LUNDS UNIVERSITET

INSTITUTIONEN FÖR PSYKOLOGI

# *Neural Correlates of Emotional Retrieval Orientation*

## *An electrophysiological investigation into strategic retrieval processing of emotional memories*

Emelie Stiernströmer

Magisteruppsats HT 2010

Handledare: Mikael Johansson

## Abstract

*Retrieval Orientation refers to the differential processing of memory retrieval cues according to the sought after information (Rugg & Wilding, 2000). The study manipulated the orientation effect by varying the retrieval demand on a block basis using two emotional source recognition conditions and a non-emotional old-new recognition condition. Event-Related Potentials (ERPs) evoked by new faces in the two emotional conditions differed reliably from those of the non-emotional condition. The ERPs of the former conditions were more negative than those of the latter non-emotional condition from 200-400 and 500 -700msec post-stimulus, showing a frontal and mid centre parietal distribution respectively. From 900 -1100msec the critical ERPs from the former conditions were more positive going than the later non-emotional condition, showing a frontal distribution. Valence congruent relationships were additionally found between emotional retrieval orientation, emotional memory retrieval and degrees of wellbeing.*



I would like to thank my supervisor Mikael Johansson for giving me the opportunity to conduct this study as well as for his patience, creative and much appreciated comments. I would also like to thank Arthur Schneider for his helpful linguistic comments and Kenneth Holmqvist at Lund University's Humanist laboratory for allowing me to conduct my study at  their EEG/ERP lab.

The present study is a neuropsychological investigation into the concept of retrieval orientation - a memory retrieval process denoting the differential processing of retrieval cues according to the form of the sought after information (Rugg & Wilding, 2000). The primary aim of this study is to characterize amplitude differences in the brain's electrophysiological response to 'new' (previously unstudied) items in memory recognition tests, using two emotional source recognition exclusion tasks and a third non-emotional old-new recognition inclusion task.

The study adds to contemporary research fields by questioning (1) whether the orientation effect can be extended to source recognition tasks in which the retrieval demands vary by means of emotion, supporting the existence of an "emotional retrieval orientation". (2) Whether the emotional orientation effect will prove to be valence specific, indicating that searching for positive memories establishes unique ERP correlates of positive orientation, different from the ERP correlates created when searching for negative memories. If in fact an emotional orientation effect can be established (be it valence-specific or in general) the study will furthermore question (3) a potential valence congruent relationship between the emotional orientation effect and emotional memory performance. The study also contributes to contemporary research by questioning (4) a valence congruent relationship between emotional orientation and wellbeing.

Attempting to elucidate these questions, the current study converges on several relevant research fields. The first section contains an elaboration of episodic memory containing several important sub-sections relevant for an understanding of episodic memory retrieval. From episodic memory, a transition is made to retrieval processes – the processes engaged when attempting to retrieve information. This section is fundamental to the study since it attempts to elucidate the concept of retrieval orientation. The following two sections concern emotional memory and memory binding. While the former section introduces research literature demonstrating differences between emotional and non-emotional memories, the latter section introduces the concept of memory binding and its neural mechanisms. The last section adheres to the discussion on depression and mood disorders and its biased effect on emotional memory. While it is beyond the scope of this study to provide a detailed overview of either of these research fields, the discussion will be limited to only the general aspects pertinent to this study necessary for an understanding of the current study.

Episodic Memory

Remembering a prior personal event, be it emotional or non-emotional, requires retrieving information concerning the event from our episodic memory, i.e. memories for personal events belonging to a specific temporal and spatial context (Tulving, 1983, 2002). Retrieving this information entails an interaction between a retrieval cue and a memory trace. Together they reconstruct either selective parts or all aspects of the event in question. To maximize the likelihood of the interactions between the retrieval cue and the specific stored memory representation, two conditions must be met. First, one must be in a certain cognitive state, referred to as ‘ a retrieval mode’ (Tulving, 1983), and second, a retrieval cue must successfully trigger the probed-for memory (Tulving, 1983). These notions are presented in principles such as *The Transfer Appropriate Processing principle* and *Encoding Specificity* (Tulving & Thomposon, 1973; Morris et al. 1977). Generally speaking, while the former principle proposes that memory is best when retrieved under circumstances identical to the original experience, the latter proposes that retrieval cues are more effective when they are processed in a manner that more closely resembles the nature of the encoded information.

On a neuronal level the initial experience of an event (i.e. the encoding) elicits a widely distributed pattern of activity in the neocortex, reflecting sensory and higher order cognitive processes (McClelland, McNaughton, & O’Reilley, 1995). These neocortical patterns are represented in a sparse format in the hippocampus, a process referred to as pattern separation (McClelland et al. 1995). Each event receives its own hippocampal index and each event is thereby bound into a coherent memory trace that is kept separate from other memory traces for other events. A later re-presentation of the event (i.e. by a retrieval cue) leads up to a partial re-instatement of the original pattern of cortical activity during encoding. The overlap between this activity and the pattern of stored activity in the hippocampal index causes the hippocampal representation to be re-activated. This re-activation then causes a full reinstatement of the event at the cortical level (Norman, & O’Reilly, 2003). This full reinstatement of cortical activity is what is said to constitute the basis for an episodic memory experience (Rugg, Johnson, Park, & Uncapher, 2008). Memory retrieval is possible, however, even when the overlap between a retrieval cue and the memory trace is less than perfect. This is due to the effectiveness of hippocampus, in generating what is termed pattern completion. Pattern completion implies that activity that only partially overlaps with the hippocampal index may be sufficient to enable a reinstatement of the stored memory (McClelland et al., 1995; Schacter, Norman & Koutstaal, 1998).

Interactions between medial temporal lobe (MTL) and prefrontal cortex (PFC) are imperative for the encoding and retrieval of episodic memory. It is assumed that the PFC exerts cognitive control by maintaining task-relevant processing and inhibiting task-irrelevant processing (Miller & Cohen, 2001). Dorsolateral and ventrolateral (VLPFC; Petrides & Mackey, 2006) prefrontal cortices are vital regions of the PFC for the encoding and retrieval of episodic memory (Simons & Spiers, 2003; Wagner, 2002). Both VLPFC and DLPFC support the organisation and evaluation of information before encoding. While the former specifies retrieval cues in order to activate relevant hippocampal memory traces during retrieval (Simons & Spiers, 2003), the latter is assumed to mediate the monitoring and evaluation of the retrieved memories that are maintained by the VLPFC (Simons & Spiers, 2003; Wagner, 2002).

Retrieving an episodic memory often entails retrieving contextual details associated with that event, for instance, the context in which the event occurred. Such memories are referred to as source memories, since they entail information that identifies the condition (i.e. the emotional context in which a specific event occurred) under which memories were acquired, such as the spatial, temporal and social context (Johnson, Hashroudi & Lindsay, 1993).

*Source- Monitoring Framework* (SMF; Johnson et al. 1993; Schacter et al. 1998), emphasizing the strategic use of memory, proclaims that source memories can be attained by taking into account the distribution of numerous qualitative characteristics of a memory trace. These characteristics should differ from events of different origins. A good illustration is a memory trace for a heard word. A heard word will contain more perceptual information than the memory trace for an imagined heard word (Johnson, Foley, Leach, 1988). Consequently, one strategy a person could adopt in order to distinguish the real from an imagined word is to evaluate the amount of perceptual detail in the memory trace. This selective focus on certain kinds of task-relevant information is an example of *Strategic Retrieval Processing*. The term refers to processes engaged during memory retrieval in accordance with the specific demands of the type of memory judgement that is required.

Retrieval Processes: Retrieval Orientation

Retrieval processing is the term given to processes engaged when attempting to retrieve information from episodic memory. Rugg & Wilding (2002) presented an influential four-way classification of retrieval processes (retrieval effort, retrieval mode, retrieval success and retrieval orientation) along with a discussion on how to index their neural activity using Event Related brain Potentials (ERPs).

ERPs have been proven particularly useful for the study of memory retrieval because of the ease with which neural activity associated with different forms of retrieval can be compared. ERPs are small voltage changes in the electroencephalogram (EEG) that are induced by sensory, cognitive or motor processes (Friedman & Johnsson, 2000; Luck, 2005). Given the high temporal resolution in milliseconds on ERPs they offer an estimate of the time required to perform a cognitive operation, for example to differentiate classes of stimuli (e.g. old and new items in a memory recognition task). A comparison of the scalp distributions of ERP effects can be used to investigate whether different classes of stimulus can evoke different patters of neural activity. Differences in scalp distributions may indicate that those stimuli engage functionally different processes (Luck, 2005).

Of particular interest for the current study is the process, referred to as retrieval orientation. This is a strategic retrieval process referring to the differential processing of retrieval cues according to the form of the sought after information. Adopting specific retrieval orientations allegedly permit us to focus retrieval attempts on a selective subset of the memories that are encoded in a given spatio-temporal context (Herron & Rugg, 2003).

While the research literature on retrieval orientation is still fairly scarce, the majority of research into this field has come from ERP studies using a variety of source memory tasks (i.e. tasks that require explicit recovery of contextual detail about the study episode). In support of each other, these empirical studies suggest that the neural activity elicited by physically identical cues does indeed vary with the nature of the information being sought (Wilding & Nobre, 2001; Ranganath & Paller, 1999, 2000; Bridger, Herron, Elward, & Widling, 2009; Herron & Rugg, 2003; Dzulkifli, Sharpe, & Wilding, 2004; Dzulkifli & Wilding, 2005; Stenberg, Johansson & Rosén, 2005). Other studies have used simpler old-new recognition tasks demonstrating the same findings (Herron & Rugg, 2004; Robb & Rugg, 2002; Rugg, Allan & Birch, 2000; Hornberger, Morcom, & Rugg, 2004).

The research literature on retrieval orientation, established using various kinds of retrieval demands and stimuli, has reported diverse findings (Dzulkifli, Sharpe, & Wilding, 2004; Dzulkifli & Wilding, 2005; Herron & Rugg, 2003; Hornberger, Morcom, & Rugg, 2004; Hornberger, Rugg, & Henson, 2006; Johnson, Kounios & Nolde, 1997; Ranganath & Paller, 1999, 2000; Robb & Rugg, 2002; Stenberg, Johansson & Rosén, 2005; Rugg, Allan & Birch, 2000; Bridger, et al., 2009). Yet it is the diversity in these results that supports the notion of strategic retrieval processing in that they all support the idea that the processes that are indexed vary according to specific task demands, just as would be suggested if they index strategic retrieval processing operations.

Indexing the strategic orientation effects requires further clarification. To reveal the neural correlates of different orientation effects, one must contrast physically identical retrieval cues either across memory tasks that differ in task retrieval demands or across 'new' test items differing from the material encoded at study (Rugg & Wilding, 2000). The rationale behind this argument is that in such contrast, any differences between the neural activities can then be attributed to processes that are engaged strategically according to the specific retrieval demands of the task. The orientation effect is thereby not confounded with other retrieval processes (Rugg & Wilding, 2000) such as retrieval effort or retrieval success.

Following an understanding of what retrieval orientation is, as well as how its neural correlates are indexed, it seems only reasonable to understand why; why are we able to adopt specific retrieval orientations? The research literature suggests two contrasting accounts. One posits that the orientation process confers benefits on subsequent memory retrieval (Dzulkifli, Herron & Wilding, 2006; Herron & Rugg, 2003; Bridger et al. 2009). The other account posits that the orientation process is a compensatory effect (Dzulkifli, Sharpe & Wilding, 2004). While the former account is supported by findings showing that the degree to which orientation is engaged is positively correlated with response accuracy, the latter account instead posits that the degree to which orientation is engaged is not positively correlated with response accuracy but with relative task difficulty. Moreover, the two contrasting accounts, both attempting to explain why we adopt retrieval orientation, suggest this ability is either related to its facilitating effects on memory retrieval or is the result of the brain's compensating for a higher degree of difficulty when retrieving specific information from stored memory traces.

As stated previously, the ERP correlates of orientation effect is differently manifested depending on retrieval qualities and stimulus material employed. Accordingly, the establishment of an orientation effect using one form of episodic quality will differ from other orientations established by means of another episodic quality.

An overview of (eight) studies illustrating the diversity in the ERP correlates of retrieval orientation will now be presented in order to aid an understanding of this retrieval process's different manifestations.

