How implicit sadness and happiness influence effort mobilization: investigating mechanisms

LASAUSKAITE SCHUEPBACH, Ruta

Abstract
La recherche présentée dans cette thèse teste les mécanismes prédits par le modèle implicit-affect-primes-effort (IAPE; Gendolla, 2012). Ce modèle explique comment l’affect implicite influence la mobilisation de l’effort mental. Les résultats de cette recherche apportent des évidences sur le rôle critique des sentiments non-émotionnels de difficulté ou de facilité de la performance, mais pas pour l’implication de l’état émotionnel explicite. De plus, nous montrons que le modèle IAPE prédit les effets de l’amorçage implicite mais pas explicite. Finalement, les résultats montrent une évidence pour un lien implicite entre tristesse et difficulté ainsi qu’entre joie et facilité. Donc, la recherche de cette thèse soutien les idées du modèle IAPE.

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HOW IMPLICIT SADNESS AND HAPPINESS INFLUENCE EFFORT MOBILIZATION: INVESTIGATING MECHANISMS

THESE

Présentée à la Faculté de psychologie et des sciences de l’éducation de l’Université de Genève pour obtenir le grade de Docteur en Psychologie

par

Ruta LASAUSKAITE SCHÜPBACH

de

Prienai, Lituanie

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Abstract

The present thesis investigated how motivation is influenced by implicit affect—automatically activated mental representations of affective experiences. More specifically, I was concerned with how implicit sadness and happiness influence mental effort mobilization. According to a recently proposed implicit-affect-primes-effort (IAPE) model (Gendolla, 2012), implicit affect cues influence effort mobilization through their effects on experienced demand. Four studies tested this proposed mechanism and contrasted it to alternative explanations. The main dependent variable—effort—was defined as resource mobilization to perform instrumental behavior and was operationalized as cardiac reactivity which is proportional to task demand as long as success is possible and justified.

The first study investigated the role of nonaffective feelings of ease or difficulty in implicit affect’s influence on effort mobilization. Half the participants were informed about a possible influence of task presentation properties on experienced task demand. This procedure is known to eliminate the effects of feeling states on evaluative judgments by attributing them to an external source. As expected, this cue manipulation diminished the effect of stronger effort-related cardiac reactivity in an implicit sadness condition. The second study used a similar paradigm and provided participants with a cue for a possible manipulation of their emotional states. This manipulation did not diminish the prime effect and cardiac reactivity was even stronger in the cue condition due to cognitive load. The third study aimed at testing how prime presentation time affects the joint effect of objective task difficulty and affect primes on effort mobilization. In a brief prime presentation condition, the results showed the expected interaction pattern of cardiac response, whereas a long prime presentation time led to an opposite pattern. These results were interpreted as being caused by psychological reactance: long prime presentation time made participants feel being manipulated and this led to a prime contrast effect in behavior in order to restore freedom. The fourth study examined implicit associations between sadness and performance difficulty and between happiness and performance ease. As expected, difficulty-related prime words facilitated the recognition of sad facial expressions while ease-related prime words facilitated the recognition of happy facial expressions. This finding provides evidence for implicit associations between sadness and difficulty and between happiness and ease.

Supporting predictions of the IAPE model, the here presented studies suggest that implicit sadness leads to higher mobilized effort than implicit happiness due to nonaffective feelings of difficulty and ease. Furthermore, the results speak against the possibility that the affect primes induced emotional feelings. Moreover, we demonstrated implicit associative links between sadness and difficulty and between happiness and ease. In sum, this thesis provides evidence for the priming mechanism proposed by the IAPE model (Gendolla, 2012).
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Chapter 1. Introductions

In the surrounding environment there is a vast amount of information, which we are not aware of but which is definitely shifting our choices, our behavior, our perceptions, our needs... This happens because the human mind is constantly integrating and selecting the available information of different modules in order to act adaptively (Abele & Petzold, 1994). Thus, it is important to understand how this adaptation is happening and why. The present thesis searches the answers to a little part of this wide topic, focusing on implicit affect-related information in the context of persons’ engagement during the performance of cognitive challenges.

The research presented in this thesis deals with the phenomenon of implicit influences on motivation. More specifically, these influences refer to motivational adjustments according to implicit affect-related stimuli. One of the main ideas of the present work is that not only affective states but also affect-related information about those states can influence human choices, judgments, performance, and motivation. I am interested in how implicit affect influences the intensity aspect of motivation while implicit affect refers to automatically activated specific affect-related knowledge in mind. The goal of this work is to investigate the informational value of affect-related stimuli on motivational intensity according to the implicit-affect-primes-effort (IAPE) model (Gendolla, 2012) – the theoretical framework underlying the conducted research.

This introductory part aims to present the IAPE model (Gendolla, 2012) based on which the experiments for this thesis were run. However, I will start with discussing motivational intensity theory (J. W. Brehm & Self, 1989), because the IAPE model is based on its principles. I will also present a model on explicit affect’s influence on behavior and, most important, on mental effort (Mood-Behavior-Model; MBM; Gendolla, 2000), because it is important to understand the mechanisms of mood’s effects on effort in order to be able to analyze the mechanisms proposed by the IAPE model. Also, I will justify the use of cardiovascular measures as operationalization of mental effort intensity—the main dependent variable in three of four studies presented in this thesis.

Motivational intensity

In this thesis, motivation refers to the process that determines the direction and energization of behavior (Elliot, 2006). The first aspect—direction—is a qualitative aspect and refers to the choice of specific behaviors: it describes what people do. The second aspect is quantitative and refers to the level of resource mobilization to execute instrumental behavior. While the behavior direction aspect has been explored more intensely (Heckhausen & Heckhausen, 2010), the second aspect deserves more attention. Effort is the term to describe motivational intensity or the amount of resources mobilized for instrumental behavior (Gendolla & Wright, 2009). Ef-
fort determines the intensity and persistence of behavior thus crucial for understanding the human motivation. The theory of motivational intensity (J. W. Brehm & Self, 1989) deals with the determinants of effort mobilization in the context of instrumental behavior.

**Effort**

In motivational intensity theory, effort is defined as mobilization of resources at a point in time in order to carry out instrumental behavior (J. W. Brehm & Self, 1989). This definition refers to the intensity aspect of motivation. In the present work, the terms effort, effort mobilization, and motivational intensity are used as equivalent. The main idea about the concept of effort is that its function is to provide resources for dealing with obstacles in the goal pursuit process. From the “difficulty law of motivation” (Ach, 1935) it follows that effort is mobilized proportionally to the perceived difficulty of behavior: the higher are the obstacles encountered during goal pursuit, the more effort is mobilized to overcome those obstacles. This principle is one of the core ideas of motivational intensity theory.

**Motivational intensity theory**

According to Brehm’s motivational intensity theory (J. W. Brehm & Self, 1989; J. W. Brehm, Wright, Solomon, Silka, & Greenberg, 1983), there are two main factors determining the level of effort. Those factors are (1) task difficulty and (2) potential motivation, defined by the importance of success. In this aspect, Brehm’s theory is different from most other motivation theories in which effort depends directly on the needs and incentives (see Wright, 2008). In Brehm’s theory, needs and incentives influence effort only indirectly by setting the level of the maximally justified effort.

**Task difficulty**

The essential idea underlying motivational intensity theory is an energy conservation principle. According to this principle, organisms avoid wasting their resources. Therefore, they expend only the necessary amount of effort to attain a certain behavior and avoid mobilizing more effort than necessary. The “difficulty law of motivation” (Ach, 1935) follows from this principle: the higher task difficulty, or the higher obstacles encountered during goal pursuit, the more effort is mobilized to overcome those obstacles. This means that when task demand is low, only little effort will be mobilized to execute behavior, while when task demand is high, high effort will be mobilized. In other words, effort will be proportional to task demand. However, when difficulty is too high, individuals disengage. If the task is so difficult that success is not possible, no effort is mobilized in order to preserve the energy according to the resource conservation principle.

A good illustration for this principle is an experiment by Richter, Friedrich, and Gendolla (2008) in which participants performed an easy, moderate, difficult, or impossible (extremely difficult) short-term memory task. Cardiovascular responses measured during the task as operationalization of the amount of mobilized effort (Wright & Kirby, 2001) corresponded to the predictions of motivational intensity theory about the link between difficulty and effort: Reactivity was low in the easy task, moderately high in the moderately difficult task, high in the difficult task, and again low in the impossible task (disengagement).
In summary, according to motivational intensity theory, which is based on the energy conservation principle, effort intensity is proportional to the task difficulty as long as success is possible and justified. This second justification limit is called potential motivation.

Potential motivation

Besides task difficulty, another essential concept in motivational intensity theory is potential motivation. Potential motivation describes the level of maximally justified engagement and refers to the amount of effort an individual is willing to invest. The function of potential motivation varies in dependence on the task: if task difficulty is clear or unclear. When task difficulty is clear, which means that the performance standard is known to the person, potential motivation influences effort indirectly by setting the maximal limit of justified task engagement. The amount of mobilized effort is, however, proportional to task difficulty until the necessary effort exceeds the level of potential motivation. If potential motivation is low, people disengage earlier (see Figure 1-A). If it is high, people will remain engaged at more difficult levels (see Figure 1-B).

In a study by Eubanks, Wright, and Williams (2002) participants performed a memory task of five difficulty levels and could win either $10 or $100 prize if they responded correctly to 90% of the task items. Effort-related cardiovascular response increased with task difficulty except for the most difficult condition where participants in $10 prize condition disengaged (cardiovascular reactivity low) while those in the $100 condition remained engaged (cardiovascular reactivity high).

When the task difficulty is unclear, potential motivation determines effort intensity directly. Unclear difficulty refers to a situation where the information about a performance standard or the level of obstacles is not available. In this case, as there is no available information about task demand, people will mobilize the maximally justified effort. This justification limit is potential motivation. It can be influenced by needs, incentives, or the value of success. For instance, in case of a high incentive, individuals will invest more resources in order to succeed than when incentive is low. In a study by Richter and Gendolla (2007), participants worked on a memory task without indications on its difficulty. They had either no incentive or could earn 10 Swiss Francs, 20 Swiss Francs, or 30 Swiss Francs for success. As predicted, cardiovascular reactivity (systolic blood pressure and heart rate) increased monotonically with increasing monetary incentive.

In summary, the main idea of motivational intensity theory can be described as follows: the amount of mobilized effort is proportional to perceived task difficulty as long as success is possible and justified. Most relevant for the present work is the effect of task difficulty on effort.

Measuring effort

Effort is defined as resource mobilization in order to carry out instrumental behavior (J. W. Brehm & Self, 1989). Effort can be quantified as beta-adrenergic sympathetic influence on the heart, as proposed by Wright (1996), who combined motivational intensity theory (J. W. Brehm & Self, 1989) with the active coping approach by Obrist (1981). Thus, in my thesis I am focusing on cardiovascular measures, especially cardiac pre-ejection period (PEP), reflecting heart contractility as indicator of effort mobilization, which is the central dependent variable in the conducted studies.
Figure 1. Schematic representation of the predictions for task difficulty effects on effort in Brehm's motivational intensity theory (J. W. Brehm & Self, 1989) when potential motivation is low (A) vs. high (B).

**Active coping and sympathetic influence on the heart**

Obrist (1976, 1981) proposed to distinguish between passive coping and active coping. This distinction was made according to participant’s ability to control performance outcomes. Active coping is a setting in which control is possible. By contrast, in passive coping setting, the person is a “helpless recipient of aversive events” and thus only minimally engaged in the task. Obrist observed that active coping is reflected by beta-adrenergic sympathetic influence on the heart. Thus, giving participants the opportunity, imaginary or real, to cope actively, led to sympathetic innervation influence on the myocardium.
In a study testing task difficulty effects on sympathetic activity on the heart (Obrist et al., 1978), all participants initially believed that they could avoid aversive stressors. However, in the first condition it was impossible, in the second condition some but not perfect success was possible, whereas in the third condition the success was granted. As expected, HR and carotid dP/dt (indirect measure of myocardial force) increased equally in all conditions. However, after 2 minutes, this increase was declining more rapidly in the minimal and maximal success conditions compared to the partial success condition. Here, the first and the third conditions are situations of passive coping because participant either learned that avoidance was impossible or that the challenge was minimal and success was almost perfect. The second condition represents the situation of active coping where active engagement of the participant was necessary to succeed. Yet, in another study by Light and Obrist (1983), men could receive a monetary incentive by meeting a time criterion in a simple auditory reaction time task. Participants in an impossible condition showed reduced responses (longer PEP and pulse transit time [PTT] and greater decreases in SBP and DBP) and reported trying less hard than those in an easy or a difficult condition. In short, these experiments have demonstrated the significance of the active-passive coping dimension.

