

2008

The dimensionality of emotion and individual differences

Leah Braganza
Edith Cowan University

Follow this and additional works at: https://ro.ecu.edu.au/theses_hons



Part of the [Cognitive Psychology Commons](#)

Recommended Citation

Braganza, L. (2008). *The dimensionality of emotion and individual differences*. https://ro.ecu.edu.au/theses_hons/1090

This Thesis is posted at Research Online.
https://ro.ecu.edu.au/theses_hons/1090

Edith Cowan University

Copyright Warning

You may print or download ONE copy of this document for the purpose of your own research or study.

The University does not authorize you to copy, communicate or otherwise make available electronically to any other person any copyright material contained on this site.

You are reminded of the following:

- Copyright owners are entitled to take legal action against persons who infringe their copyright.
- A reproduction of material that is protected by copyright may be a copyright infringement. Where the reproduction of such material is done without attribution of authorship, with false attribution of authorship or the authorship is treated in a derogatory manner, this may be a breach of the author's moral rights contained in Part IX of the Copyright Act 1968 (Cth).
- Courts have the power to impose a wide range of civil and criminal sanctions for infringement of copyright, infringement of moral rights and other offences under the Copyright Act 1968 (Cth). Higher penalties may apply, and higher damages may be awarded, for offences and infringements involving the conversion of material into digital or electronic form.

EDITH COWAN UNIVERSITY
LIBRARY

The Dimensionality of Emotion and Individual
Differences

Leah Braganza

2008

Bachelor of Arts
(Psychology) Honours

USE OF THESIS

The Use of Thesis statement is not included in this version of the thesis.

COPYRIGHT AND ACCESS DECLARATION

I certify that this thesis does not, to the best of my knowledge and belief:

- (i) incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher education;
- (ii) contain any material previously published or written by another person except where due reference is made in the text; or
- (iii) contain any defamatory material.

Signed

Date..... 4-08-08

The Dimensionality of Emotion and Individual Differences

Leah Braganza

A Report Submitted in Partial Fulfilment of the Requirements for the Award of Bachelor of Arts (Psychology) Honours, Faculty of Computing, Health and Science, Edith Cowan University.

Submitted May 2008

I declare that this written assignment is my own work and does not include:
Material from published sources used without proper acknowledgment, or
Material copied from the work of other students

Signature

Dated: 4-08-08

Acknowledgments

I would like to thank my supervisor Ken Robinson, for all his wisdom, patience and guidance.

I would also like to thank my mother for all the countless editing and unwavering support she has provided throughout my university career.

Thank you to all of the participants who gave up their time to take part in my study. My special thanks to Oliver Santiago for his kindness and understanding, and for always being there for me. Thank you to Maya Calic, Dana Gornik, and Lauren McGillivray for all their friendship and support.

Table of Contents

Title Page.....	i
Declaration	ii
Acknowledgements	iii
Table of Contents	iv

Manuscript one: Literature Review

Title Page.....	1
Abstract	2
Introduction	3
Emotion and the Information Processing Tradition	7
The Valence Versus Arousal Hypotheses	8
Categorical Negativity Hypothesis.....	10
Evolutionary Threat Hypothesis.....	12
Arousal Hypothesis	14
Dual Levels of Analysis	16
Reaction Time as Measure of the Effect of Emotion on Performance	16
Physiology as Measure of the Effect of Emotion on Performance.....	22
Applying an Individual Differences Framework to the Study of Valence and Arousal	25
Recommendations and Conclusions.....	27
References	30
Guidelines for Contributions by Authors	36

Manuscript Two: Research Report

Title Page.....	38
Abstract	39
Introduction	40
Method	48
Design.....	48

Participants	48
Materials	48
Procedure	52
Analysis	53
Results	54
General Overview	54
Phase I: Analysis Using the IAPS Ratings of Valence and Arousal.....	55
Phase II: Analysis Using the Individual Based Ratings of Valence and Arousal.....	57
Phase III: Patterns of Individual Difference	59
Phase IV: Means Based Analysis.....	61
Summary of Results	62
Discussion	62
Theoretical Implications from the Nomothetic Analysis (Phase I Results).....	63
Theoretical Implications from the Individual Differences Analysis (Phase II and III Results).....	68
Limitations and Recommendations for Further Research.....	69
Conclusion	74
References	75
Appendix A: Instructions to Participants	79
Guidelines for Contributions by Authors	81

The Dimensionality of Emotion and Individual Differences

Leah Braganza

The Dimensionality of Emotion and Individual Differences

Abstract

This paper is a critical review of the research on the relative contribution of valence and arousal to the effect of emotion on performance. It is well accepted that emotion influences aspects of cognitive performance, but there are inconsistent results concerning the relative salience of valence and arousal. Some authors support the idea that valence, rather than arousal, is the primary contributor to this effect of emotion on performance. This review analysed the methodology used in studies supporting the primary role of valence, and this analysis revealed that the two dimensions may have been confounded. The literature suggested that arousal appears to be salient when the two dimensions are controlled. Furthermore, when an individual differences perspective was also integrated, this showed that both arousal and valence have particular relevance as they are differentially perceived by each individual. It was concluded that there is value in exploring an individual difference perspective, and that this may also account for the mixed results in the literature.

Author: Leah Braganza

Supervisor: Dr. Ken Robinson

Submitted: March 2008

The Dimensionality of Emotion and Individual Differences

The advances in emotion research are increasingly coming from affective neuroscience and research using brain scans, other physiological measures (e.g. galvanic skin response) and behavioural tests (Bradley & Lang, 2007a). However, much of this research exists in the separate literatures of psychology, physiology and neurology, with few connections being made across levels of understanding on an experimental level (Davidson, 2003).

The term emotion describes a process of changes in an individual's physiological and mental state in response to internal or external stimuli relevant to their current concerns (Bradley & Lang, 2007a; Frijda, 1988; Russell, 2003; Scherer, 2005). An individual's emotional state can influence how their environment is perceived and responded to. The dimensional dynamics behind this influence is one area of debate in the psychological literature.

The structure of emotion can be separated into the two dimensions of valence and arousal (Lang, Bradley, & Cuthbert, 2005; Mehrabian & Russell, 1974; Osgood, Suci, & Tannenbaum, 1971; Power & Dalglish, 2008). Valence ranges from the extremely pleasant to extremely unpleasant, and arousal varies between extreme excitement and a state of calm (Mehrabian & Russel, 1974; Power & Dalglish, 2008). Lang, Bradley, and colleagues (2005, 2007a, 2007b) have conducted extensive investigation of the dimensional view of emotion. Conceptually separating emotion into valence and arousal has allowed these researchers to operationalise emotion and therefore study its processes and the structures involved.

The literature is divided on the relative contributions of these dimensions to the influence of emotion on performance. The term 'influence of emotion on performance' is used widely in this area as many of the tasks investigating the valence and arousal properties

of stimuli use dual or interference task paradigms. Emotional stimuli are presented at some point throughout a cognitive or motor task, and the interruption or delay in task performance is attributed to the presence of the emotion stimuli.

The question of the relative salience of these two dimensions is not a matter of whether valence *or* arousal is more important than the other. For a stimulus to be perceived as emotional it would have to be both positive or negative, and at least mildly arousing (Bradley & Lang, 2007a). In this way when a research study has concluded (e.g., Schimmack, 2005) that the arousal properties of the stimuli and not valence were responsible for interference in a cognitive task, this is meant to demonstrate the initial power that arousing stimuli have on perception and processing and not indicate valence is not important. It may also suggest that these two properties of emotion may be subject to a time course in which the arousing stimuli receive preferential processing (Anderson, 2005; Ohman, Flykt, & Esteves, 2001).

Lang, Bradley, and Cuthbert (2005) compiled what is now known as the International Affective Picture System (IAPS), a database of over 900 pictures each with standardised ratings of valence and arousal. An example of a stimulus rated as low arousal positive would be a bunch of flowers and a low arousal negative image would be represented by a cemetery. Common high arousal positive images are opposite sex models and high arousal negative images are scenes of threat, violence and blood injury (Lang, Bradley, & Cuthbert, 2005).

Figure 1¹ below illustrates the pattern of ratings from the IAPS research. As evident, there are more ratings in the low arousal positive and high arousal negative quadrants

¹ From "Emotion and Motivation" (p. 585), by M.M. Bradley and P.J. Lang, 2007. In J.T. Cacioppo, L.G. Tassinary, & G.G. Berntson (Eds.), *Handbook of psychophysiology* (3rd ed., pp. 581-607). New York: Cambridge University Press.

compared to the high arousal positive and low arousal negative quadrants. This relationship demonstrates the interaction between the two dimensions.

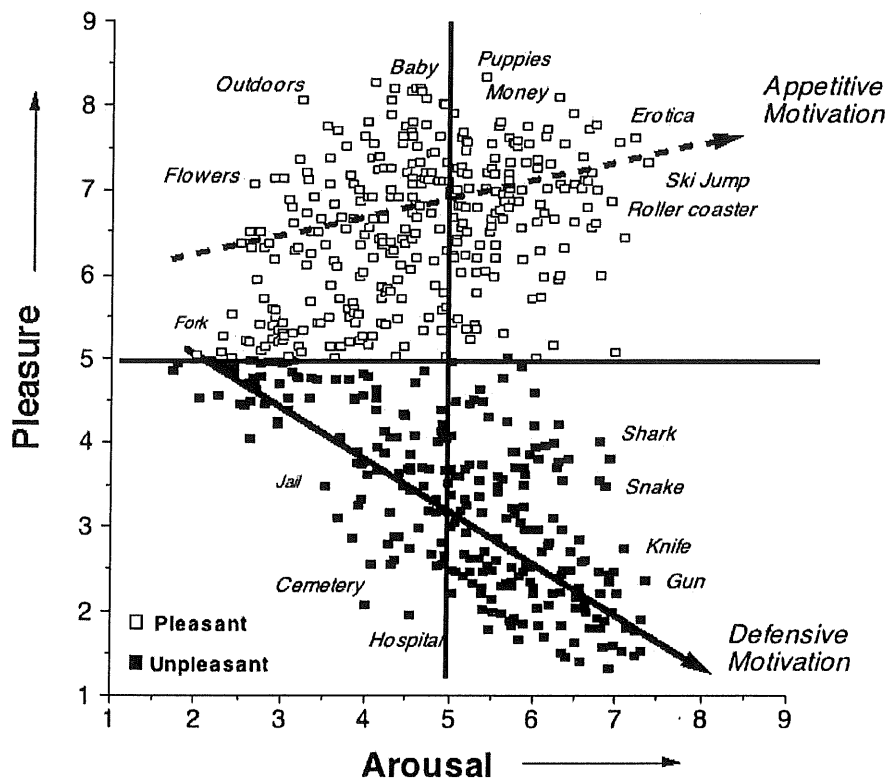


Figure 1. Ratings of valence and arousal for the pictures in the IAPS database. It is interesting to note that more pictures were judged as low arousal positive and high arousal negative compared to the other two quadrants. There is a strong trend indicating that as a stimulus becomes more negative it is rated as increasingly arousing. This same trend is evident but much weaker for the positive stimuli.

Figure 1 also demonstrates that two processes underlie the results: an approach towards positively valenced stimuli, and an avoidance of negatively valenced stimuli. The figure shows that arousal is predictive of negatively valenced stimuli. For positively valenced stimuli, however, it appears that both arousal and valence operate somewhat independently.

Note that Figure 1 does not include individual differences data, which are likely to produce better understanding of these complex relationships. This is because each individual will perceive the same stimulus in a different way based on their learning history and

personality (Kosslyn et al., 2002), with these differences introducing variability into any experimental or correlational design. When it comes to the topic of emotions, these differences in perception can be particularly accentuated. From the perspective advocated by Kosslyn et al. (2002), of enhancing knowledge gained from a group based research design with data from individual differences, the current paper also aims to establish a rationale for the inclusion of an individual differences perspective in group research on valence and arousal. It is argued in this review that using an individual differences approach may help to clarify the dimensional aspects of emotion.

As stated earlier, the literature is divided on whether valence or arousal has a more immediate effect on performance. This effect has mainly been investigated within cognitive paradigms, and therefore has been measured in terms of both a cognitive decrement and cognitive facilitation in performance observed in conditions that involve emotional stimuli (Mathews & MacLeod, 1994). Both arousal and valence have been documented as the primary contributors to the effect. For instance, Pratto and John (1991) and Fox, Russo, Bowles, and Dutton (2001) provide support for valence, while Schimmack (2005) and Buodo, Sarlo, and Palomba (2002) provide evidence supporting arousal as the primary contributor to the effect of emotion on performance.

The inconsistency in the literature may be explained when the methodological procedures of the studies are considered. Many experiments have not controlled the values of both the valence and arousal in their emotional stimuli (Schimmack, 2005). This stimulus control problem has led to inconsistent results and therefore differing conclusions on the relative salience of these dimensions (Schimmack, 2005). This review will critically analyse the studies testing the dimensional aspects of emotion with particular attention to how valence and arousal have been measured.

Emotion and the Information Processing Tradition

The measurement of emotional effects on cognitive performance is a typical approach in the area (Eder, Hommel, & De Houwer, 2007). Experiments normally involve different types of stimuli varied on emotional ratings (e.g., positive, negative, neutral pictures, or words), and these stimuli will be presented at different times during the completion of a cognitive task such as a math problem. If reaction time to the cognitive task were delayed on those trials that included an emotional as compared to a neutral stimulus, an effect of emotion on performance is said to have been demonstrated (Mathews & MacLeod, 1994). This is an example of using cognitive decrement as an index of the effect of emotion on performance (Mathews & McLeod, 1994). However, a stimulus can also be perceived outside of attention because of its affective properties and in this way represents a cognitive facilitation effect (Anderson, 2005).

There are other notable examples of the measurement of emotional effects on attention and memory. Emotional stimuli have been shown to both capture attention (e.g., Ohman & Flykt et al., 2001) and impact the time it takes to disengage attention (e.g., Fox, Russo, & Dutton, 2002). Also, emotional stimuli may improve memory consolidation and recall (e.g., Anderson, Wais, & Gabrieli, 2006; MacKay et al., 2004) and degrade it (e.g., Richards & Gross, 1999).

There is one limitation in studying emotion by using improvements or decrements in cognitive performance, and critique in this area has a long history (e.g. Navon, 1984). Navon critiqued limited resources approaches in cognition on the basis that they are superfluous to a theoretical understanding. Similarly, it is argued in this review that studying emotion through improvements or decrements in cognitive performance may be indirect, and potentially misleading, given the underlying physiology which demonstrates that 'hot' emotional

processes precede and often dominate the 'cool' cognitive processes (LeDoux, 1994; Schafe & LeDoux, 2004; Zajonc, 1980). Indeed, although emotion and cognition are integrated processes (e.g., Phelps, 2004), there is evidence that a preferential processing route exists for emotional over cognitive information (LeDoux, 1994; LeDoux, 2000; Zajonc, 1980). This evidence indicates that the human brain can perceive and processes emotional information more rapidly than non-emotional information (Anderson, 2005; LeDoux, 1994). Hence, if research is restricted to the measurement of enhanced cognitive performance or interference in cognitive performance, this may involve later stages of emotional processing that is integrated with cognitive processing (Schachter & Singer, 1962). For this reason, this paper reviews studies using interference tasks, but extends the scope to tasks such as the attentional blink which may be able to measure this preferential processing route (Anderson, 2005), and also evidence from physiological research. These data are then integrated to provide a balanced evidentiary base for assessing the relative salience of valence and arousal in the effect of emotion on performance.

The Valence Versus Arousal Hypothesis

Despite the successful adaptation of cognitive tasks to study emotion, results are inconsistent with respect to the relative contribution of valence and arousal (Shimmack, 2005). One plausible explanation for this inconsistency is that many studies have not accurately measured or considered both the valence and arousal properties of the emotional stimuli used (e.g., Pratto & John, 1991).

There is a common conclusion that the effects of emotion may only be measured in clinical groups that is, in persons who are sensitised through anxiety and fear to emotional stimuli (see Williams, Mathews, & MacLeod, 1996, for a comprehensive review). A recent example is Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, and van Ijzendoorn (2007),

who conducted a meta-analysis of 172 studies, assessing the influence of emotional stimuli on anxious compared to non-anxious individuals. Bar-Haim et al. concluded that emotional material does not attract more attention than neutral material in non-anxious compared to anxious individuals. They suggested that the standard tasks were not as sensitive as tasks that allow some mood induction, such as the blocked-design Stroop emotional task. Indeed, it is likely that the anxious individuals were more sensitised or biased toward emotional stimuli compared to the controls. A direct way of measuring this factor would be to measure arousal levels of the stimuli for each of the studies considered for the meta-analysis. Hence, the stimuli used in these studies may have been sufficiently arousing for anxious individuals, but were perceived as only mildly arousing in the non-clinical groups.