In 2002, Robb & Rugg published a study in which they manipulated the orientation effect by varying the study material using pictures and words. Test difficulty was manipulated by varying study list length and study-test delay to create easy and hard retrieval conditions for each class of material. Regardless of difficulty, ERPs elicited by 'new' test words differed markedly according to whether the study items were words or pictures. This effect was evident from around 300-1800msec post-stimulus and took the form of a topographically widespread, temporally sustained negativity in the waveforms elicited during the picture condition relative to the word condition.

Another study conducted by Herron & Rugg (2003), used pictures and words interwoven within a single study block. In separate test phases, instructions were to respond positively to test words corresponding to either studied pictures or studied words. The effect of the instructions was to induce differences in 'new' items ERPs resembling those reported in Robb & Rugg (2002). The ERP effect identified took the form of a greater negativity for critical ERPs when pictures rather than words were the sought for material. The effect was apparent from around 300msec post-stimulus lasting until about 1800msec. The differences were the largest at central midline sites and lasted for 500-600msec.

The study by Hornberger et al. (2004) used a simpler old-new recognition memory test in two experiments of which the first used study material consisting of pictures and their corresponding names and the second consisted of auditory words and pictures when the test items were visual words. The ERP orientation effect had an onset around 300msec post-stimulus lasting until approximately 800msec and demonstrated a rather diffuse scalp distribution that remained statistically invariant with time. Collectively, their study (two experiments) indicated that the critical ERPs were more negative going when pictures rather than auditory words were the targeted material. By contrast, when memory was cued by pictorial material the effect was reversed: waveforms were more negative when words were targeted for retrieval. The ERP effects observed for the pictorial material were similar to those elicited by the verbal material in respect of their time course and overall magnitude. However the scalp topographies of the two classes of material differed: the effect elicited by words demonstrated a more anterior and symmetrical distribution compared to the pictorial material.

In a similar study, Hornberger, Rugg & Henson (2005) varied the encoding procedure such that participants either encoded pictures or auditory words. A subsequent old-new recognition retrieval task tested participants on visual words. The ERP orientation effect evoked by 'new' words encoded as pictures were more negative than words encoded orally. The difference appeared around 450msec post-stimulus onset, with a duration of 1200msec showing a centrally located maxima. The study was in line with previous studies by Robb & Rugg, 2002, Herron & Rugg, 2003; Hornberger et al., 2004). There were no reliable topographic differences thus indicating that the results did not reflect different distributions of underlying neural generators.

Rather than using an old-new recognition task, Dzulkifli & Wilding (2004) used recognition memory exclusion tasks with visually presented verbal material at both encoding and retrieval. The retrieval task was separated by means of a function task and a drawing task. The ERP orientation effect evoked by 'new' words in the function target designation were more positive than those from the drawing target designation from 500-900msec post-stimulus onset and the differences were larger over the right hemisphere from 700-900msec.

Rugg, Allen & Birch (2000) also used an exclusion recognition tasks but by means of an alphabetic judgement (shallow study) task and a sentence generation (deep) study task. Their findings revealed an ERP orientation effect, which, in line with previous studies took a different form depending on task. ERPs elicited by 'new' words in the shallow study task exhibited more positive going waveforms compared to the deep study task. The differences were apparent from 300 to 1400msec post-stimulus onset and the differences were maximal over the frontal and central sites.

The study Dzulkifli et al. (2004) investigated orientation using exclusion tasks in which participants focused on retrieval of either phonological or semantic associates that were generated in the preceding encoding task. The ERP orientation effect evoked by 'new' words were apparent from 300-1400msec post-stimulus and were more prominent at anterior than at posterior locations. They took the form of a relatively greater positivity for the critical ERPs when the task required responses only to old words subjected to phonological encoding rather than semantical encoding. The scalp distribution did not differ between the tasks.

The most recent study on retrieval orientation, conducted by Bridger et al. (2009), used two verbal memory exclusion tasks with differing retrieval demands. Participants were instructed to retrieve information concerning the item presented at test, by judging whether it had previously been encoded in (a) a function task or (b) a drawing task. Their aim was to investigate the ERP orientation effect by correlating it to response accuracy. The ERPs for the high accuracy group shows that, at midline posterior sites from around 700msec post-stimulus onset, ERPs associated with 'new' items in the function target designation were relatively more positive going than those associated with the drawing target designation. In line with previous studies their study showed an extended time course with little evidence of changes in the distribution of the ERP effect over time.

Notably, the above presentation of prior investigations into retrieval orientation highlights the various manifestations of the ERP orientation effect by (1) different scalp distribution, polarity, temporal profile, and (2) how effect relates to difficulty and performance. While the stimulus material differs between studies, none of these studies presented above, or in fact any studies on retrieval orientation have, to our knowledge, used emotion as episodic retrieval material, neither pictorial nor verbal forms (visually or orally presented).

## Emotional Memory

The definition of emotion may vary, however, for the purpose of the current study emotion is defined as a multimodal phenomena that involves changes in subjective experiences, physiology (including brain mechanisms) and action tendencies (Gross, 1998). Emotions occur in response to internal or external stimuli that are meaningful to the organism's survival, wellbeing and active goals.

Memory is often enhanced for events or items that are emotionally significant (Christianson, 1992) and the enhancement has been attributed to interactions between the amygdala and other neural areas such as the hippocampus and prefrontal cortex (PFC) (Cahill & McGaugh, 1996).

On a biological level, the reason for the enhancement of emotional memories may simply be evolutionary. An enhanced memory of emotional events can from an adaptive perspective be explained in that it increases the probability that survival-relevant information will be available in the future (Hamann, 2001). On a cognitive level, factors such as increased rehearsal, enhanced attention and increased elaboration are probably some of the memory advantages observed in enhanced emotional memory. These advantages do not, however, suffice as a complete explanation. A more ample account can instead be found on a neuronal level: specific mechanisms for emotional stimuli that are not engaged by non-emotional stimuli have been shown to exist (McGaugh, 2000) at the neuronal level.

The memory bias for emotional memories has been empirically supported. Relative to emotionally neutral stimuli, free recall is greater for pictures, words and stories with emotional negative or positive content (Phelps, LaBar, & Spenser, 1997; Danion, Kauffmann-Muller, Grange, Zimmermann, & Greth, 1995; Hamann, Ely, Grafton, & Kilts, 1999). Contextual information is additionally more likely to be retrieved incidentally and to capture more attention when it is emotionally valenced (Maratos & Rugg, 2001).

The valence of an event (i.e. whether it is pleasurable or aversive) seems to be an important factor when it comes to the emotional memory performance, with negative events being remembered in greater details than positive. For instance, in recognition memory tasks negative events are often remembered better than positive events, as reflected by higher hit rates, higher judged vividness and greater confidence in memory accuracy (Kensinger & Schacter, 2006; Oschsner, 2000; Johansson, Mecklinger, & Treese, 2004). Last but not least, when examining what people remember about public events, negative emotions appear to be superior (Levine & Bluck, 2004). Another remark in relation to emotional memory relates to confabulation (i.e. the production of fabricated, distorted or misinterpreted memories about one's self or the world without the conscious intention to deceive) for which emotions seems to play a significant role (for reviews see DeLuca, 2000).

## Memory Binding

To retrieve information of a prior event, the brain must not only encode the specific aspects of an event, but it must additionally bind these different aspects of the event together in a manner that specifies the spatiotemporal context in which they were encountered. This ability to bind separate aspects to a unified whole depends on a large network of brain regions, especially the MTL and PFC, which, as previously stated, facilitate the encoding and retrieval of episodic memories (Zimmer, Mecklinger & Lindenberger, 2006).

While the discussion on binding (i.e. how we combine separate stimulus features to form an unified object representation) is most often centred to perception, it is also highly relevant for the discussion of memory. By considering memories as sets of separate features (rather than holistic units) we assume the presence of some kind of binding. Memory binding hence refers to the processes by which distinct aspects of memory are linked together to form a coherent episode (Zimmer, Mecklinger & Lindenberger, 2006)

*Binding of Items and Contexts* model (BIC; Diana, Yonelinas & Ranaganath, 2007) proposes that MTL sub-regions differ fundamentally in the types of information they receive and process, e.g. items, contexts and bindings.  Accordingly, the peririhinal cortex (PRc) receives detailed information about specific items that are to be remembered (i.e. 'what' information), whereas the parahippocampal cortex (PHc) receives detailed information about the spatial context in which each item was encountered (i.e. 'where' information). The information about what and where –two key attributes of episodic memories- then converges in the hippocampus. The BIC model suggested that the PRc and PHc encode item and context information and the hippocampus in turn encodes representations of item-context associations.

Within memory binding, a main distinction can be made between different types of binding. For example, one can distinguish within "item-binding" from between "between-item binding". Within-item information is information belonging to the object, e.g. object colour and it is associated with familiarity while the "between-item" is associated with recollection (between-item). Familiarity refers to the phenomenal experience that a particular item has been encountered before, without retrieving contextual information, whereas recollection refers to the conscious retrieval of an item together with contextual information that specifies the previous episode (Jacoby & Dallas, 1981; Mandler, 1980; Yonelinas, 2002).

On a neuronal level, familiarity (within-item) is mediated by perirhinal structures, whereas hippocampal processing is involved in recollection (between-item). These MTL structures provide the mechanisms required to bind contents represented in modality specific processing areas (Zimmer, Mecklinger & Lindenberger, 2006).

Mood Disorders & Memory

Cognition plays a central role in the degree to which people are affected by negative experiences. In cognitive studies investigating mood-congruent recall bias in depression it is suggested that depressed individuals recall more negative than positive words on explicit memory tasks. In such tasks participants typically perform an encoding task, which entails studying lists of words. They are then asked to recall these words in subsequent retrieval tasks.

Cognitive theorists attempting to explain the memory bias towards negative material in depression suggests that they engage in strategic elaboration of negative information (Williams, Watts, MacLeod, & Mathews, 1997). In other words, they engage in increased elaboration of negative material, either during or following the initial encoding phase, which increases the accessibility and ease of retrieval of negative concepts. This is empirically supported: depression is positively correlated with a tendency to respond to negative life events and negative mood states by ruminating about the event or the mood (Lyubomirsky & Nolen-Hoeksema, 1993; Nolen-Hoeksema, 2000; Nolen- Hoeksema, Morrow, & Fredickson, 1993). Taken together, elaboration of and ruminating on negative events increases the accessibility and the likelihood of facilitated retrieval of negative memories, which ultimately results in a malicious circle of rumination, mood-congruent recall bias and depressed mood states (Lyubomirsky, Caldwell, & Nolen-Hoeksem, 1998).

Cognitive control, implicating the PFC, commonly refers to top-down support for task relevant processes (MacDonald et al. 2000), i.e. processes that permit information processing and behaviour to vary adaptively depending on current goals. A related term is emotion regulation, which denotes cognitive and behavioural processes influencing the occurrence, intensity, duration and expression of emotions (Gross, 1998). These processes may support up-regulation or down-regulation of positive or negative emotions. Deficits in the cognitive control of emotions may lead to difficulties attending to and processing new information, thereby hindering the use of more adaptive emotion regulation strategies, which in turn may have a negative impact on wellbeing (Campbell-Sills & Barlow, 2009).

Depressed individuals appear to have a decreased cognitive control, mainly when processing emotional stimuli (Dozois & Dobson, 2001; Gotlib, Krasnoperova, Yue & Joormann, 2004; Koster, De Raedt, Goeleven, Franck & Crombez, 2005). Consequently, the neural mechanisms supporting cognitive controls may be altered among depressed individuals. While the lateral PFC (LPFC) is allegedly involved in cognitive control, especially when competing responses have been inhibited or new information is selected (Aron & Poldrack, 2005), the VLPFC is suggested to alter emotional responses. This modulation transpires through an attentional biasing mechanism, which acts on sub-cortical regions such as the amygdala (Wager, Davidson, Huges, Lindquist & Ochsner, 2008). In support of this account, studies have shown that individuals diagnosed with depression have reduced neural responses compared to healthy controls, particularly in VLPFC regions (Dichter, Felder & Smoski, 2009; Wang et al. 2008).

Research Objectives

The present study is an electrophysiological attempt to investigate episodic memory. On a more general level it concerns the retrieval of episodic source memories (elaborated in the opening section) and more specifically it refers to retrieval orientation – a retrieval processes engaged when we attempt to retrieve an episodic memory.

