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The Influence of Emotions on Cognitive Processing, and the Importance of Retrospective Evaluations

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Abstract

The present thesis examines how emotions influence cognitive processing in decision-making, and how people evaluate their emotions and cognitive processing retrospectively. Emotions may determine whether intuitive or analytical processing is utilized in a decision-making context. In addition, this study takes on an explorative approach and discusses different theory regarding heuristic biases that occur during self-reporting of both emotions and cognitive processing. As a result of this, different time windows reflecting theory were defined and applied to the data analysis. Further, emotions are explained in terms of arousal and valence, thus physiological and self-reported arousal measures were obtained from 153 subjects. In line with previous research, the self-reported arousal data showed that emotionally induced arousal is predicted by a summarized average, whereas self-reports of cognitive processing are subject to primacy effects. The results also showed a significant influence of arousal on analytical processing. In sum, our results provide an insight into how people evaluate past experiences and strengthens existing research that emotions affect cognitive processing, and thereby decision-making. Our findings and practical implications, future research and limitations are also discussed.

Introduction

The field of judgment and decision-making is of great concern in organizations today. The factors that are thought to influence decision-making include emotions and their effects on cognitive processing (Blanchette & Richards, 2010). This thesis aims to further investigate this relation of how emotions influence cognitive processes in decision-making. In relation to this, we are interested in how people evaluate their emotions, as well as their thinking style. More specifically, we aim to look at which moments during an emotional experience that predicts self-evaluation of emotions and cognitive processing.

The concept of emotions may be explained by the circumplex model of affect proposed, by Russell (1980). He describes emotions in terms of valence and arousal, establishing a close link between these two. Further, research have focused emotion's influence on different cognitive processing styles, explained by the dual-process theory (Epstein, 1994). This theory constitutes two different ways of processing information, knowns as intuitive processing (System 1) and analytical processing (System 2). System 1 operates faster and more effortless than does System 2. Importantly, both of these systems are subject to the influence of emotions (Kahneman, 2003a; Kahneman, 2003b; Stanovich, West, & Hertwig, 2000). Further, research suggest that valence has inconsistent effects on processing style, whereas different levels of arousal show a relation with System 1 and System 2 processing (e.g. Arnsten, 2009; Epstein, 1994). Arousal has also been suggested to play a central role in the link between the physiological and subjective experience of emotion, as it may contribute to a coherence between these two (McCall, Hildebrandt, Bornemann, & Singer, 2015; Sze, Gyurak, Yuan, & Levenson, 2010).

A common assessment of the physiological measure of emotional response is captured with the use of electrodermal activity, or more specifically by measuring the individual's skin conductance response (SCR) (Boucsein, 2012). However, there exists disagreements among researchers regarding the exact moment of arousal within an emotional response, as well as the appropriate length of a time window (a period of time that covers a certain amount of seconds of the emotional response) (Boucsein, 2012). In order to measure these signals, time windows with varying lengths will be applied to the analysis of the physiological arousal data. By doing so, we may better capture physiological arousal within an emotional response.

According to Boucsein (2012), both the physiological and subjective measures of arousal are necessary to apply when measuring emotional states. However, previous research demonstrate contradicting evidence for the coherence between self-reported and physiologically measured arousal (Jakobs, Manstead, & Fischer, 2001; Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). We will therefore include both measures, and investigate their coherence, to see whether the level of physiological arousal will have an impact on the subjectively assessed arousal (McCall et al., 2015; Sze et al., 2010).

Finally, we aim to expand the understanding of self-evaluations of physiological arousal, as well as self-evaluations of cognitive processing. In terms of self-evaluations of physiological arousal, it has been argued that individuals tend to summarize their whole emotional experience into a an average in a single evaluation (Ariely, 2001, Hsee, 1998; Shiffman, Stone, & Hafford, 2008). Other research suggest that self-evaluations are predicted by two specific moments of an emotional experience; the peak affect intensity, and the last moment of the experience (e.g. Fredrickson, 2000). Further, when it comes to self-evaluations of cognitive processing, research points to individuals as reporting based on the initial moment of the experience (primacy effect), and that this is due to the type of evaluation task participants are exposed to (Zauberman, Diehl, & Ariely, 2006).

Based on the aforementioned, our research question is as follows:

How does arousal influence cognitive processing in a decision making task? Which moments during an emotional experience predict self-evaluations of emotions and cognitive processing? Further, what is the relation between physiologically and self-reported arousal?

Theoretical Framework

Before introducing our research design, the theoretical framework will provide a review of relevant literature, and present our hypotheses. We will start by introducing emotions as a concept; how we measure emotions, and people’s subjective evaluation of emotions.

Emotions

Emotions are generally defined as "internal, mental states representing evaluative, valenced reactions to events, agents, or objects that vary in intensity (Nabi, 1999, p. 295). Additionally, Forgas (1995) argues that emotions are "intense, short-lived, and usually have a defined cause or clear cognitive content" (Forgas, 1995, p.41). Furthermore, emotions can be explained through the label of core affect, which according to Russell (2009) is a "pre-conceptual primitive process, a neurophysiological state, accessible to consciousness as a simple non-reflective feeling: feeling good or bad, feeling lethargic or energized" (Russell, 2009, p. 1264). In other words, affect is accessible as feelings evident in emotions.

Russell (1980) suggests that core affect is a circumplex, or a combination, of two underlying dimensions, namely; pleasure-displeasure (referred to as valence) and activation-deactivation (referred to as arousal). Along these dimensions, different variables of emotion as e.g. joy, excitement, contentment, depression, and distress fall into a two-dimensional space, which explains emotions as related to each other in a highly systematic fashion. Previous research on emotion, as Ekman's (1992) study of facial expressions, and Izard's (1972) theory of discrete emotions, have typically concluded that factors of affect are independent from each other, and treated them as separate or discrete dimensions These theories support the notion that basic emotions have different neural structures and pathways (Russell, 1980). However, by explaining affect in a circumplex model, one is able to plot the specific emotional states (as e.g. joy) according to the level of arousal and valence, and thus as products of two different neurophysiological systems. Thus, according to the circumplex model, these two underlying systems subserve all affective states (Posner, Russell, & Peterson, 2005). Hence, this spatial model establishes a relation between arousal and valence. Russell (1980) also support the valence-arousal combination with the circumplex model, arguing that emotions and the degree of arousal are closely linked, and that the level of arousal states may be high in preparation for action, or lower in times of inaction.

As discussed above, the circumplex model explains emotions as a product of valence and arousal combined. However, the importance of valence in producing an emotional response has been questioned. According to Posner et al.

(2005), amygdala activity (which is involved in emotional reactions) will increase with the arousal, regardless of whether the stimuli is labelled as positive or negative. This has also been supported by Detenber, Simons and Bennett (1998), who in a study showed pictures of different valence and arousal to participants. By obtaining both measures of physiological response, and self-report ratings, their results indicated that the physiological response was related to the arousal properties of the image stimuli. However, the interaction between the physiological response and image valence was not significant. In support of this, some argue that in contrast to valence, the state of arousal is central in emotion theories (Bodenhausen, 1993), and that the psychological construct of emotions has physiological arousal as one of its main components (Nabi, 1999). Moreover, according to Boucsein (2012) emotions and arousal are closely linked. Thus, considering the level of arousal is of great importance when studying emotional responses. The importance of valence on the other hand, is questionable.

Physiological and Subjective Reports of Emotions

Arousal is considered as an important dimension of emotions. It is therefore important to discuss the role of arousal in the link between physiological and subjective reports of emotions. According to emotion theory, the main components of psychological emotions are ‘the physiological component of arousal’ and ‘a subjective feeling state’ (Nabi, 1999). In support of this, Boucsein (2012) argues that emotional states should be measured by applying both physiological and subjective measures. The reason behind this is that the subjective reports address the emotional experience of the individual, and his/her awareness of signals from the autonomic nervous system. Some research point to physiological arousal and subjective arousal as correlating (Mauss et al. 2005). However, other research have found no coherence between self-reported emotions as excitement, happiness, sadness, and physiological measures of emotions (Jakobs et al. 2001). This inconsistent view of how the perceptual and physiological measures of emotion correlate is therefore of interest.

According to Kahneman (2003b) individuals tend to memorize salient moments of the affective experience, typically the peak and the end, instead of the total affective experience. Other research argue that individuals will vary in their bodily awareness, resulting in some being able to report their emotions more accurately compared to others. In relation to this, Sze et al. (2010) investigated whether individuals high in body awareness (e.g. people who have practiced meditation, and professional dancers) would demonstrate greater coherence between subjective emotional experience and physiological responding, (during an emotion). The results found that body awareness training is associated with increased emotional response coherence during film-induced emotional episodes. They further argue that the coherence between subjective and physiological arousal reflect how the organs (which are controlled by the autonomic nervous system) are important for recognizing emotions, and constructing the subjective emotional experience. Thus, based on these findings, one may assume that the objective and subjective experiences of emotion are closely related.

In addition, Sze et al. (2010) found that when films contained violent high-arousal segments, the coherence between the subjective and bodily arousal was higher, compared to other films with non-violent low-arousal segments. Thus, it might be that the coherence between the subjective and physiological experience of emotion depends on the level of arousal. McCall et al. (2015) have also reported a remarkable coherence between the arousal reported retrospectively, and the physiological arousal measured with skin conductance response. Importantly, they found this coherence to be higher during disturbing or startling (which often produce a high arousal). Therefore, one may assume that arousal is an important factor in moderating the coherence between self-reported emotions and physiological responses.