In summary, Obrist’s works proposed an important distinction between active and passive coping situations and led to the conclusion that active coping is well reflected by beta-adrenergic sympathetic impact on the heart. This notion was later adapted by Wright to operationalize effort intensity in the context of the motivational intensity theory (J. W. Brehm & Self, 1989).

Cardiovascular reactivity as indicator of effort

According to Obrist (1981), the best indicators of person’s engagement in an effortful activity, or active coping, are cardiovascular measures reflecting sympathetic beta-adrenergic activity. The best noninvasive measure of this is cardiac pre-ejection period (PEP)—the time period between the start of the excitation of the left ventricle and the opening of the left aortic valve (e.g., Benschop et al., 1994; Berntson, Lozano, Chen, & Cacioppo, 2004). The shorter the PEP, the stronger is cardiac contractility and the stronger is the influence of the sympathetic nervous system on the heart. Thus, shortened PEP indicates more engagement. PEP responds very sensitively to the changes in beta-adrenergic impact on the heart. To illustrate this relationship, in the above mentioned study by Richter et al. (2008), participants were assigned to one of four task difficulty conditions: low, moderate, high, or impossible difficulty. The results showed the predicted pattern of PEP reactivity: PEP changed proportionally to task difficulty in the low, moderate, and high difficulty conditions, while in the impossible condition PEP was low – people disengaged.

Numerous studies have also associated effort to systolic blood pressure (SBP) because it is systematically influenced by cardiac contractility via its impact on cardiac output (Gendolla & Richter, 2010; Wright & Kirby, 2001). However, SBP is also influenced by peripheral vascular resistance, which is not systematically influenced by beta-adrenergic impact (Levick, 2003), and can be masked by it. The influence of peripheral resistance on diastolic blood pressure (DBP) is even stronger. Thus, DBP is an even less reliable measure of effort then SBP. In some research also heart rate (HR) was used as a measure of effort (e.g., Eubanks et al., 2002). However, HR is under sympathetic and parasympathetic control, and its changes can reflect sympathetic impact, parasympathetic withdrawal, or both (Berntson, Quigley, & Lozano, 2007).
In sum, SBP, DBP, and HR are ambiguous as measures of sympathetic beta-adrenergic influence. However, it is important to assess blood pressure and HR together with PEP in order to control for preload and afterload effects: decreases in these measures would not allow to interpret stronger PEP reactivity as carried by heart contractility influence (Sherwood et al., 1990).

In conclusion, the best indicator of effortful engagement in a task is cardiac PEP, which will be the main dependent variable for measuring effort intensity during cognitive task in the experiments of this thesis.

**Explicit affect and mental effort**

As discussed so far, effort intensity is proportional to task demand as long as success is possible and justified (J. W. Brehm & Self, 1989). Task demand may be manipulated by objective task difficulty or it can be influenced by subjective factors: perceived ability (Annis, Wright, & Williams, 2001; Wright, 1998), fatigue (Wright, Martin, & Bland, 2003), or individuals’ affective state. Among affective states, emotions and moods differ according to their motivational properties. Emotions as affective reactions to specific events have stable motivational implications (Frijda, 1986). In contrast, moods, as diffuse long-lasting affective states are not object-related and do not influence motivation in a stable and specific way (Frijda, 1993; Gendolla, 2000). The mood-behavior-model (MBM; Gendolla, 2000) is an integrative theory about mood and motivation and predicts how mood influences the motivation process including the initiation, intensity, and persistence of behavior. Especially the intensity aspect of motivation is important in the context of this thesis, because understanding how explicit affect can influence mental effort is relevant to understand the mechanisms behind implicit affect’s effects.

**Mood-Behavior-Model**

The Mood-Behavior-Model (Gendolla, 2000) defines twofold functions of moods on behavior: directive and informative. The directive function refers to the behavioral preferences in compliance with a hedonic motive. The informative function is about moods’ influences on behavior-related judgments and appraisals, which in turn influence behavior. I will here concentrate on the informational mood’s function.

**How mood influences effort**

According to the MBM, moods informational function influences motivational intensity. In a task demand context, individual seeks all available information about task difficulty, including the information about the own affective state, or mood. Mood functions as diagnostic information when a person is evaluating task demand. In a sad mood, due to a mood congruency effects (see Abele, 1995 for a review), task difficulty judgments are pessimistic, because sadness is related to pessimism. Consequently, the task is evaluated as more difficult in a sad mood. This evaluation leads then to higher effort intensity as long as success is possible and justified because the amount of mobilized effort is proportional to perceived task demand (J. W. Brehm et al., 1983). On the contrary, in a happy mood, judgments are more optimistic and thus tasks are evaluated as easier. Consequently, less effort is mobilized. For an illustration, in a study by Gendolla, Abele, and Krüsklen (2001), participants were induced into happy or sad mood and performed then an attention task. They rated the cognitive task as more difficult in a sad mood and
effort-related cardiovascular reactivity was stronger in the sad mood condition than in the happy mood condition, in absence of mood effects during the mood induction period.

Moods can also moderate the effects of objective task difficulty on effort intensity because objective difficulty and mood have an additive effect on subjective demand. According to the MBM, in an easy task, people in a sad mood mobilize more effort than those in a happy mood, because they evaluate task difficulty as higher and therefore mobilize more resources. But when a task is difficult, people in a sad mood disengage because they evaluate the task as too difficult. By contrast, people in a happy mood evaluate the task as still feasible and stay engaged. Thus, the effort is high. In an extremely difficult or impossible task mood will lose its effects, because here effort mobilization is not justified and individuals disengage (see Figure 2).

![Figure 2](image_url)

**Figure 2.** Schematic representation of the Mood-Behavior-Model (Gendolla, 2000) predictions about happy and sad mood effects on effort for low, moderate, high, and extreme task difficulty. The figure adapted from Gendolla and Krüsken (2002a).

A study by Gendolla and Krüsken (2002a) tested the predictions of the MBM about additive effects of mood and task difficulty on mental effort. Participants worked on an easy, difficult, or extremely difficult memory task. The pattern of effort-related cardiovascular response fitted perfectly to the predictions: in the easy task, reactivity was higher in a sad mood then in a happy mood; in the difficult task reactivity was higher in the happy mood and lower in the sad mood, whereas in the extremely difficult task scores were low in both mood conditions indicating disengagement. To summarize, moods without being motivational states themselves (De Burgo & Gendolla, 2009), can influence motivational intensity through their effects on task demand evaluations.

**Why mood influences effort**

According to the mood-and-information-integration approach (Abele & Petzold, 1994), mood is always one source of information that people always integrate into a judgment. People seek all available information which is then integrated into a judgment according to their values and diagnostic weight. Thus the information about one’s affective state, or mood, is among available information. Mood has higher diagnosticity when the judgment is evaluative than when it is
nonevaluative. They influence evaluative judgments in a mood congruent manner: people are more optimistic and make more positive judgments in a happy than in a sad mood. Thus, the task is experienced as more difficult in a sad mood than in a happy mood. This experienced task demand then determines the amount of mobilized effort, as predicted by motivational intensity theory (J. W. Brehm & Self, 1989).

The informational mood influence on motivation becomes particularly evident in experiments applying a discounting paradigm (Schwarz & Clore, 1983). The main idea of applying this paradigm is that when a mood manipulation becomes salient to the person, mood loses its diagnostic value. When the changes in affective state can be attributed to external stimuli, the information provided by moods is not incorporated into the evaluative judgment about the task difficulty and the effects of moods on mental effort intensity disappear. In two experiments by Gendolla and Krüsken (2002b), after a mood induction with video excerpts, participants performed either a memory task or a letter cancellation task during which their cardiovascular reactivity was measured. Effort-related cardiovascular reactivity was higher in the sad mood condition compared to the happy mood condition. However, this effect disappeared if participants received a cue that the video could have influenced their affective state. Although the cue manipulation eliminated the effects on effort-related cardiovascular reactivity, self-report mood ratings showed that the induced mood remained. The results of these two experiments support the idea of the MBM that moods have an informational function in the context of cognitive challenges which influences task demand appraisals and consequently mental effort. Now the interesting question rises if also mere information about affective states can influence motivational intensity. A new model attempts to answer this question.

**Implicit affect and mental effort**

Recent research shows that implicit stimuli can influence behavior decisions (Winkelman, Berridge, & Wilbarger, 2005a), task performance (Aarts, Custers, & Holland, 2007; Aarts, Custers, & Marien, 2008; Aarts et al., 2008), or effort related cardiovascular response (Capa, Cleeremans, Bustin, Bouquet, & Hansenne, 2011; Capa, Cleeremans, Bustin, & Hansenne, 2011; Gendolla & Silvestrini, 2010). Recently, focusing on motivational intensity aspect, Gendolla (2012) proposed a model to explain implicit affective influences on mental effort and proposed the implicit-affect-primes-effort (IAPE) model. As explained above, moods influence effort-related cardiovascular responses during task performance due to their informational function. Moods as conscious feelings have congruency effects on task difficulty appraisals (Schwarz & Clore, 2007): task-related judgments are more positive in a happy mood than in a sad mood. The IAPE model deals with implicitly activated affect-related information, which can have similar effects on mental effort without eliciting feelings.

**Implicit affect**

Implicit affect is the automatic activation of mental representations of affective experiences (e.g., Quirin, Kazén, & Kuhl, 2009). These representations are based on memory and learning experience and have been formed during life. As explained by the IAPE model, the most important difference between explicit affect and implicit affect is that for the latter the subjective conscious experience of the respective affect is not necessary (Gendolla, 2012). The mental concept containing affect-related information is activated automatically without intention or con-
scious experience. Explicit affect, on the contrary, is experienced consciously and can be report-
ed (like, for example, moods). However, implicit affect can influence behavior without eliciting conscious feelings. This influence is cognitive-motivational and functions without conscious affective experiences. This is different from the effects of mood where the effects on mental effort occur because conscious feelings inform about task demand which influences amount of mobil-
ized effort.

Implicit affect as activated knowledge contains information about respective affective states and this information also includes knowledge about performance ease or difficulty. According to previously discussed explicit affect influences on perceived task demand (e.g., Gendolla & Krüsken, 2001), sadness should be associated with difficulty while happiness should be associated with ease. Through life experiences, individuals have developed these associative links between specific affective states and performance ease or difficulty. Over time, these links get integrated into the mental representations of the respective affective states (Niedenthal, 2008). This way, activating the concept of happiness also activates the concept of “ease” just as the “difficulty” concept is activated together with sadness concept.

Implicit-affect-primes-effort model

The IAPE model predicts how mental effort is influenced by implicit affect. More specifically, the model suggests that affect-related primes, e.g., emotional words or facial expressions, can activate mental representations of specific affective states. These representations contain information about performance difficulty or ease that is typical in those states. In a cognitive demand context, due to a momentary accessibility and applicability, this information influences the perceived task demand and, according to Brehm’s motivational intensity theory, effort intensity, as long as success is possible and justified (J. W. Brehm & Self, 1989).

Why implicit affect influences effort

The model for the effects of implicit affect on mental effort proposes a process of four levels (see Figure 3). First, (1) an individual is presented with a stimulus serving as an affective cue. This stimulus may vary in its form: it can be an emotional picture, facial expression, or a word. The stimulus is activating (2) affect-related knowledge which includes information about difficulty or ease. For example, happiness or anger activates the “performance ease” concept but sadness or fear activates the “performance difficulty” concept. In a cognitive task context, due to momentary accessibility and applicability (Förster & Liberman, 2007) of the activated concept, this knowledge influences (3) subjective task difficulty experiences. Experienced task demand then determines if (4) high effort (at high perceived difficulty) or low effort (at low perceived difficulty) will be mobilized.

How implicit affect influences effort

The effects of implicit affect on mental effort are tested within a well-established experimental paradigm, developed by Gendolla and Silvestrini (2011). Typically, an experimental session begins with several general questions and the mood measures, physiological baseline measures are taken during a habituation period. Then, participants proceed with a cognitive task with integrated affect primes.
Finally, they answer again to mood inventory items as well as to questions regarding task demand and success importance. During the task, each task trial starts with a prime, presented for 26 milliseconds and directly masked (133 milliseconds) with a random white and black dot pattern. One third of primes are affective pictures and two thirds are neutral pictures. This ratio proved to have the strongest effects on mental effort (Silvestrini & Gendolla, 2011a). Typically, most participants fail to recognize the content of the prime pictures but even those who are able to identify certain features of the presented images can never relate them to the actual study goals. This suggests that participants are unaware of the phenomenon being studied.

The main physiological measure taken during the experiment is cardiac PEP. Shorter PEP indicates stronger heart contractility and thus higher effort. Changes in SBP, DBP, and HR are also recorded in order to control for possible preload and afterload effects.