Therefore, the paradigms that have been used in this area have not always been designed to measure both valence and arousal. It is this problem of measurement that has led to some inconsistent results in the area regarding the contribution of the dimensions to performance.

One way to understand the relative salience of valence and arousal is through an analysis of the three main hypotheses in this area. The categorical negativity, evolutionary threat, and arousal hypotheses each support the conclusion that emotional information has priority in the human perceptual system (Schimmack, 2005). However, each has specific and different predictions regarding the relative salience of the arousal and valence dimensions of emotional stimuli.

Whereas Schimmack (2005) evaluates these three hypotheses in terms of how much conflicting evidence there is against them, the present review focuses on the methodological problems that exist in each individual study. Ultimately, when arousal has been taken into account in the experimental design and controlled for, it is argued in this review, that the

arousal dimension primarily contributes to the effect of emotion on performance relative to the valence dimension.

Categorical Negativity Hypothesis

According to this hypothesis, individuals categorically evaluate the information they receive from the environment (Pratto & John, 1991). This process is automatic and results in stimuli being characterised as either positive or negative. Such judgments are said to serve an evolutionary function, as negative stimuli alert the individual to potential threat (Pratto & John, 1991). Negative information is viewed as more important than positive information for survival and is therefore given preference in the human perceptual system.

This hypothesis makes two predictions about the way emotional stimuli affect performance (Pratto & John, 1991). First, negative items will always be given priority over positive items and second, any negative stimuli, despite its level of arousal, will influence performance. The main source of this set of ideas comes from a 1991 study by Pratto and John, which used an adaptation of the Stroop paradigm.

The main task in Pratto and John's (1991) study was to name the colour (blue, pink, red, green or gold) of 80 trait adjectives (40 desirable, 40 undesirable). Stimuli were selected from word pools describing the Big Five personality traits, and were rated from 'extremely undesirable' (e.g., sadistic, wicked) to 'extremely desirable' (e.g., friendly, honest) on a nine point scale. The amount of time it took the participant to say the colour of the word (i.e., latency) was recorded and used as an index of interference.

In relation to the first prediction made by these authors, results of the Analysis of Variance (ANOVA) indicated that it took 29 milliseconds (ms) longer to name the colour of the undesirable trait words compared to the desirable trait words, $F(1, 10) = 19.3, p < .001$. This result was interpreted in support of the prediction that negative information was more

important than positive information, as naming the colour of the undesirable trait words took longer, and therefore interfered more, than naming the colour of desirable trait words.

Second, the authors conducted a Pearson product-moment correlation to ascertain how much the degree of negativity (e.g., stimulus ratings from extremely negative to slightly negative) was correlated with response latencies in comparison to valence (e.g., positive and negative). It was postulated that if the degree of negativity were important, it would have a higher correlation with mean latency compared to the valence ratings. Results indicated that although using the degree of negativity ratings significantly correlated with mean latency ($r = -.23, p < .05$), this was no higher than the correlation between the use of valenced ratings and mean latency ($r = -.23, p < .05$). Because these values were equally weak, this method of comparing correlations may not have been the most thorough way to assess arousal versus valence. However, as there was no increase in the former correlation, the authors concluded that the degree of desirability was not important, and therefore that negative stimuli no matter the arousal, interfere with performance (Pratto & John, 1991).

Pratto and John (1991) did not adequately control the arousal value of their stimuli. That is, their stimuli were rated only in terms of how desirable they were, with this desirability rating supposed to reflect a measure of both the valence (i.e., desirable vs. undesirable) and arousal (i.e., implemented as a desirability rating from extremely desirable to slightly desirable) of the stimuli. As there was no objective rating of the arousal value of their stimuli, it is possible that the stimulus lists were composed of an unbalanced number of positive and negatively arousing stimuli. Indeed, when compared with the ratings from the Affective Norms for English Words database, (ANEW, Bradley & Lang, 1999) many of the positive words could be considered neutral (i.e., not arousing). Therefore, the conclusion that positive information carries less weight in the perceptual system than negative information may have been confounded by their stimulus choices.

Moreover, when the order of the word lists, from 'more undesirable' to 'more desirable' is compared to the corresponding word ratings in the ANEW database it is revealed that the stimulus lists are incorrectly ordered, on both valence and arousal dimensions. For example, 'rude' is at the top of one word list and 'stupid' near the end. However, according to the ANEW database the word 'stupid' is more negative than the word 'rude'. In addition, the word 'hostile' is placed in the middle of one of the stimulus lists however, according to the ANEW database the word 'hostile' is more arousing than those words at the top of Pratto and John's (1991) list, 'rude' and 'wicked'. While it is accepted that Pratto and John predate the ANEW database, Pratto and John's experimental manipulation was confounded by the inaccurate measurement of both valence and arousal, which is likely to have contributed to the inconsistent results on the salience of these two stimulus properties. Their conclusion that arousal was not an important dimension of emotion is therefore dependent on their potentially confounded studies.

Later studies (e.g., Buodo et al., 2002; Schimmack, 2005; Verbruggen & De Houwer, 2007) have yielded conflicting results to those of Pratto and John (1991). It is therefore recommended that researchers consider a replication and extension of Pratto and John with these factors under the appropriate experimental control, to help resolve the inconsistency in the literature, and to clarify understanding of the dimensional salience of valence and arousal, respectively.

Evolutionary Threat Hypothesis

The evolutionary threat hypothesis rejects the idea that all negative stimuli bias attention (Ohman, Lundqvist, & Esteves, 2001). Proponents of this view suggest that it is *threatening* stimuli that capture attention automatically (e.g., Ohman & Flykt et al., 2001). The stimuli most likely to influence attention in this way are those with a direct link to the

events that threatened survival during evolution, for example, angry faces and snakes (Ohman & Flykt et al., 2001; Schimmack, 2005). Therefore, it is predicted that threatening stimuli with direct relevance to human evolutionary history will affect attention (Ohman & Lundqvist, et al., 2001).

The task used by Ohman and colleagues (Ohman & Flykt et al., 2001; Ohman & Lundqvist et al., 2001) more directly measured the perceptual facilitation received by emotional stimuli than that of Pratto and John (1991). The visual search task was used, in which the participant had to detect a target (e.g., an angry face) in a display surrounded by distracting stimuli (e.g., neutral faces). In a set of experiments using simple drawings, it was hypothesised that despite the number and type of distracting pictures, that threatening faces would be detected faster than negative, positive and neutral faces (Ohman & Lundqvist et al., 2001). In each of the five experiments, the results confirmed the hypothesis, as threatening faces were detected faster than the negative, positive and neutral faces (Ohman & Lundqvist et al., 2001).

Ohman and Flykt et al. (2001) replicated these results with a different series of threatening stimuli. In these experiments, the task was to search for pictures of snakes or spiders embedded in a display of flowers or mushrooms, and vice versa. Results indicated that detecting the snakes and spiders was significantly faster than the detection of mushrooms and flowers, $F(1, 24) = 22.29, p < .0001$. This effect was also found despite the number of distracting stimuli included in the display $F(1, 29) = 38.46, p < .001$.

The attribution of results to the *threat* value of stimuli could be considered consistent with the arousal hypothesis. Inherent in threatening stimuli is some degree of arousal, as for instance some of the images of snakes and spiders represented in the International Affective Picture System database have high negative arousal ratings (IAPS, Lang et al., 2005).

Although Ohman and Flykt et al. (2001) selected the snake and spider pictures as threat stimuli based on the theoretical notion that all humans have an automatic feature detection system for identifying potential threat, the results of the Ohman and Flykt et al. (2001) could be viewed as consistent with the arousal hypothesis with specific reference to threatening stimuli.

Arousal Hypothesis

Earlier in this review, it was argued that the explanation given by the categorical negativity hypothesis in particular has contributed to the inconsistency in results and therefore difficulty in understanding this area. Moreover, although at first the evolutionary threat hypothesis may seem to be independent of the arousal hypothesis, the results of the Ohman and Flykt et al. (2001) studies may in fact be consistent with the arousal hypothesis. The purpose of this section is to illustrate how the arousal hypothesis may explain these inconsistencies and difficulties in interpretation.

When arousal has been taken into account and compared to valence in an experimental setting, results have indicated that arousal leads to the effect of emotion on performance, not valence. Studies of reaction time behaviour demonstrate this effect and this will be described in the first part of the section. A review of physiological evidence will be conducted in the second part of this section, as this level of analysis is required to consolidate the idea that arousal is key in the effect of emotion on performance.

One perspective that provides a comprehensive conceptualisation of valence and arousal is the research on what is called motivated attention by Bradley, Lang, and colleagues (e.g., Bradley & Lang, 2007b). The theoretical and methodological foundation of this set of ideas is useful as it can provide an explanation of how valence and arousal relate to each other. The research program being undertaken by Lang and colleagues is primarily concerned

with exploring the idea of two motivational systems, one approach and one avoidant, that organise human behaviour (Bradley & Lang, 2007a).

According to this view, the dimensions of valence and arousal reflect and correspond to the activation in these two underlying motivational systems (Bradley & Lang, 2007a). For example when a stimulus is rated as neutral, this can be seen to reflect activation in neither motivational system, a low level of emotional arousal and consequently a low probability of responding to the eliciting stimulus.

An increase in activation of either the approach or the avoidance systems reflects an increased level of arousal and valence corresponds to the motivational system which is active, approach (i.e., positive) or avoidance (i.e., negative). The relationship between valence and arousal can be illustrated in terms of a situation where one system is activated over the other. That is, a change in direction of behaviour depends on how arousing the stimulus is perceived to be in addition to individual difference in learning history and temperament and the social context (Bradley & Lang, 2007a). It is likely that these individual differences are consistent over time, contexts and circumstances, and so are amenable to experimental investigation.

Furthermore, these two motivational systems can be activated simultaneously in addition to operating independently (Bradley & Lang, 2007a). That is, a stimulus can be perceived having elements of being positive as well as being negative, in a situation where an individual is aroused, but behaviour is not directed at either approaching or avoiding the object because both systems are simultaneously active. Although a stimulus can have both positive and negative valence (approach-avoidance), it is not possible for a stimulus to have both low and high arousal states. Highly valenced (in particular highly valenced negative) stimuli presuppose high arousal levels, and it may not possible (especially for negative stimuli) to have highly valenced stimuli with low arousal levels. Hence, as the level of

positive or negative valence increase, it is rated as more arousing. This analysis suggests that the level of arousal determines the organism's response irrespective of the direction of the affect.

In this way arousal can be understood to be the primary influence on performance in comparison to valence. Therefore, for the purposes of this review, the notion of motivated attention is useful, as an explanation of the relationship between valence and arousal is elucidated. This is one feature not present in either categorical negativity or evolutionary threat theory, where arousal is not explicitly taken into account.

Dual Levels of Analysis

Previous studies (Fox et al., 2002; Pratto & John, 1991) have suggested a valence explanation of the effect of emotion on performance. As indicated in earlier sections of this review, these studies did not adequately control for arousal and therefore, the relative contribution of valence and arousal on emotional performance could not be ascertained. The following section argues that when the psychological reaction time and physiological evidence are considered, that the weight of evidence is consistent with the notion of a primary contribution of arousal over valence with respect to emotional effects on performance.

Reaction Time as Measure of the Effect of Emotion on Performance

Anderson (2005) investigated the effects of valence and arousal on attention using the attentional blink (AB) paradigm. This task required the individual to view a series of stimuli (e.g., words presented one after the other) and report, in this case, two target words highlighted in the colour green. After each presentation, the participant records the two target words. After reporting the first target stimulus (T1), there is a delay in the identification of the second target (T2). This is the attentional blink, and is proposed to reflect the limited capacity of the perceptual system. Indeed, as the time between (i.e., lag) the display of target

one and target two decreases the delay in reporting target two increases. Effectively the delay is a result of impaired encoding of the second target (Anderson, 2005).

The relative salience of valence and arousal on performance may be assessed using this paradigm by manipulating the stimulus dimensions of the second target word (Anderson, 2005). The second target words which are arousing (either positive or negative) should show a reduction in delay, compared with non-arousing stimuli. Anderson (2005) investigated this hypothesis in two experiments; the first compared three levels of arousal of negative words, while the second compared three levels of arousal of positive words.

Forty students participated in experiment one, half were randomly assigned to the negative word condition and half to the high arousal negative word condition (Anderson, 2005). The T1 stimuli were composed of neutral words, while the T2 stimulus lists were varied on three levels of negative arousal. This included neutral (e.g., 'apple'), negative (e.g., 'suffer') and high arousing negative taboo words (e.g., 'bastard'). In addition to manipulating the arousal value of the word, the time between the presentation of T1 and T2 was also varied. There were seven lags, ranging from lag one (no other items presented between T1 and T2) to lag seven (six additional items between T1 and T2). Anderson (2005) used ANOVA and eta squared to ascertain the contribution of arousal and negative valence to performance. Hence, the design used in this study directly assessed how perception can be shaped by emotional stimuli.

Results indicated that attentional blink was reduced for negative words compared to neutral words, and that the effect was further reduced for negatively arousing words (Anderson, 2005). Lag significantly lengthened neutral word response compared with arousing negative word response $F(1,19) = 28.83, \eta^2 = .60$. Although accuracy of T2 report depended on lag $F(1, 38) = 78.69, \eta^2 = .67$, when the negative word condition was compared

to the arousing negative word condition, accuracy in the arousing condition was less affected by lag times, $F(1, 38) = 4.31, \eta^2 = .10$. Although these results support arousal, the obtained effect was small but consistent.

The second experiment was designed to test the effects of arousal and positive valence on attention. Thirty-six students participated and the task remained the same as in the first experiment (Anderson, 2005). Stimuli were varied on three levels of positive arousal, ranging from neutral (e.g., 'nails'), to mildly arousing positive (e.g., 'beauty'), to high arousal positive (e.g., 'erotic'). Results indicated that the AB response reduced significantly for the arousing positive condition compared to the positive and neutral condition.

The second experiment mirrored the results of experiment one, as at each increase in arousal (i.e., from neutral, to positive to high arousal positive), the effects of lag systematically diminished (Anderson, 2005). That is, report was less accurate for neutral compared to positive items $F(1, 17) = 6.28, \eta^2 = .27$, less accurate for neutral compared to high arousing positive items $F(1, 17) = 19.15, \eta^2 = .53$, and less accurate for positive compared to high arousing positive items $F(1, 34) = 5.00, \eta^2 = .13$. Again, although the effects of arousal are evident, the size of this effect was small but consistent

These results are consistent with the arousal hypothesis as both positive and negative arousing words were detected faster and more accurately than low arousing and neutral words (Anderson, 2005). The results are important for two reasons. First, the findings suggest that arousal determines emotional performance. Second, the findings demonstrate that *both* positive and negatively arousing stimuli affect emotional performance, rather than only negative stimuli as postulated by the negativity hypothesis (Pratto & John, 1991).

From this study it seems that arousal is important as it alerts the system to what is happening in the environment, and it could also be inferred that events are subsequently

classified as either positive or negative. It may also be argued, however, that stimuli high on positive and negative valence lead to the high arousal. Nevertheless, physiological evidence shows that it is arousal that modulates for example skin conductance and the startle reflex. From this it may be suggested that the explanation of the perception of arousal coming first, followed rapidly by valence seems to have more evidentiary support.

Anderson's (2005) study supported the arousal hypothesis, and did not support a dominating role for valence. Moreover, this study is inconsistent with the categorical negativity and evolutionary threat hypotheses, in that both would have predicted reduced reaction times for only negatively arousing stimuli, and for categorical negativity, no difference between accuracy for both negative and negative arousing conditions. However, more evidence from a number of different paradigms is required before clear conclusions may be drawn; the effects from this one study show that that the dominance of arousal is relatively small.

Schimmack (2005) also compared the effects of valence and arousal on performance, however his study directly assessed the predictions made by each of the three hypotheses. In two experiments Schimmack tested the relative contribution of categorical negativity, arousal, and evolutionary threat to performance using two different reaction time tasks.

Twelve different picture types were used, systematically varied to assess categorical negativity, evolutionary threat and arousal (Schimmack, 2005). Valenced pictures included three levels of pleasantness and three levels of unpleasantness and neutral pictures (e.g., a car wheel). These levels included mild pleasant pictures (e.g., brownies), moderate pleasant (e.g., cherry tree), strong pleasant (e.g., a baby), mild unpleasant (e.g., trash can), moderate unpleasant (e.g., prison cell), and strong unpleasant (e.g., a battered woman). Each picture was also rated on arousal, and evolutionary threat pictures were images of snakes.