The present study builds on the research presented above, i.e. the research supporting the existence of retrieval orientation but also the extensive research stressing the uniqueness of emotional memory and the biasing of emotional memory in relation to mood-disorders. The novel contribution offered by the present study, to investigate whether retrieval orientation can be extended to include emotional source memories, justifies the section on memory binding presented earlier, in that encoding of emotional source memories requires the binding (within- item and between- item binding) of different aspects of an event in a manner specifying the spatiotemporal context (e.g. an emotional context to a natural face).

Episodic memory constitutes our personal life history in which our emotions play a pivotal role. Emotions, however we chose to define and defy them, enhance and alter (e.g. by means of confabulation) our memory in both positive and negative ways which subsequently impact on, among other things, our wellbeing. Emotions not only change the brain neural mechanisms. They also alter the body's physiological response. Intuitively this points to the importance of the current investigation. If entering a cognitive state of orientation, in which we set out to search for an emotional memory of specific valence, leaves behind a specific neural correlate associated with emotional memory and wellbeing, this may be of interest to clinicians attempting to comprehend and find solutions to the vicious circle of depression. In addition to this more clinical application, the establishment of an emotional retrieval orientation effect is of interest for scientific purposes, by adding to the neuropsychological literature on emotional memory.

The key question in this study is the nature of the critical ERP correlates elicited by ‘new’ previously unstudied test items (faces) recorded on a block basis from the retrieval phase of two pictorial emotional source exclusion conditions and one non-emotional inclusion condition. Two exclusions tasks with varying emotional source requirements in addition to an inclusion task will be employed (for further reading on inclusion-exclusion tasks see Jacoby, 1991). While the retrieval phases are varied in order to manipulate the orientation effect, the encoding phase for each task is kept constant.

Experimental Hypotheses

There are four experimental predictions: (1) Amplitude differences elicited by the critical ERPs, (i.e. those elicited by ‘new’ faces in each test task) will be reliably differentiated on the basis of test type (emotional source exclusion recognition tests vs. inclusion). (2) The amplitude differences elicited by the critical ERPs will furthermore be reliably differentiated according to valence retrieval demands, demonstrating the existence of valence specific emotional orientations. (3) There will be a valence congruent relationship between emotional retrieval orientation and emotional memory as indicated by a positive correlation between the positive orientation effect and the retrieval of positive memories. (4) The ERP correlates of emotional orientation will, in addition to the latter hypothesis, show a valence congruent relationship to wellbeing.

Evidence for the degree to which orientation was engaged is shown by, i.e. operationalized by the magnitude of the voltage differences between the ERPs elicited by ‘new’ faces in exclusion positive and exclusion negative compared with the inclusion condition. The magnitude of these voltage differences is assumed to be the neural correlates of differences in cue processing engaged by the different retrieval instructions.

Evidence for the degree to which memory performance was engaged is operationalized by means of ability to detect both positive and negative targets (c.f. Bridger et al. 2009), as well as the relative ability to retrieve positive rather than negative targets. More precisely, this latter relative memory measurement reflects a facilitated ability to retrieve positive rather than negative memories.

The experimental predictions presented here will be attained by first selecting scalp sites at which the ERP amplitude difference is most representative. Memory performance and degrees of wellbeing will thereafter be plotted against the critical ERP indexes of the degree to which the orientation effect is engaged.

The current study chooses to use pictorial stimuli rather than visually or orally presented verbal stimuli. The motivation being that pictorial stimuli, concepts, are much more likely to be remembered if they are presented as pictures rather than words, as postulated by *The Picture Superiority Effect* (Madigan, 1983). Additionally, pictorial stimuli are likely to be more effective at engaging emotional processing than verbal stimuli due to their highly concrete nature and cognitive immediacy (Smith, Dolan & Rugg, 2004). The use of pictures to provide emotionally valenced contexts may therefore lend greater power to the identification of emotion effects on the retrieval than what is afforded by verbal stimuli.

The current study furthermore used faces rather than objects as items. The motivation being that (a) faces are not associated with the same potential confound of semantic relatedness such as words (Maratos et al., 2001) and (b) the processing of facial expression is critical for our daily-life interactions and therefore the face categories used can expected to be equally relevant for all participants.

## METHOD

### Participants

Thirtysix healthy right-handed individuals (24 females), mean age 28.5 years (ranging 20-56) participated in the study. Six participants (3 females) were excluded from the analyses: two resulting from computer problems, three from insufficient behavioural performance and one participant was excluded due to defective electrodes. While participants responded to flyers posted around Lund's university campus, no requirement of enrolment at the university was made.

Participants were given a movie voucher (110 SEK (11€) as compensation for their participation. Each person provided written informed consent upon arriving at the laboratory and they were informed that the study investigated brain activation during retrieval of emotional memories.

Material

360 neutral female faces selected from four different standardised databases were used. Two of these were online databases: (1) OSLO (unknown reference), (2) FACES (unknown reference). (3) AR face database (Martinez & Benavente, 1998) and (4) NIM-STIM (Tottenham, N., Tanaka, J., Leon, A.C., McCarry, T., Nurse, M., Hare, T.A., Marcus, D.J., Westerlund, A., Casey, B.J., Nelson, C.A. (2009). The facial images were frontal views with hair, neck and ears visible. The background colour (black), position of the face and size of the image was modified in Photoshop to be standardized for all faces. The faces were balanced in terms of data base origin, age (20-25, 25-30, 30-35, 35-40) ethnicity (Caucasian white, Mediterranean, African American or Asian) and thereafter sorted into six sets, each set, containing 60 faces (balanced according to data base, age and ethnicity). 360 of the most common female names were selected from the Swedish statistical central bureau and appeared in white on a black background, using font Arial. Each name was randomly paired with a face.

A selection of 180 emotional contexts (Lang, Bradley & Cuthbert, 2008), selected from and based on the IAPS data base ratings, were used to induce emotion upon the neutral face. 90 images depicted positive emotions and 90 depicted negative. Only one sexual (negatively valenced) depiction was included in the image set. Cutoff scores excluding the most negative depictions (1.0 to 2.0) were used to reduce the likelihood of participants looking away due to the extreme nature of the images. Cutoff scores were also used for the positive emotions but rather to exclude the least positive (ranging between 5-7) to make the two groups more comparable in terms of valence and arousal. Thus, whereas the former negative values ranged from valence ratings of 2 to 5 the later positive ranged from 7 to 9.

Negative and positive contexts were categorized into five categories according to depiction. For negative images the categories used were (1) weapons, (2) unpleasant animals, (3) unpleasant scenes, (4) unpleasant nature, (5) unpleasant images of people. For positive images the categories used were (1) sports and entertainment, (2) pleasant animals, (3) pleasant children, (4) pleasant nature and sweets and (5) pleasant images of family scenes. The images were additionally sorted into three set types, each containing 30 contexts of which six images were taken from each of the above stated categories (50% negative).

Following the electrode application, the participant was seated in front of the computer screen and undertook nine study-test blocks. While the study procedure remained constant the test requirements varied according to test type. One third of the tests were comprised of a recognition inclusion test task, one-third an exclusion negative test task and the remaining third an exclusion positive test task. The order of which these test types appeared was randomised. Each study phase comprised 40 faces and 40 female names randomly paired with 40 emotional contexts (of which 50% were negative and 50% positive). Each test phase consisted single-handedly of faces of which 50% were old previously studied faces and 50% new faces. All stimuli were presented using E-prime version 2.0.1.06 (Psychology software).

The distance between participants and computer screen were approximately 70 cm. The pictorial stimuli were presented on black background on a computer monitor (11x13 inches). Each study trial was initiated with a fixation cross (500msec) followed by a black screen serving as a baseline (500msec). A face appeared in the centre of the screen with a female name beneath it, for duration of 1000msec. Following the disappearance of the face, an emotional context appeared in the centre of the screen for 1000msec. Next the same face and the same name then re-appeared together with the emotional context. While the name appeared below the face to the right, the emotional context appeared to the right of face for a duration of 4000msec. Each test trial was initiated with a fixation cross (500msec) followed by a face appearing on a black background in the centre of the screen for a duration of 500msec. A 3000msec test response window followed, during which instructions were to respond by pressing selected keys on the keyboard. Response keys (nr. 1 and 3 on the computer keyboard) were alternated with each participant. All participants were instructed to remain as still and relaxed as possible during the testing procedure. Short breaks were available between blocks.

Study Task Procedure

Instructions were given both orally and in written form, appearing both in paper form and on the computer screen before the initiation of each study procedure. The study (encoding) procedure was administered in three parts (Fig.1). First, a face and a name appeared centred on the screen. Participants were instructed to combine the face with the name by sub-vocally stating the name of the person (e.g. “this is Gabriella”). Second, an emotional image, hereafter referred to as an emotional context, appeared centred on the screen. At this point, participants were to note the emotional valence of what the picture depicted, again by sub-vocally stating what was depicted (e.g. a dangerous shark). Thirdly, the face, the name and the emotional context re-appeared conjointly on the screen. The instructions were to combine the face and the name with the emotional context, by sub-vocally generating a brief story in which they paired that specific face with that specific context (e.g. Gabriella is afraid of dangerous sharks). This biding of a face to an emotional context was used to induce emotion upon the originally neutral face.

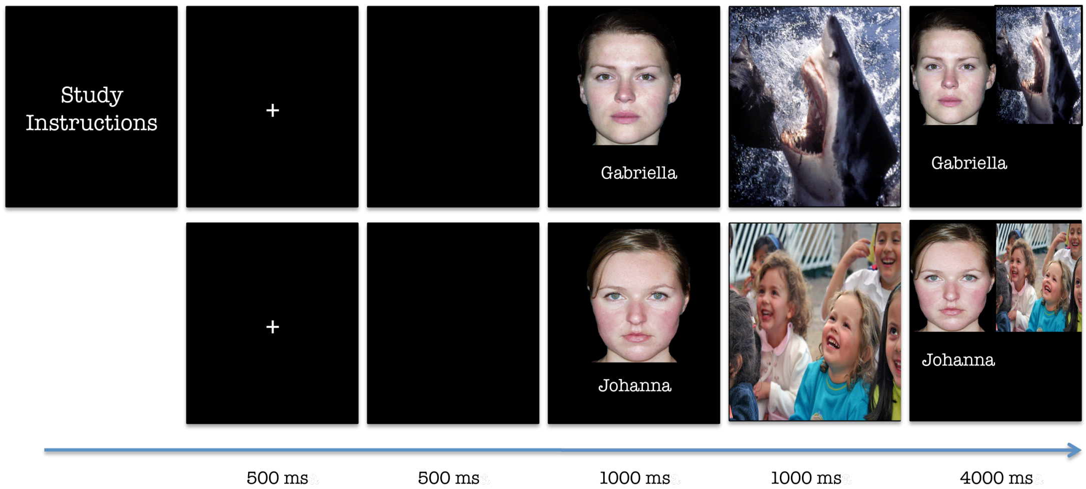


Figure 1. An illustration of the study procedure: For each run each participant must bind a neutral face to an emotional context, by which he/she induce emotion upon a neutral face. Each run is composed of 40 faces and 40 emotional contexts, of which half are negative.

Test Task Procedure

Test instructions were given both orally and in written form, appearing both on paper before initiating the experiment as well as on the computer screen before initiating each test procedure. Participants were informed that there would be 50% new faces mixed up with the previously shown faces and that their task was to judge each face separately. They were also informed that, unlike the study procedure, the retrieval requirements would vary with each test block but that informative instructions would be given on the screen indicating which requirements to fulfil for the upcoming test.

For the inclusion test, subjects were required simply to respond " old" or "new" to the face appearing on the screen using the marked keys on the keyboard. For the exclusion negative test (Fig.2), subjects were required to respond "old" only to faces that previously had been shown, and importantly only to those faces to which a negative emotional context had been paired. For all remaining faces the participant must respond "new". For the exclusion positive test, subjects were required to respond "old" only to faces that had previously been shown and paired with a positive valence context. The remaining faces were to be judged as "new". Thus, for the two exclusion tests, in order to fulfil the requirements of being classified as "old" the face must (a) have been seen in the foregoing study trial and (b) be congruent with the valence demand of the test type.

