**Review on memory, metacognition and emotion**

Fiacconi et l. **Knowing by heart: Visceral feedback shapes recognition memory judgments.**

Although theories of emotion have long noted the importance of afferent feedback from the autonomic nervous system in generating feelings, there is a growing appreciation that this feedback may also play a role in shaping cognitive experiences. At present, little is known about its functional role in memory judgments. In the current study, **we examined whether afferent cardiovascular feedback shapes recognition-memory decisions and experiences when previously encountered faces are being discriminated from novel ones**. To investigate this possibility, we capitalized on the natural variation in baroreceptor mediated cardiovascular feedback that is associated with the cardiac cycle, synchronizing the brief presentation of memory probes during retrieval with individual heartbeats. In Experiments 1 and 2, we found that faces presented during cardiac systole (i.e., when visceral feedback is maximal) were more likely endorsed as “old” than those presented during cardiac diastole (i.e., when afferent feedback is minimal). This pattern was present for targets and lures, and held for faces with fearful or neutral expressions. Combining this manipulation with a remember/know procedure, Experiment 3 showed that **the influence of afferent cardiovascular feedback is specific to trials on which participants report a feeling of familiarity without successful recollection of pertinent contextual detail. By revealing an influence of baroreceptor mediated cardiovascular feedback on familiarity, the current findings identify the functional role of a specific autonomic channel, previously implicated in emotion, in feeling states that pertain to memory experience.** (PsycINFO Database Record (c) 2017 APA, all rights reserved)

(Kensinger, 2009) posits that emotions can promote memory benefits, but that focal enhancements occur more often for negative experiences than for positive ones. This would be the case due to “ valence-dependent effects on the neural processes recruited during episodic encoding and retrieval, with negative affect associated with increased engagement of sensory processes, and positive affect leading to enhanced recruitment of conceptual processes”.

(Litman et al., 2005) investigated how knowledge-gaps, measured by feeling-of-knowing, and individual differences in epistemic curiosity contribute to the arousal of state curiosity and exploratory behaviour. Participants read 12 general knowledge questions, reported the answer was either known %``I Know''), on the tip-of-the-tongue %``TOT''), or unknown %``Don't Know''), and indicated how curious they were to see eachanswer, after which they could view any answers they wanted. Participants also responded to the Epistemic Curiosity %EC) and Curiosity as a Feeling-of-Deprivation %CFD) scales. ``TOT'' was associated with the smallest knowledge-gap ,most curiosity and exploration, and feelings of uncertainty and tension as measuredby the CFD scale. ``Don't Know'' corresponded with the largest knowledge-gap, less curiosity and exploration, and positive feelings of interest as measured by the EC scale. ``I Know'' states, which reflected the absence of a knowledge-gap, involved the least curiosity and exploration.

(Massoni, 2014) claim that worry enhances metacognitive abilities (type II) regardless of type I decision. The emotional component helps to understand the formation of confidence. **“**Emotion and cognition are known to interact during human decision processes. By inducing worry during a perceptual task they noticed that, under worry, individuals tend to have better metacognition in terms of both discrimination and calibration abilities. “Understanding the formation of confidence is better explained with taking into account the level of worry in the model. This study shows the importance of an emotional component in the formation and the quality of the subjective probabilities”.

(Kelly & Metcalfe, 2011) While humans are adept at recognizing emotional states conveyed by facial expressions, the current literature suggests that they lack accurate metacognitions about their performance in this domain. This finding comes from global trait-based questionnaires that assess the extent to which an individual perceives him or herself as empathic, as compared to other people. **Those who rate themselves as empathically accurate are no better than others at recognizing emotions**. Metacognition of emotion recognition can also be assessed using relative measures that evaluate how well a person thinks s/he has understood the emotion in a particular facial display as compared to other displays. While this is the most common method of metacognitive assessment of people's judgments of learning or their feelings of knowing, this kind of metacognition—“relative meta-accuracy”—has not been studied within the domain of emotion. As well as asking for global metacognitive judgments, **we asked people to provide relative, trial-by-trial prospective and retrospective judgments concerning whether they would be right or wrong in recognizing the expressions conveyed in particular facial displays. Our question was: Do people know when they will be correct in knowing what expression is conveyed, and do they know when they do not know? Although we, like others, found that global meta-accuracy was unpredictive of performance, relative meta-accuracy, given by the correlation between participants' trial-by-trial metacognitive judgments and performance on each item, were highly accurate both on the Mind in the Eyes task (Experiment 1) and on the Ekman Emotional Expression Multimorph task (in Experiment 2).**