Considering the aforementioned research, we hypothesize that:

H1: The correlation between self-reported and physiological arousal will be positive for those with high levels of physiological arousal, but not for those with low levels of physiological arousal.

Measures of emotions

The measure of emotions has long been a topic of interest and discussion, as it is difficult to objectively measure (Gray & Watson, 2007). Thus, the subsequent part of the thesis will focus on the measurement of emotions in terms of time windows applied to the physiological arousal, and how people self-report their emotions. In terms of the latter, we will discuss which moments of an experience that come to mind when individuals make a retrospective assessment of emotions. These assessments are often prone to accuracy problems, such as summarizing the experience into one assessment, extension neglect, or peak and end (recency) effects.

Measures of Emotions - Important Considerations

Measuring an emotion and knowing which time windows to include is difficult, due to emotions being hard to measure objectively (Gray & Watson, 2007). The duration of an emotion should be considered when defining a time window, and has been discussed by different researchers. E.g. Forgas (1995) argues that emotions are intense and short-lived, whereas others argue that its duration is highly variable (Verduyn, Tuerlinckx, & Van Gorp, 2013). Different influences on duration include e.g. time latencies and stimulus duration. These influences should be considered after inducing an emotion. The selection of appropriate time windows will be elaborated on below.

Boucsein (2012) argues that a time window should be long enough to capture the possible range of latencies of an electrodermal response following a stimulus. These latencies arise due to external influences, such as the temperature and recording site in the laboratory (Boucsein, 2012). Therefore, it has been argued that the skin conductance response is not reliable for short time segments, as changes relatively slowly (Aue, Hoeppli, & Piguet, 2012). Other research have shown that the responses to emotions have relatively long latencies of 1, 2, or even 5 seconds (Boucsein, 2012). Further, Levinson and Edelberg (1985) argue that a time window of 1 to 4 seconds, or 1 to 5 seconds have been the most common time window used in published studies in the journal of *Psychophysiology*.

However, the 1 to 5 seconds following an emotional stimuli may not be enough to capture the emotional response, as the stimulus duration may also impact the duration of an emotion, and thereby the time window. According to Cuthbert, Schupp, Bradley, Birbaumer, and Lang (2000), event-related potentials and autonomic responses to an emotionally arousing picture stimuli can be present 2-3 seconds after the picture onset, and sustained for most of the period the picture was presented. This is supported by Verduyn, Delaveau, Rotgé, Fossati,, and

Mechelen (2015) who argue that as long as the emotional stimuli is present, it is unlikely that the emotion will end.

As shown above, there exists inconsistencies as to the length of time windows, and thereby the exact moments of arousal during an emotional response (Boucsein, 2012). For this reason, time windows of different lengths will be applied to physiological arousal data of the emotional response. These time windows are theoretically grounded, which will be described in the following sections.

Self-Reports of Emotions - Summarizing an Experience

As previously argued, subjective assessments of a past affective experiences may differ from the actual physiological arousal, due to assessment biases. These assessments biases arise as people's judgements and evaluations rely on mental shortcuts, which can make them interpret an experience based on segments of it, even though this representation is incorrect (Miron-Shatz, 2009). Thus, checking for time latencies and stimulus duration is not the only thing that has to be considered when subjective assessment of emotions are included. Kahneman (2002) explains that some attributes, called natural assessments, are generated automatically, as these assessments are highly accessible with the use of system 1. Natural assessments are done without intention or effort, through what he refer to as accessibility dimensions. E.g. when presented to lines with different lengths, the representation of the set is computed automatically, including a quite precise information about the average (Kahneman, 2002). However, answers that does not come easily to mind, as e.g. adding the sum of lines of different lengths, require more deliberate effort. This is also supported by Ariely (2001), who studied human visual systems, and found that the average of a set can be calculated quite accurately, but that calculations are poor for individual items in a set. He further argues that these findings on set representations may be used in similar ways to nonvisual experiences. Thus, the natural assessment of an average may also be done automatically on more abstract properties such as e.g. affective valence and mood (Kahneman, 2002).

In addition, Kahneman (2002) argues that the value of an extensional attribute is an aggregate, and not necessarily an additive of the values over its extension. This was shown in a study by Hsee (1998) when participants were asked to give a price to sets of dinnerware. Set A included 40 dishes, but some of them were broken. Set B included 24 dishes, all in good condition. When the dinnerware was compared separately, set B was judged as more valuable than set A, meaning that the “perfect product” was valued more favorably than the imperfect product,that was objectively more valuable (Hsee, 1998). In contrast, when asked to judge the sets in a joint evaluation, the participants were willing to pay more for set A. According to Kahneman (2011), the sets in the example arerepresented by norms and prototypes. You can very quickly sense that the value for the set of broken dishes is much lower than the value of the set of dishes that are all in good condition, as you do not want to pay for the broken dishes. Since the average dominates evaluations (Ariely, 2001; Kahneman, 2002), it is not surprising that set B is valued more than set A. Based on these findings, Hsee (1998) suggested a less is more pattern, where System 1 averages values instead of adding them, by naturally engaging in intuitive thinking. However, this intuitive thinking is replaced by the logic thinking in the joint evaluation of the two sets of dinnerware, recognizing that more dishes adds value.

Moreover, it has been argued that retrospective evaluations of experiences are insensitive to extensions and thus, the duration of an experience is usually ignored. This has been referred to as extension neglect (Kahneman, 2002). Findings that report extension neglect have been discussed by Redelmeier and Kahneman (1996), who studied patients undergoing a colonoscopy. The global evaluation was measured, as patients rated the intensity of pain every 60 seconds. The results indicated that participants had momentary pain levels that varied a great amount from minute to minute. Nevertheless, the results showed that the global evaluations’ correlation with the duration of the procedure was very low (0.03). However, the correlation between the global evaluation and the average of the pain rated on two occasions correlated highly (0.67). In other words, the participants ignored most of the experience by only recalling the average of most memorable moments.

Thus, the duration of an emotion may not be the most important thing to consider when looking at self-reported measures of emotions. The abovementioned findings show that biases in decision-making occurs, as people tend to ignore the duration, and rather summarize their whole experience into a single assessment (Ariely, 2001; Hsee, 1998; Redelmeier & Kahneman, 1996;

Shiffman et al., 2008). Importantly, similar to Kahneman (2002), we believe this can be applied to self-evaluations of emotions as well.

Self-Reports of Emotions and the Peak, End and Order Effects

The results reported by Redelmeier and Kahneman (1996) are interesting, as their findings may also be explained by the peak-and-end rule. This rule posits that individuals' global evaluations of past affective episodes may be predicted by two moments; the peak affect intensity and the ending, or sometimes independently by only the peak or only the end (Fredrickson, 2000). Thus, these moments of the episode are dominating for such evaluations, and thus the duration of the whole experience is neglected. For instance, Kahneman, Fredrickson, Schreiber, and Redelmeier (1993) exposed participants to two aversive experiences, where the majority of the participants failed to take the duration of the experiments into account, and rather weighted the end of the experiment when evaluating the experience in terms of pleasantness. This research points to these salient moments as coming more easily to mind, as well as the affect associated with those moments. Supporting these findings, Redelmeier, Katz, and Kahneman (2003) conducted a follow-up study to the patients undergoing a colonoscopy. Similar to the previous study, the results indicated that participants had momentary pain levels that varied a great amount from minute to minute. However, in the end of the experiment the researchers added an extra minute for half of the participants, making sure that the pain was notably reduced. Thus, when the patients were to make a global evaluation of the experience, the participants that had an extra minute with discomfort, but with a more pleasant end of the procedure, had a significantly less painful memory of the experience, compared to the participants that did not have an extra minute with reduced pain.

Other research that can explain these findings are so-called recency and primacy effects, which are often, discovered during free recall tasks. The findings usually obtain a U-shaped serial position curve, as words at the beginning (primacy) and the end (recency) are recalled successfully, while the recall for words in the middle of the list is poor (Tan & Ward, 2000). Thus, the recency effect assumes that during free recall of a list of items, people tend to recall the final few items with higher probability (Davelaar, Haarmann, Goshen-Gottstein, Askenazi, & Usher, 2005). To explain this effect, Atkinson and Shiffrin (1968) argue that the final few items resides in a capacity-limited short-term buffer, from which items can be recalled immediately. Importantly, one may view the recency effect as an alternative explanation for why the end moment of an episode dominates individuals' global evaluations (Fredrickson, 2000). In contrast, the primacy effect is when the items presented early has a higher probability of being recalled. Findings suggest that this is because these items receive more attentional resources in the beginning, and are therefore better encoded into our memory (Sederberg, Gauthier, Terushkin, Miller, Barnathan, & Kahana, 2006). Other research has also found that words of affective states, as negative emotional words, seem to strengthen the primacy effect (Mollet & Harrison, 2007)

The examples above are included to illustrate that the experience, and the retrospective reports or global beliefs, are different perspectives of the same event. However, as research have shown, people usually recall the global beliefs or retrospective impressions more than the momentary experience of it (Shiffman et al., 2008).

Moreover, research show inconsistencies regarding the relation between physiological and subjectively measured arousal. According to abovementioned theory, people tend to base their retrospective evaluation on the peak and end moments, or as an average or sum of of the whole experience. Therefore, we hypothesize the following:

H2: When participants evaluate an emotional experience, the self-report will be based on the most intense moment of arousal (peak), arousal at the last moment of the experience (end/recency effect), or the summarized average of arousal of the experience, instead of arousal at the start of the experience (primacy effect).