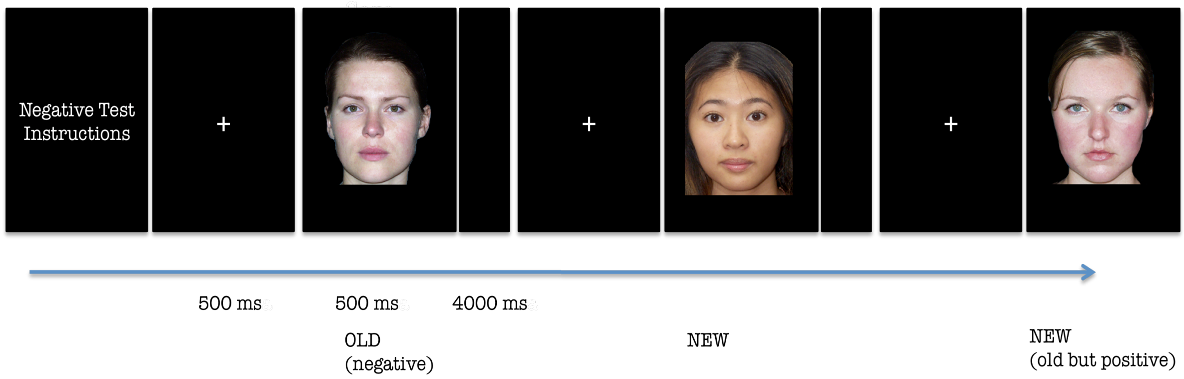


Figure 2 An illustration of the recognition testing procedure. Each run is composed of 40 faces of which 50% are new never before seen faces. Retrieval demands vary by means of recognition test: inclusion, exclusion positive or exclusion negative.

Positive and Negative Context Images

Independent sample t-testing was conducted on the 180 images to compare the mean scores of valence and arousal ratings for negative and positive images. T-tests revealed a significant difference in the mean scores between negative (*M* = 3.20, *SD* = .50) and positive (*M* = 7.50, *SD* = .37) image valence ratings: *t*(178) =- 65,81, *p* = .00). There was no significant difference in mean scores between negative (*M* = 5.06, *SD* = .78) and positive (*M* = 5.21, *SD* = .86) image arousal ratings: *t*(178) = -1.27, *p* = .21).

Analyses of variance were conducted to compare the mean scores, in terms of valence and arousal, for the three sets of negative and positive images. For the negative images, the analysis revealed that there was no significant difference in mean scores between the three sets, neither for valence (*F* = .14, *p* = .87) nor for arousal (*F* = . 57, *p* = .57). As for the positive images, the analysis showed no significant difference between the three sets of positive images in terms of valence (*F* = .41, *p* = .67) or arousal (*F* = .33, *p* = .72).

Memory Performance Measures

The experimental design was set up to collect three different types of memory measures based on behavioural responses for each participant.

The *Target Positive* measure [Target Hits exclusion positive – FA exclusion positive] was used to demonstrate the ability to detect positive targets, that is, successfully classifying 'old' positive faces as 'old' and deriving the face from a positive context (cf. Bridger et al. 2009). The *Target Negative* measure [Target Hits exclusion negative – FA exclusion negative] was used to demonstrate the ability to detect negative targets, that is, successfully classifying 'old' negative faces as 'old' and deriving the face from a negative context (cf. Bridger et al. 2009). The measure of *Relative Memory* performance [Target Negative - Target positive] was used to illustrate an increased ability to retrieve positively valenced memories rather than negative.

High scores generally were taken as evidence for better memory performance on that particular valence. For the differential memory measure, a positive score indicated a biased ability to retrieve positive rather than negative memories whereas a negative score indicted a biased ability to retrieve negative rather than positive memories.

Wellbeing: Self-Assessment Scores

After finishing the memory test and EEG recordings, participants engaged in four self-measurement questionnaires using pen and paper. The self-assessment questionnaires employed were: *Beck Depression Inventory* (BDI-II; Beck, Steer & Brown, 1996), *Montgomery Åsberg Rating Scale* (MADRS; Svanborg & Åseberg, 1994), *Positive and Negative Affect Scale* (PANAS; Watson, Clark, & Tellegen, 1988) and *The State- Trait Anxiety Inventory* (STAI; Spielberger, Gorsuch,& Lushene, 1970).

(1) BDI-II is a 21-item scale assessing the symptoms and summing the responses scores experience of depression. (2) MADRS consists of 9 items, which measures nine different symptoms of depression, rated on a seven-point scale. As with the former, severity of depression is assessed by summing up the scores. Both self-assessment questionnaires are widely used instruments for evaluating the severity of depressive symptoms in psychiatric patients. Both closely adhere with the diagnostic criteria for major depressive episode in the 4th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; American Psychiatric Association, 1994). (3) PANAS is a self- assessment scale developed

to measure the largely independent structures of positive and negative affect and it has been shown to be effective at differentiating between depression and anxiety in clinical samples (Clark & Watson, 1991). It is a 20-item questionnaire consisting of affect adjectives, 10 of which are positive affect terms (e.g. active, enthusiastic) and the remaining 10 are negative affect terms (e.g. nervous, guilty). Each adjective is rated on a 5-point scale ranging from "very slightly or not at all" to "extremely" and subjects are asked to rate the extent to which they feel this way. The version employed in the present study asked to rate the extent to which they felt this way in general. (4) STAI-II is a 20-item self-report scale for measuring trait anxiety. People are asked to describe how they feel in general and results reflect relatively stable individual differences in anxiety pre-dispositions that are impervious to situational stress. The items are rated on a scale of 1-4. Total scores ranges from 20-80. The version employed in the present study asked to rate the extent to which they felt this way in general, thus STAI-II.

The current study used a relatively small sample size of a non-clinical population to establish degrees of wellbeing using clinical self-assessment questionnaires measuring severity of depression and anxiety. Traditional cutoffscores, used when assessing severity of depression by clinicians were furthermore ignored. Instead, the current study interpreted low scores as indicative of a higher degree of wellbeing and vice versa. An exception was *PANAS positive Affect Scale* for which higher scores were taken as indicative of higher degrees wellbeing.

## EEG Recording and Analysis

EEG was recorded using a 64 channel Quick Cap based on the 10-20 system, a SynAmps 2 amplifier, and the NeuroScan Acquire software. Impedance was kept below 5 KΩ. VEOG, above and below the left eye, and HEOG, outside the outer canthi measured the electrooculogram (EOG). The electrodes were referenced to a central reference electrode online, and were re-referenced to averaged mastoids offline. The ground reference was a frontal cap-mounted electrode. The sampling rate was 250 Hz, and an online band-pass filter with cut-off frequencies of 0.1 to 70 Hz was used. A notch filter was used set at 50 Hz. Bad channel signals (no more then five per participant) were replaced offline using spherical spline interpolation with the surrounding electrodes.

Statistical analyses

The behavioural and electrophysiological data were analysed with independent t-test, paired sample t-tests, univariate ANOVA and Spearmann's correlations and repeated measure ANOVA. The Greenhouse-Geisser adjustment was used when data violated the assumption of sphericity (Greenhouse & Geisser, 1959). Main effects were followed up with subsidiary pairwise comparison using a Bonferroni correction. Effect sizes were viewed in light of Cohen's interpretation (1998).

## RESULTS

A preliminary consultation of the topographic maps (Fig.3), suggested an emotional orientation effect with a time course of 200-to 1100msec post-stimulus onset. The ERPs of emotional orientation (exclusion conditions vs. inclusion) gave rise to more negative going ERPs from around 200-700msec. From around 900 -1100msec the ERP of both positive and negative orientation were perceived as more positive than inclusion.

Tendencies towards valence specific orientation effect as evinced by the slightly more negative going ERPs in the negative orientation condition (i.e. exclusion negative vs. inclusion) compared to the positive (i.e. exclusion positive vs. inclusion) were mainly found in the first time window (Fig.3). As to the distribution of the effect, the topographic maps indicated an initial frontal distribution from 200-400msec, followed by a central- parietal distribution from 500-700msec, after which a frontal distribution re-appeared at approximately 900-1100msec.

These presumptions, based on visual consultations were subsequently tested statistically and the outcome of the statistical analyses of the ERP memory orientation effects in the three time windows were described below starting with the earliest course of events and ending with correlation analyses. Behavioural data will be presented first after which the electrophysiological data will follow.

Behavioural Data

*Correct Rejections of New Items*

Table 1 displays the probabilities of correct responses to each class of test faces in the three memory tasks. Correct rejections (CR) were calculated separately for inclusion, exclusion positive and exclusion negative. Paired sample t-tests were conducted on CR between two exclusion tasks confirming a non-significant result, $t(29) = -.74$, $p = .47$. In addition, comparing CR between inclusion and the two exclusion tasks revealed a non-significant result for both exclusion positive $t(29) = 1.44$, $p = .16$, and exclusion negative, $t(29) = 1.1$, $p = .29$.

Table 1: Mean proportions of correct responses to Target, Non-Target and New words in the Inclusion, Exclusion Positive and Exclusion Negative target designated conditions.

| Target designation | | Target type | |
|---|---|---|---|
| | Target | Non-Target | New |
| Inclusion | 80 (.13)-.76 (.12) | - | .80 (.13) |
| Exclusion Positive | .59 (.13) | .58 (.13) | .84 (.14) |
| Exclusion Negative | .56 (.16) | .57 (.14) | .82 (.16) |

Note: Inclusion Target is presented with old positive first and old negative second. Standard deviations are in parentheses.

*Memory Performance and Wellbeing Self- Assessment Scores*

Table 2 shows the descriptive statistics for the three memory measures. A paired sample t-tests, construed to compare scores from memory measures of Positive ($M = .18$, $SD = .21$) and Negative Targets ($M = .13$, $SD = .17$) revealed non significant difference, $t(29) = 1.48$, $p = .15$). The Relative performance measure ($M = .04$, $SD = .16$) revealed a significant difference when compared to Positive Targets, $t(29) = 4.31$, $p = <.05$), but not when compared to Negative, $t(29) = 1.95$, $p = .06$. Descriptive statistics for self-assessment questionnaires are presented in Table 3.

Table 2: Descriptive Statistics for emotional memory performances and wellbeing self-assessment questionnaires.

| Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| TYPE | | | | | |
| | N | M | SE | SD | Md |
| Target Positive | 30 | .18 | .04 | .21 | .22 |
| Target Negative | 30 | .13 | .03 | .17 | .07 |
| Relative Memory | 30 | .04 | .04 | .16 | .13 |
| BDI-II | 30 | 7.03 | 1.31 | 7.16 | 4.50 |
| PANAS pos Affect | 30 | 35.93 | 1.30 | 7.14 | 37.50 |
| PANAS neg Affect | 30 | 18.60 | 1.14 | 6.22 | 17.00 |
| MADRS | 30 | 54.17 | 1.57 | 8.57 | 4.00 |
| STAI | 30 | 36.60 | 2.10 | 11.51 | 34.50 |

Table 3: Descriptive Statistics for the wellbeing self-assessment questionnaires.

| Descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| TYPE | | | | | |
| | N | M | SE | SD | Md |
| BDI-II | 30 | 7.03 | 1.31 | 7.16 | 4.50 |
| PANAS pos Affect | 30 | 35.93 | 1.30 | 7.14 | 37.50 |
| PANAS neg Affect | 30 | 18.60 | 1.14 | 6.22 | 17.00 |
| MADRS | 30 | 54.17 | 1.57 | 8.57 | 4.00 |
| STAI | 30 | 36.60 | 2.10 | 11.51 | 34.50 |

Electrophysiological Data

*ERPs Evoked by Correct Rejections*

The outcome of the current study obtained reliable differences in the critical ERPs, that is, ERPs evoked by 'new' faces in the two emotional source exclusion tasks when compared to inclusion. The effect was evident from approximately 200-1100msec. While the ERP orientation effect showed more negative going ERPs from 200-700msec, the ERP orientation effect from 900-1100msec were more positive than inclusion. In addition, several reliable correlations between the ERPs of positive orientation and positive valenced memory and degrees of wellbeing were obtained

By visually consulting topographic maps (Fig.3), a selection of electrodes was used for further analyses as they covered the areas of interests conveyed in three latency regions (200-400msec, 500-700msec, 900-1100msec). The selected electrodes chosen for further analyses in the first time window were: (frontopolar) FP1, FPZ, FP2, (frontal) F7, FZ, F8, (temporocentral) FT7, FCZ, FT8. For the second time window: (central) C5, CZ, C6, (temporocentral) FT7, FCZ, FT8. For the third time window: (frontal) F7, FZ, F8.