In the first experiment, the task required participants to solve math problems (e.g., $3 \times 5 < > 2 \times 8$). At different times throughout each trial, the pictures would appear on the screen (i.e., before, during, or after the math problem). Analysis of variance was used for the analysis of general effects, with hierarchical linear modelling (HLM) used for more detailed analysis (Schimmack, 2005). This task used a measure of interference and therefore demonstrated the impact of emotional information on ongoing cognitive processing, compared to Anderson's (2005) study in the effects of emotion on perception.

For the evolutionary threat hypothesis to be supported, maths problem reaction times on snake picture trials would have to be longer than those reaction times on other picture trials. Results however, revealed that RT for snake picture trials were significantly faster than in the other trials $\gamma^{01} t(125) = 3.16, p < .01$. Similarly, when all negative pictures were compared to all other pictures no significant effects were found $\gamma^{01} t(125) = .20, p > .50$. Therefore, the results were not consistent with either the predictions of the evolutionary threat hypotheses or those of the categorical negativity hypothesis. Indeed, the results are contrary to expectation, in that the presence of snake picture improved reaction times for maths problems. The reasons why this result occurred are unclear, and therefore this experiment deserves replication.

However, the results did show a significant increase in the RT on the arousing pictures trials, and a low size of effect $t(125) = 7.11, p < .001 r = .37$. Moreover, increases in arousal linearly increased RT, as for every increase in arousal by one standard deviation, reaction times increased by 40ms.

Therefore, the first study found some support for the arousal hypothesis. However, one possible confound was the complexity of the task used to measure reaction times (Schimmack, 2005). Because of this, the second experiment adopted a simpler task. Using

the same stimuli, the task in study 2 required the participant to detect the location of a black line presented above or below each picture.

The analysis of variance revealed a significant effect for picture type $F(11, 638) = 11.97, p < .01, \eta^2 = .17$. For analysis of the specific predictions made by each theory, HLM in full was used. Line detection for the snake picture trials was significantly faster compared to other trials ($\gamma^{\text{ol}} t(59) = 2.14, p < .05$). This finding seems odd and goes against predictions made by all three hypotheses. The authors could not explain this, although it seems possible that there was an interaction between the line detection and snake detection, and this contributed to this odd result. This unexplained effect occurred in study 1 and 2, suggesting that replication using other threat stimuli such as spiders and lions may be warranted. Moreover, there was no difference in line detection RT between negative, and neutral and positive stimuli $\gamma^{\text{ol}} t(59) = 1.61, p > .10$.

In contrast, line detection RT for arousing pictures was significantly longer than for non-arousing pictures $t(59) = 5.91, p < .0001, r = .50$. Further, it was calculated that for every increase in arousal by one standard deviation, reaction time was delayed by an additional 24 ms (Schimmack, 2005).

Taken together the evidence provided by Anderson (2005) and Schimmack (2005) demonstrated the importance of arousing information in the effect of emotion on performance, over and above the effects elicited by low arousing, valenced stimuli. The results of both of these investigations were inconsistent with categorical negativity as both positive and negative arousing stimuli influence performance more in comparison to low arousing positive and negative stimuli. In addition, Schimmack (2005) demonstrated that evolutionary threat relevant images (snakes) did not lead to an increased delayed RT in comparison to other arousing images. However this is a contradictory finding because the

snake images seemed to have stimulated performance, one that needs to be reviewed to ascertain if there were any underlying problems with those snake images used, or with the integration of the line detection and snake detection inhibitor as explained earlier.

The studies reviewed here show the effects of emotion over cognitive processing at perception (Anderson, 2005), extending to ongoing processing and problem solving (Schimmack, 2005). Although these tasks addressed different aspects of information processing, they provide support for the arousal hypothesis, both in comparison to the categorical negativity and the evolutionary threat hypotheses.

Physiology as Measure of the Effect of Emotion on Performance

In this section, evidence from physiological studies will be investigated to consolidate the reaction time evidence with respect to the relative salience of valence and arousal on their effects on performance.

Most physiological researchers focus their study according to one induction context because there is differential activation in response to different stimuli (e.g., pictures vs. sounds). For example, Cuthbert, Schupp, Bradley, Birbaumer, and Lang (2000) focus on the neurological and physiological patterns of activation to affective pictures. When individuals see emotional pictures, there is a reliable activation of the anterior cingulate, the insula, occipital cortex and the amygdala (Bradley & Lang, 2007a).

The amygdala in particular has received extensive attention by researchers as one of the centres of emotion in the brain (Clark, Boutros, & Mendez, 2005). LeDoux (1994) proposed that when an emotional stimulus is perceived (e.g., a snake) this information travels from the layers of cells in the retina through the optic nerve to the thalamus, through to the occipital cortex and to the amygdala. Emotional memories are triggered through this process,

and can lead to physiological and behavioural changes through connections with the prefrontal cortex (Gazzaniga, Ivry, & Mangun, 2002; LeDoux, 2000).

The basic principle behind these studies is that when an individual is emotionally engaged, this can be revealed through looking at images of their brain (Bradley et al., 2003). The visual cortex is another commonly studied area using brain imaging techniques (e.g., functional magnetic resonance imaging, fMRI) because of its 'processing loop' with the amygdala (Bradley & Lang, 2007a; Bradley et al., 2003). Both positive and negative arousing pictures have been found to activate the amygdala and visual cortex (Bradley & Lang, 2007a).

Bradley and colleagues (2003) investigated this further, measuring the functional activity in the visual cortex in response to high and low arousal (positive and negative) images. Eighteen male university students ($M = 18.6$ years) participated in a passive viewing task. Each participant viewed 56 pictures of varying emotional arousal, and the scans were processed during the 12-second picture presentation period. Results indicated that there was a significant difference in functional activity for emotional picture content $F(6, 96) = 7.56, p < .01$. Specifically, the more arousing the picture was (positive and negative) the more functional activity was recorded in the visual cortex $F(1, 16) = 21.45, p < .01$.

The focus of the Bradley et al. (2003) study was on arousal, and as their hypotheses were confirmed there was no specific discussion on patterns that could be attributed to valence. For example, the finding that even though erotic and family picture content was rated as equally highly positive, the erotic content received the greater and stronger activation of the visual cortex in comparison to the family images. This was strong evidence for these authors on the modulating influence of arousal.

Further physiological studies have used other measures to support the importance of the arousal dimension of emotion (e.g., Adolphs, 2004; Cuthbert et al., 2000; Kensinger &

Schachter, 2005; Mourao-Miranda et al., 2003). Other physiological measures through which the effects of emotion on performance have been tested include electrodermal, somatic, cardiovascular, reflex, gastric, respiratory, central and neuroendocrine systems (Bradley & Lang, 2007a).

Bradley, Codispoti, Cuthbert, and Lang (2001) investigated the patterns of heart rate, skin conductance, facial corrugator, startle reflex, and zygomatic and orbicularis oculi muscles in response to affective pictures. Ninety five (50 females) students participated in this study, viewing a series of 72 pictures while the physiological responses were being measured. Results indicated that skin conductance varied as a function of arousal, for both negative ($F(1, 94) = 26.92, p < .0001$) and positive ($F(6, 88) = 8.89, p < .01$) pictures. For startle reflex, when pictures were ordered according to mean arousal ratings, there was a significant linear trend for both negative ($F(1, 83) = 22.62, p < .001$) and positive ($F(1, 84) = 8.47, p = .005$) pictures indicating that for arousing stimuli there was a larger startle reflex compared to neutral stimuli. Only highly arousing positive stimuli significantly affected initial magnitude of heart rate acceleration ($F(6, 87) = 3.12, p = .008$) and deceleration ($F(6, 87) = 2.34, p = .038$). In relation to facial activity, the corrugator EMG responded most to the highly arousing unpleasant pictures, while activity in the zygomaticus and orbicularis oculi was more variable (Bradley et al., 2001; see Bradley & Lang, 2007a; Bradley and Lang, 2007b for comprehensive reviews).

Hence, the evidence suggests that arousal irrespective of negative or positive valence is an important dimension of emotion. However, because effect sizes were not reported, the differential strength of these effects for negative versus positive stimuli could not be ascertained. Therefore, the finding that the arousal dimension did not modulate the measurement of facial expression may be important, as an indication that valence is also important, but has a lesser influence than arousal.

Applying an Individual Differences Framework to the Study of Valence and Arousal

Research in the previous sections of this review have shown that arousal is an important dimension of emotion using evidence from reaction time studies, neuropsychology and physiology (Anderson, 2005; Bradley et al., 2001; Bradley et al., 2003). Nevertheless, it is acknowledged that the focus has been on results obtained from group based analysis.

Although this research has provided an indication of the importance of arousal, and the lesser importance of valence to the effect of emotion on performance, important information is lost when only relying on group results (Kosslyn et al., 2002).

Bradley and Lang (2007b) acknowledged the importance of individual differences in picture perception. What is found most arousing for one individual will differ to that of the next individual. However, considering individual differences is not common practice in this area (Bradley & Lang, 2007b). The link between emotion and individual differences is clear, as what is more idiosyncratic than an individuals' emotional contour? For instance, consider a picture of a gun pointed directly at the viewer. One person might respond to this picture with indifference and rate it as mildly negative and low arousing. This person may partake in shooting as a recreational activity and is therefore desensitized to guns. Alternatively, a person who has experienced trauma involving a gun is likely to rate the image as highly negative and arousing. These two individuals will display different patterns behaviour, reaction time and physiological activation in response to the gun image.

In terms of reaction time, although it may be evident that arousal is more important than valence, when these two results of the gun ratings are averaged, the precise nature of each individual's data is lost. As highlighted in Williams et al. (1996) the degree of personal concern inherent in the experimental stimuli is more potent in affecting performance than valence. For instance, Mathews and Klug (1993) used an emotional Stroop task to compare

the levels of interference in colour naming for anxious (generalised anxiety disorder $n = 11$, panic disorder $n = 6$, social phobia $n = 3$) compared to non-anxious controls ($n = 20$). The emotional words were judged and rated for their relevance (both positive and negative) to concerns shared by these three classes of anxiety (e.g., 'panic', 'dying' & 'competent').

Results indicated that the effects of valence did not differ between anxious and control groups $F(1, 38) = 1.52, p = .23$. For the control group the anxiety related words did not lead to significantly more interference than unrelated emotional words $F(1, 19) = .65$. However, for the anxious group related words led to significantly more interference than the unrelated words $F(1, 19) = 8.9, p < .01$. Therefore, despite the valence of the stimuli, only words related to the individual's current concerns impacted performance. This is a clear illustration of the import of arousal (i.e., the relevant words were arousing to the anxious group) but more specifically, it demonstrates the effect of individual differences in picture perception. Indeed, for the anxious participants both the words 'panic' and 'relaxed' led to interference in colour naming. However, as objectively rated in the ANEW database (Bradley & Lang, 1999) the word panic is highly negative ($M = 3.12$) and highly arousing ($M = 7.02$) and relaxed is highly positive ($M = 6.4$) and non-arousing ($M = 3.2$). Therefore, it is evident that what is valenced and arousing is determined by the individual, and can deviate markedly from standardised stimulus lists. Although this is an extreme example representing a clinical group, it nevertheless illustrates the differences in individual responses to emotional stimuli.

Another example of the individual differences in the perception of valence and arousal was demonstrated in one classic study by Carl Jung (1907). In Jung's first experiment, a series of stimulus words were read out and the task required the participant ($N = 1$) to verbalise one word they associated with the stimulus word. Jung measured how long it took the participant to respond to each stimulus word. After this task, the participant was required to recall her answers. Four interesting patterns emerged. Out of 13 trials, the participant had

four reaction times above 2 minutes. For instance, the reaction time to the word 'water' took 5 minutes and the word 'lake' took 4 minutes. Incorrect recall occurred only on those trials that delayed reaction time. This is another example of the extent of deviation from standardised group ratings. For example, the word 'water' is rated in the ANEW database (Bradley & Lang, 1999) as highly positive ($M = 6.61$) and not arousing ($M = 4.97$). The word 'lake' in the ANEW database is rated as highly positive ($M = 7.10$) and neutral ($M = 3.86$). However, because these words led to such a marked disruption in the participant's performance, it is evident that they were considered highly arousing and negative to this individual. Jung (1907) further revealed that this individual had experienced certain events which had led to a momentary contemplation of suicide by drowning. Therefore, although these methods are in some ways removed from mainstream studies of emotion, Jung still demonstrated the value of an individual differences approach and the marked variation in individual compared to group judgements of emotion.

This section of the review argued that there are differences in the initial perception of a stimulus, and so there is considerable individual variation in response to psychological experiment. However, as this review demonstrated, the continued focus remains on group results. Given the marked variation in an individual's perception of emotional stimuli, the systematic documenting of idiosyncratic patterns of response is considered a fruitful direction for further research (see also Kosslyn et al., 2002).

Recommendations and Conclusions

This section addresses potential research that can address gaps in the current investigation of first, the effects of valence and arousal at different stages of cognitive processing, second, methods to integrate research from across levels of analysis, and third, the reliance on group based methodology.

Although this review attempted to integrate and provide an explanation for the diverse results in this area regarding the relative salience of valence and arousal, more work remains to be done. For instance, further research is required to give an understanding of the relative influence of these two dimensions on different stages of processing. As highlighted by Anderson (2005) much work remains to be done on the level of how emotion shapes individual's perception, and the relative salience of valence and arousal in this process.

The second area in need of further development regards the theoretical and methodological integration across different levels of analysis (e.g., Davidson, 2003). Although this may occur with large, well funded, multi-disciplined research programs, there are opportunities for integration in smaller scale projects. For example, the main problem identified in this review was the inconsistent measurement of the valence and arousal dimensions in emotional stimuli. One factor that contributed to this is the lack of available standardised stimuli sets rated on both dimensions. However, researchers from the NIHM Center for the Study of Emotion and Attention (e.g., Bradley & Lang, 2007b) have compiled standardised databases of affective pictures, words and sounds for the exact purpose of having a database that can be used to both assess different levels of analysis, in addition to providing a consistent pool of affective stimuli adequately rated on both dimensions of valence and arousal. Therefore, the use of such resources contributes to both aims of tighter stimulus control and the ability to compare across levels of investigation.

Third, the reliance on group research in this area highlights the gap in an understanding of the individual differences in picture perception. This reveals an opportunity to conduct studies on the relative influence of valence and arousal analysed on an individual level. As Kosslyn et al. (2002) notes, individual differences are a rich source of information and when integrated with a group based result, can provide explanations above and beyond that focused on by either approach independently. Although there has been some work on

individual differences in picture perception (e.g., Greenwald, Cook, & Lang, 1989; Lang, Greenwald, Bradley, & Hamm, 1993), it has not been a focus of research in this area (Bradley & Lang, 2007b). Therefore, there is scope for an investigation of the variation in individual's ratings of affective pictures. For example, a potentially fruitful direction may be to explore the correlation between emotional perception, evaluations, physiology and personality.

The inconsistency in experimental studies pertaining to the relative influence of valence and arousal was identified and considered a problem for understanding in this area. Through a critical analysis of studies across perceptual, behavioural and physiological levels, it was demonstrated that one main reason for this inconsistency was the relative control of stimulus valence and arousal. When both of these dimensions have been accurately measured and systematically varied, the arousal dimension was demonstrated as a more important contributor to the effect of emotion on performance. Additionally, the value of taking an individual differences perspective was identified as a rich area for future research, as the contemporary focus in this domain remains on group based results. Hence, it was possible to explain the inconsistencies in this area through an analysis of the measurement of the valence and arousal dimensions of emotion. In addition, systematic study of the effects of individual differences is likely to provide more understanding of the dimensional salience of valence and arousal.

References

- Adolphs, R. (2004). Processing of emotional and social information by the human amygdala. In M.S. Gazzaniga (Ed.), *The cognitive neurosciences* (3rd ed., pp. 1017-1031). Cambridge: MIT Press.
- Anderson, A. K. (2005). Affective influences on the attentional dynamics supporting awareness. *Journal of Experimental Psychology: General*, *134*, 258-281.
- Anderson, A. K., Wais, P. E., & Gabrieli, J. D. E. (2006). Emotion enhances remembrance of neutral events past. *Proceedings of the National Academy of Sciences*, *103*, 1599-1604.
- Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van Ijzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, *133*, 1-24.
- Bradley, M. M., Codispoti, M., Cuthbert, B. N., & Lang, P. J. (2001). Emotion and motivation I: Defensive and appetitive reactions in picture processing. *Emotion*, *1*, 276-298.
- Bradley, M. M., & Lang, P. J. (1999). *Affective norms for English words (ANEW): Instruction manual and affective ratings* (Tech. Rep. C-1). Gainesville, FL: University of Florida.
- Bradley, M. M., & Lang, P. J. (2007). Emotion and Motivation. In J.T. Cacioppo, L.G. Tassinary, & G.G. Berntson (Eds.), *Handbook of psychophysiology* (3rd ed., pp. 581-607). New York: Cambridge University Press.