Cognitive Processing - System 1 and System 2

The remainder of the thesis will look into cognitive processing, its relation to emotions, and the self-assessment of it.

A generous amount of research distinguish between two fundamentally different systems for cognitive processing (Johnson, 2005; Sinclair, 2011; Stanovich et al. 2000); one which operates fast, automatic, and effortless, and another where operations are slower, effortful, and more likely to be controlled and consciously monitored (Kahneman, 2003a). The former system has collectively been referred to as System 1 and the latter, System 2 (Stanovich et al. 2000). Further, research suggest that dual-process models are more successful than unitary models, in terms of explaining behavior in a wide range of settings (Mukherjee, 2010). By applying the process of thinking and decision-making into two distinguished systems, Kahneman (2003a) argued that System 1 corresponded to the everyday concept of intuition, while System 2 correspond to reasoning.

Emotions, Cognitive Processing, and Decision-Making

In relation to judgment and decision-making, the differences between the two systems have been used to explain contradictory results in studies. Kahneman (2003a) suggests that intuition (System 1) is often associated with poor performance in decision-making tasks. Nevertheless, he also acknowledges intuitive thinking as powerful and accurate, and research point to skilled decision makers as often performing better when trusting their intuition, than when engaging in a thorough analysis (Kahneman, 2003a). Further, the operating characteristics of System 1,are comparable to features of perceptual processes. Thus, System 1 generate impressions of the attributions of objects of perception and thought. In contrast, System, 2 is involved in all judgments, as these are always intentional and explicit (Kahneman, 2003a).

Further Kahneman (2003a) argued that intuitive judgements imply heuristic judgements. The heuristic process is explained by Kahneman and Frederick (2002) who proposed that "judgment is said to be mediated by a heuristic when the individual assesses a specified target attribute of a judgment object by substituting another property of that object—the heuristic attribute—which comes more readily to mind" (as cited in Kahneman, 2003a, p.707). Thus, by relying on heuristics, people make mental shortcuts that simplifies the judgement or decision tasks. In certain cases, this leads to predictable biases and inconsistencies (Plous, 1993). One of these heuristics is the "affect heuristic" which in the past few decades has become increasingly important. Slovic, Finucane, Peters, and MacGregor (2007) suggest that the affect heuristic influence people to make judgements and decisions (either conscious or unconscious) based on feelings of "goodness" or "badness". Further, Slovic et al. (2007) argue that affect plays a central role in dual-process models and decision-making, as the intuitive system relies on affect and emotion as a "quicker, easier, and more efficient way to navigate in a complex, uncertain, and sometimes dangerous world" (Slovic et al., 2007, p.1334).

Moreover, emotions' influence on decision-making are recognized by Kahneman (2003a), and has been subject to further studies in the field of judgement and decision-making. Forges (1995) suggested that emotionally loaded information influence, and becomes incorporated into, the judgment and decision-making processes. Thus, it can be argued that emotions are important to consider, as it can influence the cognitive processing and thereby, decision-making behavior (Blanchette & Richards, 2010; Loewenstein, Weber, Hsee, & Welch, 2001).

Looking Beyond Valence

Similar to measuring expression of emotions, the research involving emotions of different valence and its effect on cognitive processing have been largely inconsistent (Blanchette & Richards, 2010; Cassotti, Habib, Poirel, Aïte, Houdé, & Moutier, 2012; Forgas, 2013; Lerner & Keltner, 2000). A reason for this is that few of these studies have focused on how emotions of the same valence, but different arousal, may influence decision-making differently (Lerner & Keltner, 2000). A study by Bodenhausen, Sheppard, and Kramer (1994) found that different kinds of negative affect result in different types of cognitive processing, as there was significant difference between the angry and sad subjects' engagement in heuristic processing. The researchers argued that their findings applies to positive emotional states as well. Thus, it may be argued that the different level of arousal of emotions with the same valence may be one of the factors influencing different cognitive processing. In fact, the authors emphasized that looking beyond valence is required in order to understand the influence of emotions on information processing. Therefore, arousal may influence cognitive processing style, more than valence.

Physiological Arousal and Cognitive Processing

According to Levenson (2014), the autonomic nervous system is central in generating, expressing, experiencing and recognizing emotions. More specifically, it is claimed that the physiological measure of an emotional response may be captured by detecting electrodermal activity in the individual, or more precisely by the activity of the sweat glands (Dawson, Schell, & Filion, 2007). This is also supported by Bernat, Patrick, Benning, and Tellegen (2006), who presented participants with both positive and negative pictures of low, medium and high intensity (arousal). The results found that stimuli of high intensity increased the skin conductance response, showing that electrodermal activity is an indicator of the participants' arousal.

Moreover, neuropsychological research suggest that there is a relation between electrodermal activity and information processing. This research suggest that the affect arousal system has an impact on the information processing mechanism. The affect arousal system is a term that centers on the amygdala (a part of the brain involved in emotion regulation and decision-making) and its regulation of arousal. After reviewing several studies of problem-solving, Kahneman (1973) suggested the affect arousal system was an indicator of a process that involves allocation of attentional resources and mental activities. This means that arousal may modify information-processing resources (as cited Boucsein, 2012). In addition, electrodermal activity is used as an indicator for decision-making (Boucsein, 2012) , as the decision-making process involves brain systems that process information (Brocas, 2012). Further Damasio and Bishop (1996) argue that psychological arousal is a neurobiological process that influence reasoning and decision making, and thus, one may assume a relation between electrodermal activity and cognitive processing as being evident.

Taking the aforementioned research into consideration, it can be argued that the emotions arising from humans' bio-regulatory processes, regulate individuals' cognitive processes (Hofmann, Heering, Sawyer, & Asnaani, 2009; Russell, 1980), which may lead to decisions being made.

Levels of Physiological Arousal and Cognitive Processing

The differences in the level of physiological arousal are important when explaining how emotions influence cognitive processing and decision-making. Epstein (1994) suggests that there is a big difference in the way people think when they are emotionally aroused, compared to when they are unemotional. Highly emotional individuals typically think in a way that is categorical, unreflective, action oriented and concretive. Epstein (1994) relates these attributes to the experiential system (System 1). Along a similar line, Mandler (1975) argued that increased arousal leads to attentional selectivity, thereby the attention to internal autonomic activation may reduce information-processing capacity (as cited in Weick, 1990). This is supported by Arnsten (2009) who argues that increased levels of stress (which has been defined by Boucsein (2012) as “a state of high general arousal”, can impair cognitive abilities quite dramatically. This may be explained by the prefrontal cortex, which is involved in the decision-making process (Arnsten, 2009; Posner et al., 2005). Arnsten (2009) argues that, when psychological stress occurs, higher-order prefrontal cortex functions will become impaired, while stress pathways are activated. In turn, this strengthens the amygdala function, resulting in more reflexive, rapid and emotional thinking. On the contrary, lower level of stress will interfere less with the prefrontal cortex, and induce a more thoughtful and deliberate thinking. This demonstrates the connection between emotions, cognitive processing, and decision-making. One may also assume that the degree of arousal/stress can have an impact on the two systems of cognitive processing: as the stress/arousal level increase, System 1 may be involved to a higher degree as it operates fast. Further, lower levels of stress may engage system 2, where operations are slower.

In sum, the aforementioned demonstrates the importance of considering arousal in the investigation of emotions on cognitive processing. Various research points to high levels of arousal as a factor causing System 1 engagement, and lower levels to engage in System 2 (Arnsten, 2009; Posner et al., 2005). Valence on the other hand, yield inconsistent results, and may not be as important as arousal when understanding the influence of emotions on cognitive processing. Thus, the present thesis will test for possible effects of the arousal level on cognitive processing, (while only controlling for valence).

Based on previous research we hypothesize that:

H3a: Arousal will be positively related to intuitive processing in a decision-making task.

H3b: Arousal will be negatively related to analytical processing in a decision-making task.

Self-Reports of Cognitive Processing

Above, we point out how individuals base their retrospective evaluations on the initial moment of the experience, the peak affect intensity, the ending, or the sum of the overall experience, when evaluating a feeling caused by a given stimuli (Ariely, 2001; Hsee, 1998; Kahneman, 2002; Kahneman et al., 1993; Redelmeier & Kahneman, 1996; Redelmeier et al., 2003). On the contrary, other research point to information with an early position as being more influential, and thereby producing primacy effects (Hogarth & Einhorn, 1992). These studies emphasize the type of evaluation task and suggest that this determines which aspects of the experience is weighted more heavily.

In support of this, Zauberman et al. (2006) distinguish between the task purpose as either *hedonic* assessment of feelings or *informational* evaluative judgment, and suggest that this can determine whether earlier or later parts of an experience are perceived as more relevant to the task at hand, and thereby, weighted more heavily. According to Hogarth and Einhorn (1992), when individuals make evaluative judgments in information integration tasks, they tend to form a hypothesis and subsequently fit the information into the context of the hypothesis. Thus, the beginning of the experience is judged as more important as it forms the basis for understanding the remaining information in the task. On the other hand, in hedonic evaluations tasks, the feelings evoked by an emotional stimulus are more likely to be influenced by anticipation, and thereby places greater focus on how the experience changes and develops over time. Hence, a there exists a greater sensitivity to the final information (recency effect) (Zauberman et al., 2006).