ERP grand averages were independently computed for CR to 'new' faces for each of the three tests. The present study used a criterion of 16 accepted trials as a minimum in order to be included before averaging.

The ERP waveforms were quantified by computing mean amplitudes of CR in the three time windows. While the selection of electrodes varies with latency region, the initial repeated measures ANOVA always included three types of Tasks (inclusion, exclusion positive and exclusion negative), thus allowing a valid comparison of electrodes included in each latency region.

Further statistical actions were taken to investigate which of these selected electrodes best represented the (orientation) effect, whether orientation had been established for both positively and negatively valenced memories and whether a difference between them were to be found. This was attained subtracting the exclusion value from the baseline condition (i.e. inclusion) for both exclusion positive and exclusion negative on the above stated electrodes and separately for each time window. The electrodes presenting the strongest orientation effect were then chosen for further analyses. Figure 3 demonstrates the topographic maps and the ERP grand average waveforms from three representative electrodes, one in each time window, for which the orientation effect was maximal.

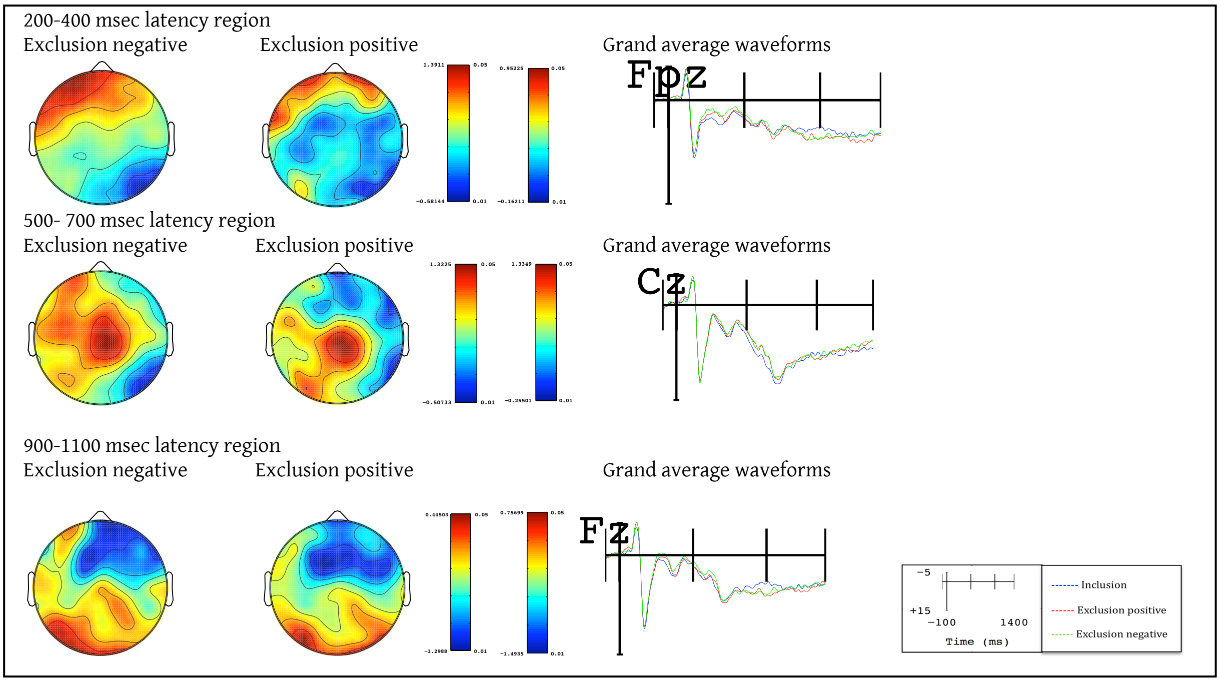


Figure 3: An illustration over the topography for the two exclusion tasks (exclusion negative and positive respectively) depicting the amplitude differences of the ERPs evoked by 'new' test items separated over tasks when compared against inclusion. The topographic maps illustrate the distribution of the orientation effect within three latency regions starting with the earliest. One electrode in each time window is presented to illustrate the orientation effect, starting with FPZ (200-400msec), followed by CZ and FZ (500-700 and 900-1100msec respectively).

*200-400msec Latency Region*

Inspection of the grand average wave forms in Figure 3 (FPZ), in the first time window, showed that the critical ERPs elicited by 'new' faces in the two exclusion tasks appeared to differ from inclusion by eliciting more negative going ERPs at approximately 200 msec post-stimulus onset, lasting until approximately 400msec. The topographic maps (Fig.3) in the first time window furthermore showed a frontal distribution for both exclusion tasks. Subsequently, the electrodes chosen for further analysis were: (frontopolar) FP1, FPZ, FP2, (frontal) F7, FZ, F8, (temporocentral) FT7, FCZ, FT8.

The effects were analysed using data from a 3x3x3 (Task, Anterior Posterior dimension and Hemisphere) repeated measure ANOVA, which revealed a main effect on TASK $F(2,58) = 5.86$, $p = .01$, partial eta squared= .17, confirming that the ERP amplitude elicited by the critical ERPs could be differentiated by means of test.

As evident in Table 4, pairwise comparisons showed a large effect sizes for both exclusion tasks. However, while comparing the two exclusion tasks with each other revealed numerical differences, neither reliable significance nor substantial effect sizes were found.

Table 4: Pairwise comparison tests for a main effect on task, separated over task type and time window.

| | Pairwise comparisons |
|---|---|
| Task Type | 200-400msec |
| Incl Vs Excl Pos | ($p$= .05, partial eta squared= .13) |
| Incl vs Excl Neg | ($p$= .00, partial eta squared= .32) |
| Excl Pos vs. Excl Neg | (p= .22, partial eta squared= .05) |
| 500-700 msec | |
| Incl Vs Excl Pos | ($p$= .05, partial eta squared= .13) |
| Incl vs Excl Neg | ($p$= .01, partial eta squared= .21) |
| Excl Pos vs. Excl Neg | ($p$= .84, partial eta squared= .00) |
| 900-1100 msec | |
| Incl Vs Excl Pos | ($p$= .04, partial eta squared= .15) |
| Incl vs Excl Neg | ($p$= .01, partial eta squared= .19) |
| Excl Pos vs. Excl Neg | ($p$= .88, partial eta squared= .00) |

*500-700msec Latency Region*

Following further inspections of the topographic maps and grand average waveforms in the second time window (Fig.3: CZ), the amplitude difference between exclusion tasks appeared to have a sustained polarity but now with a parietal distribution. Subsequently, the electrodes chosen for further analysis were: (central) C5, CZ, C6, (temporocentral) FT7, FCZ, FT8.

A 3x2x3 repeated measure ANOVA revealed an interaction between Task and Anterior Posterior dimension, $F(2,58) = 3.20$, $p = .05$, partial eta squared = .10, as well as an interaction between Task and Hemisphere, $F(4,16) = 3.13$, $p = .02$, partial eta squared = .10.

Follow up analyses of these two-way interaction effects revealed the following effects: (1) For inclusion vs. exclusion positive an effect was found for Task and Hemisphere, $F(2,58) = 4.91$, $p = .01$, partial eta squared = .15; (2) For inclusion vs. exclusion negative, the effect was evident for Task and Anterior Posterior dimension, $F(1,29) = 7.22$, $p = .01$, partial eta squared = .20, as well for Task on Hemisphere, $F(2,58) = 3.89$, $p = .03$, partial eta squared = .12). As evident in Table 5, the effect was maximal over midline central- parietal electrodes. This result was in line with the visual inspection of the topographic maps in the second time window (Fig.3).

Table 5: Illustration over 2x2 repeated measure ANOVA in which Task was administered for each electrode to find out where the largest magnitude difference between the critical classes of ERPs was located.

| | Pairwise comparison testing | |
|---|---|---|
| *P* ("New response) | | Partial Eta Squared |
| Exclusion Positive | | |
| C5 | -- | |
| CZ | .02 | .19 |
| C6 | -- | |
| TP7 | -- | |
| CPZ | .01 | .19 |
| TP8 | -- | |
| Exclusion negative | | |
| C5 | .02 | .19 |
| CZ | .01 | .23 |
| C6 | -- | |
| TP7 | -- | |
| CPZ | .00 | .22 |
| TP8 | -- | |

*900-1100msec Latency Region*

As evident from the topographic maps and grand average wave forms in the third time window (Fig.3: FZ), the ERP orientation effect now revealed a change in polarity: the critical ERPs from the two exclusion tasks elicited more positive going ERPs compared to inclusion. In addition, the orientation effect now re-appeared as a frontal distribution. The electrodes chosen for further analysis were: (frontal) F7, FZ, F8.

A 3x3 repeated measure ANOVA revealed a main effect on Task for CR: $F\ (2,58) = 4.15$, $p = .02$, partial eta squared = .13. As evident in Table 4, pairwise comparison tests showed a large effect size for both exclusion tasks, of which the negative was the stronger. The two exclusion tasks with each other revealed no significance and a small effect size.

ERP Correlation Analyses

Repeated measures ANOVA were initially performed to calculate each of the electrodes orientation value. This value was attained subtracting the exclusion value from the inclusion value on particular electrodes, which were selected visually consulting the topographic maps (Fig.3). The resulting value was then used as representative of the orientation effect on that particular electrode in that particular time window (Table 6). Of these electrodes, only those representing the largest orientation effect were chosen for further correlation analyses.

Table 6. P values and effect sizes for 'new' responses of the selected electrodes revealing the strongest difference in magnitude between the critical classes of ERPs.

| Task/Electrodes | |
|---|---|
| | P values for 200-400msec |
| Exclusion positive | |
| FT7 | .02 (.16) |
| FP1 | .03 (.15) |
| FP2 | .05 (.13) |
| Exclusion negative | |
| FPZ | .00 (.29) |
| FP1 | .00 (.28) |
| FT7 | .00 (.27) |
| | P values for 500-700msec |
| Exclusion positive | |
| CZ | .02 (.19) |
| CPZ | .01 (.19) |
| Exclusion negative | |
| CZ | .01 (.23) |
| CPZ | .00 (.22) |
| | P values for 900-1100msec |

| | |
|---|---|
| Exclusion positive | |
| FZ | .03 (.15) |
| F8 | .05 (.13) |
| Exclusion negative | |
| F8 | .03 (.15) |
| FZ | .04 (.14) |

Note: Parietal Eta Squared value is presented in parentheses.

Retrieval Orientation, Memory Performance and Wellbeing Self-Assessment Scores

*Correlation of Retrieval Orientation and Memory Performance*

As evident in Table 7, the analysis showed a significant positive correlation between orientation and Memory performance in the first time window. The relationship was located on FP1 between exclusion positive and *Relative Memory* performance (*rho* = .40, *p* = < .05). Neither the second nor the third time window contained a significant correlation.

Table 7: Spearmann's correlation analysis showing effect sizes (rho) conducted on emotional memory performance and orientation, on the electrodes best representing the effect, separated according to task and time window.

| Memory Type | | | Orientation electrodes | | | |
|---|---|---|---|---|---|---|
| | Exclusion Positive | | | Exclusion Negative | | |
| 200-400msec | | | | | | |
| | FT7 | FP1 | FP2 | FPZ | FP1 | FT7 |
| TRPos | -.24 | .14 | .05 | .07 | .11 | .10 |
| TRNeg | .20 | -.20 | -.08 | .14 | -.03 | .04 |
| RelM | -.16 | **.40*** | .29 | -.11 | .17 | .01 |
| 500-700msec | | | | | | |
| | CZ | CPZ | | | CZ | CPZ |
| TRPos | -.29 | -.32 | | | .00 | -.02 |
| TRNeg | -.05 | -.1o | | | -.01 | -.04 |
| RelM | -.31 | -.31 | | | .11 | .10 |
| 900-1100msec | | | | | | |
| | FZ | F8 | | | F8 | FZ |
| TRPos | -.25 | .00 | | | -.06 | -.03 |
| TRNeg | .01 | -.16 | | | .05 | -.02 |
| RelM | -.25 | .12 | | | -.09 | -.03 |

* Indicates *p*= < .05. Bold numbers indicate that the effect sizes are medium to large according to Cohen's (1998). Note. TRpos (Positive Targets); TRneg (Negative Targets); RelM (Relative Memory performance).

