard to the intensity of the emotion induced, that is, the degree of arousal. Nevertheless, emotional arousal has been reported to affect familiarity-based (rapid-response) recognition independently of valence (Dougal, 2003), and experiments in which liberal recognition bias was induced by positively and negatively valent stimuli but not by neutral stimuli also suggest an effect of arousal rather than valence itself (Johansson, Mecklinger, & Treese, 2004).

To better understand the influence of emotion on memory, it seems necessary to make some minimal assumptions as to the basic organization or structure of emotion. In this sense, an approach widely accepted view emotion as a phenomenon that can be described by its coordinates in a two-dimensional space, the basic dimensions being identified as valence, which ranges from unpleasant (negative) to pleasant (positive), and arousal, which ranges from calm to excited (Bradley, 1994; Kensinger, 2004). Accordingly, both dimensions need to be considered in order to assess effects of emotion on memory in general, including autobiographical memory. Thus, for example, it was found that autobiographical memories are organized in terms of emotional valence, but not arousal (Schulkind & Woldorf, 2005).

We report here the results of a study of the influence of both the valence and arousal dimensions of emotionality on pictorial material recognition in a long-term memory task. To situate stimuli in two-dimensional affective space we used the International Affective Picture System (IAPS, CSEA-NIMH, 1999; Lang, Bradley, & Cuthbert, 1999), a standard set of colour pictures with contents eliciting a wide range of emotions. The validity and reliability of the IAPS have been thoroughly verified, and normative values have been obtained in a number of different countries, including Spain. We focused our attention primarily on bias effects, for sensitive evaluation of which we employed a signal detection theory (SDT) approach.

Method

Participants

Of the 220 first-year psychology students who took part in the study as a class requirement, 27 failed to comply with instructions regarding the correct interpretation of the valence and arousal dimensions in the evaluation phase. Thus the definitive sample comprised 193 individuals (56 men, 137 women).

Overall study design

The study comprised three phases: training, rating, and recognition. In the first, the participants were trained in rating IAPS pictures for valence and arousal. In the second, they were asked to rate IAPS pictures they had not seen previously. Two months later, in the third phase, they were shown a sequence of rating-phase pictures mixed with previously unseen IAPS pictures («new» pictures), and were asked to rate their confidence as to whether they had seen these pictures previously. A multi-point rating scale was used (rather than a yes/no question) so as to be able to construct a reasonably complete memory operating characteristic (MOC) for SDT analysis (Snodgrass, Levy-Berger, & Haydon, 1985). Training took place in a room adjoining the laboratory in which rating and recognition were performed. The same researcher was at hand in all three phases to resolve queries.

It was used a 2×2 within-subjects design, with Picture Exposure Status (*old, new*) as the first factor, and Arousal (*unarousing, arousing*) or Valence (*unpleasant, pleasant*) as the second factor.

Materials

On the basis of their normative valence and arousal ratings in the Spanish population (Molto et al., 1999), three sets of IAPS pictures were chosen: 6 for the training phase, 36 for the rating phase, and 72 new pictures for the recognition phase. Each set was representative of all areas of affective space. Care was taken that the pictures in each set would not resemble any pictures in the other two sets sufficiently closely. This was done to avoid high levels of false recognition. Similarly, whenever possible, the stimulus sets were matched for semantic content. Thus, if a picture of a gun was placed in a set, a picture of a different gun was placed in the other sets, in order to thus maintain equivalent levels of valence and arousal in each stimulus set. The same procedure has been followed therefore that in other studies that examined effects of emotion in recognition memory and that used IAPS pictures as stimulus material (e.g., Bradley et al., 1992; Ochsner, 2000). As Ochsner (2000) notes, matching for content «was also thought to be desirable to ensure that memory for photos would not be at ceiling, which was a concern given that recognition memory for pictures can be quite robust even after long delays» (p. 246).

For evaluation of IAPS pictures in terms of valence and arousal in the training and rating phases of the study, we used a paper-and-pencil version of the Self-Assessment Manikin scale (SAM; Lang, 1980). This scale allows IAPS pictures to be rated from 1 (low) to 9 (high) for both valence and arousal (for a detailed description of the SAM scale, see Lang, Greenwald, Bradley, & Hamm, 1993).

Procedure

Preliminary training phase. After the use of SAM had been individually explained to the participants, they practised by rating the 6 IAPS pictures chosen for this phase, after which any remaining queries they had on how to rate these pictures with SAM were answered by the researcher. This phase served not only to train participants formally in the use of SAM, but also for them to establish points of reference for subsequent picture evaluation in the rating phase.