This thesis takes on an explorative approach when it comes to investigating which moments of an experience individuals will base their self-evaluation of cognitive processing on. Nevertheless, in light of the abovementioned theory, we consider self-evaluation tasks of cognitive processing to be more appropriate for the informational evaluative judgment category, as it is not a type of evaluation task that intend to evoke any particular feelings, nor does it involve an assessment of feelings. Thus, it will direct the attention towards the beginning of the experience. More specifically, when people assess their cognitive processing, they will base it on the arousal at the start of the experiment, and not arousal present at other moments, such as the peak, end or summarized average arousal. Therefore, we hypothesize the following:

H4: When participants self-evaluate cognitive processing, the self-evaluation will be based on arousal at the start of the experience (primacy effect) instead of the most intense moment of arousal (peak), the arousal at the last moment of the experience (end/rececny), or the average arousal of the experience.

Methodology

The present thesis aims to investigate how emotions measured subjectively and physiologically, influence cognitive processing in a decision-making task. In addition, we will look at the relation between physiological and subjective measures of emotions, as well as retrospective evaluations of both emotions and cognitive processing.

The data has been collected by an ongoing research project at BI Norwegian Business School. The data was collected in the Spring/Summer of 2016. The following methodology section will elaborate on the collected data, as well as providing description of the equipment and measures that were used. In addition, we will describe the adjustments and changes we made, as according to the aim of the thesis.

Sample

The original sample consisted of 160 subjects. However, due to missing data, our sample consists of 153 subjects, in which 46 (30%) of the participants were male and 107 (70%) were female. Most of the participants were recruited from BI Norwegian Business School.

Equipment and Experimental Design

Equipment

The experiment was designed and ran with E-Prime 2.0, a software tool that provides a precise timing of events and data collection (Psychology Software

Tools: E-Prime application suite for psychology experiment design, implementation, and analysis, 2016). In order to induce different emotional states, pictures were retrieved from the International Affective Picture System (IAPS) (Lang, Bradley, & Cuthbert, 2008). Five pictures have been chosen for the present experiment: 2045 (Happy Baby), 9410 (Soldier), 5800 (Leaves), 9075 (Starving Child), and 8186 (Skysurfer) (see Appendix 1). Each picture triggers a different combination of valence and arousal, based on the core affect construct (Russel, 1980), see Figure 1 for a distribution (Lang et al., 2008).

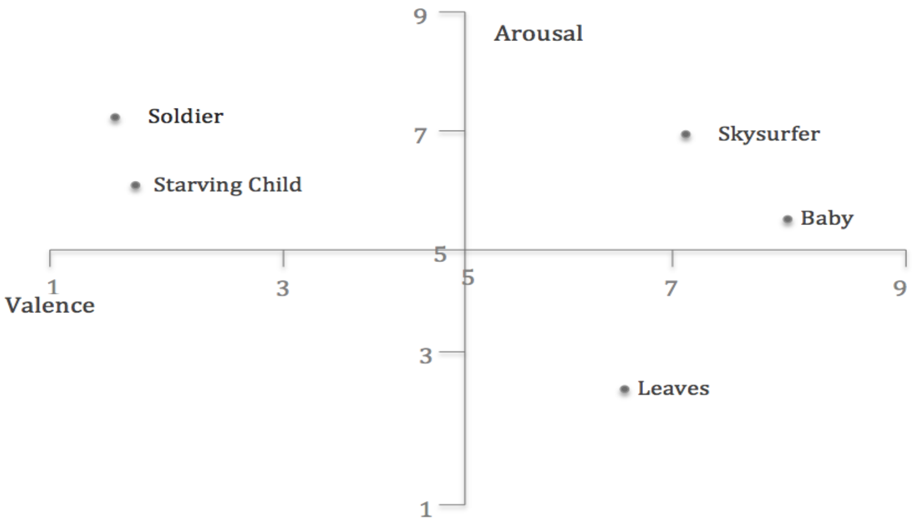

Figure 1. Distribution of the pictures based on arousal and valence level

Further, the participants were introduced to the Asian Disease scenario in the gain frame dilemma (see Appendix 2). The Asian disease scenario has been used in decision-making research (Tversky & Kahneman, 1981) and is a suitable decision-making task as the subjects are equally likely to apply either analytical or intuitive processing. Thus, we consider this as an appropriate task to investigate the subject's type of cognitive processing.

In order to measure participants' physiological arousal, the Biogauge Sudologger was utilized, which is an instrument used for sweat activity measurements. The sudologger measures skin conductance response (SCR) through three electrodes that are connected to the palm and forearm in the participant's left or right (non-dominant) hand. The instrument recorded the participants' electrodermal responses on a 1.111 Hz sampling frequency, and was applied prior to the experiment.

A Ledalab software run through Matlab, was used to prepare the data for further analysis of the SCR. This will be elaborated below, where SCR is discussed in detail.

Experimental Design

The experiment consisted of a relax phase, exposure to an emotional stimuli, a decision-making task, self-reported measures and a questionnaire. The experiment was performed with maximum 5 participants at a time, and each participant were placed in a separate cubicle to avoid any influence from others. The experiment lasted for approximately 2 minutes, before answering the cognitive processing questionnaire. The participants were placed in front of a computer, and three electrodes were applied to their arm prior to the start of the experiment. Subsequently, the computer provided the participants with the experiment's instructions. After filling in demographics, they were instructed to relax for 60 seconds. The participants were randomly assigned to one of five experimental conditions, which would present them to a picture stimuli from the IAPS database for 15 seconds (distribution of participants can be seen in Table 1). Further, the participants were presented to a decision-making task in form of the Asian Disease Dilemma in the gain frame. After responding to this, participants were instructed to subjectively assess how they felt when viewing the picture, in terms of valence and arousal. After completing the experiment, the participants filled out a self-assessment questionnaire, which allows them to report on their cognitive processing style during the decision-making task.

Table 1: *Distribution of participants between experiment conditions*

		Experiment Condition					
		Happy Baby	*Leaves*	*Skysurfer*	*Soldier*	*Starving Child*	**Total**
Gender	*Male*	12	6	7	10	11	46
	Female	20	23	24	20	20	107
Total		32	29	31	30	31	153

N = 153

Measures

Cognitive processing

Cognitive processing was measured in two ways: by the cognitive processing questionnaire (CPQ) and participants' response time to the dilemma task. The two measures will be described below.

Cognitive Processing Questionnaire (CPQ)

A self-assessment questionnaire of cognitive processing was used to assess whether the participant engaged in analytical or intuitive cognitive processing, when responding to the decision-making task. The cognitive processing questionnaire (CPQ) is developed by Bakken, Haerem, Hodgkinson, and Sinclair (2017), and constitutes a five-dimensional construct in assessing cognitive processing, forming two higher-order dimensions: analytical and intuitive processing. The analytical dimension consist of *rational* (5 items) and *control* (6 items), whereas the intuitive dimensions consist of *affective* (3 items), *knowing* (4 items) and *urgency* (4 items). The items were rated on a scale ranging from strongly disagree (1) to strongly agree (5) (see Appendix 3). The descriptives showed that the scales had acceptable reliabilities .70. In addition, a confirmatory factor analysis of the CPQ has been performed by previous thesis work (e.g. García & Motiiets, 2016; Borge & Hedenstad, 2016). Their analysis showed that the model proposed by Bakken et al., 2017 provided close to a good fit (X^2(199)=283.72, RMSEA=0.06, CFI=0.89) (Borge & Hedenstad, 2016).

Table 2 demonstrate the means, standard deviations (SD) and intercorrelations between the abovementioned subscales. As shown in Table 2, the subscales correlate significantly in the expected direction, except *knowing* which correlates significantly with *rational* (r= .29, p< .001). Bakken et al. (2017) report similar results, in which *knowing* is positively correlated to the analytical subscales; *control* and *rational*. These results further support Bakken et al.'s (2017) argument that knowing may be shared by both analytical and intuitive thinking styles. Based on this, we choose remove *knowing* from further data analysis.

Table 2: *Descriptive statistics for CPQ (means, standard deviations, and intercorrelations).*

	Mean	SD	1	2	3	4	5
1. Rational	3.76	0.74	1				
2. Control	3.50	0.66	.55***	1			
3. Affective	3.39	0.97	-.09	-.11	1		
4. Urgency	2.50	0.88	-.24**	-.23**	.18*	1	
5. Knowing	2.63	0.81	.29***	.13	.034	.094	1

Note. † p < 0.10. * p < 0.05. ** p < 0.01. ***p < 0 .001.

Response Time

The participants' response time to the dilemma task was also recorded. According to theory, the response time may indicate the use of intuitive or analytical processing. E.g. Sinclair (2004) argued that there is a positive association between processing speed and intuitive cognitive style, and a negative relation between processing speed and analytical cognitive style. Thus, Bakken et al. (2017) argued that the intuitive processing subscales; *knowing*, *affective,* and *urgency* should correlate negatively with response time, while the analytical processing subscales; *rational* and *control* should correlate positively with response time.

In order to test Bakken et al.'s (2017) assumption, correlations were obtained between the dilemma response time and the cognitive processing styles (see Table 4). The intuitive scale correlated negatively and significantly with response time (*r*= -.16, p=.049). This means that subjects who reports intuitive processing styles also use less time when making a decision in the dilemma task. The correlation between analytical scale and response time was in the expected direction, but not significant (*r*=.055). Furthermore, there was a significant correlation between the intuitive and analytical scale (*r*=-24, p=.001), which supports Bakken et al.'s (2017) observation of the two scales as interdependent systems, operating side-by-side.