- Bradley, M. M., & Lang, P. J. (2007). The international affective picture system (IAPS) in the study of emotion and attention. In J. A. Coan, & J. J. B. Allen (Eds.), *Handbook of emotion elicitation and assessment* (pp. 29-46). New York: Oxford University Press.
- Bradley, M. M., Sabatinelli, D., Lang, P. J., Fitzimmons, J. R., King, W., & Desai, P. (2003). Activation of the visual cortex in motivated attention. *Behavioral Neuroscience*, *117*, 369-380.
- Buodo, G., Sarlo, M., & Palomba, D. (2002). Attentional resources measured by reaction times highlight differences within pleasant and unpleasant, high arousing stimuli. *Motivation and Emotion*, *26*, 123-137.
- Clark, D. L., Boutros, N. N., & Mendez, M. F. (2005). *The brain and behaviour: An introduction to behavioural neuroanatomy* (2nd ed.). Cambridge: Cambridge University Press.
- Cuthbert, B. N., Schupp, H. T., Bradley, M. M., Birbaumer, N., & Lang, P. J. (2000). Brain potentials in affective picture processing: Covariation with autonomic arousal and affective report. *Biological Psychology*, *52*, 95-111.
- Davidson, R. J. (2003). Seven sins in the study of emotion: Correctives from affective neuroscience. *Brain and Cognition*, *52*, 129-132.
- Eder, A. B., Hommel, B., & De Houwer, J. (2007). How distinctive is affective processing? On the implications of using cognitive paradigms to study affect and emotion. *Cognition and Emotion*, *21*, 1137-1154.
- Fox, E., Russo, R., Bowles, R., & Dutton, K. (2001). Do threatening stimuli draw or hold visual attention in subclinical anxiety? *Journal of Experimental Psychology: General*, *130*, 681-700.

- Fox, E., Russo, R., & Dutton (2002). Attentional bias for threat: evidence for delayed disengagement from emotional faces. *Cognition and Emotion, 16*, 355-379.
- Frijda, N. H. (1988). The laws of emotion. *American Psychologist, 43*, 349-358.
- Gazzaniga, M. S., Ivry, R. B., & Mangun, G. R. (2002). *Cognitive Neuroscience: The biology of the mind* (2nd ed.). New York: W.W. Norton & Company.
- Greenwald, M. K., Cook, E. W., Lang, P. J. (1989). Affective judgement and psychophysiological response: Dimensional covariation in the evaluation of pictorial stimuli. *Journal of Psychophysiology, 3*, 51-64.
- Jung, C. G. (1907). On psychological relations of the associative experiment. *The Journal of Abnormal Psychology, 1*, 247-255.
- Kensinger, E. A., & Schacter, D. L. (2005). Retrieving accurate and distorted memories: Neuroimaging evidence for effects of emotion. *NeuroImage, 27*, 167-177.
- Kosslyn, S. M., Cacioppo, J. T., Davidson, R. J., Hugdahl, K., Lovallo, W. R., & Spiegel, D., et al. (2002). Bridging psychology and biology: The analysis of individuals in groups. *American Psychologist, 57*, 341-351.
- Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2005). *International Affective Picture System (IAPS): Affective ratings of pictures and instruction manual* (Tech. Rep. A-6). Gainesville, FL: University of Florida.
- Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology, 30*, 261-273.

- LeDoux, J. E. (1994). Emotion, memory and the brain: The neural routes underlying the formation of memories about primitive emotional experiences, such as fear, have been traced. *Scientific American*, *12*, 62-71.
- LeDoux, J. E. (2000). Emotion circuits in the brain. *Annual Review of Neuroscience*, *23*, 155-184.
- MacKay, D. G., Shafto, M., Taylor, J. K., Marian, D. E., Abrams, L., & Dyer, J. R. (2004). Relations between emotion, memory, and attention: Evidence from taboo Stroop, lexical decision, and immediate memory tasks. *Memory and Cognition*, *32*, 478-488.
- Mathews, A., & Klug, F. (1993). Emotionality and interference with color-naming in anxiety. *Behaviour Research and Therapy*, *31*, 57-62.
- Mathews, A., & MacLeod, C. (1994). Cognitive approaches to emotion and emotional disorders. *Annual Review of Psychology*, *45*, 25-50.
- Mehrabian, A., & Russell, J. A. (1974). *An approach to environmental psychology*. Cambridge, MA: MIT Press.
- Mourao-Miranda, J., Volchan, E., Moll, J., de Oliveira-Souza, R., Oliveira, L., Bramati, I., et al. (2003). Contributions of stimulus valence and arousal to visual activation during emotional perception. *NeuroImage*, *20*, 1955-1963.
- Navon, D. (1984). Resources – A theoretical soup stone? *Psychological Review*, *91*, 216-234.
- Ohman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General*, *130*, 466-478.

- Ohman, A., Lundqvist, D., & Esteves, F. (2001). The face in the crowd revisited: A threat advantage with schematic stimuli. *Journal of Personality and Social Psychology, 80*, 381-396.
- Osgood, C. E., Suci, G. J., & Tannenbaum, P. H. (1971). *The Measurement of Meaning*. Chicago: University of Illinois Press.
- Phelps, E. A. (2004). The human amygdala and awareness: Interactions between emotion and cognition. In M.S. Gazzaniga (Ed.), *The cognitive neurosciences* (3rd ed., pp. 1005-1017). Cambridge: MIT Press.
- Power, M., & Dalgleish, T. (2008). *Cognition and emotion: From order to disorder* (2nd ed.). New York: Psychology Press.
- Pratto, F., & John, O. P. (1991). Automatic vigilance: The attention-grabbing power of negative social information. *Journal of Personality and Social Psychology, 61*, 380-391.
- Richards, J. M., & Gross, J. J. (1999). Composure at any cost? The cognitive consequences of emotion suppression. *Personality and Social Psychology Bulletin, 25*, 1033-1044.
- Russell, J. A. (2003). Core affect and the psychological construction of emotion. *Psychological Review, 110*, 145-172.
- Schachter, S., & Singer, J. (1962). Cognitive, social, and physiological determinants of emotional state. *Psychological Review, 69*, 379-399.
- Schafe, G. E., & LeDoux, J. E. (2004). The neural basis of fear. In M.S. Gazzaniga (Ed.), *The cognitive neurosciences* (3rd ed., pp. 987-1005). Cambridge: MIT Press.

- Scherer, K. R. (2005). What are emotions? And how can they be measured? *Social Science Information, 44*, 695-729.
- Schimmack, U. (2005). Attentional interference effects of emotional pictures: threat, negativity, or arousal? *Emotion, 5*, 55-66.
- Verbruggen, F., & De Houwer, J. (2007). Do emotional stimuli interfere with response inhibition? Evidence from the stop signal paradigm. *Cognition and Emotion, 21*, 391-403.
- Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin, 120*, 3-24.
- Zajonc, R. B. (1980). Feeling and thinking: Preferences need no inferences. *American Psychologist, 35*, 151-175.

Guidelines for Contributions by Authors

Emotion

Instructions to Authors

Please consult APA's Instructions for All Authors for information regarding

- Manuscript Preparation
- Submitting Supplemental Materials
- Abstract and Keywords
- References
- Figures
- Permissions
- Publication Policies
- Ethical Principles

Submission

Submit manuscripts electronically through the Manuscript Submission Portal in Rich Text Format (.rtf). All tables and figures should be included in the manuscript file. General correspondence may be directed to the Editor's Office.

Mail Submission

Submit manuscripts through the mail if Internet access is not available. Please submit one hard copy of the manuscript along with a complete disk copy (text, tables, and figures) to the Editor,

Elizabeth A. Phelps, PhD
Department of Psychology
New York University
6 Washington Place
Room 863
New York, NY 10003

All copies should be clear, readable, and on paper of good quality. The complete disk copy should include a clear notation of the file names and the word processing and graphics software used. Figures may be submitted on a separate disk or on a Zip disk.

Masked Review Policy

Masked reviews are optional, and authors who wish masked reviews must specifically request them when they submit their manuscripts. For masked reviews, the manuscript must include a separate title page with the authors' names and affiliations, and these ought not to appear anywhere else in the manuscript. Footnotes that identify the authors must be typed on a separate page. Authors are to make every effort to see that the manuscript itself contains no clues to their identities.

Manuscript Submission Guidelines

In addition to addresses and phone numbers, authors should supply electronic mail addresses and fax numbers for use by the editorial office and later by the production office. The majority of correspondence between the editorial office and authors is handled by e-mail, so a valid e-mail address is important to the timely flow of communication during the editorial process. Authors should provide electronic mail addresses in their cover letters and should keep a copy of the manuscript to guard against loss. Manuscripts are not returned. Manuscripts for *Emotion* can vary in length; typically they will range from 15 to 40 double-spaced manuscript pages. Manuscripts should be of sufficient length to ensure theoretical and methodological competence. Most of the articles published in *Emotion* will be reports of original research, but other types of articles are acceptable.

- Case studies from either a clinical setting or a laboratory will be considered if they raise or illustrate important questions that go beyond the single case and have heuristic value.
- Articles that present or discuss theoretical perspectives on the basis of published data, may also be accepted.
- Comprehensive reviews of the empirical literature in an area of study are acceptable if they contain a meta-analysis and/or present novel theoretical or methodological perspectives.
- Comments on articles published in the journal will be considered.

Brief Reports

- *Emotion* also publishes brief reports. Manuscripts submitted as Brief Reports should not exceed 3,400 words, exclusive of references and figure captions. There should be no more than 2 figures or tables and no more than 30 references.

Theoretical Notes

- *Emotion* publishes articles that make important theoretical contributions to research areas that are of major importance for the study of emotion and affect. Preference is given to manuscripts that advance theory by integrating prior work and by suggesting concrete avenues for the empirical investigation of the theoretical predictions. Extensive, systematic evaluation of alternative theories is expected.

Manuscripts devoted to surveys of the literature are acceptable only if they can be considered as a major contribution to the field, documenting cumulative evidence and highlighting central theoretical and/or methodological issues of scientific debate. *Emotion* also publishes, as Theoretical Notes, commentary that contributes to progress in a given subfield of emotion or affect. Such notes include, but are not limited to, discussions of alternative theoretical approaches, and metatheoretical commentary on theory testing and related topics. Manuscripts submitted as Theoretical Notes should not exceed 5,000 words (exclusive of references). There should be no more than 50 references.

The Dimensionality of Emotion and Individual Differences

Leah Braganza

The Dimensionality of Emotion and Individual Differences

Abstract

This explorative study tested the relative contribution of valence and arousal to ratings of emotionality, and the potential for an individual differences approach to increase the explained variance in comparison to a group based approach was assessed. Thirty female participants were recruited from the psychology student population at Edith Cowan University. A ratings task was used, whereby participants had to rate a set of affective pictures in terms of overall emotionality, valence and arousal. The arousal hypothesis would predict that the highly arousing pictures, despite their valence, would have the biggest effect on performance. The Friedman and Wilcoxon non-parametric tests were used to analyse the data. From phase I, results indicated that both valence and arousal had a significant effect on emotionality rating $p < .05$. However, effect sizes revealed that arousal could explain 11.6% of the variance, in comparison to the 1.4% explained by valence. Phase II results revealed that an added 15% of the variance could be explained when individual differences were accounted for. These results are consistent with the arousal hypothesis, and highlight the power of an individual based design. There are many potential projects for further research, for instance, adapting the present design to investigate stimulus-limited effects on emotional perception which would then allow investigation of the relative contributions of valence and arousal across a time course.

Author: Leah Braganza

Supervisor: Dr. Ken Robinson

Submitted: May 2008

The Dimensionality of Emotion and Individual Differences

The structure of emotion may be separated into two dimensions of valence and arousal (Mehrabian & Russel, 1974). Whereas valence refers to the quality of the emotion as either positive or negative, the arousal dimension accounts for the intensity of that positive or negative experience (Kensinger & Schacter, 2006; Power & Dalgleish, 2008). These two dimensions have not always been accurately measured in research investigating the effect of emotion on performance (Schimmack, 2005). It is argued that because of inconsistency in the operationalisation of these dimensions, divergent conclusions exist in the literature concerning the relative contribution of valence and arousal to emotion.

The inconsistency in operationalisation is probably best explained by reviewing the three main hypotheses in this area: the categorical negativity hypothesis (Pratto & John, 1991), the evolutionary threat hypothesis (Ohman, Lundqvist, & Esteves, 2001) and the arousal hypothesis (Bradley & Lang, 2007a). One of the reasons for the inconsistency is the relatively independent development of these hypotheses (Schimmack, 2005). Schimmack (2005) provided one of the first reviews of each of the three hypotheses, and has tested the effects of valence and arousal using predictions made by each of the hypotheses. This integrative approach used by Schimmack can help in the understanding of this diverse field.

Another reason for the inconsistency is methodological implementation, in the way each study measures the two dimensions. Concerning studies with non-clinical samples, the combined literature shows that when both valence and arousal have been accurately measured, it is arousal that is found to influence emotional performance more than valence (e.g., Schimmack, 2005). However, when arousal has not been considered or not measured accurately, valence is considered to be the primary dimension of emotion.

The study by Pratto and John (1991) represents the main support for the categorical negativity hypothesis. Pratto and John argued that humans have an inbuilt tendency to categorically evaluate their perceptions of the world around them. In terms of emotion, individuals are said to evaluate events in terms of how positive or negative they are. First, because of the desire to avoid negative events, Pratto and John proposed that negativity is more important for emotion and attention compared to positive events. The negative valence of an event is therefore ascribed to have more importance than the intensity of that event in affecting emotion.

In a test of the influence of negative valence on task performance, Pratto and John (1991) conducted an adaptation of the Stroop paradigm. The participants had to name the colour of 80 different trait adjectives (e.g., the word 'wicked' printed in green ink), where the trait words differed in terms of how desirable they were, from extremely undesirable/desirable, to slightly undesirable/desirable. The negative ('undesirable' traits) words took significantly longer to name in comparison to the positive ('desirable' traits) words ($p < .001$). Furthermore, no difference was found between how long it took for the participants to respond to the extremely negative compared to the slightly negative words, and so Pratto and John concluded that negative valence dominated emotional performance.

These results were used as evidence that valence is more important than arousal. However, when the actual stimuli were analysed, it was evident that the valence and arousal qualities of these stimuli had not been accurately measured. When the Affective Norms for English Words (ANEW; Bradley & Lang, 1999a) database was used to analyse Pratto and John's (1991) stimuli, it became evident that the word lists of Pratto and John were inappropriately rated. The positive word list contained words at a lower level of arousal than the negative word list, with the negative word lists having a mix of high and low arousal words populating both the extreme and slight negative emotion word lists. The Pratto and

John study, which predated Bradley and Lang (1999a), represents the main support for the categorical negativity hypothesis, and it would appear that the valence and arousal properties of the affective stimuli were not independently manipulated, and were therefore confounded.

The evolutionary threat hypothesis proposes that *threatening* stimuli with direct links to human evolutionary history (e.g., angry faces & snakes) will influence task performance more than stimuli that are not threat related (Ohman, Flykt, & Esteves, 2001; Ohman, Lundqvist, & Esteves, 2001). Ohman, Flykt, and Esteves (2001) tested the perceptual facilitation that snakes and spiders received in comparison to flowers and mushrooms (i.e., the target stimuli). Pictorial stimuli were presented in a 3 x 3 matrix. The task required the individual to press a button when they detected the target stimuli within the matrix. For example, when the participant detected the snake picture amongst the mushroom pictures, or vice versa, they would have to indicate this with a button press. Ohman and Flykt et al. (2001) found that the snakes and spiders were detected significantly faster in comparison to the flowers and mushrooms ($p < .001$). These authors demonstrated the effects with differing matrix sizes and for individuals who did and did not have a particular fear of snakes. However, in each of the experiments, measurements of effect size were not given so the magnitude of this difference in perception between fear relevant and fear irrelevant stimuli cannot be established from this study.

In Ohman and Flykt et al. (2001) and in Ohman, Lundqvist, and Esteves (2001), the stimuli hypothesised to facilitate perception were the threatening, or fear relevant pictures. The dimensionality of emotion was not specifically addressed when threat was operationalised. However, it would appear that fear relevant stimuli (i.e., snakes and spiders) are inherently more arousing than the non-fear relevant stimuli (i.e., flowers and mushrooms). This is important, as it may be possible to explain the results of experiments that support the evolutionary threat hypothesis by the arousal hypothesis.