Rating phase. Each subject was seated in a soundproof experimental booth facing a computer monitor screen. On the screen, participants could initially read that the experiment formed part of a study on the emotive content of images, and that during the session they would have to use SAM to rate a series of pictures for valence and arousal. At no point were participants informed that there would be a subsequent phase in which they would be asked to recognize pictures. The 36 rating phase IAPS pictures were presented individually on the screen in random order. In each case, display of the picture itself for 6 seconds was preceded by a five-second display of a text asking the subject to prepare to rate the next picture, and was followed by display of a text asking for the picture to be rated for valence and for arousal. The time allowed for rating each picture was 20 seconds.

Recognition phase. Two months after the rating phase, participants returned to the same booth as previously. The text initially shown on the monitor screen informed them that they would be presented with a series of pictures, some of which they had seen in the rating phase. For each picture they were asked to use the recognition rating form to rate the confidence with which they could assert having seen it before. The six-point rating scale used was: --- (certainly hadn't), -- (probably hadn't), - (more probably hadn't than had), + (more probably had than hadn't), ++ (probably had), +++ (certainly had). The 36 rating phase IAPS pictures («old» pictures) and 72 new recognition phase IAPS pictures were then presented in random order except that the presentation of more than two old pictures in a row was prevented. The 72 new recognition phase pictures had been chosen following termination of the rating phase. For each rating phase picture, two pictures were chosen that a) did not resemble any pictures used in the previous phases sufficiently closely for there to be an obvious risk of mistaken recognition, and b) had normative valence and arousal values that were no more than 1 unit from the corresponding average ratings awarded by participants to the rating phase picture.

Results

The valence and arousal ratings given to the IAPS pictures used in the rating phase exhibited distributions with the same typical boomerang shape as has been observed in other studies (e.g., Bradley, Cuthbert, & Lang, 1996).

Table 1 lists the aggregate recognition phase results for new and old pictures. Use of the trapezoid rule to approximate the area under the corresponding 5-point memory operating characteristic (MOC, Snodgrass, Levy-Berger, & Haydon, 1985) affords a value of 0.76. This value means that the subjects exhibited a recognition ability greater than the value 0.5 corresponding to random recognition decisions.

Table 1
Pooled picture recognition confidence data

Exposure status	---	--	-	+	++	+++
Frequency matrix						
OLD	546	756	618	1183	1714	2131
NEW	5276	3795	1997	1449	1015	364
Cumulated probability matrix						
OLD	1	.92	.81	.72	.55	.31
NEW	1	.62	.35	.20	.10	.03
Uncumulated probability matrix						
OLD	.08	.11	.09	.17	.24	.31
NEW	.38	.27	.15	.10	.07	.03
Mean recognition proportions (A')						
				.84	.83	.80

We performed ANOVAs on the reduced data set obtained when +, ++ and +++ ratings were all treated as a «Yes» response and -, -- and --- ratings were all treated as a «No» response. To determine whether true and/or false recognition claims were influenced by picture valence or arousal, the old and new picture groups were each split into subgroups separated by the median normative valence or arousal rating of that group (median valence was 5.37 for old pictures and 5.45 for new pictures, and median arousal 5.61 for old pictures and 5.69 for new pictures). For old pictures, the mean valences of the high and low arousal picture groups were 4.55 (*SD*= 1.47) and 4.16 (*SD*= 1.22), respectively, and the mean arousal values of the high and low valence groups were 6.56 (*SD*= 0.55) and 6.13 (*SD*= 1.14), respectively. For new pictures, the mean valences of the high and low arousal picture groups were 4.43 (*SD*= 2.23) and 4.27 (*SD*= 0.62), respectively, and the mean arousal values of the high and low valence groups were 6.71 (*SD*= 1.05) and 5.96 (*SD*= 1.75), respectively. The *t* tests showed that the two valence groups are matched for arousal [$t(17)= .78$, $p>.05$, for old pictures and $t(35)= .48$, $p>.05$, for new pictures] and the arousal groups matched for valence [$t(17) = 1.70$, $p>.05$, for old pictures and $t(35) = 1.99$, $p>.05$, for new pictures]. Table 2 lists the sample means and standard deviations of the proportions of true and false recognition claims made by each subject for each of these picture groups. These data were analysed by 2 × 2 repeated measures ANOVAs, with Picture Exposure Status (*old, new*) and Arousal (*unarousing, arousing*) as the within group factors and levels in one case, and Picture Exposure Status and Valence (*unpleasant, pleasant*) in the other.