Arousal

As highlighted in the theoretical framework, researchers have conceptualized emotions as constituting a physiological component, as well as a subjective component (e.g. Nabi, 1999). Thus, when measuring emotions, both physiological measures and subjective reports should be applied (Boucsein, 2012). Therefore, the present thesis measures arousal in terms of a self-reported measure and a physiological measure.

Subjective Arousal and Subjective Valence

In order for subjects to assess their emotions, a subjective rating called the Self-Assessment Manikin (SAM) of arousal level and valence was applied. Subjects rated both the affective dimensions of valence and arousal with on a 9-point Likert scale, including graphic pictures (see Appendix 4). The subjects indicate whether they felt “unhappy - happy” (valence), and “calm - excited” (arousal) (Bradley & Lang, 1994).

Physiological Arousal

The physiological arousal of the participants, or the electrodermal activity, was measured with the Sudologger, which passes a current through a pair of electrodes located on the skin surface. This is done with a firing rate of multiple sudomotor fibers in the skin that creates a sudomotor nerve burst (a single spike in nerve activity), which corresponds to the SCR. It has been argued that the SCR is a reliable measure of autonomic expressions of emotions, as it is under the control of the sympathetic branch of the nervous system (Khalfa, Isabelle, Jean-Pierre, & Manon, 2002).

Further, we applied a Continuous Decomposition Analysis in Ledalab to the skin conductance activity in order to decompose the data into continuous phasic and tonic components (Benedek & Kaernbach, 2010b). This method allows us to control for the baseline dependency, or the skin conductance level, that the participants already have when starting the experiment. E.g. If the skin conductance level is already very high, the SCR will only increase to a limited degree. However, by using the continuous decomposition method to extract the phasic driver, we reduced the amount of error arising from natural variance between individuals (Bryman & Bell, 2013), and the risk of underestimating SCR amplitude (Benedek & Kaernback, 2010). We also defined the minimum amplitude threshold at the 0.01 level, which was applied to the data. This level was chosen, as it is outside the range to be sensitive to external influences. When extracting data for analysis, we used the SCR Amplitude, which contains the difference between the baseline and the highest SCR level at a specific point in time. The SCR Amplitude provided us with the information needed to analyse the SCR values in all of our time windows, except the Max Peak window. For this particular window, we used CDA PhasicMax, which constitutes the maximum value of phasic activity (Benedek & Kaernbach, 2010).

Application of Time Windows

When measuring participants' physiological arousal (SCRs), various time windows were defined based on the different theories highlighted in the literature review. Thus, we applied a window that reflected the average arousal of an experience, the peak of maximum intensity, the end and recency effect, and primacy effects. This resulted in six different time windows. Firstly, based on previous research' findings that people tend to summarize their whole experience into an average of a single assessment (Hsee, 1998; Kahneman, 2002; Shiffman et al. 2008), we defined a time window constituting an average of the experience (referred to as the Average window) from the onset of the emotional stimuli to a response was given to the Asian Dilemma task. These SCR scores were standardized for further analysis. Secondly, based on theories regarding the peak effect (e.g. Fredrickson, 2000), we used a time window starting from the onset of the emotional stimuli and ending at the completion of the Asian Dilemma task (referred to as the Max Peak window). During this time interval, we looked at the peak of maximum phasic intensity. Thirdly, in accordance with physiopsychology research and the primacy effect (Aue, Hoeppli, & Piguet, 2012; Levinson & Edelberg, 1985), we applied one time window with a duration of 5 seconds and one with 10 seconds, both starting immediately after the onset of the presentation of the emotional stimuli (referred to as the 5 Seconds window, and the 10 Seconds window). By including the 5 and 10 seconds time windows, we are able to control for time latencies, and take the stimulus duration (15 seconds) into account (Benedek & Kaernbach, 2010). Finally, when investigating the significance of the end-moment (e.g. Fredrickson, 2000) and recency effects (e.g. Davelaar, 2005) we applied a time window with a duration of 5 seconds before the onset of a subjective ass essment task, and a time window of 10 seconds before the onset of a subjective assessment task (referred to as the 5 Seconds End window, and the 10 Seconds End window). Thus, the six different windows (i.e. the Average-, Max Peak-, 5 Seconds-, 10 Seconds-, 5 Seconds End-, and 10 Seconds end- window) were applied to the data analysis.

Exploring the Data

The data were explored in SPSS to check for normality and extreme values.

Transforming the Data

The results showed that the data was highly skewed in several of the time windows. To perform parametric tests, the data must be normally distributed (Hair et al., 2010). Thus, we transformed the data using the natural logarithm (ln). With this transformation, the skewness was reduced for all the variables, showing a skewness of less than 1, which is acceptable for further parametric testing (Hair, et al. 2010).

Outliers and Missing Values

Extreme values in the data were considered for values that fell outside 3 standard deviations from the mean in the subjective valence measure. However, we did not find any such values. Further, when comparing the means of all our variables to the 5% trimmed means, we found that none on the extreme values were affecting the means enough to justify their removal.

Further, the data included some missing values. Thus, to increase the power of our further data analysis, missing values were controlled for by using pairwise deletion (Hair et al., 2010).

Manipulation Checks

To check if the picture manipulation worked, the five different pictures and their effects on self-reported and physiological arousal were further investigated. We would expect that the means for the Skysurfer and Soldier pictures to be higher than means for the rest of the pictures. Further, we would expect the Leaves picture to show the lowest mean compared to the rest of the pictures. The means and SDs of the arousal in each time window and self-reported arousal are presented in Table 3 (see Appendix 5 for non-transformed means and SDs).

Table 3: *Mean and SD for physiological arousal in each time window and self-reported arousal in each experimental condition*

Condition		**Average***	**Max Peak***	**5 - sec***	**10-sec***	**5 Sec End***	**10 Sec End***	**Self-Reported Arousal**
Skysurfer	*Mean*	-2.59	1.16	-1.22	- 0.27	-0.63	0.01	5.00
	(SD)	(0.42)	(.80)	(1.02)	(.75)	(.97)	(.91)	(2.10)
Happy Baby	*Mean*	-2.22	1.06	-1.00	-0.15	-0.56	0.02	3.90
	(SD)	(0.53)	(.74)	(1.13)	(.87)	(0.76)	(.77)	(1.62)
Leaves	*Mean*	-2.29	0.89	-1.08	-0.44	-0.93	-0.28	3.25
	(SD)	(0.52)	(.92)	(0.87)	(0.93)	(1.05)	(0.81)	(2.01)
Soldier	*Mean*	-2.38	1.16	-0.97	-0.27	-0.45	0.04	4.10
	(SD)	(0.53)	(.78)	(0.85)	(0.76)	(0.83)	(.72)	(1.88)
Starving Child	*Mean*	-2.07	1.27	-1.10	-0.39	-0.38	0.26	3.81
	(SD)	(0.74)	(.85)	(0.98)	(.86)	(.98)	(.94)	(1.78)

*****The means and SDs are obtained from the transformed SCR data

To check whether the picture manipulation was in successful in producing significant differences among the group means of self-reported arousal, we performed a univariate ANOVA with the pictures as the independent variable and self-reported arousal as the dependent variable. The results showed a significant effect of the picture manipulation ($F(4, 146)= 3.41$, $p=.01$). Further, the Bonferroni post-hoc test indicated significant differences between Leaves (M= 3.25, SD= 2.01) and Skysurfer (M= 5.00, SD= 2.10) conditions ($p=.005$). These results show that the conditions were successful in manipulating different levels of self-reported arousal between the participants in the experiment. In addition, the manipulation worked in the expected direction, since the difference in self-reported arousal was between the lowest arousal picture (Leaves) and the high arousal picture (Skysurfer).

Further, to see if there were any significant differences among the group means of different conditions of physiological arousal, we performed a univariate ANOVA with each time window as dependent variable, and the pictures as independent variable. The results found a significant effect of the pictures on arousal in the Average window ($F(4, 148)=3.662$, $p=.007$). Further, a Bonferroni post hoc test showed significant differences between the Skysurfer (M= -2.59, SD= 0.42) and Starving Child condition (M= -2.07, SD= 0.74), ($p=.004$). This means that the picture manipulation was successful in producing different levels of arousal in the Average window between these conditions. However, these results should be interpreted with caution as the differences we obtained was between two pictures that did not produce arousal in the expected direction, as the Skysurfer condition (predicted to have the highest level of arousal) had the lowest level of physiological arousal and the Starving Child had the highest level of arousal. Further, no significant differences were found between the picture manipulation and any of the remaining time windows, meaning that the pictures largely failed to produce the expected differences in arousal among conditions. Thus, the results must be interpreted with caution.

The results obtained from the two ANOVA tests are interesting, as the self-reported arousal produced a significant difference between the conditions, in the expected direction, while the physiological measure of arousal failed to do so. This may suggest that there is a lack of correlation between self-reported arousal and physiological arousal (Jakobs et al., 2001), and supports the notion that both should be included when measuring emotions (Boucsein, 2012). However, the coherence between the two will be further investigated in later parts of our analysis.