Buodo, Sarlo, and Palomba (2002) compared threatening and high arousal stimuli in a reaction time task. The threatening pictures (e.g., attack/violence) were equated on level of arousal with the other type of high arousal negative pictures (e.g., blood/injury). Two types of high arousal positive images were also included in the design (e.g., adventure/sport & erotic) and equated on level of arousal. Neutral pictures consisted of images of household items. The task required participants to press a button when they heard a tone presented while viewing each picture. Results indicated that reaction times were significantly delayed ($p < .0001$) while viewing images of blood/injury and erotica compared to threat and adventure/sport.

The Buodo et al. (2002) study demonstrated that threatening images delayed reaction times more than neutral pictures. Although this finding corroborated the results of Ohman and Flykt et al. (2001), Buodo et al. also demonstrated that this effect was modulated by the level of arousal of the stimulus types. Therefore, while threatening images are important for fast perception and continued processing, this may be explained by the level of arousal of the particular threatening stimuli, and not necessarily by a categorical association with evolutionary threat.

In light of the evidence of Buodo et al. (2002), it is possible to argue that the evolutionary threat hypothesis may be explained by the concept of arousal. Thus the evolutionary threat hypothesis may be conceptualised as subsisting under a broader arousal hypothesis. Although evolutionary threat does not necessarily explain the facilitation received by high arousal positive stimuli, it may be thought of as an explanation having specific relevance to instances of high arousal threatening, and therefore negative, stimuli.

The arousal hypothesis has been attributed to the work of Bradley, Lang and colleagues (e.g., Bradley & Lang, 2007a, 2007b). These individuals have research programs

extending from across the behavioural (e.g., Anderson, 2005) to the physiological domains (e.g., Adolphs, 2004; Bradley, Codispoti, Cuthbert, & Lang, 2001; Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Kensinger & Schachter, 2006; Mourao-Miranda et al., 2003). This work has led to the development of the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005), the Affective Norms for English Words database (ANEW; Bradley & Lang, 1999a), and the International Affective Digitised Sounds system (IADS; Bradley & Lang, 1999b) all rated in terms of valence and arousal. Much of the research investigating both valence and arousal uses these databases to gain accurate measurement and control over the stimulus dimensions.

On a behavioural level, Anderson (2005) used the attentional blink (AB) task to compare the effects that valence and arousal have on perception. In this task, the participant viewed a series of stimuli (e.g., words presented one after the other) and reported, in this case, two target words highlighted in the colour green. The attentional blink effect is observed when the report of the second target word is delayed. As the time between (i.e., lag) the targets decreases, the delay in reporting the second target increases. This is thought to be a result of impaired encoding of the second target.

The relative salience of valence and arousal on emotional performance may be assessed using this paradigm by manipulating the stimulus dimensions of the second target word (Anderson, 2005). The second target words that were arousing (either positive or negative) showed a reduction in delay, compared with non-arousing stimuli. The results of two experiments showed that at each increase in arousal (i.e., from neutral, to positive/negative to high arousal positive/negative), the effects of lag systematically diminished. These results provide evidence for the arousal hypothesis as both high arousing positive and negative arousing words were detected faster and more accurately than low arousing and neutral words (Anderson, 2005).

One limitation of the Anderson (2005) study was that a direct comparison of positive and negative stimuli was not carried out as the two experiments examined each dimension separately. To definitively assess the effects of arousal over valence, the attentional blink effect would have to be demonstrated to be equal for positive compared to negative stimuli.

Although using a different task to that of Anderson (2005), Schimmack (2005) directly compared positive and negative valence within the same experiment. Schimmack compared the emotional effects of valence and arousal on cognitive performance. In two experiments, Schimmack tested the relative contribution of categorical negativity, arousal, and evolutionary threat to cognitive performance using two different reaction time tasks. The first task required the participant to solve maths problems either before, after or during, seeing an emotional picture. Results indicated that reaction time was significantly delayed when solving math problems ($p < .001$) only in response to the highly arousing pictures. The effect of arousal was confirmed in the results of the second task, requiring participants to indicate the location of a line located either above or below an emotional picture. In comparison to the other picture types, when the line was presented bordering a high arousal picture, reaction time was significantly delayed ($p < .0001$).

The effects of arousal over valence have therefore been demonstrated on two levels. Schimmack (2005) demonstrated how emotional stimuli impair performance on a secondary task (i.e., math problem and line detection), whereas Anderson's (2005) showed that emotional stimuli facilitated detection performance. Taken together, the evidence provided by Anderson and Schimmack demonstrated the importance of arousal on emotion, over and above the effects elicited by low arousing, valenced stimuli. Highly arousing stimuli were detected faster (Anderson, 2005) and significantly impair cognitive performance (Schimmack, 2005). Both of these investigations are inconsistent with the categorical negativity hypothesis as arousing stimuli had similar effects whether they carried a positive or negative valence.

Moreover, this pattern of results is not compelling for the evolutionary threat hypothesis because, as Buodo et al. (2002) demonstrated, negative stimuli which have a higher arousal level than threatening stimuli interfere more in task performance. Furthermore, Schimmack found no evidence for task performance interference on the snake picture trials.

There is also substantial evidence for arousal on the physiological level of analysis. For example, Kensinger and Schacter (2006) found a pattern of increased and strengthened activation of the amygdala in response to highly arousing information, irrespective of valence. Similarly, Bradley et al. (2003) found heightened activation of the occipital cortex when individuals viewed highly arousing pictures, in comparison to low arousing pictures. There is also substantial evidence for modulation of the startle reflex, cardiac deceleration, skin conductivity and event recorded potentials by high versus low arousing stimuli (Bradley & Lang, 2007a; Bradley, Codispoti, & Cuthbert et al., 2001; Cuthbert et al., 2000).

It seems reasonable to assume that a task that directly accesses emotion might yield more information regarding the relative salience of valence and arousal. If such an alternate task were to be conducted, it would be preferable to use a simple rating task, rather than having to deal with the complexities of secondary interference tasks as used by Schimmack (2005).

Work in this area should further adopt standardised operational definitions of valence and arousal, to make results comparable across studies and research laboratories. The International Affective Picture System (Lang et al., 2005) provides this opportunity, as it is a database compiled of pictures rated by both male and females, with standardised ratings of both valence and arousal.

Additionally, it would appear that this area may benefit from an individual differences approach. As Kosslyn et al. (2002) note, a full appreciation of a psychological effect cannot

be gained alone from group research. The nomothetic approach can provide an area with general knowledge about trends and reactions shared by people, and with the further integration of an individual differences perspective, more can be learnt about the intricacies of these phenomena (Kosslyn et al., 2002). Indeed, one of the only consideration for individual differences in this literature has been that between males and females, as when people look at pictures there are significant differences mainly in the areas of highly arousing negative (e.g., blood/injury) and highly arousing positive (e.g., erotica) stimuli for males and females (Bradley, Codispoti, Sabatinelli, & Lang, 2001). Therefore, in addition to group based research, what is needed in this area is an approach that takes individual differences into account in the processing of valence and arousal.

The rationale for this present exploratory research was to directly measure emotion using a rating scale, and to incorporate individual differences into the analysis. Participants were asked to complete a simple judgement task of emotional pictures drawn from a standardised database systematically varied on levels of valence and arousal. It was hypothesised that highly arousing images, despite their positive or negative valence, will determine the emotionality rating. This would be consistent with the arousal hypothesis (Bradley & Lang, 2007a). In contrast, the categorical negativity hypothesis (Pratto & John, 1991) would provide a strong prediction that negatively valenced images determine the emotionality rating, irrespective of arousal. With respect to the evolutionary threat hypothesis, although the experiment was not designed to test it directly using naturalistic threat stimuli, it would be expected that arousing negatively valenced images would determine the emotionality rating. In addition, and in accordance with the Kosslyn et al. (2002) argument to include individual differences, it is hypothesised that the analysis integrating individual differences will account for more of the explained variance in

emotionality ratings in comparison to the analysis based on group ratings of valence and arousal.

Method

Design

A within-subjects design was used, where the dependent variable was operationalised as the participant's rating of the overall emotional quality of the picture. There were five levels of the independent variable. Specifically, there were high arousal negative and positive pictures, low arousal negative and positive pictures and neutral pictures.

Participants

Thirty female participants (ages: $M = 34.6$ years, $SD = 11.7$ years) were recruited from the psychology student population of Edith Cowan University (ECU). All participants had normal or corrected to normal vision. Males were excluded in this study because of the significant gender differences found when viewing emotional pictures (Bradley et al., 2001)

Materials

The stimulus presentation software, SuperLab version 4.0 (Cedrus Corporation, 2006), was used to undertake the experiment. The stimuli were drawn from the female subjects list of the International Affective Picture System (Lang et al., 2005). As evident in Figure 1 below, stimuli were rated by valence and arousal, and placed into five categories: high arousal positive and negative stimuli, low arousal positive and negative stimuli and neutral stimuli. There were nine pictures in each category, making a total of 45. Each picture was displayed the size of the computer screen (1024 x 768) pixels.

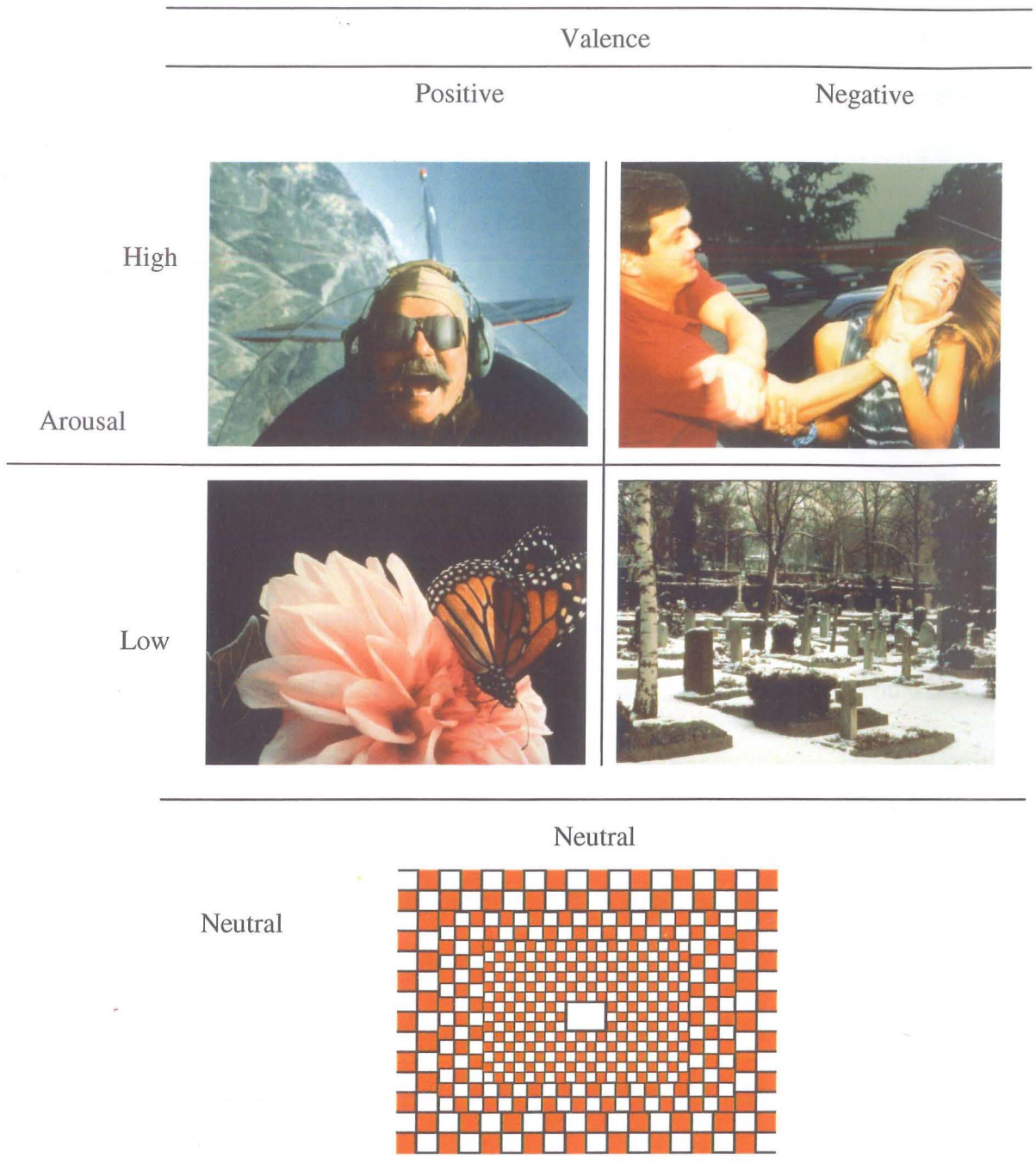


Figure 1. Examples of each of the five picture types: high arousal negative, high arousal positive, low arousal negative, low arousal positive and neutral.

The IAPS ratings range from 1 to 9. A rating of 1 on the valence dimension indicates negative emotion, whereas 9 represents positive emotion. On the arousal dimension, 1 to 9

represents low to high arousal. To select the pictures for this study, both valence and arousal lists were separated into three categories. To control for valence, pictures rated from 1 to 4 were classified as negative, ratings from 4 to 6 were considered neutral and ratings from 6 to 9 were considered positive. To control for arousal, pictures rated from 1 to 4 were considered low arousing, ratings of 4 to 6 were classified as neutral and 6 to 9 indicated a high level of arousal.

After the list had been rated in order of both valence and arousal, the list rated by arousal was further divided into separate lists for low, neutral and high arousal pictures. The low and high arousal lists were then sorted according to valence. As a product of this process both high and low arousal lists were separated to represent high arousal positive (HAP), high arousal negative (HAN), low arousal positive (LAP) and low arousal negative (LAN). Neutral stimuli were selected through the same process, and represented values between 4 and 6 on both valence and arousal dimensions.

Each stimulus list was ranked from the highest rating to the lowest rating in each of the five sets. There were two picture selection criteria. These criteria mainly affected selection from the high arousal lists. First, of the positive lists, erotic content (e.g., candid sex scenes, complete nudity of same or opposite sex models) was excluded. Second and concerning the negative lists, mutilation (e.g., victims of disease) and excessive blood/injury (victims of attack/natural disaster) picture content were excluded. Therefore, pictures were selected from the top of each list in a descending order, pending their relation to content of the above criteria.

As evident in Figure 2, the five-point Self Assessment Manikin (SAM) was used as the rating instrument for each picture (Lang et al., 2005). The SAM was used to rate the pictures in the IAPS database and can be used as a five point or nine point rating scale. It is

noted that the IAPS pictures were originally rated using the nine point scale, however the five point was considered more appropriate for this task as it was considered a simpler choice response for participants. In addition, Lang et al. (2005) implies that either scale may be used. In the present experiment a low rating corresponded to more highly emotional, high intensity, and positivity. This represents a point of departure from Lang et al. (2005), where a low rating would correspond to a low intensity and extreme negative valence.