The Picture Exposure Status versus Arousal ANOVA on the proportions of recognition claims detected a significant effect of Arousal, $F(1, 192)= 53.20$, $p<.01$, as well as the expected effect of Picture Exposure Status, $F(1, 192)= 1540.58$, $p<.01$. There was also an interaction between both variables, $F(1, 192)= 6.53$, $p<.01$), showing that the proportion of pictures eliciting recognition claims was significantly greater for arousing than for unarousing pictures both when these claims were true, $t(192)= 2.48$, $p<.01$, and, even more markedly, when they were false, $t(192)= 9.16$, $p<.01$. The Picture Exposure Status *versus* Valence ANOVA detected significant effects of both Picture Exposure Status, $F(1, 192)= 1540.58$, $p<.01$, and Valence, $F(1, 192)= 4.91$, $p<.05$, and again there was significant modulation of one effect by the other, $F(1, 192)= 10.51$, $p<.01$. The latter effect showed that unpleasant pictures elicited significantly more false recognition

Table 2
Proportions of «yes» (+, ++ or +++) responses in picture subgroups defined by Exposure status (old or new) and Valence or Arousal level. Data are means and standard deviations (in parentheses) of the proportions observed for each subject

Exposure status	Valence: Unpleasant	Valence: Pleasant	Arousal: Unarousing	Arousal: Arousing
OLD	.72 (.17)	.73 (.17)	.71 (.18)	.74 (.17)
NEW	.22 (.12)	.19 (.13)	.17 (.13)	.24 (.13)

claims than pleasant pictures, $t(192)= 5.65$, $p<.01$, but there was no such difference for true claims, $t(192)= .67$, $p>.05$.

The fact that for both old and new pictures the probability of a recognition claim was greater for arousing than unarousing pictures shows primarily that arousal introduced liberal bias into recognition judgements. However, the fact that the increase in the probability of false recognition associated with unpleasantness was not accompanied by a significant increase in the probability of true recognition suggests primarily that unpleasantness may have reduced discrimination between old and new pictures.

To assess the influence of both emotion dimensions (arousal and valence) on recognition memory performance a signal-detection approach was used.[1] More specifically, we analysed discrimination and response bias measures based on a non-parametric model (*A'* and B''_D, respectively; Donaldson, 1992; Snodgrass, Levy-Berger, & Haydon, 1985). Values of *A'* can vary between 0 and 1: higher values indicate greater discrimination and .5 indicates chance performance. Values of B''_D can vary between -1 and +1: negative values indicate liberal bias, positive values indicate conservative bias, and 0 indicates neutral bias.

Table 3 lists the pooled values of *A'* and B''_D at each confidence level of «yes» responses, for emotional valence and arousal. The values of *A'* reflect considerable discrimination between old and new pictures in both arousal and valence levels. With regard to the valence dimension, discrimination was significantly higher for pleasant pictures than for unpleasant ones, $t(192)= 2.32$, $p<.05$, while in terms of arousal, discrimination was greater for unarousing pictures than for arousing ones, $t(192)= 2.22$, $p<.05$. Looking next at response bias values, with regard to the valence dimension the unpleasantness introduced a significantly less conservative bias than the pleasantness in all confidence levels. On the other hand, with regard to arousal, when the participants indicated high confidence (+++) in recognition, no differences were found between arousing and unarousing pictures, $t(192)= 0{,}91$, $p>.05$. However, when the participants showed the lowest confidence (+) in their recognition judgements, a significantly lower bias was obtained for arousing pictures than for unarousing ones, $t(192)= 6{,}65$, $p<.01$. Similarly, when the participants used an intermediate criterion (++) between the two aforementioned ones, the bias for high-arousal pictures was lower than for the low-arousal ones, $t(192)= 5{,}00$, $p<.01$.

Discussion

When the old and new pictures were divided in high- and low-arousal subgroups, ANOVA suggested that, relative to unarousing pictures, arousing pictures were judged with a liberal recognition bias: for both old and new pictures, recognition claims were more probable for an arousing than for an unarousing picture. This finding was confirmed by the signal detection analysis (Table 3). However, this latter analysis furthermore shows that the relative liberal bias applied to arousing pictures was in fact due to unarousing pictures being judged with conservative absolute bias (as measured by B''_D), the absolute bias applied to arousing pictures being almost zero ($B''_D= .03$) when the participants showed the lowest confidence (+) in their recognition judgements.

It is true that a conservative bias was to be expected, due to there having been twice as many new pictures as old pictures in the recognition phase of the study. However we consider the fact that the low arousal pictures are associated with a relatively high bias to be a relevant result. It is noteworthy taking into account the lack of bias in arousing pictures when a gross decision («+» in confidence scale) between recognition and non- recognition was required.