(Sommer et al., 2008) According to the modulation hypothesis, arousal is the crucial factor in the emotional enhancement of memory (EEM). However, the multifactor theory of the EEM recently proposed that cognitive characteristics of emotional stimuli, e.g., relatedness and distinctiveness, also play an important role. The current study aimed to investigate the individual contribution of arousal to the neural correlates of the EEM by controlling for these additional cognitive factors. **We observed the characteristic neuronal correlates of the EEM, in particular enhanced activity in the amygdal aand hippocampus, which provides evidence for an arousal-driven EEM in the amygdala as proposed by the modulation hypothesis**.

(Wolters & Goudsmit, 2005)

(Heereman & Walla, 2011) We successfully manipulated decision confidence in a probabilistic prediction task by means of stress as induced by excessive cognitive demands. In particular, our results indicate that decisions (based on high and low, but not intermediate levels of uncertainty) made under stress (confirmed by skin conductance measures) are associated with increased confidence when outcome probabilities are incompletely known (20% residual uncertainty). A different pattern was found when outcome probabilities were completely known (0% residual uncertainty). **Here, stress led to decreased decision confidence when decisions were associated with intermediate levels of uncertainty but had no effect in case of high and low levels of uncertainty.** In addition we provide evidence for ambiguity—(understood as implicit-risk) assessment being impaired under stress conditions.

(Schaefer et al., 2011) Extensive evidence shows that emotional events tend to be remembered in greater detail and with an enhanced sense of vividness compared to neutral events. The current study investigated the neural correlates of this phenomenon during retrieval using the [event-related potentials](https://www.sciencedirect.com/topics/medicine-and-dentistry/event-related-potential) technique (ERP). Participants were asked to perform a memory recognition test of previously studied (“Old”) and unstudied (“New”) emotional and neutral pictures encoded a week before the test session. Next, they were asked to perform a Remember–Know task ([Gardiner and Java, 1993](https://www.sciencedirect.com/science/article/abs/pii/S1053811910010037?casa_token=KlPSRvlbiU8AAAAA:kzYyo1NWPb6ZuD2RE_L0JURFbSfI2oUxuEUp2kGU9kEcGOjRv5MnK3HY3ovkZFE-I1RPgkJaeQ#bb0110)) for each “old” decision. ERPs were created for retrieval activity corresponding to six conditions: Remember–Emotional, Remember–Neutral, Know–Emotional, Know–Neutral, New–Emotional and New–Neutral. **Results showed that negative emotion enhanced three distinct subtypes of the electrophysiological old–new effect specifically for old items associated with a “Remember” judgment**. This effect was observed for ERP old–new effects conforming to an early frontal P2 old–new effect peaking at ~ 180 ms, a midfrontal old–new effect starting at ~ 300 ms (the “FN400”) and a late positive complex (LPC) with parietal maxima observed at 500–700 ms. **In addition, a breakdown of our data in different levels of emotional arousal revealed that the relationship between ERP correlates of retrieval and arousal conformed to a nonlinear, inverted U-shaped function for posterior late effects (500–700) and to a linear function for early effects (P2 and FN400). Taken together, these results suggest that multiple retrieval subprocesses contribute to the emotional enhancement of recollective experience** ►Three ERP correlates of recognition (P2, FN400 and LPC) are enhanced by emotion. ►This effect is specific to items accompanied with a feeling of remembering. ►Emotions probably modulate multiple recognition subprocesses.

(Adelman & Estes, 2013) “Emotional memory benefits have been attributed to arousal. At most, valence’s role has been posited as a moderating factor. We re-examined these roles using recognition memory data for over 2500 words. Positive and negative words had a benefit that was not attributable to arousal. **That is, arousal is not a necessary component of emotional memory benefits.** Much evidence indicates that emotion enhances memory, but the precise effects of the two primary factors of arousal and valence remain at issue. Moreover, the current knowledge of emotional memory enhancement is based mostly on small samples of extremely emotive stimuli presented in unnaturally high proportions without adequate affective, lexical, and semantic controls. To investigate how emotion affects memory under conditions of natural variation, we tested whether arousal and valence predicted recognition memory for over 2500 words that were not sampled for their emotionality, and we controlled a large variety of lexical and semantic factors. **Both negative and positive stimuli were remembered better than neutral stimuli, whether arousing or calming. Arousal failed to predict recognition memory, either independently or interactively with valence. Results support models that posit a facilitative role of valence in memory.** This study also highlights the importance of stimulus controls and experimental designs in research on emotional memory”.