**Simple effects**

A series of experiments empirically tested the predictions of the IAPE model (Gendolla, 2012). In studies by Gendolla and Silvestrini (2011; Silvestrini & Gendolla, 2011a), participants were presented with affect primes during a cognitive task. Effort-related cardiovascular reactivity was stronger in a sadness-prime condition than in a happiness- or an anger-prime conditions. According to the IAPE model, sadness primes activated sadness-related knowledge in mind, including knowledge about performance difficulty. This information was integrated in the task difficulty appraisals and led to higher effort. In contrast, happiness and anger primes activated knowledge of performance ease which led to lower effort. Furthermore, subjective task difficulty

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**Stimulus**  
**Information (Affect Knowledge)**  
**Experience**  
**Behavior**

Sadness Cue → Difficulty → High Demand → High Effort

Fear Cue →

Happiness Cue → Ease → Low Demand → Low Effort

Anger Cue →

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**Figure 3.** Schematic representation of the IAPE model (Gendolla, 2012) and the mechanism of how affect-related stimuli influence effort through their effects on subjective task demand. Figure taken from Gendolla (2012). Affect pictures taken from AKDEF database (Lundqvist & Litton, 1998).
ratings were higher in the sadness-prime condition than in the happiness- and anger-prime conditions, which corresponded to the pattern of effort-related cardiovascular reactivity pattern.

**Task difficulty effects**

Implicit affect moderates difficulty effects on mental effort similarly as explicit affect, i.e. moods. When participants are performing a task with integrated affect primes, objective task difficulty is moderated by the effects of implicit affect: in a study by Silvestrini and Gendolla (2011b), participants performed an easy or difficult attention task (Brickenkamp & Zillmer, 1998), while being briefly presented with happy or sad facial expressions. In the easy task, when presented with sadness cues, participants evaluated the task as more difficult and mobilized higher effort, because sadness is related to performance difficulty and it lead to higher task demand appraisals. In the difficult task, participants who processed happiness primes showed higher effort-related cardiovascular reactivity and evaluated the task to be easier than those presented with sadness cues and who disengaged and thus showed lower effort-related cardiovascular reactivity. Corresponding effects on effort are also found with sadness vs. anger primes (Freydefont, Gendolla, & Silvestrini, 2012a), where anger primes have the same effects as happiness primes, because anger is related to performance ease and influences the task demand experience which determines effort mobilization (see Figure 4).

In another study by Freydefont and Gendolla (2012) that tested the effects of potential motivation, participants performed a difficult task while being presented with sadness versus anger primes and expected low versus high monetary success incentive. Effort-related cardiovascular reactivity did not differ in the anger-prime condition as a function of incentive. But in the sadness-prime condition, high incentive led to higher cardiac reactivity than low incentive condition. According to the authors’ interpretation, anger primes did not boost the effort in the high incentive condition, because the activated ease concept reduced subjective demand during performance. Thus, high effort was not necessary. However, in the sadness-prime condition, the sadness-primes activated the difficulty concept, leading to very high task demand. Thus, higher effort was mobilized in the high-incentive condition, because the high necessary effort was justified in contrast to the low-incentive condition, where participants disengaged, because the high necessary effort was not justified.

To sum up, the IAPE model predicts that in performance context affect primes have their effects on mental effort due to their influence on experienced task demand. However, the so far identified prime effects of self-report measures of perceived difficulty are ambiguous. Furthermore, even if participants do not report mood changes after being exposed to implicit affect primes, we cannot exclude that the primes in fact induce affective states, which in turn influence mental effort. Therefore, the present thesis concentrated on exploring the mechanism proposed by the IAPE model and tested the role of experienced task demand and explicit affective states in affect primes’ effects on mental effort.
Outline of the present studies

The IAPE model (Gendolla, 2012) explained how implicit affect influences effort. The goal of this thesis is to test the mechanism via which implicit affect influences effort mobilization and to contrast this against some alternative explanations. The IAPE model posits that:

- Affect primes influence mental effort through their effects on ease or difficulty experience during task performance;
- The effects of affect primes arise without eliciting conscious emotional feelings;
- There are associational links in mind between specific affect concepts and the concepts of performance ease and difficulty.

Four empirical studies aimed to test these proposed mechanisms. The first experiment aimed to clarify the role of nonaffective feelings of ease or difficulty in the sadness- and happiness-prime effects on effort-related cardiovascular response. A discounting manipulation was used in order to allow a more conclusive test than self-reported ratings. The second study used a similar discounting manipulation, but here the aim was to clarify the role of explicit emotional feelings. In the third experiment, the prime exposure time was manipulated, where a long presentation time (explicit affect cue) served as a cue for presented affective information during the task. Two alternative hypotheses were tested in this study: optimal presentation of affective stimuli was expected to either induce explicit affective feelings and to have the same effects on mental effort as moods (Gendolla & Brinkmann, 2005), or, according to psychological reactance theory (J. W. Brehm, 1966), to eliminate the effect of the affect-primes without changing the affective state.

In all three studies the main dependent variable was effort-related cardiovascular reactivity, especially cardiac PEP. Finally, the fourth experiment was run to test the hypothesis that specific affect primes are associated with performance difficulty or ease concepts. A sequential priming paradigm was used to test these associative links.
Chapter 2. The role of nonaffective feelings of ease or difficulty

Abstract

The present study sought to clarify the role of nonaffective cognitive feelings of performance ease or difficulty in the effects of implicit affect on mental effort. According to the implicit-affect-primes-effort (IAPE) model (Gendolla, 2012), affect primes influence mental effort through their effect on subjective task difficulty. It was expected that a cue informing for the possible manipulation of ease or difficulty feelings should diminish the effect of higher effort-related cardiovascular response in the sadness-prime condition than in the happiness-prime condition. The expected pattern was observed in the no-cue condition for the cardiac PEP reactivity scores. In the cue condition, the affect prime effect was not significant, but the cue × prime interaction failed also to be reliable. Thus, the results of this study provide some, but not strong evidence that nonaffective ease or difficulty feelings are determining the primes’ effects on mental effort.

Introduction

Recently, multiple studies have demonstrated that people who are suboptimally presented with sadness-related cues showed stronger effort-related cardiac response during performance of cognitive tasks compared to people presented with happiness- or anger-related primes (Freydefont et al., 2012a; Freydefont & Gendolla, 2012; Gendolla & Silvestrini, 2011; Silvestrini & Gendolla, 2011b). According to the implicit-affect-primes-effort (IAPE) model (Gendolla, 2012) affect cues influence mental effort in the context of a cognitive challenge through their impact on experienced difficulty. According to this model, affect primes automatically activate mental representations of specific affective states (implicit affect). These representations include affect-related features like those of performance ease or difficulty. More specifically, the knowledge activated by sadness stimuli includes information about performance difficulty while the knowledge activated by happiness or anger stimuli includes information about performance ease. In the context of cognitive task performance, this accessible information influences the
level of experienced demand and consequently the intensity of mobilized effort (see J. W. Brehm & Self, 1989).

The experience of task ease or difficulty is a nonaffective cognitive feeling (Clore, 1992). Nonaffective feelings might be feeling hungry or tired, but also a cognitive feeling like feeling certainty or confusion as an assertion about one's state of knowledge. According to Clore, nonaffective feelings are not valenced—i.e. not positive or negative—but they can cause affective reactions. Also, nonaffective feelings can influence appraisals and judgments, and thus behavior.

In the context of cognitive task performance, ease or difficulty feelings should determine the amount of mobilized effort, as predicted by the IAPE model. However, post-task self-report ratings of subjective demand assessed in previous work of our lab have been ambiguous: in some studies, participants evaluated the task as more difficult when presented with sadness primes compared to those presented with happiness- or anger-primes (Gendolla & Silvestrini, 2011; Silvestrini & Gendolla, 2011b), while other studies found no significant effects on difficulty ratings (Freydefont et al., 2012a; Freydefont & Gendolla, 2012). Also, we know that retrospective ratings might be biased and thus not reliable (Robinson & Clore, 2002). Thus, a more conclusive test is needed in order to clarify the role of subjective demand in implicit affect's effects on mental effort.

According to the feeling-as-information approach (Schwarz & Clore, 1983, 1988; Schwarz, 2012), the ease or difficulty feeling, if attributed to an external source, should lose its informational value for judgments. Thus applied to the present context, attribution of feelings of ease or difficulty to an external source should reduce the affect prime effect on effort. Gendolla and Krüsken (2002b) demonstrated that, during performance of a cognitive task, effort-related cardiovascular reactivity was stronger when people were in a sad mood than when they were in a happy mood and that this effect disappeared when they are given a cue about a possible manipulation of their moods. Similarly, a cue for the manipulation of ease or difficulty feelings should eliminate the effects of suboptimally presented primes on mental effort.

The present research

In the present experiment, we sought to clarify the role of nonaffective ease or difficulty feelings within the effect of affect primes on mental effort. As in previous studies of our lab, we quantified effort by changes in cardiovascular reactivity during the cognitive challenge. Our main measure was cardiac pre-ejection period (PEP) – the most sensitive noninvasive indicator of sympathetic beta-adrenergic influence on the heart and thus a reliable measure of effort (Kel- sey, 2011; Obrist, 1981; Wright, 1996). Additionally, we assessed systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) because contractility can systematically influence SBP, and because blood pressure and HR should be assessed together with PEP, to control for preload and afterload effects (Sherwood et al., 1990). We expected, as demonstrated by previous studies of our lab (see Gendolla & Silvestrini, 2011; Silvestrini & Gendolla, 2011a), stronger PEP reactivity in the sad-prime condition compared to the happy-prime condition. Most important, we predicted that this prime effect should disappear after providing participants with a cue for the possible influence of task presentation properties on task difficulty experiences. We followed the idea that people should then assign their subjective task difficulty feeling to the "flickers" and would not trust it in their task difficulty evaluations. That is, we expected a prime × cue interaction effect on PEP.
Method

Participants and design

Sixty students (36 women, mean age 23 years) voluntarily and anonymously participated in the experiment for monetary remuneration. They were randomly assigned to a 2 (prime: sadness, happiness) × 2 (cue: no cue, cue) between-persons design cells. The number of men and women in each cell was equilibrated. Four participants were considered as extreme outliers according to the univariate boxplot criteria (Tukey, 1977) and thus excluded from the sample, leaving 56 participants for the final analysis.

Apparatus and physiological measures

To assess heart rate and cardiac PEP, impedance cardiogram (ICG) and electrocardiogram (ECG) signals were noninvasively assessed (sample rate 1000Hz) with a Cardioscreen® 1000 system (medis, Ilmenau, Germany) (see Scherhag, Kaden, Kentschke, Sueselbeck, & Borggreve, 2005 for a validation study). Four pairs of disposable spot electrodes were placed on the right and left side of the base of the participant’s neck and on the left and right middle axillary line at the height of the xiphoid.

We additionally assessed blood pressure with a Vasotrac® AMP205A monitor (MEDWAVE®, St. Paul, MN). This system uses applanation tonometry with a pressure sensor placed on the wrist on top of the radial artery applying a varying force on the artery. Internal algorithms yield systolic and diastolic pressures as well as heart rate approximately each 12–15 heart beats, i.e. 4–5 values per minute (see Belani, Buckley, & Poliac, 1999 for a validation study). All obtained cardiovascular measures were stored on internal drive and transferred to a personal computer. PEP, blood pressure, and HR values were calculated for 1-minute intervals.

Affect prime stimuli

As affect primes we used pictures of averaged neutral (FNES, MNES), sad (FSAS, MNAS), and happy (FHAS, MHAS) front perspective, low resolution, grayscale facial expressions taken from the Averaged Karolinska Directed Emotional Faces (AKDEF) database (Lundqvist & Litton, 1998). Half the pictures showed male faces; half showed female faces.

Procedure

After having obtained signed consent, the experimenter attached the electrodes and the blood pressure sensor and went to a control room. The procedure was computerized (E-Prime, Psychology Software Tools, Pittsburgh, PA). Instructions were presented on the computer screen; responses were given with a numerical keyboard. At the beginning of the session, participants answered biographical questions and rated their current mood with 2 positive (joyful, cheerful) and 2 negative affect items (sad, depressed) of Matthews, Jones, and Chamberlain’s (1990) UWIST mood scale (1 = not at all to 7 = very much). Then students watched a neutral documentary film of landscapes (8 min) while physiological baseline measures were taken. This was followed by an adapted Sternberg (1966) short-term memory task (5 min). In the task, each trial started with a fixation cross (1000 ms), followed by an AKDEF database low-resolution facial expression picture (26 ms), which was backward masked with a random black and white dot
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pattern (133 ms). The mask was followed by a string of four letters and a backward mask consisting of a string of “X” letters. Then a target letter appeared above the mask and participants had to indicate, by pressing a “yes” or a “no” key, if the letter was part of the previously presented string or not. The task comprised 32 experimental trials.