*Retrieval Orientation and Wellbeing Self—Assessment Scores*

As evident from Table 8, in the early time window, Spearmann's correlations showed two significant positive correlations on FT7 within exclusion positive: (1) *PANAS positive Affect scale* ($rho = .38$, $p = < .05$) and (2) *MADRS depression rating scale* ($rho = -.39$, $p = < .05$). In the mid time window, Spearmann's correlation showed a significant negative correlation on CZ between exclusion positive and *MADRS depression rating scale* ($rho = -.36$, $p = < .05$). In addition, a significant negative correlation was established on CPZ between exclusion positive and *MADRS depression rating scale* ($rho = -.39$, $p = < .05$). In the last time window, a significant negative correlation was found on FZ between exclusion positive and *BDI-II self-assessment questionnaire* ($rho = -.48$, $p = < .01$). A negative correlation was also found on the same electrode between exclusion positive and *PANAS positive Affect scale* ($rho = 40$, $p = < .05$).

Table 8: Spearmann's correlation analysis stating the sizes (rho) conducted on self-assessment scores and orientation, on the electrodes best representing the effect, separated according to task and time window.

| Orientation electrodes | | | | | | |
|---|---|---|---|---|---|---|
| Self-Assessment scales | Exclusion Positive | | | Exclusion Negative | | |
| | FT7 | FP1 | FP2 | FPZ | FP1 | FT7 |
| 200-400msec | | | | | | |
| BDI-II | -.34 | -.08 | .05 | -.30 | .07 | .03 |
| PANASn | -.29 | .06 | -.01 | -.14 | .13 | .11 |
| PANASp | **.38*** | .20 | .08 | .30 | .08 | .00 |
| MADRS | **-.39*** | .08 | .06 | -.23 | .08 | .02 |
| STAI | -.23 | -.00 | .05 | -.18 | .05 | .15 |
| 500-700msec | | | | | | |
| | CZ | CPZ | | | CZ | CPZ |
| BDI-II | -.23 | -.25 | | | -.25 | -.34 |
| PANASn | -.16 | -.20 | | | -.15 | -.18 |
| PANASp | .18 | .21 | | | .04 | .15 |
| MADRS | **-.36*** | **-.39*** | | | -.10 | -.14 |
| STAI | -.25 | -.26 | | | .03 | -.04 |
| 900-1100msec | | | | | | |
| | FZ | F8 | | | F8 | FZ |
| BDI-II | **-.48**** | -.28 | | | .24 | -.20 |
| PANASn | -.34 | -.16 | | | -.26 | -.22 |
| PANASp | **.40*** | .23 | | | .09 | .11 |
| MADRS | -.35 | .08 | | | -.11 | -.13 |
| STAI | -.31 | -.14 | | | -.32 | -.04 |

* Indicates $p = < .05$, ** indicates $p = < .01$. Bold numbers indicate that the effect sizes are medium to large according to Cohen's (1998).

*Memory Performances and Wellbeing Self- Assessment Scores*

As evident from Table 9, Spearmann's correlation analysis show four positive correlations between Positive correlations were found between the ability to detect *Positive Targets* and (1) *BDI-II self-assessment questionnaire* (*rho* = .42, *p* = < .05), (2) *PANAS negative Affect scale* (*rho* = .38, *p* = < .05), (3) *MADRS depression rating scale* (*rho* = .47, *p* = < .05), (4) *STAI anxiety measurement scale* (*rho* = .51, *p* = < .05). Positive correlations were additionally found between *Relative Memory* and (1) *BDI-II self-assessment questionnaire* (*rho* = .42, *p* = < .05), (2) *PANAS negative Affect scale* (*rho* = .38, *p* =<. 05) (3) *MADRS depression rating scale* (*rho* = .47, *p* = < .05), and (4) *STAI anxiety measurement scale* (*rho* = .51, *p* = < .05).

Table 9: Spearmann's correlation analysis conducted on emotional memory performance measure and self-assessment scales illustrating effect sizes (rho).

| | Self-assessment questionnaires | | | | |
|---|---|---|---|---|---|
| Performance type | | | | | |
| | BDI-II | PANAS neg | PANAS pos | MADRS | STAI |
| Target Positive | **.42*** | **.38*** | -.15 | **.47*** | **.51*** |
| Target Negative | .07 | .09 | .08 | -.01 | .08 |
| Relative Memory | **.42*** | **.38*** | **-.30** | **.63**** | **.55*** |

* Indicates $p = < .05$, ** indicates $p = < .01$.

Summary of Results

The objective with the analyses from the ERP data was to characterize amplitude differences in the brain's electrophysiological response to 'new' faces in memory recognition tests, using two emotional source recognition exclusion tasks and a baseline old-new recognition inclusion condition.

In support of previously studies on retrieval orientation, the current study replicated the retrieval orientation effect using source recognition tasks of emotional and non-emotional retrieval demands. This corresponded to differences in ERPs evoked by 'new' faces in the two emotional source exclusion tasks when compared to inclusion. The effect was evident from approximately 200- 1100msec. While the effect took the form of a negative going ERPs from 200-700msec, the critical ERPs were more positive going from 900-1100msec. As indicated by the topographic maps (Fig.3), the early effect had an initial frontal distribution, followed by a mid centre parietal distribution after which a frontal distribution re-appeared. The correlation analysis revealed a positive relationship between ERP correlates of positive orientation and positive valenced memory performance in the first latency region.  A positive correlation between the ERP correlates of positive orientation and wellbeing was found in all three latency regions.

**DISCUSSION**

The critical ERPs, elicited by 'new' test faces attracting correct responses, varied according to task requirements, thereby supporting the most central hypothesis predicting that the concept of retrieval orientation could be extended to include emotion as an episodic quality. For clarification, differences in critical ERPs found in exclusion positive task will here on be referred to as the ERP correlates of positive orientation effect and the critical ERPs found in exclusion negative as ERP correlates of negative orientation effect.

The second hypothesis, concerning potential valence specific orientation effects, was rejected. While there were numerical ERP amplitude differences evoked by 'new' faces in both orientation conditions, showing slightly more going ERPs for negative orientation primarily in the first time window (Fig.3), the differences were not statistically significant.

The third hypothesis predicted a valence congruent relationship between emotional retrieval orientation and emotional memory, as evinced by a positive correlation between the two variables. The hypothesis was confirmed (Table 7). The significant correlation between ERP correlates of positive orientation and relative memory performance established in the first time window were of a positive nature. Hence, the stronger the establishment of the ERP correlates of positive orientation effect, the better relative memory performance for retrieving positive targets.

The fourth hypothesis was an extension of the latter, reflecting the existence of a valence congruent relationship between orientation and memory, by which it was hypothesized that such congruent associations would additionally adhere to wellbeing. This hypothesis was confirmed (Table 8). While the direction of the relationship was negative, the conclusion after inverting the self-assessment scores was that the stronger the establishment of the ERP correlates of a positive RO the higher degree of wellbeing

At the present moment we offer no conclusive explanation for why the second hypothesis predicting a valence specific retrieval orientation effect did not sustain statistical support in either time window (Table 4). A valence specific orientation effect would have implied that, when searching for positive valenced memories, this would lead to an establishment of a unique orientation that could be separated from the an orientation effect established when searching for negative valenced memories. A potential reason why the current study fell short in achieving the aforementioned is speculative at best. Perhaps a between-subject design, in which valence is separated on a group basis, would attained a statistically reliable effect. Perhaps did the within- subject block design employed in the current study created an emotional valenced transfer effect, which negatively influenced the results.

Emotional Retrieval Orientation

Robust differences between ERPs elicited by 'new' items have been reported in several studies (Dzulkifli, Sharpe, & Wilding, 2004; Dzulkifli & Wilding, 2005; Herron & Rugg, 2003; Hornberger, Morcom, & Rugg, 2004; Hornberger, Rugg, & Henson, 2006; Johnson et al. 1997; Ranganath & Paller, 1999, 2000; Robb & Rugg, 2002; Stenberg, Johansson & Rosén, 2005; Rugg, Allan & Birch, 2000; Bridger, Herron, Elward, & Widling, 2009). However, to our knowledge there have been no published reports of whether the effect can be extended to include emotion.

The current study successfully contributed with the first empirical support of an emotional retrieval orientation. The motivation for introducing emotion into the concept of retrieval orientation was based on the fact that emotion in memory literature holds a unique position, be it from an evolutionary, cognitive or from a neuronal perspective. Emotional memories, being more durable, are supported by neural mechanisms different from neural mechanisms supporting non-emotional memories (see introduction). Thus, it would seem highly likely that the processing of a retrieval cue would be different when the information being probed is of a emotional character (i.e. the exclusion tasks) compared to when the information being probed for is of a non-emotional character (i.e. the inclusion tasks), as shown in prior exclusion studies presented in the introduction. Additionally, the effect appears to have an earlier onset compared to previous studies using non-emotional material (see introduction). The reason may be explained using an evolutionary perspective: a predisposition to prepare for retrieval or emotional memories compared to non-emotional episodic qualities.

Correct Rejections to New Faces

The orientation effect was indexed using correctly classified 'new' faces only. As discussed in the introduction, the orientation effect can therefore not be a reflection of processing associated with or contingent upon positive recognition judgements such as retrieval success.

Furthermore, the behavioural analysis revealed no significant difference in levels of difficulty across tasks. The effect of orientation was successfully obtained despite equivalent levels of CR across target designation as well as between emotional valence designations. This is imperative since it suggests that any differences between ERPs elicited by unstudied faces separated according to target designation were unlikely to reflect different levels of difficulty across tasks. This interpretation is supported by previous studies (Rubb and Rugg 2002; Wilding, 1998; Hornberger, Rugg & Henson, 2004) (see also Dzulkifli, Sharpe & Wilding 2004). The current study did, however, not take reaction times into account and therefore there is a possibility that reaction time differed between tasks, which could have affected the results. Nonetheless, with a few exceptions, other studies have found no relationships between the magnitude of the orientation effect and difference in reaction times (Rugg et al. 2000; Hornberger et al. 2004).

Findings from the current study suggest an early and a late orientation effect. An early emotional orientation effect was apparent from 200msec post-stimulus onset and remained until approximately 700msec. The ERPs evoked by CR within this time frame were more negative going than were the ERPs evoked by CR in the inclusion condition.

In terms of the distribution of effect, an initial frontal distribution was evident from 200-400 msec, followed by a mid centre parietal distribution from 500-700msec. The last time window, 900-1100msec, showed a re-appearance of the initial frontal distribution. This change in distribution can be taken as evidence for an engagement of functionally different processes during emotional retrieval orientation.

The study additionally demonstrated a second later orientation effect was at around 900msec and lasted until approximately 1100msec. The direction of the critical ERPs was now more positive than compared to inclusion and, as opposed to the effect evident from 200-700msec. While not statistically reliable the ERP orientation effect in this last time window appeared to be frontally distributed. The extended time course (approximately 1100msec) of the emotional orientation effect found in the present study is in line with previous studies on orientation, in which the general time course is approximately 300 to 1500msec (Wilding, 1999; Bridger et al. 2009; Dzulkifli, Sharpe & Wilding, 2004; Herron & Rugg, 2003; Hornberger, Rugg & Henson, 2005).

Concerning the comparison of the scalp distributions stated above, different distributions of ERP effects could be used to investigate whether different classes of stimulus evoke different patterns of neural activity. In contrast to previous orientation studies in which no change in distribution was found (see introduction), the current emotional orientation effect showed an initial frontal distribution, which than changed into a mid-centre parietal distribution, followed by the re-appeared of the initial frontal distribution. While the change in distribution is contrary to some of the previous orientation studies (i.e. Hornberger, Rugg & Henson, 2005; Dzulkifli et al. 2004; Bridger et al. 2009), the distribution of prior orientation effects commonly show frontal and central distributions (Herron & Rugg, 2003; Hornberger, Rugg & Henson, 2005; Rugg, Allan & Birch, 2000).