(Dietrich et al., 2000) Depressive patients show deficits in memory functions. However, the underlying mechanisms remain unclear. Experiments with a special emphasis on the link between emotion and cognition appear challenging. The aim of this study is to **investigate the influence of the emotional content of words on memory in non-medicated depressive patients** (*n*=11) compared with a control group (*n*=11) utilizing [event-related brain potentials](https://www.sciencedirect.com/topics/psychology/event-related-brain-potential) (ERPs). In a continuous word recognition paradigm brain responses to repeated items are characterized by more positive waveforms of ERPs. This recognition effect (‘old/new effect’) has been shown to be sensitive to parameters relevant for memory processing. For the purpose of this ERP experiment visually presented words were classified into three different categories of emotional content. **The ERPs for the correctly detected ‘old’ (repeated) words showed an increased positivity beginning approximately 250 ms post-stimulus, concurring with a good recognition performance. In addition, old/new effect and behavioral data were sensitive to words’ different emotional connotations in the control group. In contrast, the depressive patients performed worse and showed no significant old/new effect. Nevertheless, their recognition performance was also enhanced by the emotional content. Furthermore, a differential effect of the emotional content on frontal ERPs was found between groups**. In contrast to the control group, a reduced old/new effect indicates a reduced [working memory capacity](https://www.sciencedirect.com/topics/psychology/working-memory-capacity) in the moderately depressed patients. This is suggested to be partially due to changes of the emotion/cognition coupling related to [ruminations](https://www.sciencedirect.com/topics/neuroscience/rumination) with preferably negative emotional connotation. However, the emotional content also affects recognition performance in the depressive patients.

(Henson et al., 2000) “**We used event-related functional magnetic resonance imaging (efMRI) to investigate brain regions showing differential responses as a function of confidence in an episodic word recognition task.** Twelve healthy volunteers indicated whether their old-new judgments were made with high or low confidence. **A right dorsolateral prefrontal region showed a greater response to correct low-versus correct high-confidence judgements. Several regions, including the precuneus, posterior cingulate, and left lateral parietal cortex, showed greater responses to correct old than correct new judgements. The anterior left and right prefrontal regions also showed an old-new difference, but for these regions the difference emerged relatively later in time. These results further support the proposal that different subregions of the prefrontal cortex subserve different functions during episodic retrieval.** These functions are discussed in relation to a monitoring process, which operates when familiarity levels are close to response criterion and is associated with nonconfident judgements, and a recollective process, which is associated with the confident recognition of old words”.

(Tabert et al., 2001) This study used fMRI to examine the response of the amygdala in the evaluation and short-term recognition memory of unpleasant vs. neutral words. **The right side amygdala activation revealed a greater amplitude signal for the unpleasant relative to the neutral words during an emotional decision but not in their memory task**. The amygdala might be involved in facilitating long term consolidation of emotional content. Their finding “corroborate those by other researchers that the amygdala can modulate early processing of visual information in the occipital cortex”.

(Lufityanto et al., 2016) showed that even unconscious, emotional information can can improve perceptual accuracy, confidence and RT for sensory decisions. They added that “Contrary to the assumption that emotional informa-tion simply increases the gain, or the overall sensitivity, of the decision-making mechanism (Etkin, Egner, & Kalisch, 2011), our data suggest that the presence of emotion alone is not enough to boost decision accuracy significantly (Experiment 3). This interpretation is supported by the finding that decisions accompanied by negative images were no more accurate than decisions accompanied by positive images, despite the known asymmetry in salience between positive and negative emotions”.

(Meessen et al., 2016) investigated whether interoceptive awareness (in a heartbeat perception task) was related to metacognitive awareness of a memory task performance. Participants gave their confidence in their tasks and also replied to questionnaires relative to interoceptive sensibility, depression, anxiety, and socio-demographic characteristics. They found that memory performance was significantly related to metamemory awareness, but the interoceptive awareness was not related to it.

They have focused on clinical inventories, instead of psychometric tasks…studied… questionnaires correlated with depression and anxiety

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