Before the task, participants performed 10 training trials with neutral facial expressions as primes and received immediate feedback whether their answer was correct. No correctness feedback was given during the task to avoid possible affective reactions that could interfere with the affect primes’ impact. In the main task, masked emotional expressions were randomly displayed in 1/3 of the trials. The remaining 2/3 of the trials displayed neutral expressions. This prime ratio has been found to be the most effective in the present paradigm (Silvestrini & Gendolla, 2011a). Moreover, prime recognition tests and funnel debriefing procedures in previous studies of our lab revealed that the primes are processed without awareness in this paradigm. Expressions were randomized in blocks of 6 (2 emotional, 4 neutral); the same picture did not appear successively. Most important, in the task their instructions, half the participants received a non-specific (not indicating the direction) cue that feeling of performance ease or difficulty might be manipulated by the presentation properties of the task: “During the following task, keep in mind that the way of presenting the task might make it look easier or more difficult for you”. This manipulation was expected to diminish the prime effects on effort-related cardiovascular measures, if affect-primes induce the nonaffective feelings of performance ease or difficulty.

After the task, participants rated (1 = not at all to 7 = very much) subjective task difficulty, mobilized effort, capability, the value of success, and the importance of success. Finally, they rated the same 4 mood adjectives as at the procedure’s onset for assessing if the affective primes had an effect on their conscious mood. After the experiment participants were debriefed, thanked, and received their remuneration.

Data analysis

ICG signals were processed offline with software developed in our lab (Richter, 2010). B-point location was estimated based on the RZ interval of valid heart beat cycles (Lozano et al., 2007), visually inspected, and if necessary corrected as recommended (Sherwood et al., 1990). PEP (in milliseconds) was determined as the interval between R-onset and B-point (Berntson et al., 2004). Shorter PEP indicated stronger cardiac contractility.

The cardiovascular baseline and reactivity scores and performance indices were analyzed with 2 (prime) × 2 (cue) between-persons ANOVAs. The mood measures were analyzed with 2 (prime) × 2 (difficulty) × 2 (time) mixed model ANOVA.

Results

Cardiovascular baselines

Baseline scores for PEP, SBP, DBP, and HR were calculated as the averages of the last 5 minutes of the habituation period (Cronbach’s αs > .99). Cell means and standard errors appear in Table 1. Exploratory between-persons ANOVAs did not find any significant effects (all ps > .09).
Results

Table 1. Cell means standard errors (in brackets) of cardiovascular baseline scores.

<table>
<thead>
<tr>
<th></th>
<th>No cue</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Happiness</td>
<td>Sadness</td>
<td>Happiness</td>
<td>Sadness</td>
<td></td>
</tr>
<tr>
<td>PEP</td>
<td>98.75 (2.94)</td>
<td>97.45 (2.60)</td>
<td>95.67 (2.14)</td>
<td>99.40 (3.50)</td>
<td></td>
</tr>
<tr>
<td>SBP</td>
<td>118.37 (4.24)</td>
<td>110.17 (3.10)</td>
<td>112.21 (2.73)</td>
<td>110.15 (1.70)</td>
<td></td>
</tr>
<tr>
<td>DBP</td>
<td>66.48 (2.76)</td>
<td>61.79 (2.21)</td>
<td>63.90 (1.96)</td>
<td>61.36 (1.47)</td>
<td></td>
</tr>
<tr>
<td>HR</td>
<td>71.13 (2.61)</td>
<td>73.03 (2.91)</td>
<td>77.01 (3.56)</td>
<td>74.40 (1.81)</td>
<td></td>
</tr>
</tbody>
</table>

Note. Cells ns ranging from 12 to 15. PEP: pre-ejection period; SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate. Units of measures are milliseconds for PEP, millimeters of mercury for SBP and DBP, and beats per minute for HR.

Cardiovascular reactivity

Physiological reactivity scores were calculated for each participant by subtracting the baseline scores from the scores obtained during the task. As the 1-minute change scores were highly consistent (Cronbach’s αs > .92 for PEP, SBP, and DBP; Cronbach’s α = .85 for HR), we created average reactivity scores for the entire task performance period. First, we tested for possible associations between baselines and reactivity scores with analyses of covariance (ANCOVAs) in order to prevent carry over or initial value effects (Llabre, Spitzer, Saab, Ironson, & Schneiderman, 1991). There were no significant associations between cardiovascular baseline and reactivity scores (ps > .18). Thus, we used cardiovascular reactivity scores without baseline correction for the final analysis.

Cardiac PEP

The PEP reactivity scores are depicted in Figure 5. A 2 (prime) × 2 (cue) ANOVA revealed significant prime main effect, F(1, 52) = 4.22, p = .045, ηp² = .08: PEP reactivity was stronger in the sadness-prime condition (M = -3.59, SE = 0.63) than in the happiness prime condition (M = -1.70, SE = 0.68). Neither the cue main effect nor the interaction was significant (ps > .44). Cell means were: happiness/no cue (M = -1.05, SE = 0.69), sadness/no cue (M = -3.53, SE = 1.01); happiness/cue (M = -2.34, SE = 0.83), sadness/cue (M = -3.65, SE = 1.01). However, focused cell contrasts revealed a significant difference between sadness- and happiness-prime cells in the no-cue condition, t(52) = 1.86, p = .034 (one tailed), ηp² = .06. In the cue condition, this effect was not significant (p = .310). These comparisons speak for a weak cue influence on the prime effects on PEP reactivity, though the interaction was not significant.

SBP, DBP, and HR

The cell means and standard errors of the reactivity scores appear in Table 2. The 2 (prime) × 2 (cue) ANOVAs did not find any significant effects on SBP (ps > .58), DBP (ps > .46), or HR (ps > .49) reactivity scores.

Task performance

The 2 (prime) × 2 (cue) ANOVAs did not find any significant effects neither on accuracy percentages (ps > .50) nor on average reaction times for correct responses (ps > .35). The cell means and standard errors are presented in the Table 3.
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Figure 5. Cardiac PEP reactivity scores and standard errors in the experimental conditions.

Table 2. Cell means and standard errors (in brackets) of physiological reactivity scores.

<table>
<thead>
<tr>
<th></th>
<th>No cue</th>
<th>Cue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Happiness</td>
<td>Sadness</td>
</tr>
<tr>
<td>SBP</td>
<td>7.01 (1.52)</td>
<td>6.74 (1.00)</td>
</tr>
<tr>
<td>DBP</td>
<td>4.45 (1.11)</td>
<td>3.80 (0.51)</td>
</tr>
<tr>
<td>HR</td>
<td>1.09 (0.77)</td>
<td>1.39 (0.63)</td>
</tr>
</tbody>
</table>

Note. Cells ns ranging from 12 to 15. SBP: systolic blood pressure; DBP: diastolic blood pressure; HR: heart rate. Units of measures are millimeters of mercury for SBP and DBP, and beats per minute for HR.

Table 3. Cell means and standard errors (in brackets) of task performance measures – reaction time for correct responses and response accuracy.

<table>
<thead>
<tr>
<th></th>
<th>No cue</th>
<th>Cue</th>
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<tbody>
<tr>
<td></td>
<td>Happiness</td>
<td>Sadness</td>
</tr>
<tr>
<td>Reaction time</td>
<td>949.91 (46.65)</td>
<td>889.93 (51.52)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>97.69 (0.96)</td>
<td>96.85 (1.46)</td>
</tr>
</tbody>
</table>

Note. Cell ns ranging from 12 to 15. Units of measures are milliseconds for reaction time and percentage of correct responses for accuracy.

Self-report measures

Conscious mood

Given the high correlations between positive and inversed negative UWIST scale items, we created sum scores for the pre-task (Cronbach’s α = .85) and post-task (Cronbach’s α = .80)
mood measures. The cell means and standard errors appear in the Table 4. A 2 (prime) × 2 (cue) × 2 (time) mixed model ANOVA did not reveal any significant effects (ps > .26) on self-reported mood measures.

**Table 4.** Cell means and standard errors (in brackets) of mood measures.

<table>
<thead>
<tr>
<th></th>
<th>No cue</th>
<th></th>
<th>Cue</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Happiness</td>
<td>Sadness</td>
<td>Happiness</td>
<td>Sadness</td>
</tr>
<tr>
<td>Pre-task</td>
<td>19.83 (1.03)</td>
<td>19.93 (1.30)</td>
<td>21.07 (1.17)</td>
<td>20.80 (1.30)</td>
</tr>
<tr>
<td>Post-task</td>
<td>19.50 (0.76)</td>
<td>19.73 (1.11)</td>
<td>21.07 (1.01)</td>
<td>22.20 (0.98)</td>
</tr>
</tbody>
</table>

*Note.* Cell ns ranging from 12 to 15. Measure units are sums of four ratings on the scale ranging from 1 to 7.

**Task ratings**

The cell means and standard errors across conditions are presented in the Table 5. The 2 (prime) × 2 (cue) ANOVAs found a prime main effect on importance of success, $F(1, 52) = 8.37, p = .006, \eta^2_p = .14$, and on value of success ratings, $F(1, 52) = 4.71, p = .035, \eta^2_p = .08$. For both measures, the ratings were higher in the happiness-prime condition (importance: $M = 6.10, SE = 0.25$; value: $M = 5.49, SE = 0.27$) than in the sadness-prime condition (importance: $M = 5.10, SE = 0.23$; value: $M = 4.70, SE = 0.25$). The ANOVAs of the value of success and importance of success ratings did not find any other significant effect (ps > .17). The 2 (prime) × 2 (cue) ANOVAs did not reveal any significant effects neither for difficulty, nor for capability, nor for mobilized effort verbal ratings (ps > .22).

**Table 5.** Cell means and standard errors (in brackets) of task ratings.

<table>
<thead>
<tr>
<th></th>
<th>No cue</th>
<th></th>
<th>Cue</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Happiness</td>
<td>Sadness</td>
<td>Happiness</td>
<td>Sadness</td>
</tr>
<tr>
<td>Difficulty</td>
<td>2.67 (0.31)</td>
<td>2.53 (0.26)</td>
<td>2.36 (0.43)</td>
<td>2.07 (0.25)</td>
</tr>
<tr>
<td>Capability</td>
<td>5.83 (0.21)</td>
<td>5.27 (0.33)</td>
<td>5.79 (0.32)</td>
<td>5.80 (0.24)</td>
</tr>
<tr>
<td>Effort</td>
<td>3.83 (0.21)</td>
<td>3.73 (0.33)</td>
<td>3.71 (0.27)</td>
<td>3.20 (0.39)</td>
</tr>
<tr>
<td>Importance</td>
<td>6.33 (0.19)</td>
<td>4.87 (0.35)</td>
<td>5.86 (0.35)</td>
<td>5.33 (0.45)</td>
</tr>
<tr>
<td>Value</td>
<td>5.42 (0.45)</td>
<td>4.67 (0.30)</td>
<td>5.57 (0.31)</td>
<td>4.73 (0.40)</td>
</tr>
</tbody>
</table>

*Note.* Cell ns ranging from 12 to 15. Measure units are ratings on scales ranging from 1 to 7.

**Discussion**

This experiment sought to clarify the role of nonaffective cognitive feelings of performance ease or difficulty in the systematic implicit affect influence on mental effort. As expected, and replicating previous findings, sadness primes led to stronger cardiac PEP response—the most sensitive measure of task engagement reflecting changes of beta-adrenergic sympathetic influence on the heart—than did happiness primes (Gendolla & Silvestrini, 2011; Silvestrini & Gendolla, 2011b). The difference between the sadness- and happiness-prime cells was significant in the no-cue condition, while it was not significant in the cue condition, as evident in focused cell comparisons of cardiac PEP reactivity scores. This result was mainly carried by the increase of effort in the happiness/cue condition compared to happiness/no cue condition while
reactivity in sadness condition did not seem to differ in cue versus no cue cells. These results speak for a cue influence on the prime effect. However, the prime × cue interaction was not significant. Thus, the present study shows that the cue manipulation had only a weak effect and does provide some, but not strong evidence that nonaffective feelings of ease and difficulty determine affect primes’ effect on mental effort.

The prime effect was found only on cardiac PEP reactivity scores while other cardiovascular parameters did not show this pattern, although blood pressure measures, especially SBP, are also systematically influenced by cardiac contractility and might reflect the changes of the sympathetic influence on the heart, as demonstrated in previous studies (see Gendolla, Wright, & Richter, 2012; Wright & Kirby, 2001). However, effects of vascular resistance might mask the contractility influence on the blood pressure. For this reason, blood pressure is only an indirect indicator of cardiac contractility and thus not as sensitive measure of mental effort as cardiac PEP. However, the absence of significant decreases in blood pressure and HR measures indicates that the effects on cardiac PEP arose due to beta-adrenergic sympathetic influence instead of effects of cardiac preload and afterload (Sherwood et al., 1990). In sum, it is not surprising that the effects were demonstrated only on the cardiac PEP reactivity measures and did not arise on other cardiovascular measures.