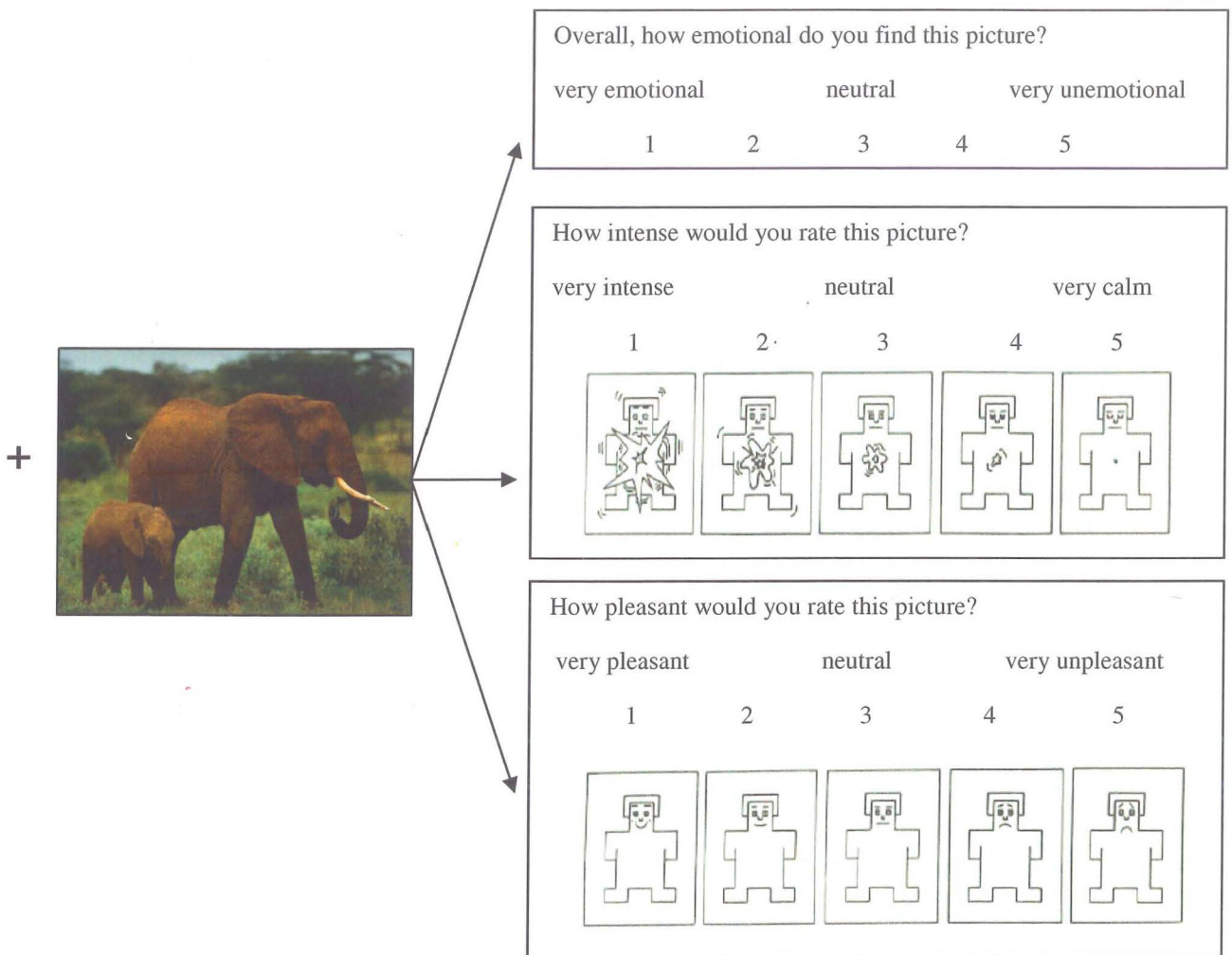


Figure 2. This illustrates the process of one trial. The fixation remained on the screen for 1 second, immediately followed by the affective picture for a duration of 4 seconds. The emotionality question always appeared first after the picture, followed by either the arousal question or valence question.

Procedure

Participants were tested individually in quiet rooms in the Psychology department. After signing the consent form and filling out demographic information, the participant read the instructions (see Appendix A). The instructions were adapted from those given in the original testing for the compilation of the IAPS pictures (Lang et al., 2005). The instructions stated that after viewing each picture, the participant would have to rate each picture in terms of general emotionality, valence, and arousal. One slide was shown on the computer screen to illustrate the correspondence of each of the five points to the figures on the SAM scale. After the participant had read the instructions, the process was explained again and any questions answered before they commenced the task.

The task began with a practice phase consisting of four trials. The experimental phase began immediately after the practice. Trials started with a fixation point that remained on the screen for one second. Following this, the picture was presented for 4 seconds, followed immediately by the three test questions. The trial waited for a response for each of three decisions (emotionality, valence and arousal).

The first question on each trial related to the overall emotional quality of the image (i.e., overall, how emotional do you find this picture? 1 = very emotional; 2 = emotional; 3 = neutral; 4 = unemotional; 5= very unemotional). The second question addressed how arousing the participant found the picture (i.e., ‘how intense would you rate this picture?’ 1 = very intense; 2 = intense; 3 = neutral; 4 = calm; 5= very calm), and the third question asked how pleasant the participant found the picture (i.e., ‘how pleasant would you rate this picture?’ 1 = very pleasant; 2 = pleasant; 3 = neutral; 4 = unpleasant; 5= very unpleasant).

Each of the three blocks consisted of fifteen trials, corresponding to the presentation of 15 images per block, with three examples of each of the five stimulus types per block (i.e.,

three high arousal positive, three high arousal negative, three low arousal positive, three low arousal negative and three neutral). The presentation order of the pictures was randomly generated for each participant on each trial to control for order effects. Moreover, the order of the dimensionality questions (valence and arousal) was counterbalanced, as half of the participants received the arousal question before the valence question and the other half received the valence question before the arousal question. The task took approximately 15 minutes to complete.

Analysis

Given the nature of a within-subjects design, equal cell sizes for the IAPS rated data set were obtained, but unequal cell sizes were obtained for the individually rated data set. This occurred because respondents had the freedom to rate arousal and valence, dependent on their own experience. In the present study, the individual differences were large ($n = 449$ high arousal negative group; $n = 159$ high arousal positive group; $n = 143$ low arousal negative group; $n = 368$ low arousal positive group). One recommended option if the differences are large is to make group sizes equal (Field, 2005) and accordingly, the frequency of responses in each of the cells were made equal using the SPSS data function. This process involved the random selection of 143 cases, being the minimum group size, out of the HAN, HAP, and LAP columns. This resulted in a balanced design, where $n = 143$.

Both the IAPS and individual based data were significantly skewed. In the IAPS based analysis, each of the picture types were positively skewed $p < .05$. For the individual based analysis, each picture type was positively skewed $p < .05$, except for the low arousal negative picture type displaying a negative skew. Variances in both analyses were unequal between groups $p < .05$. For these reasons, non-parametric statistics were used to analyse the data.

Friedman's test was conducted where the HAN, HAP, LAN and LAP were treated as four levels of picture type. Wilcoxon signed-rank test computed the equivalence of main effects for arousal and valence, and was also used as the post-hoc statistic.

These non-parametric tests do not automatically produce effect size analyses. Because of this, Cohen's d was calculated for valence and arousal to ascertain the size of the effect and then how much variance could be explained by each. Cohen's d was calculated using the row and column means and standard deviations for both variables. The contribution of each of the cell comparisons was obtained the same way. Once Cohen's d was obtained, the relevant percentage overlap between the two distributions was calculated to obtain percentages of explained variance.

Results

General Overview

The data were organised in four phases. First, a group analysis using the IAPS ratings of valence and arousal was conducted. Second, a group based analysis using individual ratings of the dimensions of valence and arousal was carried out. The third phase compared the effect sizes and explained variance from phases I and II, and the fourth phase reports a confirmatory means based analysis on the individual data.

From the phase I analysis, results showed that arousal explained 11.6% of the variance in emotionality ratings compared to the 1.4% explained by valence. The second phase of the analysis which incorporated individual differences was able to explain considerably more variance (almost 15%) in the emotionality ratings in comparison with the IAPS based analysis. For both the IAPS and individually based analysis, valence and arousal had a significant effect on emotionality rating $p < .05$.

Phase I: Analysis Using the IAPS Ratings of Valence and Arousal

The analysis based on the IAPS ratings of valence and arousal showed the dominating effect of arousal over valence in explaining emotionality ratings. Friedman's test displayed an overall significant effect of picture type on emotionality rating $\chi^2(3) = 225.02, p < .05$. The Wilcoxon test revealed a significant main effect of arousal $T = 13\,780.5, p < .05$ indicating that both high arousal negative ($M = 1.55, SD = 1.01$) and positive ($M = 2.18, SD = 1.13$) pictures were rated as significantly more emotional compared to the low arousing negative ($M = 2.78, SD = 1.34$) and positive ($M = 2.76, SD = 1.32$) pictures.

Individual cell comparisons using the Wilcoxon test showed that the high arousal negative pictures were significantly more emotional compared to the low arousing negative ($T = 2239$) and positive images ($T = 2428.5$). In addition, the high arousal positive pictures were significantly more emotional compared to the low arousal negative ($T = 4071.5$) and positive pictures ($T = 4589$). The Bonferroni procedure is recommended to correct for the number of tests being conducted ($\alpha/\text{number of comparisons}$; Field, 2005). Therefore, the significance values are at the Bonferroni corrected level of .008.

The effect of valence on emotionality rating was also significant $T = 18\,831.5, p < .05$. This indicated that negative pictures, across levels of arousal were rated as more emotional than positive pictures. This effect was caused by a difference in valence at the level of the high arousal condition only ($T = 2461$), and not at the level of low arousal ($T = 6784.5, n.s.$). This trend is evident on Figure 3 below.

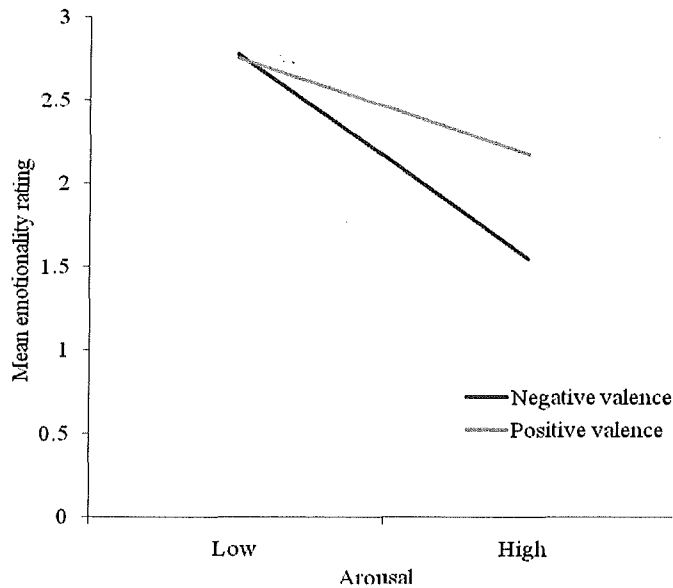


Figure 3. Estimated marginal means for each of the four picture types from the IAPS based analysis. Note that a smaller number on the y-axis (emotionality rating) represented a higher emotionality. The figure shows a main effect of arousal, as well as an effect of valence, but only at the level of high arousal.

The size of the main effects results were computed using Cohen's d (Cohen, 1988; Howell, 2002). The effect of arousal was medium, $\kappa = -0.727$ explaining 11.6% of the variance in emotionality ratings, in comparison to a small effect of valence $\kappa = -0.244$ accounting for 1.4% of the variance in emotionality ratings.

Turning to the cell comparisons, there was a large significant difference between the high arousal negative pictures and both low arousal positive and negative pictures (see Table 1 below). There was a medium difference between the high arousal positive pictures and the low arousal pictures. A small and non-significant difference was found between positive and negative valence at the level of low arousal.

Table 1

Measures of Effect Size for the IAPS Based Comparisons

Comparison	κ	r	r^2
HAN-HAP	-0.586*	-0.281	7.8%
HAN-LAN	-1.035*	-0.459	21%
HAN-LAP	-1.028*	-0.457	20.8%
HAP-LAN	-0.483*	-0.234	5.4%
HAP-LAP	-0.471*	-0.229	5.2%
LAN-LAP	0.015	0.007	0%

Note. * Indicates significant comparison at $p < .008$

Phase II: Analysis Using the Individual Based Ratings of Valence and Arousal

There was an overall effect of picture type on emotionality rating using the Friedman's test $\chi^2(3) = 171.60, p < .05$. There was a main effect of arousal, $T = 1988, p < .05$ indicating that both the highly arousing negative ($M = 1.66, SD = .98$) and positive ($M = 1.83, SD = .91$) pictures were considered significantly more emotional compared to both low arousing negative ($M = 3.5, SD = 1.28$) and positive ($M = 2.85, SD = 1.31$) images.

These results were confirmed when cell by cell comparisons were made. Identical to the phase I analysis, a Bonferroni correction was used and therefore, results are reported at a significance level of .008. The high arousing negative pictures were rated as significantly more emotional than the low arousing negative pictures ($T = 361$) and the low arousing positive pictures ($T = 583.5$). The high arousing positive pictures were also rated as significantly more emotional than the low arousing negative ($T = 118.5$) and positive pictures ($T = 656$).

Valence was also significant $T = 6518.5, p < .05$. However, this significance arises from the difference at the level of low ($T = 1347$), not high arousal ($T = 1391$, n.s.) as evident on Figure 4 below.

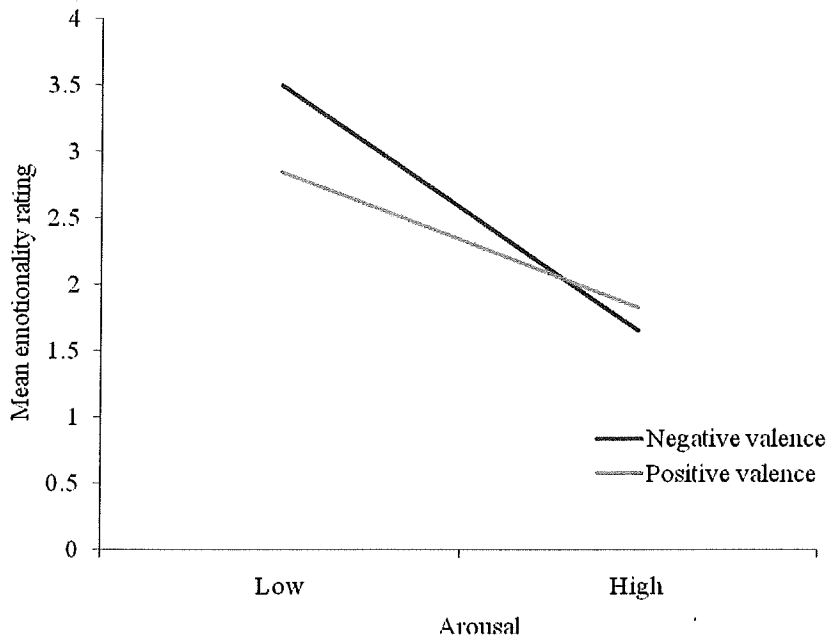


Figure 4. Estimated marginal means for each of the four picture types from the individually based analysis. Note that lower ratings on the y-axis (emotionality) denotes an increased emotionality. The figure shows the same general trend as shown in Figure 3, with a significant effect of arousal. The effect of valence, however, is seen in the low arousal conditions, rather than the high arousal conditions depicted in Figure 3.

The main effect of arousal was large $\kappa = -1.235$, and explained 27.5% of the variance in emotionality ratings. The effect of valence was small $\kappa = .182$, explaining $< 0.1\%$ of the variance in emotionality ratings.

Effect sizes were calculated for each of the four conditions. The two largest differences in emotionality ratings were between the low arousal negative pictures and both the high arousal negative and positive pictures (see Table 2 below). There was also a large difference between low arousal positive pictures and both high arousal negative and positive pictures.

The significant difference between the low arousal positive and negative pictures was a medium effect, and at the level of high arousal the difference in valence was small.

Table 2

Measures of Effect Size for the Individual Based Comparisons

Comparison	κ	r	r^2
HAN-HAP	-0.179	-0.089	0%
HAN-LAN	-1.612*	-0.627	39.3%
HAN-LAP	-1.026*	-0.456	20.7%
HAP-LAN	-1.500*	-0.600	36%
HAP-LAP	-0.901*	-0.410	16.8%
LAN-LAP	0.500*	0.242	5.8%

Note. * Indicates significant comparison at $p < .008$

Hence, the size of the comparisons confirms the dominance of arousal over valence, with respect to determining emotionality. That is, the largest differences existed between the high arousal versus low arousal conditions, while only small and medium effects were evident between valence at the level of low and high arousal.

Phase III: Patterns of Individual Difference

The third phase of the analysis concentrated on the further sensitivity gained when using individual differences, compared with a nomothetic approach. In particular, the question posed in the introduction, was whether an individual differences approach was able to account for more of the variance in emotionality ratings compared to the ratings of valence and arousal by the IAPS. This question was posed at an exploratory level and was approached by the simple method of looking at the difference between the capabilities of the IAPS rated data compared to the individually rated data to explain the variance in emotionality ratings.

As illustrated on Figure 5 most of the variance is explained by arousal, a trend that is heavily accentuated when individual differences are considered. Using the individual dimensionality ratings, arousal explains 27.5% of the variance, in comparison to the 11.6% explained by arousal in the IAPS based analysis. Furthermore, the individual analysis shows the magnitude of the effect of valence. That is, whereas in the IAPS analysis valence accounted for 1.4% of the variance, the individual analysis shows valence as explaining < 0.1% of the variance in emotionality ratings.