Choice of Time Windows

Several significant correlations were obtained between physiological arousal in the different time windows and the other variables. (see Table 4). Due to the overlapping of various time windows (5 Seconds and 10 Seconds window, and 5 Seconds End and 10 Seconds End window), we chose to proceed with the time windows that showed the highest correlation with the other variables. This included the 10 Seconds window. As mentioned, both time latencies of the SCR following a stimulus (Boucsein, 2012; Levinson & Edelberg, 1985), and stimulus duration (Benedek & Kaernbach, 2010; Cuthbert et al. 2000; Verduyn et al. 2015) could be the reason why emotional arousal was detected as late as 10 seconds

Table 4: *Overview of Pearson's correlations*

	1	2	3	4	5	6	7	8	9	10	11
1. Intuitive	-										
2. Analytical	-.243**	-									
3.Self-reported Valence	.092	-.021	-								
4.Self-reported Arousal	.242**	-.196*	-.127	-							
5. Average	-.115	-.016	-.130	.135†	-						
6. 5 sec	-.095	-.154†	.036	.053	.092	-					
7. 10 sec	-.052	-.223**	.014	.150†	.135†	.745***	-				
8. Max Peak	-.002	-.016	-.181*	.158†	.133	.297***	.387***	-			
9. 5 Sec End	.039	-.148†	-.156†	.193*	.334**	.334***	.445***	.495***	-		
10. 10 Sec End	.031	-.113	-.092	.186*	.217**	.415***	.485***	.531***	.876***	-	
11. Reaction Time	-.159*	.053	.098	.048	-.056	-.021	-.056	-.058	-.076	-.087	-

Note. † $p < 0.10$. * $p < 0.05$. ** $p < 0.01$. ***$p < 0 .001$.

after the presentation of the picture. Thus, the 5 Second window may have been too short to capture the autonomic response. In addition to the 10 Seconds window, the 5 Seconds End window also showed high correlations with the other variables, and both of these time windows are theory-based. Further, the Max Peak window and the Average window were also chosen for further analysis, due to their theoretical significance.

Results

Physiological Arousal Level and Self-Reported Arousal

In hypothesis 1 we predicted a positive relation between the level of physiological arousal and self-reported arousal. In order to determine this relation, the level of arousal was divided into low-aroused and high-aroused groups, for each time window. The means were used to categorize the participants' scores into high and low arousal groups based on whether the SCR scores fell above or below their respective mean. Further, correlations were conducted testing the relation between the subjects perceived arousal with the SCR in the following time windows: 10 Seconds, Max Peak, Average and 5 Seconds End window.

The correlation between the high arousal group in the 5 Seconds End window and self-reported arousal was significant in the expected direction (r=.287, N=66, p<.019). As hypothesised, there was no significant correlation was obtained in the low arousal group between the 5 Seconds End window, and self-reported arousal (r=.008, N=82, p=.940). Thus, these findings supports hypothesis hypothesis 1, and are in line with Sze et al.'s (2010) finding of the coherence between subjective and physiological experience of arousal depending on the arousal level. Further, no significant correlations were found with the other time windows (Average, End 5, Max Peak and 10 Seconds). Based on this, we consider the results as offering partial support for hypothesis 1, as significant findings were only obtained in one of the time windows.

Testing the Time Windows that Best Predict Self-Reported Arousal

Several of the time windows correlate significantly with self-reported arousal (see Table 3). To test hypothesis 2 and to investigate which of these time windows that best predict self-reported arousal, we conducted a linear regression analysis (see Table 5). The regression included self-reported arousal as the dependent variable, and the time windows (Average, 10 Seconds, Max Peak, 5 Seconds End) as predictor variables, while controlling for valence (Model 1). Model 2 yielded significant results, showing that the Average window was significantly and positively related to self-reported arousal (*p*=.013), explaining 11,1% of the variance in self-reported arousal (R^2= .159, Adjusted R^2= 0.111). This means that when controlling for valence, the Average window predicts self-reported arousal, partly confirming hypothesis 2, and the suggestion that people summarize an experience into one assessment when evaluating their arousal.

Table 5: *Multiple linear regression analysis.*

Dependent variable: Self-reported Arousal		
	Model 1	**Model 2**
	B *SE(B)*	*B* *SE(B)*
Soldier (Low valence)	.041 (.49)	.064 (.48)
Starving Child (Low valence)	-.008 (.49)	-.024 (.48)
Leaves (Medium valance)	-.117 (.50)	-.081 (.49)
Skysurfer (High valence)	.230 (.48)*	.294 (.48)**
10 Seconds		.063 (.21)
Average		.208 (.28)*
Max Peak		.027 (.22)
5 Seconds End		.115 (.21)
Constant	3.903 (.34)***	5.537 (.77)***
R^2	.079	.159
Adjusted R^2	.053	.111
F for change in R^2	3.07*	3.31*

Note. † p < 0.10. * p < 0.05. ** p < 0.01. ***p < 0 .001. The table includes the Standardized Coefficients Beta, and the Coefficients Standard Error (in parenthesis).

Cognitive Processing Regressions Analysis

A univariate ANOVA between the picture manipulation and the cognitive processing styles was performed to evaluate the effect of the experiment's condition on the dependent variables. The results showed that there were no significant differences between the picture manipulation and intuitive processing, and the picture manipulation and analytical processing. This is expected, as the picture manipulation largely failed to produce the expected differences in arousal among conditions. Further, these findings may suggest that participants have experienced the same emotional stimuli differently. Thus, the regression analysis will be based on the participant's individual responses.

In order to test whether arousal is positively related to intuitive processing (H3a) and negatively related to analytical processing (H3b), we conducted hierarchical multiple regressions analysis. Two different regressions were conducted, with analytical processing and intuitive processing as dependent variables (see Table 6). Further, the variables of interest were entered hierarchically as predictors into a multiple regression using the standard method (enter).

Model 1 included self-reported valence and self-reported arousal. Self-reported arousal was a significant predictor in a positive direction, (p=.002), explaining 5, 5% of the variance in intuitive processing (R^2= .068, Adjusted R^2= .055). When using analytical processing as a dependent variable, we observed a significant negative relation between self-reported arousal and analytical processing, (p=.009), explaining 3.4% of the variance in analytical processing (R^2 = .047, Adjusted R^2=.034). These findings supports other research emphasizing the importance of including the subjective assessment of arousal, as it shows how individuals address their physiological arousal signals (Boucsein, 2012). Further, the findings show that self-reported valence was not a significant predictor of either analytical or intuitive processing. As self-reported valence did not have any significant impact on cognitive processing, it supports our claim that the type of valence is not as important as the level of arousal in predicting cognitive processing, and that one should look beyond valence to understand how emotions influence cognitive processing (Bodenhausen et al., 1994; Posner et al., 2005).

Table 6: *Multiple linear regression analyses.*

Dependent variable: Intuitive Processing			
	Model 1	**Model 2**	**Model 3**
	B *SE(B)*	*B* *SE(B)*	*B* *SE(B)*
Self-reported Valance	.104 (.05)	.103 (.05)	.122 (.05)
Self-reported Arousal	.253 (.06)**	.272 (.06)**	.288 (.06)**
10 Seconds		-.079 (.16)	-.085 (.16)
Average		-.114 (.20)	-.119 (.20)
Max Peak		-.009 (.17)	-.013 (.16)
5 Seconds End		.068 (.16)	.058 (.16)
Response Time			-.218 (.01)**
Constant	4.827 (.36)***	4.169 (.66)***	4.762 (.69)***
R^2	.068	.087	.133
Adjusted R^2	.055	.048	.090
F for change in R^2	5.30**	.711	7.52**

Dependent variable: Analytical Processing			
	Model 1	**Model 2**	**Model 3**
	B *SE(B)*	*B* *SE(B)*	*B* *SE(B)*
Self-reported Valance	-.030 (.04)	-.004 (.04)	-.010 (.05)
Self-reported Arousal	-.218 (.05)**	-.194 (.05)*	-.199 (.05)*
10 Seconds		-.204 (.14)*	-202 (.14)*
Average		.061 (.18)	.063 (.18)
Max Peak		.141 (.14)	.143 (.14)
5 Seconds End		-.098 (.14)	-.095 (.14)
Response Time			.065 (.004)
Constant	7.902 (.33)***	7.675 (.58)***	7.520 (.61)***
R^2	.047	.100	.104
Adjusted R^2	.034	.061	.059
F for change in R^2	3.55*	2.08†	0.65

Note. † p < 0.10. * p < 0.05. ** p < 0.01. ***p < 0 .001. The table includes the Standardized Coefficients Beta, and the Coefficients Standard Error (in parenthesis).

Further, to test the influence of physiological arousal, the time windows (Average, Max Peak, 5 Seconds End and 10 Seconds) was added in model 2 for both intuitive and analytical processing as dependent variables. With analytical processing as the dependent variable, the results showed that the 10 seconds time window was negatively and significantly related to analytical processing (p=.030), explaining 6,1% of the variance (R^2= .100, Adjusted R^2=.061). As both physiological and self-reported arousal are significant predictors and negatively related to analytical processing, this confirms hypothesis *H3b*. The results also supports hypothesis *H4,* as 10 Seconds time window is the only significant predictor. This means that the self-evaluation of cognitive processing was based on the initial moment of the experience.

However, no significant results were found in model 2 with intuitive processing as the dependent variable, indicating that physiological arousal does not predict intuitive processing. Thus, hypothesis *H3a* is not supported by adding physiological arousal to the regression model, but only partially supported by the significant finding between self-reported arousal and intuitive processing in model 1.