It has been shown that the affect prime manipulation can also have effects on task difficulty ratings assessed after performance (Gendolla & Silvestrini, 2011; Silvestrini & Gendolla, 2011b): in those studies, the task was rated as more difficult in the sadness-prime condition than in the happiness-prime condition. However, in other studies, this effect did not appear (Freydefont et al., 2012a; Freydefont & Gendolla, 2012). In the current study, this effect was also not significant. The prime effects on subjective task demand would have supported the idea of the IAPE model that mental effort is determined by subjective difficulty of the task. However, one can hardly interpret zero effects. Most relevant, the IAPE model predicts prime effects on subjective task difficulty and thus mental effort during the cognitive challenge situation. But self-reported measures are retrospective and thus not reliable (Robinson & Clore, 2002): people respond to the questions about the task after and not during the performance. Thus we were measuring the remembered experience and not the experience during its manifestation. All this might have been the reasons for the absence of prime effects on the post-task difficulty ratings.

The primes had effects on task ratings of importance to succeed and the value of success. These findings correspond to those of Gendolla and Silvestrini (2011), where people rated the value of success as higher when presented with happiness-primes than when presented with sadness- or anger-primes. In the mentioned study, these effects were explained as reflecting relatively high justified effort in the happiness-prime condition, which was, however, not mobilized due to relatively low experienced difficulty, which did not require higher effort. In the present experiment, we keep the same interpretation, although without evidence of significant effects on the task difficulty ratings. However, given that effort in the sadness-prime condition was higher than in the happiness-prime condition, one cannot explain the effect on being caused by higher importance of success in the happiness-prime condition.

The results of the present experiment support the idea of the IAPE model that affect primes influence effort-related cardiac response: sadness-primes lead to stronger effort while happiness-primes lead to weaker effort. However, we could not clearly confirm the idea of the mechanism that nonaffective difficulty feelings determine the mobilized effort. However, the null results do not allow us to claim the absence of predicted effects. We cannot reject the null hypothesis, but we also cannot conclude that there was no effect since no evidence for effect does not mean evidence for no effect. Also, $p$-value is a random variable (Murdoch, Tsai, & Ad-
cock, 2008). For this reason, if the $p$-values in the present experiment are not providing evidence for predicted effects on cardiovascular and self-reported scores, it is possible that it is just a random case. Thus, the results do not allow us clear conclusions.

Another possible reason for the weak cue effect is that people are not familiar with non-affective ease or difficulty feelings in their everyday life, as they are with affective feelings. This could be a reason why they were not able to clearly "correct" this state in the cue condition. The other reason why the cue effect was weak might be that the cue instruction was unspecific – it mentioned task ease or difficulty regardless the prime condition. Specific cues (see Winkielman, Zajonc, & Schwarz, 1997 for examples of specific and unspecific cues) allow people to know the direction of their feeling correction. The suboptimally presented stimuli influencing the ease or difficulty feelings are not salient to the person and that is why a more specific hint should rather diminish this effect of affect primes on mental effort.

To conclude, the present experiment replicated the well-established prime effects on effort-related cardiac PEP reactivity in absence of strong evidence for diminished effects by providing a cue about possible manipulation of difficulty or ease feelings. This way, the next step is to look for a different kind of cue in order to clarify the predicted mechanisms of implicit affect’s impact on mental effort within the IAPE model.
Chapter 3. The role of explicit affective feelings

Abstract
This experiment sought to clarify the potential role of emotional feelings in the systematic impact of implicitly processed affective stimuli on mental effort mobilisation. Participants worked on an attention task during which they were primed with suboptimally presented happiness versus sadness expressions. Before the task, half the participants received a cue for the possible affective influence of “flickers” to be presented during the task. This manipulation usually reduces the impact of conscious feelings on resource mobilisation. As anticipated, sadness primes resulted in higher experienced task demand and higher mental effort (stronger cardiac contractility assessed as shortened pre-ejection period) than happiness primes. Most importantly, instead of reducing the prime effects on mental effort, the cue manipulation significantly increased participants’ effort in general, reflecting additional cognitive demand. The results speak against the idea that affect primes influence effort mobilization by eliciting conscious emotional feelings.

Introduction
Recent experiments of our laboratory have revealed that affect primes that were suboptimally presented during cognitive tasks systematically influence the mobilization of mental effort. People mobilized higher resources when they were exposed to sadness-primes than when they processed happiness-primes during the performance of cognitive tasks (Gendolla & Silvestrini, 2011; Silvestrini & Gendolla, 2011a). Correspondingly, the tasks were subjectively experienced as more difficult in the sadness-prime condition than in the happiness-prime condition. When objective task difficulty was manipulated additionally to the type of affect primes, the primes and objective difficulty had an additive effect on experienced task demand, leading to disengagement due to too high demand when sadness primes were processed during a difficult task (Freydefont et al., 2012a; Silvestrini & Gendolla, 2011b). Moreover, participants in those

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1 This chapter is based on Lasauskaite, R., Gendolla, G.H.E., & Silvestrini, N. (2013). Do sadness-primes make me work harder because they make me sad? Cognition & Emotion.
The role of explicit affective feelings

Affect primes, feelings, and effort mobilization

Extending our previous research, the present study focused on the process by which affect primes have their effect—a theoretically important issue that was not addressed in the previous studies. More specifically, we aimed at testing if affect primes influence motivation because they evoke explicit affect in terms of conscious emotional feelings. Affect primes have been found to be able to influence conscious mood states (e.g., Chartrand, van Baaren, & Bargh, 2006), which can in turn function as information for demand appraisals and effort (e.g., Gendolla & Krüsken, 2002a). However, such evidence for prime effects on feelings is rare and also our previous experiments found no significant affect prime effects on measures of conscious mood. But non-significant affect prime effects on mood measures do not allow any conclusions about the absence of prime effects on affective experiences—at least if one wants to avoid a type II error in statistical inference. Thus, we conducted the present experiment as a more conclusive test of the possibility that affect primes influence resource mobilization by eliciting explicit affect in terms of emotional feelings. We did so by applying a strategy that usually reduces explicit affect’s effect on cognition and behavior—if feelings are elicited (see Schwarz & Clore, 2007): We manipulated the diagnostic value of possible feelings for individuals’ demand appraisals and the correspondingly mobilized effort.

The logic behind the present research starts with the well-replicated observation that explicit affect in terms of conscious mood states systematically influences mental effort intensity: When asked to “do their best”, people in a sad mood mobilize more effort for cognitive tasks than people in a happy mood. This effect has been explained by mood’s informational function for evaluations of task difficulty (e.g., Gendolla & Krüsken, 2002a, 2002b). Due to a mood congruency effect on demand appraisals, task difficulty is experienced as higher in a sad mood than in a happy mood. Consequently, more effort is mobilized in a sad mood, because effort is mobilized proportionally to experienced demand as long as success is possible and justified (J. W. Brehm & Self, 1989). However, mood’s effect on mental effort diminishes when participants receive a cue for the mood manipulation (Gendolla & Krüsken, 2002b). This happens because such a cue calls the diagnostic value of mood as task-relevant information into question (see Schwarz & Clore, 2007).

Winkielman, Zajonc, and Schwarz (1997) examined if also suboptimally presented affect primes lose their impact on evaluative judgments when people are informed about their possible affective influence. More specifically, the authors tested if cues for affect primes’ possible affective influence moderate the effect of masked smiling or frowning faces on evaluations of hedonically neutral Chinese ideographs. The studies did not find significant cue effects on the evaluative judgments. However, as outlined above, zero-effects do not allow firm conclusions and, most relevant for our research, those studies did not inform why and how implicitly processed affect stimuli influence effort mobilization. This calls for more research testing the role of feelings in the affect prime effect on mental effort.

To explain how suboptimally presented affect primes influence effort mobilization, Gendolla (2012) has suggested the Implicit-Affect-Primes-Effort (IAPE) model according to which affect primes influence mental effort by activating affect knowledge (Niedenthal, 2008; Zemack-Rugar, Bettman, & Fitzsimons, 2007). Due to their learning history, individuals have established the idea that sadness is associated with difficulty while happiness is associated with ease (e.g,
Method

31 Gendolla & Krüsken, 2002a, 2002b). This way, implicitly processed affect primes can influence demand appraisals without eliciting explicit affective states. It is sufficient that the primes activate the concepts of ease vs. difficulty to influence subjective task demand and thus effort mobilization. However, given that the effects of sadness and happiness primes on effort mobilization resemble those of conscious sad and happy mood states, previous studies could not exclude the possibility that the affect primes elicited feelings, and that those feelings were in fact responsible for the affect prime effects on effort mobilization.

The present research

We aimed at conducting a more conclusive test of the role of potentially elicited emotional feelings in the systematic impact of affect primes on mental effort. As in our previous studies, we quantified effort as cardiac response in the context of task performance. According to Wright’s (1996) integration of motivational intensity theory (J. W. Brehm & Self, 1989) with the active coping approach (Obrist, 1981), effort is mirrored by beta-adrenergic sympathetic nervous system impact on the heart. Noninvasively, this impact is best reflected as cardiac pre-ejection period (PEP)—the time interval (in ms) between the onset of left ventricular excitation and the opening of the aortic valve (Berntson et al., 2004). PEP is systematically influenced by the level of experienced task demand (e.g., Richter et al., 2008). Cardiac contractility can also influence systolic blood pressure (SBP) via its impact on cardiac output. Thus, also SBP responses may reflect effort mobilization (see Wright & Kirby, 2001). But because PEP is directly influenced by beta-adrenergic sympathetic impact, it is a more reliable and valid measure of effort than SBP, which is additionally influenced by peripheral vascular resistance and can be masked by it (Richter et al., 2008).

Participants worked on a cognitive task and were exposed to suboptimally presented sadness vs. happiness primes. We expected to replicate the effect of stronger PEP reactivity in the sadness-prime than in the happiness-prime condition (e.g., Gendolla & Silvestrini, 2011). Most relevant, half the participants were informed that their emotional state could be manipulated by “flickers” presented during the task (cf. Winkielman et al., 1997). If affect primes influence mental effort intensity by eliciting emotional feelings, their influence should be diminished by this cue manipulation (Gendolla & Krüsken, 2002b).

Method

Participants and design

Fifty-five healthy university students (all women, mean age 20.5 years) from a different subject pool than in our previous studies participated voluntarily and anonymously in the experiment (remuneration 10 Swiss Francs, corresponding to 11 USD) and were randomly assigned to a 2 (Prime: happy, sad) × 2 (Cue: no cue, cue) between persons design.2 Data of one participant

2 Women were more available as participants when the study was run. Our previous studies never found that gender moderated masked affective primes’ effects.
were discarded from the analysis because her task response accuracy was at the chance level. Two other participants were identified as extreme outliers because their PEP responses exceeded both the grant sample mean and their condition means by more than 2.5 SDs. This left a final sample of 52 participants.

**Affect primes**

We used pictures with averaged neutral (FNES, MNES), sad (FSAS, MNAS), and happy (FHAS, MHAS) front perspective, low resolution, grayscale facial expressions taken from the Averaged Karolinska Directed Emotional Faces (AKDEF) database (Lundqvist & Litton, 1998). Half the pictures showed averaged male faces; half showed averaged female faces.

**Apparatus and physiological measurements**

To assess cardiac PEP, impedance cardiogram (ICG) and electrocardiogram (ECG) signals were noninvasively assessed (sample rate 1000Hz) with a Cardioscreen® 1000 system (medis, Ilmenau, Germany). Four pairs of disposable spot electrodes were placed on the right and left side of the base of the participant’s neck and on the left and right middle axillary line at the height of the xiphoid. ICG signals were processed offline with software developed in our lab (Richter, 2010). B-point location was estimated based on the RZ interval of valid heart beat cycles (Lozano et al., 2007), visually inspected, and if necessary corrected as recommended (Sherwood et al., 1990). PEP (in milliseconds) was determined as the interval between R-onset and B-point (Berntson et al., 2004). Shorter PEP means stronger cardiac contractility.3

**Procedure**

After having obtained signed consent, the experimenter attached the electrodes and went to a control room. The procedure was computerized (E-Prime, Psychology Software Tools, Pittsburgh, PA). Instructions were presented on the computer screen; responses were given with a numerical keyboard. At the beginning of the session, participants answered biographical questions and rated their current mood with 2 positive (joyful, cheerful) and 2 negative (sad, depressed) affect items of Matthews, Jones, and Chamberlain’s (1990) UWIST mood scale (1 not at all to 7 very much). Then participants watched a neutral documentary film of landscapes (8 min) while physiological baseline measures were taken. This was followed by a modified d2 mental concentration task (Brickenkamp & Zillmer, 1998).