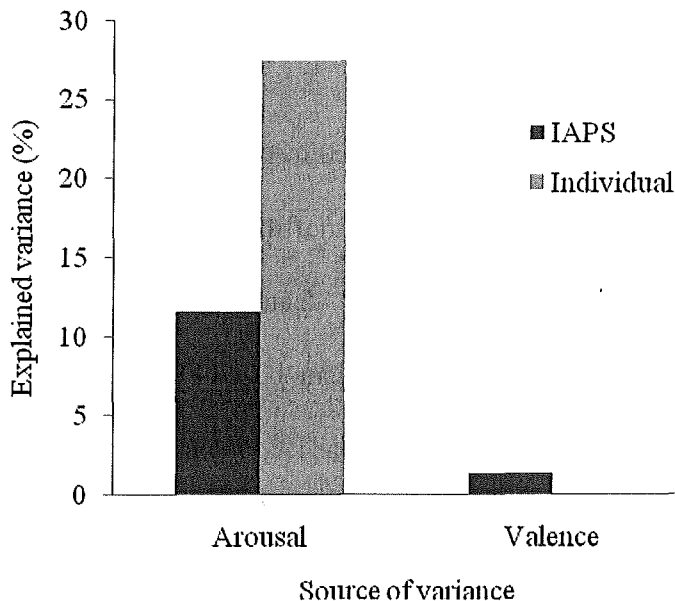


Figure 5. Variance in emotionality rating accounted for by valence and arousal in both phases of analysis. The individually based analysis accentuates the dominance of arousal over valence. The overall clarity achieved by an individual based approach is also evident with the increase of almost 15% of explained variance attributed to the analysis based on individual dimensionality ratings.

The analysis using the individual ratings of valence and arousal was able to explain more of the variance in comparison to the results based on the IAPS ratings. This is indicative of the increased sensitivity and power of the individually based analysis.

Given the enhanced sensitivity of the design when incorporating individual differences, it would be expected that variability would be reduced, compared with the nomothetic IAPS analysis conducted in phase 1. The results showed that the variability at the level of high arousal was reduced. That is, compared to the standard deviations of the high arousal pictures from the IAPS analysis (HAN $SD = 1.01$, HAP $SD = 1.13$), those from the individual analysis were smaller (HAN $SD = .98$, HAP $SD = .91$). This further evidence demonstrates how additional variance was explained when incorporating individual differences into design and methodology.

Phase IV: Means Based Analysis

There was also a marked difference in the frequency that each picture type was judged in the individual analysis. If each person had perceived and rated the pictures identical with the objective IAPS ratings, there would have been a total of 270 ratings per picture type. However, this was not the case as 449 pictures were rated as high arousal negative, 159 as high arousal positive, 143 as low arousal negative and 368 as low arousal positive. These differences were significant $\chi^2(7) = 2.543E2, p < .05$.

As a consequence of this, each row in the individual analysis did not necessarily represent one individual's results. It could, for example, be argued that the phase II results were dominated by individuals who used the low arousal negative response category, and therefore may have confounded the results. To rule out potential biases in the main analysis, a means test was conducted. This involved taking the mean score of each picture type for each individual so as to have each row representing one person's results. This procedure ensures that equal weight is given for all respondents in the design, and was considered superior to a parametric approach such as regression, which would have given more weight to those individuals who had contributed more to certain response categories.

The Wilcoxon test revealed that arousal had a significant effect on emotionality ratings $T = 272, p < .05$. Valence was not significant $T = 766, p > .05$. This result is consistent with the results reported thus far, and the ability of the analysis based on individual raw scores to increase the sensitivity of the design.

Summary of Results

Taken together, each analysis was consistent with the dominance of arousal over valence in explaining emotionality ratings. In addition, the increased effect sizes and explained variance in the individually based analysis demonstrated the importance of taking individual differences into account.

Discussion

High arousal stimuli, both positive and negative, were hypothesised to be rated as more emotional in comparison to the low arousing positive and negative pictures. The results from the phase one IAPS analysis show that highly arousing images were found more emotional in comparison to the low arousing stimuli. For the highly arousing stimuli, negative valence impacted more on emotionality rating than positive valence. These results are partly consistent with the categorical negativity hypothesis (Pratto & John, 1991), the evolutionary threat hypothesis (Ohman & Flykt et al., 2001) and are consistent with the arousal hypothesis (Bradley & Lang, 2007a, 2007b).

The additional consideration of individual differences explained more of the variance in emotionality rating compared to a nomothetic analysis based on the IAPS ratings. These results are consistent with the argument made by Kosslyn et al. (2002), that statistical inclusion of individual differences can lead to increased explained variance.

Theoretical Implications from the Nomothetic Analysis (Phase I Results)

The IAPS based analysis found that both valence and arousal had a significant effect on emotionality rating $p < .05$. However, as predicted, it was the highly arousing stimuli that had the biggest effect on emotionality ratings, explaining 11.6% of the variance in comparison to the 1.4% explained by valence. The overall trend indicated that the highly arousing stimuli were rated as more emotional compared to the low arousing stimuli.

These results have implications for the categorical negativity, evolutionary threat and arousal hypotheses. The categorical negativity hypothesis (Pratto & John, 1991) would have predicted that the negative stimuli (high and low arousal) would have had the biggest effect on emotionality ratings, and be perceived as the most emotional pictures in comparison to the positive stimuli. These predictions were not supported, as both positive and negative highly arousing stimuli explained more of the variance and were rated as more emotional compared to the low arousing stimuli. In addition, the low arousal negative stimuli were rated as less emotional compared to the low arousing positive stimuli, a finding not consistent with the categorical negativity hypothesis.

Although the main findings contradict the predictions this hypothesis would make, valence was still found to have a significant effect on emotionality rating. This may be attributed to the result that the high arousing negative stimuli were found more emotional than the high arousal positive stimuli. This indicates that the positive stimuli, even though highly arousing were not found as emotional as the negative stimuli. This interaction suggests an avenue for further study. A replication of the Pratto and John (1991) study taking arousal into account, and specifically searching for an interaction would help to clarify these issues.

This general trend for negative stimuli to be given more weight in the perceptual system is noted by many studies in the area. For example, Bradley and Lang (2007a) explain

that although humans generally have both a positive and an approach oriented disposition, when a highly arousing negative event is perceived, a rapid defensive and avoidant disposition takes over. They argue that this is consistent with physiological evidence demonstrating the existence of separate approach and avoidance systems. The avoidance system is particularly well tuned to high arousing negative stimuli (Bradley & Lang, 2007a).

The results of this explorative study confirm results indicating that arousal has a greater influence than valence. For example, in the attentional blink study by Anderson (2005), both the highly arousing negative and positive targets received perceptual facilitation in comparison to the low arousing and neutral targets. In addition, Schimmack (2005) reported that both positive and negative highly arousing stimuli led to greater delayed reactions when solving maths problems and detecting the location of a line, in comparison to low arousing stimuli.

Although both Anderson (2005) and Schimmack (2005) tested the predictions made by the categorical negativity hypothesis they found no evidence for a negativity bias. The present study did find a negativity bias, and this is consistent with the categorical negativity hypothesis. Given this result, it is recommended that further research be conducted to replicate and extend Pratto and John's (1991) design. The results of this exploratory study may also have implications for the evolutionary threat hypothesis. This study did not explicitly test the evolutionary threat hypothesis as specific *threatening* stimuli were not operationalised or included in the design. However, as noted by Kensinger and Schacter (2006), threatening stimuli are generally arousing stimuli. Moreover, there is physiological evidence that the amygdala although traditionally conceptualised as responding mainly to fear evoking stimuli, has a broader role in processing highly arousing information, regardless of its valence (e.g., Anders, Lotza, Erb, Grodd, & Girbaumer, 2004; Kensinger & Schacter, 2006). As a consequence, it is possible to argue that the arousal hypothesis can encapsulate the

evolutionary threat hypothesis. That is, the finding (i.e., Ohman & Flykt et al., 2001; Ohman & Lundqvist et al., 2001) that angry faces, snakes and spiders receive perceptual facilitation in comparison to neutral faces, flowers and mushrooms is consistent with what the arousal hypothesis would predict. This is because the threatening stimuli were more arousing than the non-threatening stimuli, and it was the arousal that led to the facilitation effect, rather than the threatening nature itself. Further exploration of the effects of threatening, but not arousing stimuli would be helpful to better understand the explanatory power of the evolutionary threat hypothesis.

Schimmack (2005) directly compared the effects of ecologically threatening stimuli (snakes) and other highly arousing stimuli (a battered woman). That study found that the ecologically threatening stimuli did not result in greater interference in task performance. However, it is possible that because the ecologically threatening and other arousing pictures were not equated on arousal, that the arousing pictures were more arousing than the snake pictures. Indeed, on the threat trials, performance was actually enhanced, a contradictory finding especially within the context of an interference task. A replication and extension of the Schimmack task would allow for further experimental investigation of the relative contribution to emotion of ecological threat and arousal.

Buodo et al. (2002) directly compared highly arousing negative pictures (e.g., scenes of blood/injury), threatening pictures (e.g., scenes of violence/attack), highly arousing positive stimuli (e.g., erotic scenes & sport/adventure) and neutral stimuli (e.g., household items). The highly arousing negative and positive pictures were equated on levels of arousal. In a reaction time task, the highly arousing negative pictures of blood/injury and the erotic pictures delayed reaction time in comparison to the threat, sport/adventure and neutral pictures ($p < .0001$). This result is consistent with the proposal that arousal is a more important dimension than threat in determining emotion. That is, although these picture types

were equated on level of arousal, the blood/injury and erotic pictures interfered more in task performance compared to the threatening pictures and the other high arousal positive images. Instead of interpreting this result from an evolutionary threat perspective, these results make sense from an arousal hypothesis perspective. That is, although objectively rated as equal on level of arousal, the blood/injury images were found to be more arousing than the threat scenes.

The present results and previous literature (e.g., Anderson, 2005; Buodo et al., 2002; Schimmack, 2005) suggests that the evolutionary threat hypothesis is supported when understood in terms of a general arousal hypothesis framework. It has been argued that threatening stimuli attracts more attention than non threatening stimuli, but only if they are more arousing than those non-threatening stimuli. It is recommended that this hypothesis be tested to allow for further understanding of the role of arousal and threat.

In the present results, arousal explained an additional 10% of the variance in emotionality ratings when compared to valence. This result is supported on the behavioural level as evidenced above, in addition to the findings from physiological studies that indicate the importance of arousal in comparison with valence (Bradley & Lang, 2007a, 2007b).

There are a number of neurological studies demonstrating differential brain activity when participants view high versus low arousing stimuli. Regarding the amygdala, Kensinger and Schacter (2006) found that the amygdala responded more to highly arousing pictures despite their positive or negative valence. Bradley et al. (2003) monitored functional activity in the occipital cortex and similarly found both increased and stronger activation in this region for highly arousing pictures compared to low level arousing positive and negative pictures. These increased patterns of activation are stipulated to represent the importance of stimuli perceived to be highly arousing (Bradley & Lang, 2007a).

Cuthbert et al. (2000) specifically relate changes in event-related potential (ERP) to increased perceptual processing of emotionally relevant stimuli. They measured participants' ERP, skin conductance and affective report for a variety of emotional pictures controlled on levels of valence and arousal. Results indicated that ERP activity was increased for those pictures rated as more highly arousing, in addition to evoking higher skin conductance responses. These results were interpreted as being evidence for the enhanced perception and processing of stimuli perceived to be highly arousing and therefore important for the individual.

Bradley, Codispoti, and Cuthbert et al. (2001) showed that highly arousing stimuli affect a number of different physiological measures apart from skin conductance. For example, while participants viewed high arousal images, there were marked increases in skin conductance, cardiac deceleration, and the startle reflex in comparison with viewing low arousing images. The patterns of activity in the facial muscles were however, found to vary with picture content as opposed to being modulated by the arousal level of the picture.

Therefore, there appears to be considerable physiological evidence that arousal is a primary contributor to task performance. However, it is acknowledged in the work of Bradley and Lang (2007a, 2007b) that valence is also important in terms of determining the direction of behaviour, with the arousal determining the strength of that behaviour enacted in a particular direction. In this way, both valence and arousal are important for different reasons.

It follows that the relations between behavioural and physiological studies nevertheless provide a strong case for the effects of arousal on emotion and performance, from perception (Cuthbert et al., 2000), neurological processing (Bradley et al., 2003; Kensinger & Schacter, 2006), autonomic reactions (Bradley, Codispoti, & Cuthbert et al., 2001; Lang, Greenwald, Bradley, & Hamm, 1993) to behavioural responses (Anderson, 2005;

Schimmack, 2005). The present exploratory study shows a similar pattern when emotion is directly rated.

Theoretical Implications from the Individual Differences Analysis (Phase II and III Results)

The results based on the individual ratings of valence and arousal followed the same general pattern as that for the nomothetic IAPS based analysis. That is, both valence and arousal were significant, but arousal explained 27.5% of the variance, while valence explained < 0.1%. When the explained variance is compared across both analytic procedures, it was found that the individual based analysis could explain almost 15% more of the variance in emotionality rating than the nomothetic, IAPS based analysis. This is consistent with Kosslyn et al. (2002), in that inclusion of individual differences leads to increased understanding. The additional variance explained derived from the more sensitive design that incorporated individual differences, and so reduced error variance was obtained across each level of valence and arousal compared to the first phase of analysis.

Kosslyn et al. (2002) argued that the nomothetic and idiographic approaches to research should be complimentary, not opposing. Group research can provide extensive information as to general trends and patterns common to all individuals. However, an individual differences perspective can be integrated in order to increase the applicability of developing theories and to enrich our understanding of these general themes.

An important issue in the individual differences data, was that the individual based analysis revealed a different pattern of interaction compared to the IAPS based data. For the IAPS based data, there was marked variation at the level of high arousal and small variation at the level of low arousal. For the individual based analysis the variation was reduced at the level of high arousal and increased at the level of low arousal. This result would be expected, given that the second phase explained more variance and was better able to account for the

results. It might tentatively be concluded that the perception of the low arousing stimuli is subject to greater individual differences compared to the strength of the nomothetic trend at the level of high arousal. Further replication and extension of the statistical procedures employed in this study would test this provisional conclusion.

The increased sensitivity of a design that incorporates individual differences was also demonstrated in the finding that both valence and arousal had a significant effect on emotionality rating. As indicated earlier, valence is not often detected as a significant influence on task performance. Indeed, when the current data were analysed according to the mean scores for each category across each individual, arousal showed the only significant effect on emotionality rating. Therefore, although the effect size is consistent with the view that arousal is dominant, valence is also of importance, as indicated by the individual differences analysis.

On an exploratory level, the results of this present study demonstrate the power of incorporating individual differences into a research design. Although the strongest and general trends will emerge from group based research (i.e., effect of arousal from the IAPS based analysis), the extent of these effects are accentuated in individually based analysis.

Limitations and Recommendations for Further Research

There were at least four main limitations of the current design. Carry over effects stemming from the high arousal negative stimuli may have led to a response bias in dimensionality ratings. Second, the all female sample may have accentuated this bias as it is documented that women respond more strongly to negative stimuli. Third, the subjective nature of the study and fourth, because this study used a task that tested a relatively late stage of processing, there is much potential for investigations into the very early perception of emotional stimuli.

The response bias was evident from the individual based analysis where 449 pictures were rates as high arousal negative, 159 as high arousal positive, 143 as low arousal negative and 368 as low arousal positive. If participants had rated them identical to the IAPS, there should have been 270 ratings for each picture type. It is interesting to note that some individuals did not use the low arousal negative classification, and their responses were dominated by high arousal negative classifications.

This distribution of ratings may be evidence of a carry-over effect. Carry over effects refer to stimuli from one trial influencing ratings in subsequent trials. It is possible that the participant's perception of the high arousing negative pictures acted as a perceptual benchmark from which all other pictures were judged. This would have lead to a lower frequency of low arousal negative stimuli, as these picture types were perceived as more highly arousing. It may also have led to many of the high arousal positive images being perceived as less arousing, which would then account for the increased frequency of the low arousal positive picture type.

These results can be explained by the concept of context effects (Godden & Baddeley, 1980). The current experiment was the context, and within this context participants established perceptual anchors. Prototypical highly arousing negative pictures became points at which to make judgements about the dimensional and affective quality of all other pictures. This context became dominated by the affective quality of the high arousal negative images. Because of this, more of the low arousing negative pictures were seen as more arousing, and in comparison to the high level of negative arousal not many pictures were perceived as highly arousing positive.

The problem with these unequal frequencies was that, because the number of observations per picture type had to be made equal for the within-subjects analysis, some data

from each column except the low arousal negative column was not selected. In this way, the data may have over represented those individuals who gave more ratings of the low arousal negative category and it is possible that these people may differ in important ways to those who did not. However, a means based analysis was conducted and reported in phase IV of the results section that confirmed the dominating influence of arousal over valence.

