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Salivary cortisol and short and long-term memory for emotional faces in healthy young women

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Summary Elevated levels of the stress hormone cortisol are associated with increased episodic memory for emotional events. Elevated levels of cortisol are also seen in anxiety and depression disorders. Because it is well documented how both depression and anxiety are related to valence-specific biases in attention and memory, the present study sought to establish relations between basal cortisol levels and episodic memory for neutral, positive and negative stimuli. Thirty-nine healthy young women performed an immediate recall and long-term (20 min) version of a task measuring spatial memory for neutral, happy and fearful faces. The sample as a whole showed a valence-specific better performance for happy faces than for neutral faces in the immediate recall condition, and a better performance for all emotional faces in the long-term condition. Salivary cortisol measures were found to be related to better memory for emotional faces in the long-term condition. This relation to cortisol was not valence-specific and is similar to effects predicted by a model on long-term consolidation and the influence of cortisol in this process.

1. Introduction

A wealth of experimental evidence has established that episodic memory favours emotionally arousing material. In human research this has been established for emotional words, pictures and movies (for reviews, see Cahill and McGaugh, 1998; Hamann, 2001). Functionally, this is plausible, since emotions can be described as attentional and physiological states that are elicited by primary biological rewards and punishments or any internal or environmental stimulus associated with reward and punishment through a process of reinforcement learning (Rolls, 2000). It is obvious that for a system of emotion to function, there should be potent mechanisms for preferential encoding, consolidation and/or retrieval of environmental information associated with such reinforcing qualities.

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Whereas some predict better cognitive performance for emotionally arousing stimuli in general, be it of positive or negative valence (McGaugh, 2000; Roozendaal, 2000), others predict valence-specific and appraisal-specific biases in attention (e.g. Mansell et al., 1999; van Honk et al., 2001) and memory (e.g. Bower, 1981; Mogg and Bradley, 1998). From a functional viewpoint, a stronger mnemonic bias towards negatively valenced stimuli seems more probable, as is the case for selective attention to emotional stimuli (e.g. Öhman et al., 2001), since the failure to adequately process valid predictors of punishment would likely result in less evolutionary fitness than failures to attend to non-arousing or positive predictors (Öhman et al., 2000).

Looking at the neural bases of the processing of emotional stimuli, the amygdala is responsible for attentional and autonomic activation in relation to the perception of emotional stimuli (e.g. Rolls, 2000). When aversive, stressful stimuli are perceived, the amygdala signals the paraventricular nucleus of the hypothalamus to initiate the release of cortisol through the hypothalamus–pituitary–adrenal (HPA) axis. This results in release of the stress hormone cortisol. Through the modulating actions of the stress hormones cortisol and adrenaline in the basolateral nucleus of the amygdala and the hippocampus, memory for emotional events is enhanced (McGaugh, 2000; Roozendaal, 2000; Cahill and Alkire, 2003). Both human and animal studies show that memory for emotional but not neutral stimuli is influenced by the stress hormones (O'Carroll et al., 1999; McGaugh, 2000; Roozendaal, 2000; Buchanan and Lovallo, 2001; Cahill and Alkire, 2003).

Because pathological anxiety and depression are associated with enhanced attention to and selective memory of negative emotional stimuli, and because these pathologies are usually associated with elevated levels of cortisol and/or central corticotrophin releasing hormone, we hypothesize that mnemonic biases in memory as related to cortisol, can be valence-specific. Tops et al. (in press) and van Honk et al., 2003 indeed showed valence-specific biases in memory to be related to cortisol. Nevertheless, Buchanan and Lovallo (2001) convincingly showed that both negative and positive information is better consolidated after post-learning administration of cortisol. Consolidation is of course just one factor of importance. Only information that is initially encoded can eventually be consolidated, and factors influencing selectivity during the retrieval process greatly influence what consolidated information is finally reported (Singer and Salovey, 1988). Selective attention plays a crucial role in both these processes.

It has been well established that emotional traits and states influence the cognitive mechanisms responsible for the allocation of (spatial) attention in a valence-specific manner (for an overview, see Vuilleumier, 2002). A well-known phenomenon in the field of selective attention, as mentioned earlier, is the greater impact of negative over positive information. Much of the valence-specific results are related to mood-congruency; attentional preference to stimuli of which the valence concurs with prevailing emotional states. Research in memory for emotional material—at least at relatively short retention intervals—provides similar results (most recently Ridout et al., 2003). van Honk et al. (1998) found evidence for basal cortisol-dependent, valence-specific attentional biases to pictures of emotional faces. Hypercorticolism is associated with several anxiety and depressive disorders (e.g. Kirschbaum and Hellhammer, 1994; Kara et al., 2000; Wedekind et al., 2000) which are thought to be characterized by enhanced selective attention to, and memory for, negative stimuli (Mogg and Bradley, 1998). Most studies in human emotional memory identifying the role of cortisol in the process of consolidation have employed designs wherein cortisol is acutely administered. However, anxiety and depression disorders that are characterized by aberrant selective cognitive performance for emotional stimuli are often characterized by chronic hypercorticolism. By measuring influences of endogenous pre-task cortisol levels on emotional memory, we hope to identify relations of influence in the etiology of these pathologies. van Honk et al. (2003) recently investigated the relation between basal cortisol levels and encoding of negative and positive facial expressions and found indices of cortisol-related selectivity. This immediate recall task likely measured the influence of cortisol on the encoding phase and the results corroborated earlier findings on the influence of basal cortisol on performance on a task measuring selective attention to these same stimuli (van Honk et al., 1998). In the current study, we sought to replicate and extend these attentionally modulated effects by using a different negative stimulus, the fearful facial expression, and by extending the procedure to include a measure of long-term memory (20 min retention interval). Again, basal cortisol levels were estimated from pre-task saliva samples.

The task employed, the Face Relocation Task (the FRT), is a modification of the Object Relo-