When the old and new pictures were divided in pleasant and unpleasant subgroups, ANOVA suggested that among new pictures unpleasantness might increase the probability of recognition claims. But the fact that there was no parallel for this result among old pictures seemed to point to a reduction in discrimination between old and new pictures that are associated with unpleasantness. This result was confirmed by the corresponding signal detection analysis with the index *A'*. The signal detection analysis also revealed a conservative bias in all confidence levels, and this was always lower for unpleasant pictures.

It should be mentioned that there is little empirical evidence related to signal detection analysis regarding recognition memory for emotional stimuli. Bearing this in mind, when words are used as emotional stimuli, the recognition accuracy results are inconclusive (see Johansson et al., 2004). The same is true when pictures are used as emotional stimuli. Thus neither Bradley et al. (1992) nor Johansson et al. (2004) found any significant differences regarding discrimination between pleasant and unpleasant pictures. However, Ochsner (2000) found greater accuracy for unpleasant pictures than for pleasant ones. Finally, the results from our study contradict those of Ochsner, as they show greater discrimination for pleasant pictures that for unpleasant ones. There is a similar disparity in the results concerning arousal. Thus, Bradley et al. (1992) found better recognition memory performance for arousing pictures as opposed to unarousing ones, while Ochsner (2000) found greater accuracy for medium-arousal pictures as opposed to high- or low-arousal ones. However, our results show greater accuracy for unarousing pictures than for arousing ones. Cross (1999) obtained similar results, though words were employed as stimuli.

Regarding the bias, although they used words as emotional stimuli, Windman & Kutas (2001) obtained a more liberal bias for negative words than for neutral ones. Using IAPS pictures as stimuli, Ochsner (2000, Experiment 1) found a more liberal bias for negative pictures than for positive ones. This last result is similar to that obtained in the present study, in which a more liberal bias was obtained for unpleasant pictures than for pleasant ones in all confidence levels. As regards the arousal dimension, in the three experiments reported by Oshner (2000), a more liberal bias was found for the high-arousing pictures that for low-arousing ones. This finding is also consistent with that obtained in our research, in which the bias for arousing pictures was more liberal than for unarousing pictures, at least in the lowest confidence levels. Consequently, our bias data, unlike the accuracy data, are in line with the scant empirical evidence that is available.

Table 3
Mean B''_D values at each confidence level of «yes» responses and pooled values (+, ++, +++) for *A'* in valence and arousal dimensions

		B''_D +	B''_D ++	B''_D +++	*A'*
Valence	**Pleasant**	.18 (.53)	.74 (.31)	.97 (.08)	.85 (.09)
	Unpleasant	.10 (.50)	.65 (.34)	.95 (.12)	.83 (.09)
Arousal	**Arousing**	.03 (.51)	.65 (.33)	.96 (.08)	.83 (.09)
	Unarousing	.26 (.54)	.74 (.33)	.96 (.11)	.85 (.09)

Standard deviation are given in the parenthesis

In general, our data show that greater discrimination is accompanied by a more conservative response bias for pleasant and for unarousing pictures than for unpleasant and for arousing ones. Thus, these results preclude the conclusion that «memory for the occurrence of an emotional stimulus associated with high arousal is better than for a stimulus rated low in arousal, regardless of its pleasantness» (Bradley et al., 1992, p. 388). Moreover, these results suggest that the response bias may be influenced by emotional arousal, and not only by emotional valence, resulting in new evidence in connection with the emotion-induced recognition bias. More precisely, the contribution of the two-dimesional approach of emotion lies in signalling the importance of the arousal dimension as well as that of valence. Even the results of Johansson et al (2004), using faces as emotional stimuli and taking into account both dimensions, suggest «that a flexible criterion setting may occur as a function of emotional arousal rather than of negative valence» (p. 1848). Lastly, given that in the present study pictures (and not words) have been employed as stimuli, the semantic coherence hypothesis may not hold. This same conclusion was reached by Johansson et al. (2004), who did not use verbal stimuli in their research, and hence their results are also difficult to explain in terms of semantic coherence.

In future research it would be of interest, firstly, to continue using the two-dimensional approach for the study of the emotion-induced recognition bias. Secondly, it would be convenient to use, wherever possible, standardized scaled emotional stimuli, such as those appearing in IAPS or in the ANEW (Affective Norms for English Words; Bradley & Lang, 1999). This would facilitate the handling of the location of the stimuli in the affective space, as well as the replication of the results. A study taking the aforementioned points into consideration could shed more light on whether the mechanism underlying the emotion-induced recognition bias is due to semantic coherence or to emotionality *per se*.

[1] For recent evidence on the viability of different models of recognition memory, see, e.g., Malmberg, 2002; Pelegrina & Tejeiro, 2006; Slotnick & Dodson, 2005; Yonelinas, 1999.

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