In the task, participants had to decide if the letter “d” with two apostrophes was displayed on the screen or not by pressing a “yes” or a “no” key. Distraction stimuli were the letter “p” with 2 apostrophes and letters “d” and “p” with 1, 3, or 4 apostrophes. Participants worked under “do-your-best” instructions and tried to respond correctly and as fast as possible. The 48 trials started with a fixation cross (1000 ms), followed by a masked facial expression (26 ms) that was backwardly masked with a noise picture showing scattered black and white dots (125 ms).

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3 In contrast to previous studies (e.g., Richter et al., 2008), we analyzed the 1000 Hz ICG signal without down-sampling, which was possible after a system upgrade.
Then the target symbols appeared until a response was entered (maximal response window 2000 ms). This was followed by the feedback "Response entered" displayed for 2500 ms minus the reaction time. That way the task had the same duration for all participants, independently of their response speed. The inter-trial interval randomly varied between 2 and 5 seconds. Before the task, participants performed 10 training trials with neutral facial expressions as primes and received immediate feedback whether their answer was correct. No correctness feedback was given during the task to avoid possible affective reactions that could interfere with the affect primes’ impact. In the main task, masked emotional expressions were randomly displayed in 1/3 of the trials. The remaining 2/3 of the trials displayed neutral expressions. This priming procedure has been found to the most effective in the present paradigm (Silvestrini & Gendolla, 2011a). Moreover, prime recognition tests and funnel debriefing procedures in our previous studies repeatedly do not find evidence for stimuli awareness in this paradigm. Expressions were randomized in blocks of 6 (2 emotional, 4 neutral); the same picture did not appear successively.

In the cue condition, participants read the following message right before task onset: "Short flickers that are presented during the task may have an impact on certain persons’ emotional state. While performing the task, take into consideration that your emotional state could be influenced by the flickers.” In the no-cue condition this information was absent.

After the concentration task, participants rated (1 = Not at all to 7 = Very much) subjective task difficulty, mobilized effort, capability, the importance of success, and the same 4 mood adjectives as at the procedure’s onset for assessing if the affective primes had an effect on their conscious mood. After the experiment participants were debriefed, thanked, and received their remuneration.

### Results

#### Cardiac pre-ejection period

PEP baseline values (averages of the last 5 min of baseline measurement, \(\alpha = .98\), see Table 1) did not differ between the conditions, according to a 2 (prime) \(\times\) 2 (cue) between persons ANOVA (\(p_s > .48\)). Reactivity scores, which were not correlated with the baseline scores (\(p > .20\)), were obtained by subtracting the baseline values from the averaged task-related values (\(\alpha = .99\)). Cell means are presented in Table 6. A 2 \(\times\) 2 ANOVA of PEP reactivity during task performance revealed a prime main effect. As expected, PEP responses in the sadness-prime condition (\(M = -3.74, SE = 0.67\)) were significantly stronger than in the happiness-prime condition (\(M = -1.22, SE = 0.48\)), \(F(1,48) = 9.67, p = .003, \eta^2_p = .17\), showing that processing sadness primes led to higher effort. Also the cue-manipulation had a significant effect, as evident in a main effect of

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4 Although awareness check was not run in this experiment, the masking procedure is analogical to the previous experiments of our lab where prime recognition rate was not significantly different from chance level (50%; Freydefont, Gendolla, & Silvestrini, 2012a; Gendolla & Silvestrini, 2011; Silvestrini & Gendolla, 2011a). Although zero effects cannot lead us to conclusions about unawareness, we neither have indications that the facial expressions in this experimental paradigm might have been processed with awareness.
The role of explicit affective feelings

the cue manipulation: PEP reactivity was significantly stronger in the cue condition \((M = -3.39, SE = 0.73)\) than in the no-cue condition \((M = -1.60, SE = 0.45)\), \(F(1,48) = 4.80, p = .033, \eta_p^2 = .09\). The interaction was not significant \((p = .41)\). Thus, the cue manipulation had a significant effect, but it did not reduce the affective primes’ impact on effort-related cardiac response. Rather, it increased effort mobilization in general.\(^5\)

**Table 6.** Cell Means and Standard Errors (in Parentheses) of Cardiac Pre-ejection Period (PEP) Baseline Values.

<table>
<thead>
<tr>
<th></th>
<th>Happiness-prime</th>
<th>Sadness-prime</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-cue</td>
<td>96.63 (1.67)</td>
<td>98.94 (2.68)</td>
</tr>
<tr>
<td>Cue</td>
<td>98.88 (3.18)</td>
<td>100.77 (3.61)</td>
</tr>
</tbody>
</table>

*Note:* Units of measures are milliseconds. Cell \(n\)s = 12 to 14.

**Figure 6.** PEP reactivity scores during task performance. Error bars show the standard errors of the means.

\(^5\) We also assessed systolic and diastolic blood pressure and heart rate, which are less sensitive measures of effort intensity than PEP (see Richter et al., 2008). No significant effects emerged on the baseline \((ps > .15)\) or reactivity scores \((ps > .09)\) of these measures.
Task performance

As response accuracy was very high ($M = 98.28\%$, $SD = 2.63$), we focused on reaction times. Responses of one participant were much slower (> 2 $SD$) than those of the other participants. Given that performance was not our central dependent variable, we replaced this participant’s average response time by the sample mean instead of simply deleting it. That way we could keep the same degrees of freedom for all statistical tests. A 2 (prime) x 2 (cue) ANOVA revealed only a prime main effect, $F(1,48) = 4.08$, $p = .049$, $\eta^2_p = .08$: Responses in the sadness-prime condition ($M = 685.64$, $SE = 17.83$) were faster than in the happiness-prime condition ($M = 746.34$, $SE = 24.29$), (other $ps > .61$). A positive correlation, $r(52) = .28$, $p < .05$, indicating that reaction times decreased with stronger PEP reactivity, further reflected a link between effort and performance.

Verbal measures

Conscious mood

Mood scores were calculated by summing the scores of the positive and inverse-coded negative affect items for the baseline and post-task measures ($\alpha > .70$). A 2 (prime) x 2 (cue) x 2 (time) ANOVA found no significant effects (all $ps > .68$; pre-manipulation $M = 20.83$, $SE = 0.49$; post-manipulation $M = 20.79$, $SE = 0.49$) and thus no evidence for the possibility that the affect primes elicited conscious emotional feelings.

Task ratings

Given that participants’ ratings of the items referring to subjective demand were highly correlated, we created a subjective demand index by averaging participants’ difficulty, effort, and inverse-coded capability ratings ($\alpha = .73$). The score of one participant exceeded the sample mean by more than 2 $SD$ and was replaced by the mean. A 2 (prime) x 2 (cue) ANOVA revealed a prime main effect on subjective demand, $F(1,48)= 5.49$, $p = .023$, $\eta^2_p = .10$, which was higher in the sadness-prime condition ($M = 2.84$, $SE = 0.18$) than in the happiness-prime condition ($M = 2.27$, $SE = 0.16$). No other effect was significant (both $ps > .69$). An ANOVA of the importance of success ratings found no significant effects (all $ps > .10$, $M = 5.83$, $SE = 0.14$).

Discussion

As expected, participants who processed sadness-primes during the mental concentration task mobilized more effort—assessed as performance-related responses of PEP, an index of beta-adrenergic impact on the heart (Berntson et al., 2004)—than participants who processed happiness-primes. Correspondingly, the sadness primes also led to higher subjective task demand and faster correct responses, reflecting a systematic link between affect primes, subjective task demand, effort intensity, and performance. Most relevant, these effects were not reduced by providing a cue for the primes’ possible effect on emotional feelings. Rather, that cue, which has previously been demonstrated to significantly diminish the effects of conscious affect on effort-related cardiovascular response (e.g., Gendolla & Krüsken, 2002b), had a significant main effect and increased effort in general. That is, the cue manipulation was effective. But it did not have an
The role of explicit affective feelings

effect in support of the idea that affect primes induced conscious emotional feelings whose impact was corrected in the cue condition. These results elaborate findings by Winkielman et al. (1997), who only found cue zero-effects on evaluative judgments. Our study revealed a corresponding cue-zero-effect on judgments of task demand and self-reported affective states. However, our cue manipulation had a significant—and thus interpretable—effect on effort intensity, our central dependent variable. But the significant cue impact did not reduce the affect primes’ impact on effort mobilization.

We explain the significant cue effect on PEP response as reflecting additional cognitive demand during task performance. Participants in the no-cue condition concentrated “only” on the task, while participants in the cue condition had to concentrate on both the task and the possible impact of the “flickers”. That is, participants in the cue condition worked under more demanding conditions, which typically leads to stronger cardiovascular response (Obrist, 1981). From this perspective, it also makes sense that the cue manipulation had no effect on the response times, because the stronger PEP response in the cue condition occurred due to higher general cognitive load rather than directly task-related effort.

We acknowledge that there is evidence that implicit affective stimuli can produce conscious feelings under certain conditions and in certain procedures (Chartrand et al., 2006). But those procedures differ from our affect-priming paradigm in which we assess the dependent variable (effort mobilization) during and not after prime exposure. Given the present findings and the fact that we have not found evidence that the affective primes induced conscious emotional feelings in our present or previous research (Freydefont et al., 2012a; Gendolla & Silvestrini, 2011; Silvestrini & Gendolla, 2011a, 2011b), we keep explaining implicit affective stimuli’s systematic influence on mental effort according to IAPE model (Gendolla, 2012): Masked affective stimuli can influence evaluative judgments and behavior by the activation of mental concepts (see Niedenthal, 2008; Zemack-Rugar et al., 2007). Being activated in the context of task performance, this knowledge—happiness is associated with ease while sadness is related to difficulty (see Gendolla & Brinkmann, 2005)—is applicable to evaluate subjective task demand, which in turn takes effect on effort intensity (see J. W. Brehm & Self, 1989). Accordingly, it is not necessary that primes induce emotional feelings in order to influence difficulty appraisals and corresponding effort intensity.
Chapter 4. Implicit versus explicit affect cues

Abstract

Participants worked on an easy versus difficult arithmetic task with integrated happiness versus sadness primes, presented either suboptimally or optimally. As predicted by the IAPE model (Gendolla, 2012), affect prime moderated the task difficulty effect on mental effort in the suboptimal prime condition: Cardiac pre-ejection period response was stronger in the sadness/easy and happiness/difficult conditions than in the happiness/easy and sadness/difficult cells. Most important, these effects were reversed in the optimal prime presentation condition. Moreover, neither suboptimally nor optimally presented affect primes had prime-congruent effects on conscious mood assessed via self-report. The results demonstrate differential effects of implicitly versus explicitly processed affect cues on mental effort and support the idea that suboptimal affect primes influence effort mobilization without inducing emotional feelings.

Introduction

Numerous studies have demonstrated that suboptimally presented and implicitly processed affective stimuli—like emotion words or facial expressions—significantly influence behavior (see Eastwood & Smilek, 2005; Öhman, Flykt, & Lundqvist, 2000; Winkielman et al., 2005a for overviews). Focusing on the systematic impact of implicitly processed affective stimuli on effort-related cardiovascular response, the implicit-affect-primes-effort (IAPE) model (Gendolla, 2012) posits that affect primes can influence effort mobilization through their effects on task demand experienced during performance. Because effort mobilization follows a resource conservation principle, the amount of mobilized effort is proportional to subjective demand as long as success is possible and justified (J. W. Brehm & Self, 1989). In achievement contexts, people thus use all available information for evaluating task difficulty. According to the IAPE

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Implicit versus explicit affect cues

model, affect primes automatically activate knowledge about the respective affective states (i.e. *implicit affect*), including information about typically experienced performance ease or difficulty: Sadness is associated with difficulty—therefore sadness primes lead to the experience of high demand and, as long as success is possible and justified, to higher effort. By contrast, happiness and anger are associated with performance ease and consequently lead to lower experienced demand.