To some extent, carry over effects were controlled for in the current design through the complete randomisation of the order in which every picture appeared in each trial for every person. However, in order to partial it out of an experimental design, further research is required to design a task explicitly measuring these carry over effects. One method to approach this would be to include a question, once every five to ten trials specifically asking the participant, for example 'have there been any pictures in the preceding trials that have affected you in any way?'. Once these pictures have been isolated, the next step would be to do a follow up experiment excluding the noted pictures from the stimulus set. Although this could be argued to dull down the affective quality and range of a stimulus set, it is necessary to assess the magnitude of these carry over effects if work is to be reliably done investigating the dimensionality of emotion.

The second limitation is the lack of generalisability that occurs due to the sole employment of female participants. Although men and women both show the greatest physiological reactivity to threat, mutilation and erotic picture content, important differences have been found between the sexes within these picture types (e.g., Bradley, Codispoti, & Sabatinelli et al., 2001). In a direct comparison of the physiological and subjective ratings of emotional pictures by men and women, Bradley, Codispoti, and Sabatinelli et al. (2001) found that the female participants were more likely to both experience (e.g., indexed from heart rate) and express (e.g., indexed from facial EMG activity, blink reflexes, subjective ratings)

negative emotion after viewing unpleasant pictures, despite the specific negative content of the image.

These sex differences in picture perception were acknowledged, which is why females were used in the absence of the ability to obtain a balanced number of each sex. However, as the response bias discussed above was mainly concerned with high arousing negative picture content, it is possible that the higher reactivity to negativity experienced by females has exaggerated this general bias toward negative stimuli found in both males and females. This limitation does not invalidate my results, but limits them to the female psychology student population. Further research would be able to explore if the same general trend exists if a balanced sample of both genders were obtained.

A third direction for further research stems from the apparent carry over effects. It may be that this negativity bias was reflective of the personality dispositions of the participants. It is reasonable to argue that the degree of extraversion, neuroticism and even optimism and pessimism that an individual has will influence their responses in an emotional task. There is evidence in the cognitive literature that this is the case, with temperament and degree of state/trait anxiety influencing emotional task performance (see Derryberry & Reed, 1994; Fox, Russo, & Dutton, 2002). It is therefore possible that for a sample of people high in optimism, there may have been the opposite pattern than that observed in the current study, resulting in the disproportionate influence of positive emotion. This may present the opportunity for an adaptation of the current design to be of use diagnostically. To address this direction, a research project could investigate the relations between emotional task performance and personality (see Greenwald, Cook, & Lang, 1989; Lang et al., 1993).

The fourth limitation of this study involves the subjective nature of the task. Because the task used self report, this would have been open to bias in terms of the individuals'

conceptual understanding of the terms 'emotionality', 'arousal', and 'valence'. Therefore, each participant may have categorised the pictures according to their understanding of these concepts and not the researcher's definition as provided in the instructions. One modification to the design would be to measure a physiological response, which would then indicate the validity of an emotional rating.

A related issue is the student sample used, as a sample drawn from the female psychology population may differ in certain ways to the general population. A follow up study using individuals from the general population, with objective measures of valence, arousal and intensity would help to clarify these limitations.

The present study explored ratings of emotionality, a process involving much conscious thought. In the context of a time line, this rating task would involve later stages of processing. This is a trend reflected in the literature where much of the research that looks at the relative contribution of valence and arousal uses interference tasks that can be considered to involve late stages of processing (e.g., Buodo et al., 2002; Verbruggen & DeHouwer, 2007).

Finally, it is accepted that the present study is exploratory, and provides for a direct, but subjective, measure of emotionality. Replication and extension of the work is recommended. One extension that may produce results would focus on early perceptual stages of processing (e.g., Anderson, 2005). These kinds of tasks involve stimuli being presented very rapidly, almost as if the image has not consciously registered with the participant. The use of stimulus-limited procedures might further reveal preferential processing of highly arousing stimuli, as in the enhanced encoding of target stimuli in Anderson, and the use of stimulus onset asynchronies by Schimmack (2005) and Buodo et al. (2002). There is therefore strong potential to expand the current paradigm to specifically

explore its sensitivity to determining picture valence and arousal at earlier stages of emotional processing.

Conclusion

In summary, this exploratory study has provided evidence for the dominance of arousal over valence. This pattern of results is partly consistent with the categorical negativity hypothesis and is consistent with both the evolutionary threat (as a subset of arousal hypothesis) and the arousal hypothesis. Secondly, the results based on the incorporation of individual differences accounted for more of the variance in emotionality rating than the nomothetic IAPS based analysis. This shows the power of an individual differences approach over traditional nomothetic group analysis. Finally, this experimental report has shown that a direct measure of emotionality is possible and has probably increased the number of potential research directions to further clarify the role of arousal and valence in determining emotion. In particular, the task may be modified to include a direct physiological measure associated with emotion (for example galvanic skin response), and in addition, may examine stimulus-limited procedure to explore earlier stages of emotional processing.

References

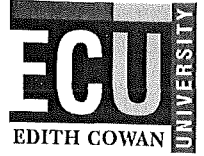
- Adolphs, R. (2004). Processing of emotional and social information by the human amygdala. In M.S. Gazzaniga (Ed.), *The cognitive neurosciences* (3rd ed., pp. 1017-1031). Cambridge: MIT Press.
- Anders, S., Lotze, M., Erb, M., Grodd, W., & Girbaumer, N. (2004). Brain activity underlying emotional valence and arousal: A response-related fMRI study. *Human Brain Mapping, 23*, 200-209.
- Anderson, A. K. (2005). Affective influences on the attentional dynamics supporting awareness. *Journal of Experimental Psychology: General, 134*, 258-281.
- Bradley, M. M., Codispoti, M., Cuthbert, B. N., & Lang, P. J. (2001). Emotion and motivation I: Defensive and appetitive reactions in picture processing. *Emotion, 1*, 276-298.
- Bradley, M.M., Codispoti, M., Sabatinelli, D., & Lang, P. J. (2001). Emotion and motivation II: Sex differences in picture processing. *Emotion, 3*, 300-319.
- Bradley, M. M., & Lang, P. J. (1999). *Affective norms for English words (ANEW): Instruction manual and affective ratings* (Tech. Rep. C-1). Gainesville, FL: University of Florida.
- Bradley, M. M., & Lang, P. J. (1999). *The international affective digitized sounds (IADS): Stimuli, instruction manual, and affective ratings* (Tech. Rep. B-2). Gainesville, FL: University of Florida.
- Bradley, M. M., & Lang, P. J. (2007). Emotion and Motivation. In J.T. Cacioppo, L.G. Tassinary, & G.G. Berntson (Eds.), *Handbook of psychophysiology* (3rd ed., pp. 581-607). New York: Cambridge University Press.

- Bradley, M. M., & Lang, P. J. (2007). The international affective picture system (IAPS) in the study of emotion and attention. In J. A. Coan, & J. J. B. Allen (Eds.), *Handbook of emotion elicitation and assessment* (pp. 29-46). New York: Oxford University Press.
- Bradley, M. M., Sabatinelli, D., Lang, P. J., Fitzimmons, J. R., King, W., & Desai, P. (2003). Activation of the visual cortex in motivated attention. *Behavioral Neuroscience*, *117*, 369-380.
- Buodo, G., Sarlo, M., & Palomba, D. (2002). Attentional resources measured by reaction times highlight differences within pleasant and unpleasant, high arousing stimuli. *Motivation and Emotion*, *26*, 123-137.
- Cedrus Corporation (2006). SuperLab Stimulus Presentation Software (Version 4.0) [Computer software]. San Pedro, CA: Cedrus Corporation.
- Cohen, J. (1988). *Statistical power analysis for the behavioural sciences*. New Jersey: Lawrence Erlbaum Associates, Inc.
- Cuthbert, B. N., Schupp, H. T., Bradley, M. M., Birbaumer, N., & Lang, P. J. (2000). Brain potentials in affective picture processing: Covariation with autonomic arousal and affective report. *Biological Psychology*, *52*, 95-111.
- Derryberry, D., & Reed, M. A. (1994). Temperament and attention: orienting toward and away from positive and negative signals. *Journal of Personality and Social Psychology*, *66*, 1128-1139.
- Field, A. (2005). *Discovering statistics using SPSS* (2nd ed.). London: Sage Publications.
- Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition and Emotion*, *16*, 355-379.

- Greenwald, M. K., Cook, E. W., Lang, P. J. (1989). Affective judgement and psychophysiological response: Dimensional covariation in the evaluation of pictorial stimuli. *Journal of Psychophysiology*, 3, 51-64.
- Godden, D., & Baddeley, A. (1980). When does context influence recognition memory? *British Journal of Psychology*, 71, 99-104.
- Howell, D. C. (2002). *Statistical methods for psychology* (5th ed.). USA: Duxbury.
- Kensinger, E. A., & Schacter, D. L. (2006). Processing emotional pictures and words: Effects of valence and arousal. *Cognitive, Affective, & Behavioral Neuroscience*, 6, 110-126.
- Kosslyn, S. M., Cacciopo, J. T., Davidson, R. J., Hugdahl, K., Lovallo, W. R., & Spiegel, D., et al. (2002). Bridging psychology and biology: The analysis of individuals in groups. *American Psychologist*, 57, 341-351.
- Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2005). *International Affective Picture System (IAPS): Affective ratings of pictures and instruction manual* (Tech. Rep. A-6). Gainesville, FL: University of Florida.
- Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology*, 30, 261-273.
- Mehrabian, A., & Russell, J. A. (1974). *An approach to environmental psychology*. Cambridge, MA: MIT Press.
- Mourao-Miranda, J., Volchan, E., Moll, J., de Oliveira-Souza, R., Oliveira, L., Bramati, I., et al. (2003). Contributions of stimulus valence and arousal to visual activation during emotional perception. *NeuroImage*, 20, 1955-1963.

- Ohman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General*, *130*, 466-478.
- Ohman, A., Lundqvist, D., & Esteves, F. (2001). The face in the crowd revisited: A threat advantage with schematic stimuli. *Journal of Personality and Social Psychology*, *80*, 381-396.
- Power, M., & Dalgleish, T. (2008). *Cognition and emotion: From order to disorder* (2nd ed.). New York: Psychology Press.
- Pratto, F., & John, O. P. (1991). Automatic vigilance: The attention-grabbing power of negative social information. *Journal of Personality and Social Psychology*, *61*, 380-391.
- Schimmack, U. (2005). Attentional interference effects of emotional pictures: threat, negativity, or arousal? *Emotion*, *5*, 55-66.
- Verbruggen, F., & De Houwer, J. (2007). Do emotional stimuli interfere with response inhibition? Evidence from the stop signal paradigm. *Cognition and Emotion*, *21*, 391-403.

Appendix A

**Instructions**

We thank you for coming today and appreciate your participation in this experiment. In this study, we are interested in how people respond to pictures that represent a lot of different events that occur in life. For about the next 15 minutes, you will be looking at different pictures on the computer screen in front of you, and you will be rating each picture in terms of how it made you feel while viewing it. There are no right or wrong answers, so simply respond as honestly as you can.

Now let me explain your involvement in more detail. In this task you will view a variety of emotional pictures. After seeing each picture you will need to rate it in terms of how emotional, intense and positive it is. While there is no limit on the time you take to rate each picture, try not to think about your ratings for too long.

In terms of the general emotionality, you can rate the picture from 1 to 5, from “very emotional” to “very unemotional”. For intensity and pleasure, if you’ll look at the computer screen, you will see 2 sets of 5 figures, each arranged along a continuum. We call this set of figures SAM, and you will be using these figures to rate how intense and pleasant you felt while viewing each picture.

SAM shows two different kinds of feelings: Happy vs. Unhappy, and Excited vs. Calm.

In this illustration, the first SAM scale is the happy-unhappy scale, which ranges from a smile to a frown. At one extreme of the happy vs. unhappy scale, you felt happy, pleased, satisfied, contented, hopeful. If you felt completely happy while viewing the picture, you can indicate this by pressing the yellow sticker on your keyboard marked “1”. The other end of the scale is when you felt completely unhappy, annoyed, unsatisfied, melancholic, despaired, bored. You can indicate feeling completely unhappy by pressing the sticker marked “5”. If you felt completely neutral, neither happy nor unhappy, press sticker marked “3”. The stickers labeled “2” and “4” allow you to make more finely tuned ratings of how you feel.

At one extreme of the intensity scale you felt stimulated, excited, frenzied, jittery, wide-awake, aroused. If you felt completely aroused while viewing the picture, indicate this by pressing the sticker marked “1”. On the other hand, at the other end of the scale, you felt completely relaxed, calm, sluggish, dull, sleepy, unaroused. You can indicate you felt completely calm by pressing the sticker marked “5”. If you are not at all excited nor at all calm, press the sticker marked “3”. Again, the stickers “2” and “4” allow you to make a more finely tuned rating of how excited or calm you feel.

Your rating of each picture should reflect your immediate personal experience, and no more. Please rate each one AS YOU ACTUALLY FELT WHILE YOU WATCHED THE PICTURE.

You'll have only a few seconds to watch each picture. Please view the picture for the entire time it is on and make your ratings immediately after the picture is removed. It is very important not to dwell on your ratings of the pictures.

Although some of the pictures will truly be neutral for you, **it is very important to avoid over-responding with a rating of "3".**

Before we begin, there will be a practice phase that is just to help you get a feel for how the ratings are done.

Are there any questions before we begin?

Guidelines for Contributions by Authors

Emotion

Instructions to Authors

Please consult APA's Instructions for All Authors for information regarding

- Manuscript Preparation
- Submitting Supplemental Materials
- Abstract and Keywords
- References
- Figures
- Permissions
- Publication Policies
- Ethical Principles

Submission

Submit manuscripts electronically through the Manuscript Submission Portal in Rich Text Format (.rtf). All tables and figures should be included in the manuscript file. General correspondence may be directed to the Editor's Office.

Mail Submission

Submit manuscripts through the mail if Internet access is not available. Please submit one hard copy of the manuscript along with a complete disk copy (text, tables, and figures) to the Editor,

Elizabeth A. Phelps, PhD
Department of Psychology
New York University
6 Washington Place
Room 863
New York, NY 10003

All copies should be clear, readable, and on paper of good quality. The complete disk copy should include a clear notation of the file names and the word processing and graphics software used. Figures may be submitted on a separate disk or on a Zip disk.

Masked Review Policy

Masked reviews are optional, and authors who wish masked reviews must specifically request them when they submit their manuscripts. For masked reviews, the manuscript must include a separate title page with the authors' names and affiliations, and these ought not to appear anywhere else in the manuscript. Footnotes that identify the authors must be typed on a separate page. Authors are to make every effort to see that the manuscript itself contains no clues to their identities.

Manuscript Submission Guidelines

In addition to addresses and phone numbers, authors should supply electronic mail addresses and fax numbers for use by the editorial office and later by the production office. The majority of correspondence between the editorial office and authors is handled by e-mail, so a valid e-mail address is important to the timely flow of communication during the editorial process. Authors should provide electronic mail addresses in their cover letters and should keep a copy of the manuscript to guard against loss. Manuscripts are not returned. Manuscripts for *Emotion* can vary in length; typically they will range from 15 to 40 double-spaced manuscript pages. Manuscripts should be of sufficient length to ensure theoretical and methodological competence. Most of the articles published in *Emotion* will be reports of original research, but other types of articles are acceptable.

- Case studies from either a clinical setting or a laboratory will be considered if they raise or illustrate important questions that go beyond the single case and have heuristic value.
- Articles that present or discuss theoretical perspectives on the basis of published data, may also be accepted.
- Comprehensive reviews of the empirical literature in an area of study are acceptable if they contain a meta-analysis and/or present novel theoretical or methodological perspectives.
- Comments on articles published in the journal will be considered.

Brief Reports

- *Emotion* also publishes brief reports. Manuscripts submitted as Brief Reports should not exceed 3,400 words, exclusive of references and figure captions. There should be no more than 2 figures or tables and no more than 30 references.

Theoretical Notes

- *Emotion* publishes articles that make important theoretical contributions to research areas that are of major importance for the study of emotion and affect. Preference is given to manuscripts that advance theory by integrating prior work and by suggesting concrete avenues for the empirical investigation of the theoretical predictions. Extensive, systematic evaluation of alternative theories is expected.

Manuscripts devoted to surveys of the literature are acceptable only if they can be considered as a major contribution to the field, documenting cumulative evidence and highlighting central theoretical and/or methodological issues of scientific debate. *Emotion* also publishes, as Theoretical Notes, commentary that contributes to progress in a given subfield of emotion or affect. Such notes include, but are not limited to, discussions of alternative theoretical approaches, and metatheoretical commentary on theory testing and related topics. Manuscripts submitted as Theoretical Notes should not exceed 5,000 words (exclusive of references). There should be no more than 50 references.