The findings in the current study indicate that the differences between the critical ERPs were most pronounced in the first time window. The reason may be explained as the initial engaging in a retrieval orientation process. When the brain first begins to selectively search for a particular memory trace with a particular episodic quality (emotion), prompted by a retrieval cue (a face). It would seem likely that the initiation of such strategic retrieval processing would leave behind a relatively strong neural imprint.

In addition to the effect being strongest in the first time window, the ERP correlates for negative orientation compared to the ERP correlates for positive orientation showed a stronger effect, in all time windows. This may be supported by the fact that negative items also seem more likely to be remembered with specific details than with positive memories. Negative memories benefits from a focus on memory for detail (Kensinger, 2007), which makes sense within an evolutionary framework. A primary function of emotion is to guide action (Lazarus, 1991) and thus it is logical that attention would be focused on potentially threatening information and that memory mechanisms would ensure that details predictive of an events affective relevance would be encoded precisely.

As presented in the introduction, PFC plays an important role in episodic memories and anterior scalp distributions of retrieval orientation have been associated with and draw support from generator or generators positioned in PFC (Wilding, 1999). Empirical studies focusing on memory retrieval have supported the idea that the functional integrity of PFC is necessary for strategic retrieval processing (see Ranganath & Paller, 2000). Therefore, there may be good reasons to believe that the differences found in the current study between the critical ERPs at frontal scalp locations (in the first and last time window) may reflect activity in the prefrontal cortex related to the emotional orientation effect found in the current study. It has furthermore been proposed that processes supporting the retrieval of contextual information become available around 900msec (Yonelinas & Jacoby, 1994), at which time the current study shows the re-appearance of the frontal distribution.

The most economical explanation for the differences between the critical ERPs evoked by the two classes of 'new' faces in the current study is that they are an index of the engagement of different retrieval orientations (emotional and non-emotional) and that the degree to which the task-specific retrieval processes are engaged is not modified by task difficulty. The findings presented here are taken in support of the proposal that people process retrieval cues differently according to the form of the sought after information, here illustrated using emotional vs. non-emotional pictorial stimuli. This allows us to focus retrieval attempts on only a selective subset of memories, which optimizes its effectiveness as a retrieval cue. This follows from the suggestion that episodic memory retrieval is facilitated when overlap between cue and target processing is high, as embodied in theoretical principles such as the transfer appropriate processing and encoding specificity (see introduction). Consequently, the findings presented here further support the notion that retrieval orientation engages strategic source monitoring processes.

### Emotional Retrieval Orientation and Emotional Memory Performance

The current study predicted that the ERP correlates of positive orientation would be positively related to the retrieval of positive memory, demonstrating a congruent relationship between emotional orientation and emotional memory retrieval. The rationale for such prediction stems from empirical studies demonstrating the mood-congruent memory recall bias, stating that depressed individuals present a memory bias towards negative memories (see introduction). The congruence between mood and the facilitated ability to retrieve emotional memories raises the question whether this biased effect additionally could influence the brains electrophysiological response when processing an emotional retrieval cue according to a specific valence demand.

The results indicated valence congruent relationship between ERP correlates of positive orientation and relative memory performance. In other words, the ERP correlates of positive orientation effect facilitated the retrieval of positive relative to negative memories. What could a relationship between positive orientation effect and positive memory represent? If a positively valenced emotional retrieval orientation effect facilitates the detection of positive targets relative to negative this would extend the notion of mood-congruent memory recall bias to include strategic memory retrieval processes.

In the current study, the ERP correlates of negative orientation presented neither reliable correlations nor reasonable effect sizes in relation to memory performance in any of the three latency regions. A speculative reason underlying the absence of such may be related to the relatively healthy degree of wellbeing in the sample size employed which again would support the notion of mood-congruent memory recall bias.

Emotional Retrieval Orientation and Wellbeing Self-Assessment Scores

The current study predicted a valence congruent relationship between orientation and wellbeing: i.e. that the ERP correlates of positive orientation would be negatively correlated with the self-assessment questionnaires. As in the former hypothesis, the rationale for such prediction stems from the fact that depressed individuals present a memory bias towards negative memories and the current study sought to extend such bias to include the orientation effect.

The finding confirmed negative correlations between the positive orientation effect and self-assessment questionnaires which signified that the stronger the orientation effect, the lower the self-assessment scores. When inverting the scores, results implied that the stronger the orientation the higher the degree of wellbeing. In fact, considering all correlations made between orientation and wellbeing it was evident that the stronger the orientation effect is, the higher the degree of wellbeing.

The predictions addressed questions concerning what implication an emotional retrieval orientation effect could have for our wellbeing, or put differently, what implications could our wellbeing have for the establishment of emotional retrieval orientation. Could perhaps a larger establishment of negative retrieval orientation be indicative of depression? If so, the establishment of orientation effects may be used as a supplementary method of diagnosing mood disorders or at least as a measure indicating tendencies towards depression.

Reflecting on the absence of reliable correlations between the ERP correlates of negative orientation and wellbeing (in line with above presented correlations with memory), a credible presumption is that the outcome would be different had the current study employed a clinical sample. For one must remember that the sample size used in the current study, whilst speaking of higher and lower degree of wellbeing as assessed by the self-assessment scores, the scoring of the participants as at a healthy level. As a result of the participants not scoring high enough, the scores were treated independently of the traditional cutoff scores.

Focusing solely on the relationship between emotional memory performance and wellbeing, it was evident that those participants who had the lower degree of wellbeing showed the best performance on positively valenced memories. While not explicitly part of the experimental predictions, the findings that memory and wellbeing is correlated in this particular way was highly surprising. These findings are contrary to the notion of mood-congruent recall. Could it possibly be that those with a lower degree of wellbeing (while not being clinically depressed) compensate by attending more to the positive targets and thus show a higher performance for such? The reason why these results are in contrast to the traditional findings may be due to the simple reason that the current study used a rather small sample size of a non-clinical population and it did not use the accompanying traditional cutoff scores. As previously stated, the clinical tests employed in this study may simply not be sensitive enough to be used in the current context by means of sample type and sample size.

To summarise, the important aspects of the current findings are (1), support for that participants adopted different retrieval orientations depending on the emotional or non-emotional nature of the information that must be retrieved to satisfy the task requirement, even when the tasks were of equal difficulty. Constraining the processing of retrieval cues to match the encoded information should be beneficial in that it would increase the likelihood of successful recognition or rejection of test items. While the first of its kind to include emotion as an episodic source memory retrieval quality, the findings support previously reported ERP retrieval orientation effects. (2) Support for a valence congruent relationship between positive retrieval orientation and the ability to retrieve positive emotional memories. (3) Support for a valence congruent relationship between orientation and wellbeing.

The establishment of the emotional retrieval orientation effect here presented is of high reliability since the effect was evident in three latency regions. The usage of a baseline condition (i.e. inclusion) to which the differences were compared further support the validity of the present findings. Merely comparing source memory recognition (exclusions) conditions would not adequately explain any possible ERP difference found across retrieval tasks.

Limitations of the current study

In the current study, a few remarks were made in relation to the emotional stimulus material, particularly the employment of “neutral faces”. One may go so far as to question the existence of a “neutral" human face. Some eyes just seem to smile at you while others scare. Such individual differences may negatively influence the results. If a natural face is perceived as negative yet paired with a positive image, an incongruency effect may effect the later retrieval processing. While the problem may never be completely avoided, future studies may gain by using computerized faces. Today’s technology could likely create a credible computerized neutral human face, which would further standardize the stimulus material.

Another remark valid for most studies of emotional memory is that you examined short-lived emotional reactions to stimuli. This happens, for instance, when showing pictures of a gun presented within a safe laboratory environment. One could question whether such mnemonic influences are comparable to those that arise when you experience highly arousing events in real life. Most of us would agree that a picture of a loaded gun would fail to induce a comparable response as having a gun really pointed at your face.

Other difficulties in emotional memory studies concern the comparing of emotionally valenced images. For instance, a positive valenced image, as positive as it may be, rarely can measure up to a highly negative. As stated in the introduction, negative valence seems to be remembered with more details compared to positive information and, while such bias makes perfect sense from an evolutionary perspective, it creates problems for designing experiments of emotional memory. One way of decreasing the difference between emotionally valenced images could be to select which particular negative emotions one takes into account (e.g. disgust, fear or sadness). The present study fell short in doing so.

Future Directions

Since the literature on retrieval orientation is already very scarce, further research on emotional retrieval orientation is needed in order to fully comprehend its characterization.

A fruitful step would be further investigations into whether an emotional orientation effect, as in line with Bridger et al. (2009), serves as a facilitating mechanism. This would be achieved using a median split to correlate high and low relative memory performance (of positive and negative nature) with the neural correlates of positive and negative retrieval orientation.

Another idea is to extend the previous study using emotional words (visually and/or orally presented) in order to see whether the manifestation of the emotional orientation effect differs from the one established using pictorial stimuli. As stated in the introduction, while verbal material has already been used to investigate the orientation effect, none has used non- emotional verbal material (in either format). The interest in comparing verbal vs. pictorial emotional stimuli arises from the notion that pictures, in contrast to words, stand in a relation of likeness to the object they represent. Intuitively one could assume that pictures are perceived in a different way than words, being essentially based on linguistic conventions.

While the current study, using a non-clinical population, found correlations between the ERP correlates of positive orientation, memory performance and wellbeing, none was found within negative orientation. If positive orientation facilitates positive memory retrieval and wellbeing in a healthy population (thereby possibly explaining the absence of correlations within a negative orientation effect), future studies may look to clinical populations, comparing the manifestation of positive and negative orientation effects in clinical and non-clinical samples. From this perspective, the establishment of positive and negative emotional orientation effects may be used indicative of mental health, which would be useful for clinicians working with mood-disorders.

Another possibility would be to include emotion regulation as a variable, investigating whether different regulatory strategies affect differently the neural correlates of orientation. The interest being the importance of cognitive control of emotion for human adaptive functioning and the notion that a deficiency in the cognitive control effecting emotion regulation is a common factor in mood-disorders.

**REFERENCES**

Aron, A.R., Poldrack, R.A. (2005). The cognitive neuroscience of response inhibition: relevance for genetic research in attention-deficit/hyper activity disorder. *Biological Psychiatry*, 57, 1285-1292.

Beck AT, Steer RA, Brown GK: *Manual for Beck Depression Inventory II* (BDI-II). San Antonio, TX, Psychoogy Corporation, 1996.

Bridger, E.K., Herron, J.E., Elward, R.L., Wildring, E.L., (2009). Neural Correlates of Individual Differences in Strategic Retrieval Processing. *Journal of Experimental Psychology: Learning, Memory and Cognition*. 35:5, 1175-1186.

Cahill, L., & McGaugh, J.L. (1998). Mechanisms of emotional arousal and lasting declarative memory. *Trends in Neuroscience*, 2, 352-363.

Campbell-Sills, L., & Barlow, D.H. (2009). In J.J. Gross (Eds). *Handbook of emotion regulation* (pp. 542-560). New York: Guildford Press.

Christianson, S.A. (1992). *The handbook of emotion and memory*. Hillsdale, Nj: Erlbaum.

Cohen, J. W. (1988). *Statistical power analysis for the behavioural science* (2nd edn). Hillsdale, NJ: Lawrence Erlbaum Associates.

Danion, J.M., Kauffmann-Muller, D., Grange, D., Zimmermann, M.A., Greth, P. (1995). Affective valence of words, explicit and implicit memory in clinical depression. *Journal of Affective Disorders*, 34, 227-234.

DeLuca, J. (2000). A cognitive perspective on confabulation. *Neuro- Psychoanalysis*, 2, 119–132.

Diana, R.A., Yonelinas, A.P., & Ranganath, C. (2007). Imaging recollection and familiarity in the medial temporal lobe: A three- component model. *Trends in Cognitive Sciences,* 11, 379–386. representation of context. Trends in Cognitive Sciences, 12, 24–30.

Dichter, G.S, Felder, J.N., Smoski, M.J. (2009). Affective context interferes with cognitive control in unipolar depression: an fMRI investigation, *Journal of Affective Disorders*, 114, 131-142.

Dozois, D.J.A., & Dobson, K.S. (2001). Information processing and cognitive organization in unipolar depression: specificity and comorbidity issues. *Journal of abnormal psychology*, 110, 236-246.