A series of studies assessing effort as performance-related cardiovascular response has revealed support for the systematic influence of implicit affect on effort mobilization posited by the IAPE model. Under “do-your-best” conditions, suboptimally presented sadness primes led to stronger effort-related cardiovascular response than both happiness and anger primes (Gendolla & Silvestrini, 2011; Lasauskaite, Gendolla, & Silvestrini, 2013; Silvestrini & Gendolla, 2011a). Corresponding to the IAPE model logic, participants in the sadness-prime condition also rated subjective task demand as higher than those in the happiness-prime condition. Moreover, affect primes moderate the effect of objective task difficulty on effort-related cardiovascular response. In a study by Silvestrini and Gendolla (2011b), participants processed suboptimally presented happy versus sad facial expressions during an objectively easy versus difficult attention task. Affect-primes and objective task difficulty had an additive effect on ratings of task demand. Corresponding to this, in the easy task, cardiovascular reactivity in the sadness-prime condition was stronger than in the happiness-prime condition. This finding suggests that sadness primes activated the difficulty concept, leading to higher perceived task demand and consequently to higher effort. Happiness primes, on the contrary, activated the ease concept, leading to lower subjective demand and thus lower effort. However, in the difficult task, participants in the sadness-prime condition were expected and found to disengage, because the objectively difficult task was experienced as over-challenging due to the additional sadness-prime effect on subjective demand. By contrast, in the happiness-prime condition, effort-related cardiovascular response was expected and found to be strong, because task demand was experienced as high but still feasible. Freydefont et al. (2012a) found corresponding effects for suboptimally presented sadness versus anger primes during the performance of an easy versus difficult task. Finally, the effort mobilization deficit of people suboptimally primed with sadness could be compensated by high performance-contingent incentive (Freydefont & Gendolla, 2012), making it implausible that affect primes might have their effects on effort mobilization by taking effect on available cognitive resources.

Suboptimal versus optimal prime presentation

In experiments on implicit affect, primes are usually presented suboptimally to give participants limited awareness of the primes’ content in order to facilitate automatic responses and to prevent controlled reactions and the elicitation of full-blown emotions. Nevertheless, there has been considerable debate about the role of emotional feelings in affect priming (e.g., Clore, Storbeck, Robinson, & Centerbar, 2005; Winkielman, Berridge, & Wilbarger, 2005b; Winkielman & Schooler, 2011). Therefore, Lasauskaite et al. (2013) aimed to test if suboptimally presented sadness- and happiness-primes have their effects on effort-related cardiovascular response because they induce emotional feelings. Half the participants were informed that “flickers” (i.e. primes) presented during the task could have an effect on their affective state. It was expected that this cue should diminish the prime effect on effort-related cardiovascular response, if the primes induced emotional feelings (e.g., Gendolla & Krüsken, 2002b). However, the prime effect in the cue-condition remained and cardiac reactivity was generally stronger in the cue-
condition, which was explained by increased cognitive load. Additionally, no evidence for prime effects on conscious feelings was found.

The question arises, what happens if affect primes are presented optimally and are thus fully perceptible for participants, resulting in higher potential for eliciting emotional feelings than suboptimally presented primes. Emotion chronometry studies suggest that stimuli must be presented for at least 500 milliseconds in order to elicit emotional reactions (see Gendolla, 2012). However, there is also evidence that suboptimally presented primes have stronger effects on affective reactions than optimally presented primes. Murphy and Zajonc (1993), for example, found prime-congruent effects on evaluative judgments of neutral targets only if affect primes were presented suboptimally (in this case even subliminally: 4 ms). In the optimal prime condition (1000 ms), there was a trend to a prime-contrast effect in participants’ judgments, suggesting controlled processing and correction of the prime influence (cf. Herr, 1986). That is, explicit prime processing can also reduce the effects of affect primes.

Rotteveel, Groot, Geutskens, and Phaf (2001) presented happy and angry faces masked by unknown ideographs. In one study, participants rated the affective meaning of the ideographs, in another study facial electromyography was assessed as more implicit affect measure. Both studies found stronger suboptimal than optimal prime effects on the dependent variables. Recently, Siegel and Weinberger (2012) found in a study on masked and unmasked phobic stimuli a double dissociation between the effects of suboptimally presented (25 ms) and visible (120 ms) phobic stimuli (spiders): Suboptimal exposure reduced avoidance of a tarantula and did not elicit distress, whereas the visible stimuli increased distress but did not reduce avoidance behavior. This suggests that implicit prime processing has different and stronger effects than explicit prime processing. However, these studies on suboptimal versus optimal prime presentation were not concerned with effort mobilization and the potential role of emotional feelings in this process.

For achievement contexts, we see two alternatives for the effects of optimal affect prime exposure. The first alternative suggests that optimally presented primes induce conscious affect and then have the same effect as suboptimal primes, but due to a different process. Conscious affect can be used as information for evaluations of task demand and have mood-congruency effects on demand appraisals and thus on corresponding effort mobilization: Subjective demand is high in a sad mood than in a happy mood (see Gendolla & Brinkmann, 2005; Gendolla, Brinkmann, & Silvestrini, 2012 for reviews). The second alternative refers to the theory of psychological reactance (J. W. Brehm, 1966; S. S. Brehm & Brehm, 1981). Accordingly, optimally presented primes lose their effect due to a correction process. Clearly visible primes can elicit reactance by giving participants the feeling to be manipulated, which means a restriction of their freedom. This leads to reactance and behavior correction effects to restore freedom. Consequently, optimally presented primes should lose their effect and may even produce a prime-contrast effect due to correction (cf. Herr, 1986). The present study tested these alternative hypotheses.

**Effort-related cardiovascular response**

As in previous studies of our lab, we operationalized effort as cardiac response in the context of task performance. In accordance with Wright’s (1996) integration of motivational intensity theory (J. W. Brehm & Self, 1989) with the active coping approach (Obrist, 1981), effort is mirrored by beta-adrenergic sympathetic nervous system impact on the heart. Non-invasively, this impact is best reflected as increased cardiac contractility and thus shortened cardiac pre-ejection period (PEP)—the time interval (in ms) between the onset of left ventricular excitation
and the opening of the aortic valve (Berntson et al., 2004). Systolic blood pressure (SBP) can also be systematically influenced by cardiac contractility due to its impact on cardiac output (see Gendolla, Wright, et al., 2012; Wright & Kirby, 2001)—numerous previous studies have quantified effort as SBP because of this effect (see Gendolla, Wright, et al., 2012; Wright & Kirby, 2001). However, PEP is much more reliable and valid measure of resource mobilization, because it is directly influenced by beta-adrenergic sympathetic impact (Kelsey, 2011). SBP is additionally influenced by peripheral vascular resistance, which is not systematically influenced by beta-adrenergic impact (Levick, 2003). Diastolic blood pressure (DBP) is even more strongly influenced by peripheral resistance. Heart rate (HR) is controlled by both sympathetic and parasympathetic influence and should reflect effort mobilization only to the degree of sympathetic impact (Berntson et al., 2004). Thus, in short, PEP is the purest indicator of effort intensity among these indices. Nevertheless, HR and blood pressure should always be assessed together with PEP in order to control for possible pre- or afterload effects on PEP (Sherwood et al., 1990).

The present study

The present study aimed at testing the effects of suboptimally versus optimally presented affect primes on effort-related cardiovascular response. First, we expected to replicate the task difficulty moderation effect of suboptimally presented affect primes’ impact on resource mobilization (Silvestrini & Gendolla, 2011b). Second, and most relevant, we tested the two alternative hypotheses about the effects of optimal prime exposure.

![Figure 7](image-url)

**Figure 7.** Theoretical predictions for objective task difficulty effects on effort moderated by suboptimally presented sadness versus happiness primes. Averaged emotional facial expressions are prime examples from the AKDEF database (Lundqvist & Litton, 1998). The Figure is adapted from Silvestrini and Gendolla (2011b).

Participants worked on an objectively easy or difficult arithmetical task during which they were exposed to suboptimally (26 ms) versus optimally (780 ms) presented sadness- or happiness-primes. In the suboptimal prime condition, we predicted a prime × difficulty crossover interaction effect on PEP reactivity, which has been found previously (Silvestrini & Gendolla, 2011b). More specifically, we anticipated a weak PEP response in the happiness-prime/easy and
the sadness-prime/difficult conditions, and a strong PEP response in the sadness-prime/easy and happiness-prime/difficult conditions (see Figure 7). As outlined above, this is predicted because suboptimally presented sadness-primes should lead to higher subjective demand than happiness-primes in the easy condition. By contrast, when the task is objectively difficult, sadness-primes should lead to disengagement because the task is experienced as over-challenging while happiness-primes should lead to high but feasible demand. In the optimal prime condition, where the primes were clearly visible, we expected either the same effects but additional prime-related effects on conscious mood ratings or diminished (or even reversed) prime effects due to reactance, as explained above.

Method

Participants and design

One-hundred-and thirty-four university students (127 women, average age 21 years) voluntarily and anonymously participated in the experiment for course credit or monetary remuneration (CHF 10, equivalent to USD 11) and were randomly assigned to a 2 (prime: sadness, happiness) × 2 (task difficulty: easy, difficult) × 2 (prime presentation: suboptimal, optimal) between-persons design.7

Affect prime stimuli

We used pictures of averaged neutral (FNES, MNES), sad (FSAS, MNAS), and happy (FHAS, MHAS) front perspective, low resolution, grayscale facial expressions taken from the Averaged Karolinska Directed Emotional Faces (AKDEF) database (Lundqvist & Litton, 1998) as affect primes. Half the pictures were male faces; half were female faces.

Apparatus and physiological measures

To assess heart rate and cardiac PEP, impedance cardiogram (ICG) and electrocardiogram (ECG) signals were noninvasively assessed (sample rate 1000Hz) with a Cardioscreen® 1000 system (medis, Ilmenau, Germany). Four pairs of disposable spot electrodes were placed on the right and left sides of the base of the participant’s neck and on the left and right middle axillary line at the height of the xiphoid.

We additionally assessed blood pressure with a Vasotrac® AMP205A monitor (MEDWAVE®, St. Paul, MN). This system uses applanation tonometry with a pressure sensor placed on the wrist on top of the radial artery applying a varying force on the artery. Internal algorithms yield systolic and diastolic pressures as well as HR approximately every 12–15 heart beats, i.e. 4–5 values per minute (see Belani et al., 1999 for a validation study). All obtained car-

7 Due to technical measurement problems, there were missing data for some participants. Therefore, the sample sizes slightly varied across the analysis of the dependent variables: n = 134 for PEP, n = 133 for HR, and n = 130 for SBP and DBP.
diovascular measures were stored on internal drive and transferred to a personal computer. PEP, blood pressure, and HR values were calculated for 1-minute intervals.

**Procedure**

The procedure conformed to the ethical standards of the University of Geneva and had been approved by the local ethical committee. After having obtained signed consent, the experimenter attached the electrodes and the blood pressure cuff and went to a control room. The procedure was computerized (E-Prime, Psychology Software Tools, Pittsburgh, PA). Instructions were presented on the computer screen; responses were given with a numerical keyboard. At the beginning of the session, participants answered biographical questions and rated their current mood with 2 positive (joyful, cheerful) and 2 negative affect items (sad, depressed) of the Matthews, Jones, and Chamberlain (1990) UWIST mood scale (1 = not at all to 7 = very much). Then participants watched a neutral documentary film showing landscapes (8 min) while physiological baseline measures were taken. This was followed by an arithmetic task (5 min) adapted from Bijleveld, Custers, and Aarts (2010).

In the task, each trial consisted of the presentation of an arithmetic problem, consisting of three added up single digits and a two-digit result presented on the computer screen (e.g., “7+5+3=14”). Participants had to decide for each equation if it was correct or not, by pressing a “yes” or a “no” key. Half of the presented equations were correct and half were incorrect. Participants received the instruction to try to respond correctly and as fast as possible. Each of the 36 trials started with a fixation cross (1000 ms), followed by a facial expression picture (26 ms vs. 780 ms) that was backward-masked with a noise picture showing scattered black and white dots (133 ms). Then the target equation appeared. Based on pretests, the maximal time response windows were 6000 ms (easy task) vs. 4000 ms (difficult task). Participants’ responses were followed by the feedback “Response entered” displayed for 6500 ms (easy task) or 4500 ms (difficult task) minus the response time. That way all trials had the same length, resulting on the same task duration for all participants. The inter-trial interval randomly varied between 2 and 5 seconds.

Before the task, participants performed 10 training trials with neutral facial expressions as primes and received immediate feedback whether their answer was correct or not. No correctness feedback was given during the task to avoid possible affective reactions that could interfere with the affect primes’ impact (e.g., Kreibig, Gendolla, & Scherer, 2012). In the main task, emotional expressions were randomly displayed in 1/3 of the trials. The remaining 2/3 of the trials displayed neutral expressions. This priming procedure has been found to the most effective in the present paradigm (Silvestrini & Gendolla, 2011a). Facial expressions pictures were randomized in blocks of 6 (2 emotional, 4 neutral) and the same expression did not appear successively.