When adding dilemma response time in model 3, with intuitive processing as the dependent variable, the quality of the model increases as dilemma response time is significantly related in a negative direction to intuitive processing (p=.007), accounting for 9% of the variance (R^2=.133, Adjusted R^2=.090). This suggests that the less time used to answer the dilemma, the more intuitive processing is applied. Adding response time in model 3 with analytical processing as the dependent variable did not yield any significant results.

Discussion

The aim of the present thesis was to investigate the influence of emotions on cognitive processing, as well as the coherence between physiological arousal and self-reported arousal. By applying time windows to physiologically measured emotional response, this study has attempted to provide a more in-depth view on arousal during an emotional response. In addition, we have considered retrospective evaluations of both arousal and cognitive processing styles to investigate how individuals perceive their emotional experiences and thinking styles. The proceeding paragraphs will discuss these findings.

Levels of Physiological Arousal and Self-Reported Arousal

Firstly, we wanted to see whether coherence between physiological arousal and self-reports of arousal was greater for those with high arousal, than for those with low arousal. As predicted, we found a significant relation between physiological arousal at the end of the experiment (the 5 Seconds End window) for the high arousal group and self-reported arousal, whereas no relation was found for the low arousal group. These results are in line with the findings of Sze et al. (2010) who also found coherence between high arousal groups and subjective arousal, and McCall et al. (2015) whose results demonstrated a strong relation between self-reported arousal and physiological arousal. Further, the 5 Seconds End window and its link to self-reported arousal can be explained in terms of the recency effect. More specifically, individuals with high arousal in the 5 Seconds End window remember their arousal well since the arousal takes place at the end of the experience, and hence, their memory of arousal resides in the capacity-limited short-term buffer, from which items can be recalled immediately (Atkinson & Shiffrin, 1968). In addition, the findings also support the end effect (as in the peak and end effect) as being dominating in evaluations of past experiences. Research points to the end as a salient moment of the emotional experience, and the affect associated with this moment as coming more easily to mind (e.g. Kahneman, 1993, Redelmeier, 2003). In sum, the combination of a high arousal that may be more recognizable for the participants, and the high arousal being easy to immediately recall, may explain why this result was only obtained in this specific time window. The lack of correlation between the 5 Seconds End window low arousal group and self-reported arousal may be due to the low arousal being less recognizable for individuals. Further, since coherence between higher levels of arousal and self-reported arousal was only present in one of the time windows, it does not provide full support our hypothesis.

Self Reported Arousal as a Summarized Average

Above, the results were obtained by dividing the participants into groups of high and low arousal. However, when removing these groups, and analysing the participants' individual self-reported arousal, we found that individuals summarize physiological arousal during the entire experience into an average. Thus, our results are in accordance with finding which suggest that a subjective average can be calculated automatically (Hsee, 1998), and quite accurately (Ariely, 2001). In addition, it supports Kahneman's (2002) explanation of the natural assessment of the average as highly accessible to individuals, and that individuals summarize their arousal as an average of the whole experience, rather than thinking back to arousal at the start, or at other particular moments, during the experience.

This finding suggest that individuals are not in fact influenced by the peak and end effect in retrospective evaluations. It may be that arousal based on a peak moment of intensity, or the end of an experience, best applies to studies where the stimuli changes and/or varies over time, causing a change in intensity. For instance, a study which used annoying sounds as stimuli and presented participants with different patterns of sounds, i.e. some patterns had increasing final trends (sound went up at the end), whereas other patterns had decreasing final trends (sound went down at the end). The authors found that people rated the experience of the sounds as more intense and less intense, respectively (Ariely & Zauberman, 2000). This demonstrates that the way experiences develop over time, influences how experiences are evaluated. Similar findings are evident in various other studies, such as the colonoscopy study, in which the pain was slightly reduced towards the end for half the participants, which made the memory of the colonoscopy significantly less painful for them, compared to the other half (Redelmeier et al. 2003). In the context of the present study, one single picture stimulus was presented at the beginning of the experiment, instead of several pictures that differed in levels of arousal. This may have led to the absence of a peak or an end effect, as there was no manipulated change in intensity during the experience. Thus, future research could include pictures at different points in time during the experience, and with varying levels of arousal to see whether a peak and end effect is evident.

Cognitive Processing and Arousal

We were also interested in the impact of arousal on cognitive processing, and our results found a negative relation between physiological arousal and analytical processing. This finding supports existing research suggesting that lower levels of stress lead to a more thoughtful and deliberate thinking style (Arnsten, 2009), engaging system 2, which operates slower during decision-making tasks (Kahneman, 2003a; Stanovich et al. 2000). However, we did not find a positive relation between physiological arousal and intuitive processing. A possible explanation for this is that the emotional stimulus may have failed to produce a significant amount of physiological arousal to increases stress and thus, lead to rapid and intuitive thinking (Arnsten, 2009). Further, it is important to keep in mind that in this case, the physiological arousal is located within 10 Seconds window, which has not obtained any relation with self-reported arousal, in our results. Thus, the findings suggest that for intuitive processing, the participants have shown an incoherency regarding their physiological reactions and their subjective experience of it. These contradicting findings highlight the importance of including both physiological and subjective measures of arousal when investigating its effects on cognitive processing.

Finally, we investigated whether primacy effects predict retrospective evaluations of cognitive processing. Our results found a link between self-reports of cognitive processing and the 10 Seconds time window. As this particular window is located early on in the emotional experience, this finding supports previous research, claiming the existence of primacy effects when the evaluation task it not hedonic (Zauberman et al., 2006). Another plausible explanation may be that people are not as easily influenced by physiological arousal when making a retrospective evaluation of cognitive processing, as they are when making a retrospective evaluation about emotions. This is because affective assessment is generally recognized by research to be prone to assessment biases, such as the peak and end heuristic, and the average heuristic (e.g. Gray & Watson, 2007; Kahneman, 2002).

Practical Implications

The findings of the present thesis have various practical implications relevant for organizations today. Firstly, the moments during an experience which people base their retrospective evaluations on, can be applied to a variety of settings such as evaluations and assessments of both leaders and employees in organizations. For instance, it would be interesting to see whether people's evaluations are based on specific incidents or whether they are based on an average of incidents over time. For example, employees could rate their well-being multiple times a day, on a daily basis for a week. Then, at the end of the week, employees could be asked to rate their well-being during the whole week, as one single assessment. By doing this, researchers may be able see how people self-evaluate experiences. A similar rating of well-being has been successfully tested using a method for characterizing daily life experiences, named "The Day Reconstruction Method". Participants were instructed to record their emotions during each episode of the previous day (Kahneman, Krueger, Schkade, Schwarz, & Stone, 2004). Other versions of the methods have also been utilized, such as one instructing participants to rate experienced emotional peaks and lows in during the day (Kahneman, Schkade, Fischler, Krueger, & Krilla, 2010). We propose that by replacing ratings of well-being with ratings of leaders and employees' performance, a clearer picture of the current state of an organization's workforce can be established, and improvements can be made.

Another implication for practice concerns the importance of taking arousal into consideration in the context of decision-making. In other words, this thesis emphasize the need for organizations to account for the effects of emotions on employee's cognitive abilities. People are faced with arousing situations everyday, as well as multiple cognitive-demanding tasks. As demonstrated, emotions influence how individuals think, and thus, precautions must to be taken for individuals to make beneficial decisions. We suggest that organizations make emotion-awareness and maybe even emotion-coping areas of focus.

Limitations

This thesis constitutes some limitations that will be mentioned below.

Firstly, the sample was quite homogenous, as it consisted of mainly young students (mostly females) with a mean age of 25, recruited from BI Norwegian Business School. In addition, our sample only included approximately 30 participants in each condition. The results may have been more robust if more participants were included. This makes it difficult to generalize our results.

Another limitation concerns external influences on the SCR measure used during the experiment. For instance, environmental factors such as room temperature, noise, and the presence of others may have had an effect on the SCR recordings. These disturbances could have been reduced by having one participant at a time taking the experiment. Moreover, the laboratory settings are rather artificial and this can affect the participants behavior and decisions in the experiment.

Furthermore, we found that the pictures failed to produce any significant differences in physiological arousal and cognitive processing between the different emotional conditions, apart from the Average window. A possible explanation for this may be that the pictures were not strong enough emotional stimuli, and therefore did not produce the expected arousal to generate variation in the different conditions. Future research may want to consider using video clips or writing about real-life events as emotional stimuli, as this has been used by other researchers (Gilet, 2008).

In addition to using EDA to measure emotional arousal, other applications of physiological arousal could be applied as heart rate and facial muscle activity (Aue et al. 2012; Scherer, 2005). By including more measures of physiological arousal, it can provide us with more insight into the effect of emotion on physiological reactions in a decision-making context.

Future Research

Future research should carefully consider heuristic influences and cognitive processing styles. In other words, what is the relation between cognitive processing styles and individuals' susceptibility to heuristics in retrospective evaluations? This requires the establishment of the mechanisms underlying cognitive heuristics, and attention to individual differences as an important influence on cognitive processing style. In addition, considering that our regressions showed mixed results, future research should look further into the relation between subjective and physiological arousal, and their link with cognitive processing.