Dzulkifli, M.A., Sharpe, H.L., & Wilding, E.L. (2004). Separating item-related electrophysiological indices of retrieval effort and retrieval orientation. *Brain and Cognition*, 55, 433-443.

Dzulkifli, M.A., & Wilding, E.L. (2005). Electrophysiological indices of strategic episodic retrieval processing. *Neuropsychologia*, 43, 1152-1162.

Friedman, D., & Johnson, J.R. (2002). Event-related potential (ERP) studies of memory encoding and retrieval: a selective review. *Microscopy Research and Technique*, 51, 6-28.

Gotlib, I.H., Krasnoperova, E., Yue, D.N., Joormann, J. (2004). Attentional biases for negative interpersonal stimuli in clinical depression. *Journal of abnormal psychology*, 113: 127-135.

Greenhouse, G.W., & Geisser, S. (1959). On methods in the analysis of profile data. *Psychometrika*, 49, 95-112.

Hamann, S.B., Ely, T.D., Grafton, S.T., & Kilts, C.D. (1999). Amygdala activity related to enhanced memory for pleasant and aversive stimuli. *Nature Neuroscience*, 2, 289-293.

Hamann, S.B. (2001). Cognitive and neural mechanisms of emotional memory. trends in *Cognitive Science*, 5, 394-400.

Herron, J.E., & Rugg, M.D. (2003). Retrieval orientation and the control of recollection. *Journal of Cognitive Neuroscience*, 15, 843-854.

Hornberger, M., Rugg, M.D., & Henson, R.N. (2006). ERP correlates of retrieval orientation: Direct versus indirect memory tasks. *Brain Research*, 1071, 124-136.

Hornberger, M., Morcom, A.M., & Rugg, M.D. (2004). Neural correlates of retrieval orientation: Effects of study-test similarity. *Journal of Cognitive Neuroscience*, 16, 1196-1210.

Jacoby, L.L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language*, 20, 513-541.

Jacoby, L. L. & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. Journal of Experimental Psychology: General, 110, 306-340.

Johansson, M., Mecklinger, A., Treese, AC. (2004). *Journal of Cognitive Neuroscience,* 16(10), 1840-1853.

Johnson, M.K., Foley, M.A., Leach, K. (1998). The consequence for memory of imagining in another person's voice. *Memory and Cognition*, 16, 337-42.

Johnson, M.K., Hashtroudi, S., Lindsay D.S. (1993). Source monitoring. *Psychological Bulletin*, 1143-28.

Johnson, M.K., Kounios, J., & Nolde, S.F. (1997). Electrophysiological brain activity and memory source monitoring. *NeuroReport*, 8, 1317-1320.

Kensinger, E. A. (2007) Negative Emotion Enhances Memory Accuracy: Behavioral and Neuroimaging Evidence. *Current Directions in Psychological Science*, 16(4), 213-218.

Kensinger, E.A., & Schacter, D.L. (2006). When the red sox shocked the Yankees: comparing negative and positive memories. *Psychonomic Bulletin & Review*, 13(5), 757-763.

Koster, E.H.W., De Raedt, R., Goeleven, E., Franck, E., Crombez, G. (2005). Mood-congruent attentional bias in dysphoria: maintained attention to and impaired disengagement from negative information. *Emotion,* 5, 446-455.

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (2008). *International affective picture system (IAPS): Affective ratings of pictures and instruction manual.* Technical Report A-8. University of Florida, Gainesville, FL.

Lazarus, Richard (1991). Cognition and Motivation in Emotion, *American Psychologist* 46, 362–67.

Levine, L.J., & Bluck, S. (2004). Painting with broad strokes: Happiness and the malleability of event memory. *Cognition and Emotion*, 18, 559-574.

Luck, S.J. (2005). An introduction to the event-related potential technique. Cambridge, MA: MIT Press.

Lyubomirsky, S., Caldwell, N. D., & Nolen-Hoeksema, S. (1998). Effects of ruminative and distracting responses to depressed mood on retrieval of autobiographical memories. *Journal of Personality and Social Psychology*, 75, 166 –177.

Lyubomirsky, S., & Nolen-Hoeksema, S. (1993). Self-perpetuating properties of dysphoric rumination. *Journal of Personality and Social Psychology*, 65, 339 –349.

Lyubomirsky, S., Caldwell, N.D., & Nolen-Hoeksema, S. (1998). Effects of ruminative and distracting response to depressed mood on retrieval of autobiographical memories. *Journal of Personality and Social Psychology*, 65, 339–349.

Madigan, S. (1983). Picture Memory. In, J.C. Yuille (Eds.). *Imagery, memory and cognition: Essays in honor of Allan Paivio* (pp.65-89). Hillsdale NJ; Erlbaum.

Mandler, G. (1980). Recognizing: The judgement of previous occurrence. Psychologica Review, 87, 252-271.

Maratos, E.J., & Rugg, M.D. (2001). Electrophysiological correlates of the retrieval of emotional and non-emotional context. *Journal of Cognitive Neuroscience*, 13, 877-891.

Maratos, E.J., Dolan, R.J., Morris, J.S., Henson, R.N., & Rugg, M.D. (2001). Neural activity associated with episodic memory for emotional context. *Neuropsychologia*, 39, 910-920.

Martinez, A.M., & Benavante, R. (1998). *The AR face databse*. CVC Technical Report #24.

McClelland, J.L., McNaughton, B.L., & O'Reilly, R.C. (1995). Why there are complementary learning systems in the hippocampus and neocortex: Insights from the successes and failures of connectionist models of learning and memory. *Psychological Review*, 102(3), 419-457.

McGaugh, J.L., (2000). *Memory: a century of consolidation*. Science, 287. 248-251.

Miller, E.K., & Cohen, J.D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience*, 24, 167-202.

Morris, C.D. et al. (1977). Levels of processing versus transfer appropriate processing. *Journal of Verbal Learning and Verbal Behaviour*, 16, 519-533.

Nadel, L.N., & Moscovitch, M. (1997). Memory consolation, retrograde amnesia and the hipppocampal complex. *Current Opinion in Neurobiology*, 7, 217-227.

Nolen-Hoeksema, S., Morrow, J., & Fredrickson, B. L. (1993). Response styles and the duration of episodes of depressed mood. *Journal of Abnormal Psychology*, 102, 20–28.

Nolen-Hoeksema, S. (2000). The role of rumination in depressive disorders and mixed anxiety/depressive symptoms. *Journal of Abnormal Psychology*, 109, 504 –511.

Norman, K.A., & O'reilly, R.C. (2003). Modelling hippocampla and neocortical contributions to recognition memory: a complementary –learning systems approach. *Psychological Review*, 110 (4), 611-46.

Ochsner, K.N. (2000). Are affective events richly recollected or simply familiar? The experience and processes of recognizing feelings past. *Journal of Experimental Psychology*: General, 129(2), 242-261.

Petrides, M., & Mackey, S. (2006). The orbitofrontal cortex: sulcal and gyral morphology and architecture. In D.H. Zald & S.L. Rauch (Eds.). *The orbitofrontal cortex* (pp. 19-38). New York: Oxford University Press.

Ranganath, C., & Paller, K.A. (1999). Frontal brain potentials during recognition are modulated by requirements to retrieve perceptual details. *Neuron*, 22, 605-613.

Ranganath, C., & Paller, K.A. (2000). Neural correlates of memory retrieval and evaluation. *Cognitive brain research*, 9. 209-222.

Robb, W.G.K., & Rugg, M.D. (2002). Electrophysiological dissociation of retrieval orientation and retrieval effort. *Psychonomic Bulletin and Review*, 9, 583- 589.

Rugg, D.M., Allan, K., Birch, C.S. (2000). Electrophysiological evidence for the modulation of Retrieval Orientation by depths of study processing. *Journal of Cognitive Neuroscience*, 12(4), 664-678.

Rugg, M., Johnson, J.D., Park, H., & Uncapher, M.R. (2008). Encoding – retrieval overlap in human episodic memory: A functional neuroimaging perspective. In W. Sossin, J.-C. Lacaille, V. Castelluci, & S.Belleville (Eds.) *The essence of memory* (vol. 169, pp. 339 352). Elsevier, B.V.

Rugg. M.D., Wilding, E.L. (2000). Retrieval processing and episodic memory. *Trends in cognitive sciences*, 4(3), 108-115.

Schacter, D.L., Norman, K.A.,, & Koutstaal, W. (1998). The cognitive neuroscience of constructive memory. *Annual Review of Psychology*, 49, 289-318.

Simons, J.S., & Spiers, H.J. (2003). Prefrontal and medial temporal lobe interactions in long term memory. Nature Review Neuroscience, 4(8), 637-648.

Smith, A.P.R., Dolan, R. J., & Rugg, M.D., (2004). Event-Related Potential Correlates of the Retrieval of Emotional and Non-emotional Context. *Journal of Cognitive Neuroscience, 16*(5), 760-775.

Spielberger, C. D., Gorsuch, R.L., and Lushene. R.E. (1970). *Manual for the State-Trait Anxiety Inventory.* Palo Alto, CA: Consulting Psychologists Press.

Stenberg, G., Johansson, M., & Rosén, I. (2006). Conceptual and perceptual memory: Retrieval orientations reflected in event-related potentials. *Acta Psychologica*, 122, 174 205.

Svanborg, P., & Åsberg, M. (1994). A new self-rating scale for depression and anxiety states based on the Comprehensive Psychopathological Rating Scale. *Acta Psychiatrica Scandinavica, 89*, 21-28.

Thompson, S.S. & McCarrther, R. (1964). "What and WhereAre the Primary Affects? Some Evidence for a Theory. *Perceptual and Motor Skills*, 18, 119-158).

Tottenham, N., Tanaka, J., Leon, A.C., McCarry, T., Nurse, M., Hare, T.A., Marcus, D.J., Westerlund, A., Casey, B.J., Nelson, C.A. (2009). The NimStim set of facial expressions: judgments from untrained research participants. *Psychiatry Research*, 168(3):242-9.

Tulving, E. (1983) *Elements of episodic memory*. New York: Oxford University Press.

Tulving, E. (2002). Episodic memory and common sense: how far apart? In A.Baddele, M. Conway, & J.P. Aggleton (Eds.), *Episodic memory: new directions in research* (pp. 269-288). New York: Oxford University Press.

Tulving, E. and Thomson, D.M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, 80, 353-373.

Zimmer, Hubert, D., Mecklinger, A., Lindeberger, U. (2006). Levels of binding: types, mechanisms and functions of binding in remembering. In Zimmer, Hubert, D., Mecklinger, A., Lindeberger, U. (Eds), *Handbook of binding and memory. Perspectives from cognitive neuroscience* (pp. 5-22). Oxford University Press.

Wagner, A. (2002). Cognitive control of episodic memory. In L.R. Squire & D.L. Schacter (Eds.), Neuropsychology of memory (3 ed., pp.174-192). New York: Guilford Press.

Wager, T.D., Davidson, M.L., Huges, B.L., Lindquist, M.A., Ochsner, K.N. (2008) Prefrontal-subcortical pathways mediating successful emotion regulation. *Neuron*, 59, 1037-1050.

Wang, L., LaBar, K.S., Smoski, M., Rosenthal, M.Z., Dolcos, F., Lynch, T.R., et al. (2008). Prefrontal mechanisms for executive control over emotional distraction are altered in major depression. *Psychiatry Research*, 163: 143-155.

Watson, D., Clark, L.A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063-1070.

Wilding, E.L., (1999). Separating retrieval strategies from retrieval success: An event related potential study of source memory. *Neuropsychologia*, 37, 441-454.

Wilding, E.L. & Nobre, A.C. (2001). Task-switching and memory retrieval processing: Electrophysiological evidence. *NeuroReport*, 12, 3613-3617.

Williams, J. M. G.,Watts, F. N., MacLeod, C., & Mathews, A. (1997). *Cognitive psychology and emotional disorders* (2nd ed.). New York: Wiley.

Yonelinas, A.P. (2002). The nature of recollection and familiarity: A review of 30 years of research. Journal of Memory and Language, 46, 441-517.

Yonelinas, A.P., & Jacoby, L.L. (1994). Dissociations of processes in recognition memory – Effects of interference and of response speed. *Canadian Journal of Experimental Psychology*, 48, 516-535.