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Emotion as a boost to metacognition: How worry enhances the quality of confidence

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ABSTRACT

Emotion and cognition are known to interact during human decision processes. In this study we focus on a specific kind of cognition, namely metacognition. Our experiment induces a negative emotion, worry, during a perceptual task. In a numerosity task subjects have to make a two alternative forced choice and then reveal their confidence in this decision. We measure metacognition in terms of discrimination and calibration abilities. Our results show that metacognition, but not choice, is affected by the level of worry anticipated before the decision. Under worry individuals tend to have better metacognition in terms of the two measures. Furthermore 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.

1. Introduction

How humans combine emotion and cognition during their decision process is a central question in the behavior sciences. The initial philosophical dissociation between rational and emotional decision (Plato, Descartes, and Kant) has been superseded by a view in which emotions are integrated in the decision process. Emotions are an important component of the decision and are useful to make accurate judgments (Damiaso, 1994; LeDoux, 1996). In this study we will focus on a specific aspect of cognition: metacognition, i.e. the knowledge an individual has about his own cognition. How emotion interacts with this specific kind of cognition is for the moment an open question.

Recent studies have focused on inter-subject and inter-task variation in metacognition (Fleming, Weil, Nagy, Dolan, & Rees, 2010; Song et al., 2011; McCurdy et al., 2013) but none have examined how metacognition could be affected by internal processes such as emotions. The only exception that we are aware is Garfinkel et al. (2013) who show that the level of metacognition in a memory task is modulated by the timing of the stimulus with respect to the phase of the heartbeat. This result confirms the idea of the present study: the internal processes may have an effect on the metacognition. Here we want to characterizes this effect and shows that metacognition is improved by the emotional valence of the decision.

We measure metacognition via two different abilities: calibration (or bias) reveals how close confidence judgments are on average to real success (Harvey, 1997) and metacognitive accuracy refers to the discrimination (or resolution) of how variations of confidence match the variation of performances (Fleming & Dolan, 2012). A potential relationship between

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metacognition and emotion is hypothesized at the light of advances on the neural basis of confidence judgments. Recent studies show that metacognition is associated with activity in the anterolateral prefrontal cortex (PFC) (Yokoyama & et al., 2010 using a short-memory task) and the lateral PFC (Fleming, Huijgen, & Dolan, 2012; Fleming et al., 2010; Rounis, Maniscalco, Rothwell, Passingham, & Lau, 2010 using a perceptual task). Emotions have been more extensively studied and robust evidence has been found in favor of a central role of the orbitofrontal cortex (Bechara, Damasio, & Damiaso, 2000) and the amygdala (Seymour & Dolan, 2008) in the emotional part of decision-making. Nevertheless, some studies document a network of brain area activated during the cognitive – emotional integration rather than specific area for the two aspects (Pessoa, 2008) and this integration of emotions in cognition may occur in lateral PFC (Gray, Braver, & Raichle, 2002). This view gives support to the existence of an emotional effect on the metacognitive abilities. A more intuitive way of thinking about the link between emotion and metacognition is provide by the attentional effect of emotion. The affective significance of a stimulus is known to induce changes in sensory processing and attention (Vuilleumier, 2005; Yiend, 2010). Negative emotions, such as anxiety and worry, are generally associated with a decrease in attentional control (Eysenck, Derakshan, Santos, & Calvo, 2007) and dysregulation of attentional focus (Bishop, 2008). Nevertheless a differentiation between the effects of state and trait anxiety (Pacheco-Unguetti, Acosta, Callejas, & Lupianez, 2010) gives support to a potential positive impact of stated worry on metacognition by increased willingness to (over)control information. This tendency to over-react under worry could have a positive impact on the quality of metacognition with the use of more precise rating strategies and thus better discrimination ability. We might also expect better calibration with a diminishing of the overconfidence by a depressive effect.

Our experimental design induces emotions by framing effects. We use loss vs. gain and high vs. low stake frames to generate variations on the self-reported level of worry of subjects. Loss aversion is the tendency to weight loses greater than equivalent gains in decision-making (Kahneman & Tversky, 1979). Recently this well documented bias has been studied with the help of neuronal data and there is evidence that loss aversion could be linked to emotional interactions on the cognitive process (see Takahashi, 2013). Indeed De Martino, Kumaran, Seymour, and Dolan (2006), De Martino, Camerer, and Adolphs (2010) found an activation of the amygdala in the case of loss frame. Even if another fMRI study (Tom, Fox, Trepel, & Poldrack, 2007) was not able to replicate this finding (they found activation of the lateral PFC and the striatum), there exists evidence for an emotional aspect for loss choices compared to gains (Sokol-Hessner, Camerer, & Phelps, 2013; Sokol-Hessner et al., 2009, confirm this hypothesis using physiological and fMRI measures). Thus using a loss vs. gain frame in an experiment should induce variations in the worry felt by subjects facing their choices. We also use a high stake vs. low stake frame to increase the variations of the stated level of worry. High stake decisions are known to be more emotionally demanding than low stake cases (see Kunreuther & et al., 2002, for a review of high stakes decision making). Overall we can expect to succeed in inducing some variations of a negative emotion that will be measured in terms of a worry scale. We define worry as "a cognitive phenomenon [...] concerned with future events where there is uncertainty about the outcome, the future being thought about is a negative one, and this is accompanied by feeling of anxiety" (MacLeod, Williams, & Bekerian, 1991 – p. 478). This approach focuses on the central role of uncertainty (Dugas, Gosselin, & Ladouceur, 2001) and makes sense in our design where the outcomes are uncertain and may be negative with important losses. The influence of anxiety on decision-making is well-studied (Hartley & Phelphs, 2012) but it remains unclear that worry leads always to worse decisions. As our design is not based on cognitive tasks but perceptual ones with emotionally neutral stimuli (but worrying frames), we expect to find a positive effect of worry on metacognition due to an increase of energy and attentional effort. We assume that metacognition will be improved when subjects reveal their confidence after making a decision under a worried mood. This assumption that worse mood leads to better metacognition is also supported by results from neuropsychiatric disorders studies. Metacognition, defined as insight or awareness of illness, is improved by negative moods (David, Bedford, Wiffen, & Gilleen, 2012). We can hypothesize that this link is also valid for healthy individuals and thus that metacognition is improved by worried mood.

2. Methods

2.1. Participants

The experiment was conducted in May and July 2012 at the Laboratory of Experimental Economics in Paris (LEEP) of the University of Paris 1. Subjects were recruited by standard procedure in the LEEP database and gave written informed consent to take part in the experiment. 103 healthy subjects (54 men; age 18–38 years, mean age, 22.9 years, most enrolled as undergraduate students at the University of Paris) participated in this experiment for pay. The sessions lasted around 120 min and subjects were paid on average €27.1. We excluded 6 subjects from analysis due to insufficient variation (s.d. < 0.03) of confidence or worry. The final sample included 97 subjects for analysis.

2.2. Stimuli

The experiment was conducted in MATLAB using Psychophysics Toolbox version 3 (Brainard, 1997). We use a 2AFC numerosity task, which is known to be convenient to fit SDT models (Nieder & Dehaene, 2009) and may be positively affected by emotions (see Phelps, Ling, & Carrasco, 2006, for the effect of emotions on perception). The stimuli consisted of two circles with