Mindfulness is another concept of interest when examining the influence of emotions on cognitive processing, as some research argue that the use of mindfulness can help reduce stress, and is associated with facets of cognitive control (Prakash, Hussain, & Schirda, 2015). Therefore, it may be that mindfulness can reduce susceptibility to biases that arise when individuals evaluate past experiences. It could also be of further interest to explore how the use of mindfulness to moderate the relation between arousal and intuitive/analytical processing. Additionally, it has been argued that bodily information is conditioned by mindfulness (Tsur, Berkovitz, & Ginzburg, 2015). Future research could therefore investigate whether the use of mindfulness can affect body awareness, and whether the coherence between subjective and physiological arousal would increase.

Another concept of interest is that of emotion regulation, which individuals use to regulate the impact of emotions during cognitive processes (Martin & Delgado, 2011). Emotion regulation constitutes, among others, two techniques referred to as *cognitive reappraisal* and *expressive suppression* (Gross & John, 2003). Cognitive reappraisal is a form of cognitive change and involves reinterpreting an emotional stimulus in a way that changes its emotional impact. Expressive suppression on the other hand, involves the inhibition of a current emotional state in order to regulate its impact (Gross, 1998, cited in Gross & John, 2003). Research has found emotion regulation to act over cognitive evaluations and the behavioral response that in turn changes both the physiological reaction and perception of the situation (Gross & John, 2003). Based on this, future research should consider investigating the moderating effects of emotion regulation in the relation between arousal and cognitive processing.

Concluding Remarks

The present thesis has looked into how individuals make retrospective evaluations in studies involving affect. Although previous studies have established various effects of emotions on cognitive processing, this study fully investigates the heuristic biases that occur during self-reporting of both emotions and cognitive processing by the use of different time windows. By doing this, we get a more detailed insight into arousal during an emotional response, as well as how individuals self-evaluate experiences. In addition, the establishment of the negative relation between arousal and analytical processing, strengthens existing research' findings on the effect of emotions on information-processing. Finally, the lack of relation between physiological arousal and intuitive processing demonstrates the need for achieving successful emotion induction, and further improvement of these methods.

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Appendices

Appendix 1 – IAPS Experiment Pictures

Picture Manipulation: High valance – Medium Arousal

Happy Baby – 2045

Picture Manipulation: Low valance - High arousal

Soldier – 9410

Picture Manipulation: Positive valance – Low arousal

Leaves – 5800

Picture Manipulation: Low valance – Medium Arousal

Starving Child - 9075

Picture Manipulation: High valance – High arousal

Skysurfer – 8186

Appendix 2 – Asia Disease Scenario (Gain frame)

Asian Disease

Imagine that your country is preparing for the outbreak of an unusual Asian disease, which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. Assume the exact scientific estimates of the consequences of the programs are as follows:

Program A: 200 people will be saved.

Program B: there is a 1/3 probability that 600 people will be saved, and 2/3 probability that no people will be saved.

Which of the two programs would you favor?

(Select the program by pressing “A” or “B”)

Appendix 3 – Cognitive Processing Questionnaire

Please, think back on the dilemma you were presented with at the beginning of the experiment and in the decision you made and answer the following questionnaire. For each statement below, indicate on the scale whether you agree or disagree with the statement, from 1= strongly disagree to 5 = strongly agree.

During the dilemma

	1	2	3	4	5
I evaluated systematically all key uncertainties	O	O	O	O	O
I considered carefully all alternatives	O	O	O	O	O
When making decisions, I considered all options	O	O	O	O	O
I analyzed all available information in detail	O	O	O	O	O
I made the decision in a logical and systematic way	O	O	O	O	O
I can describe step-by-step how I made my decision	O	O	O	O	O
I considered all consequences of my decision	O	O	O	O	O
Before I started deliberating, I double-checked the available information to make sure I had the right facts	O	O	O	O	O
I based the decision on my inner feelings and reactions	O	O	O	O	O
It was more important for me to feel that the decision were right than to have rational reasons it	O	O	O	O	O
I relied on my instinct	O	O	O	O	O

I made the decision because it felt right to me	O	O	O	O	O
I knew the answer before I started analyzing the data	O	O	O	O	O
There was little need to examine detailed information	O	O	O	O	O
I had enough knowledge to make the best decision almost immediately	O	O	O	O	O
I only examined the information that was relevant in the situation	O	O	O	O	O
I based my decision on the overall picture	O	O	O	O	O
My knowledge of similar situations led me to quickly recognize a solution	O	O	O	O	O
I took time to read all available information carefully before making the decision	O	O	O	O	O
I double-checked the description of the situation before making the decision	O	O	O	O	O
There was little need to think because I know ”how things work” in this kind of situation	O	O	O	O	O
I decided on the first solution that I could think of	O	O	O	O	O
It was easy to get a clear picture of what needed to be done	O	O	O	O	O
When I had made a decision there was no doubt that this was the right action to take	O	O	O	O	O
I would be very surprised if my decision turned out to be wrong	O	O	O	O	O

It was easy to make a quick decision because the alternatives looked very similar	o o o o o
It was better to make a quick and perhaps faulty decision than making the decision too late	o o o o o
If I made a mistake I would make sure that I did not make the same mistake again	o o o o o
I did all I could in order to avoid mistakes	o o o o o
It was more important to avoid violation of formal rules and procedures than to make a quick decision	o o o o o
I could easily imagine the consequences of my decision	o o o o o
I focused only on the most important information	o o o o o
I knew my decision was correct even if I cannot explain my reasoning in detail	o o o o o
If the information was conflicting I tried to look for additional information that could disconfirm my assumptions	o o o o o
Even if the information was uncertain I tried to make a quick decision	o o o o o
If I was uncertain about what to do I tried to look for information that would narrow the choices	o o o o o
It was more important to make a quick decision than to wait for additional information	o o o o o
Before I made my decision I tried to think if there was	o o o o o

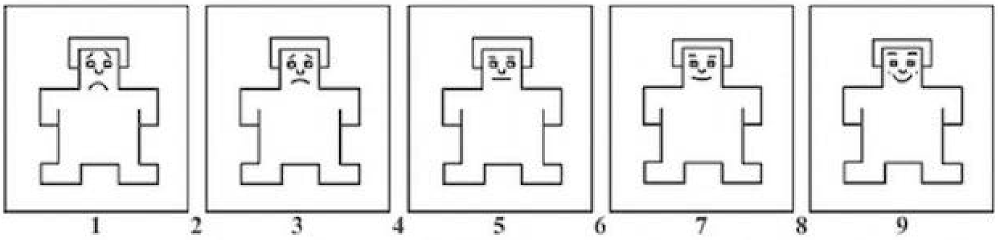
any information that could challenge my assumptions	
It was more important to make a quick decision than to think about all possible consequences	O O O O O
I did not make any decision until I had thought about all possible outcomes, even if some were highly unlikely	O O O O O
When I had made up my mind about what to do, I did not hesitate to put things into action	O O O O O
Even if a decision seemed obvious I took time to think through if I might have overlooked something	O O O O O
When I first got the idea of how to do it, I acted immediately	O O O O O

Appendix 4 – Self-Assessment Manikin

SAM Valance (Self-reported valance)

Please indicate, using the scale represented below, how you FELT when viewing the picture

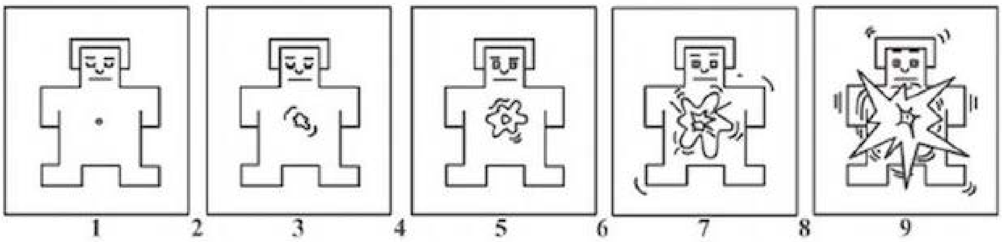
Unhappy **Happy**



SAM Arousal (Self-reported arousal)

Please indicate, using the scale represented below, how you FELT when viewing the picture

Calm **Excited**



Appendix 5: Mean and SD for physiological arousal in each time window and self-reported arousal, in each experimental condition

Condition		**Average**	**Max Peak**	**5 - sec**	**10-sec**	**5 Sec End**	**10 Sec End**	**Self-Reported Arousal**
Skysurfer	*Mean SD*	0.08 (0.03)	4.54 (5.38)	0.45 (0.53)	1.13 (1.67)	0.98 (1.80)	1.72 (3.14)	5.00 (2.10)
Happy Baby	*Mean SD*	0.13 (0.11)	3.68 (2.75)	0.78 (1.64)	1.41 (2.26)	0.80 (0.85)	1.49 (2.01)	3.90 (1.62)
Leaves	*Mean SD*	0.12 (0.07)	3.40 (2.49)	0.46 (0.40)	0.89 (0.65)	0.58 (0.63)	0.99 (0.71)	3.25 (2.01)
Soldier	*Mean SD*	0.11 (0.06)	4.22 (3.21)	0.52 (0.54)	0.99 (0.72)	0.91 (0.95)	1.36 (1.23)	4.10 (1.88)
Starving Child	*Mean SD*	0.18 (0.20)	4.84 (4.14)	0.55 (0.76)	0.99 (1.05)	1.26 (2.31)	2.42 (4.67)	3.81 (1.78)

*****The means and SDs are obtained from the non-transformed exploration of the data