After the task, participants rated subjective task difficulty, mobilized effort, the capability to succeed, the importance of success, their mathematical capacities, and how comfortable they feel in general with mental calculations (1 = not at all to 7 = very much). The last two items were assessed to control for participants’ ability beliefs regarding arithmetic, which can systematically influence perceived task demand and effort (Wright & Kirby, 2001; see Wright, 1998). Finally, participants rated the same 4 mood adjectives as at the procedure’s onset for assessing if the affect primes had an effect on their conscious mood. After the experiment participants were debriefed, thanked, and received either course credit or the remuneration.
Data Analysis

ICG signals were processed offline with software developed in our lab (Richter, 2010). PEP (in milliseconds) was determined as the interval between R-onset and B-point (Berntson et al., 2004). Shorter PEP indicated stronger cardiac contractility. B-point location was estimated based on the RZ interval of valid heart beat cycles (Lozano et al., 2007), visually inspected, and if necessary corrected as recommended (Sherwood et al., 1990).

With exception of the mood scores, data were analyzed with 2 (prime) × 2 (difficulty) × 2 (prime presentation) between-persons ANOVAs, or ANCOVAs respectively. Mood scores were analyzed with a 2 (prime) × 2 (difficulty) × 2 (prime presentation) × 2 (time) mixed model ANOVA. Significant three-way interactions were decomposed with focused 2-way interaction contrasts using the ANOVA MSE in order consider the total sample variance of the entire design for all statistical tests. The small number of men in our sample did not permit including gender as a separate factor. However, analyses ran without men led to basically the same results as those reported below. To facilitate interpretation of the results, effect sizes of 1 df tests were transformed to eta-square.

Ability can influence subjective task demand, effort-related cardiovascular response (see Wright, 1998), and performance (Locke & Latham, 1990). Consequently, we tested for possible associations between participants’ arithmetic ability beliefs and both cardiovascular responses and task performance. Given high correlations between the ratings of perceived capacity in mathematics and the self-evaluation of ease for mental calculations, we created an ability-index (Cronbach’s α = .90; grand mean M = 3.53, SE = 0.15). Preliminary ANCOVAs found significant associations between the ability-index and both response times, $F(1, 125) = 23.32, p < .001, \eta^2_p = .16$, and accuracy scores, $F(1, 125) = 36.21, p < .001, \eta^2_p = .23$, in the arithmetic task. Therefore the ability-index was included as a covariate in the analysis of these task performance indices (see below). No associations emerged between the ability-index and any of the cardiovascular reactivity scores ($p$s > .34). Consequently, the ability-index was not included as a covariate in these analyses.

Results

Cardiovascular baselines

Cardiovascular baseline scores for PEP, SBP, DBP, and HR were calculated as the averages of the last 5 minutes of the habituation period, which provided stable values (Cronbach’s $\alpha$s > .99). Cell means and standard errors appear in Table 7. Exploratory between-persons ANOVAs found significant task difficulty main effects for SBP, $F(1, 122) = 18.28, p < .001, \eta^2_p = .13$ (easy $M = 120.77, SE = 1.66$, difficult $M = 110.35, SE = 1.79$), and DBP, $F(1, 122) = 15.05, p < .001, \eta^2_p = .11$, (easy $M = 68.53, SE = 1.19$, difficult $M = 61.72, SE = 1.29$) baseline measures, while other effects were not significant ($p$s > .31). Later we will deal with these findings with ANCOVAs. The ANOVAs of PEP and HR baseline scores did not reveal any significant effects ($p$s > .16).

Cardiovascular reactivity

Physiological reactivity scores were calculated for each participant by subtracting the baseline scores from the scores obtained during the task. As the 1-minute change scores were
highly consistent (Cronbach’s α > .95), we created average reactivity scores for the entire task performance period. First, we tested for possible associations between baselines and reactivity scores within ANCOVAs in order to control for possible carryover or initial value effects (Llabre et al., 1991). There were no other significant associations between cardiovascular baselines and reactivity scores (ps > .13). Thus, reactivity scores were analyzed without baseline adjustments.

Table 7. Cell means and standard errors (in parentheses) for cardiovascular baseline values.

<table>
<thead>
<tr>
<th></th>
<th>Easy task</th>
<th>Difficult task</th>
<th>Easy task</th>
<th>Difficult task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Happiness prime</td>
<td>Sadness prime</td>
<td>Happiness prime</td>
<td>Sadness prime</td>
</tr>
<tr>
<td>PEP</td>
<td>97.08</td>
<td>96.19</td>
<td>99.31</td>
<td>102.30</td>
</tr>
<tr>
<td></td>
<td>(3.68)</td>
<td>(2.61)</td>
<td>(2.95)</td>
<td>(2.75)</td>
</tr>
<tr>
<td>SBP</td>
<td>124.27</td>
<td>118.24</td>
<td>110.08</td>
<td>109.76</td>
</tr>
<tr>
<td></td>
<td>(4.08)</td>
<td>(5.20)</td>
<td>(1.89)</td>
<td>(2.29)</td>
</tr>
<tr>
<td>DBP</td>
<td>70.21</td>
<td>67.74</td>
<td>61.26</td>
<td>62.19</td>
</tr>
<tr>
<td></td>
<td>(2.55)</td>
<td>(3.90)</td>
<td>(1.56)</td>
<td>(1.88)</td>
</tr>
<tr>
<td>HR</td>
<td>76.39</td>
<td>75.73</td>
<td>79.72</td>
<td>79.08</td>
</tr>
<tr>
<td></td>
<td>(2.52)</td>
<td>(2.81)</td>
<td>(3.41)</td>
<td>(2.97)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Happiness prime</td>
<td>Sadness prime</td>
<td>Happiness prime</td>
<td>Sadness prime</td>
</tr>
<tr>
<td>PEP</td>
<td>95.83</td>
<td>100.32</td>
<td>101.08</td>
<td>98.12</td>
</tr>
<tr>
<td></td>
<td>(3.31)</td>
<td>(2.66)</td>
<td>(2.70)</td>
<td>(1.89)</td>
</tr>
<tr>
<td>SBP</td>
<td>119.18</td>
<td>121.38</td>
<td>111.71</td>
<td>109.83</td>
</tr>
<tr>
<td></td>
<td>(3.51)</td>
<td>(3.21)</td>
<td>(1.74)</td>
<td>(2.54)</td>
</tr>
<tr>
<td>DBP</td>
<td>67.25</td>
<td>68.92</td>
<td>62.32</td>
<td>61.12</td>
</tr>
<tr>
<td></td>
<td>(2.36)</td>
<td>(2.53)</td>
<td>(1.49)</td>
<td>(1.61)</td>
</tr>
<tr>
<td>HR</td>
<td>77.38</td>
<td>76.95</td>
<td>74.19</td>
<td>76.97</td>
</tr>
<tr>
<td></td>
<td>(2.63)</td>
<td>(2.91)</td>
<td>(2.93)</td>
<td>(1.96)</td>
</tr>
</tbody>
</table>

Note. Cell ns ranging from 14 to 19. PEP = pre-ejection period; SBP = systolic blood pressure; DBP = diastolic blood pressure; HR = heart rate. Units of measures are milliseconds for PEP, millimeters of mercury for SBP and DBP, and beats per minute for HR.

Cardiac PEP reactivity

Cell means and standard errors are depicted in Figure 8. A 2 (prime) × 2 (difficulty) × 2 (prime presentation) ANOVA of PEP reactivity revealed a significant three-way interaction, $F(1, 126) = 8.48, p = .004, \eta^2 p = .06$. To decompose this interaction, we ran focused crossover interaction contrasts which showed significant prime × difficulty interactions in both the suboptimal-prime condition, $F(1, 126) = 4.37, p = .039, \eta^2 p = .03$, and the optimal-prime condition, $F(1, 126) = 4.11, p = .045, \eta^2 p = .03$. As visible in Figure 8, the pattern of PEP reactivity in the suboptimal prime condition corresponded to our prediction about the moderation of objective task difficulty effects by implicit affect priming. Most relevant for the present research, this pattern was reversed in the optimal condition.

Additional cell contrasts revealed that the sadness-prime and happiness-prime cells differed significantly from one another when the task was difficult in both the suboptimal, $t(126) = 2.16, p = .033, \eta^2 = .04$, and optimal, $t(126) = 2.48, p = .015, \eta^2 = .05$, prime presentation conditions. However, the directions of the effects were opposite: In the suboptimal-prime condition, reactivity in the happiness-prime/difficult condition ($M = -2.95, SE = 1.20$) was stronger than in the sadness-prime/difficult condition ($M = 0.23, SE = 1.54$). By contrast, in the optimal-prime condition, PEP reactivity in the sadness-prime/difficult condition ($M = -2.16, SE = 0.62$) was stronger than in the happiness-prime/difficult cell ($M = 1.49, SE = 1.09$). The cell differences between sadness- and happiness-prime cells were not significant in the easy condition (both $p > .45$; suboptimal presentation: happiness-prime $M = -1.98, SE = 0.69$, sadness-prime $M = -3.00, SE = 0.98$; optimal presentation: happiness-prime $M = -2.00, SE = 0.94$, sadness-prime $M = -1.58, SE = 0.67$). Moreover, as visible in Figure 8, PEP responses in the happiness-prime/difficult con-
dition clearly differed between the suboptimal and optimal prime conditions, as evident in significant focused contrast, \( t(126) = 3.01, p = .003, \eta^2 = .07 \).

**SBP, DBP, and HR reactivity**

Cell means and standard errors are presented in Table 8. The 2 (prime) \( \times \) 2 (difficulty) \( \times \) 2 (prime presentation) ANOVA of the SBP responses revealed a significant task difficulty \( \times \) prime presentation interaction, \( F(1, 122) = 5.06, p = .026, \eta^2 = .04 \). While the difference between the easy (\( M = 4.57, SE = 1.23 \)) and difficult (\( M = 5.21, SE = 0.71 \)) conditions was not significant in the suboptimal-prime condition (\( p = .602 \)), SBP response was higher in the difficult (\( M = 6.52, SE = 0.83 \)) than in the easy condition (\( M = 1.55, SE = 0.85 \)), \( F(1, 122) = 13.73, p < .001, \eta^2 = .10 \), in the optimal prime-condition. The three-way interaction on SBP reactivity was not significant (\( p = .210 \)), although the pattern of cell means corresponded to the effects of cardiac PEP.

A 2 (prime) \( \times \) 2 (difficulty) \( \times \) 2 (prime presentation) ANOVA of the DBP reactivity scores found effects that corresponded to those of SBP. The task difficulty \( \times \) prime presentation interaction was significant, \( F(1, 122) = 4.06, p = .046, \eta^2 = .03 \), in absence of a significant three-way interaction (\( p = .205 \)). Again, the difference between the easy (\( M = 3.27, SE = 0.89 \)) and difficult (\( M = 3.57, SE = 0.51 \)) conditions was not significant in the suboptimal-prime condition (\( p = .723 \)). But in the optimal-prime condition, DBP reactivity was stronger in the difficult (\( M = 4.21, SE = 0.57 \)) than in the easy condition (\( M = 1.17, SE = 0.57 \)), \( t(122) = 3.20, p = .002, \eta^2 = .08 \).

A 2 (prime) \( \times \) 2 (difficulty) \( \times \) 2 (prime presentation) ANOVA of HR reactivity did not find any significant effects or interactions (\( ps > .23 \)).

![Figure 8. PEP reactivity scores (+/- SEM) in the experimental conditions.](image-url)
Implicit versus explicit affect cues

**Table 8.** Cell means and standard errors (in parentheses) of the blood pressure and heart rate reactivity scores.

<table>
<thead>
<tr>
<th>Suboptimal prime</th>
<th>Easy task</th>
<th>Difficult task</th>
<th>Optimal prime</th>
<th>Easy task</th>
<th>Difficult task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Happiness prime</td>
<td>Sadness prime</td>
<td>Happiness prime</td>
<td>Sadness prime</td>
<td>Happiness prime</td>
</tr>
<tr>
<td>SBP</td>
<td>2.51 (1.40)</td>
<td>6.52 (1.93)</td>
<td>5.79 (1.09)</td>
<td>4.63 (0.91)</td>
<td>0.65 (1.08)</td>
</tr>
<tr>
<td>DBP</td>
<td>1.85 (0.91)</td>
<td>4.62 (1.47)</td>
<td>3.91 (0.77)</td>
<td>3.23 (0.69)</td>
<td>0.80 (0.68)</td>
</tr>
<tr>
<td>HR</td>
<td>2.74 (0.66)</td>
<td>4.15 (0.97)</td>
<td>2.49 (0.71)</td>
<td>3.23 (1.24)</td>
<td>2.92 (1.00)</td>
</tr>
</tbody>
</table>

*Note.* Cell *n*s ranging from 14 to 19. Units of measures are millimeters of mercury for SBP and DBP and beats per minute for HR.

**Task performance**

Cell means and standard errors appear in the Table 3. A 2 (prime) × 2 (difficulty) × 2 (prime presentation) ANOVA of ability-index-adjusted task performance measures did not find any effects neither on response times for correct responses (*p*s > .40) nor on accuracy scores (*p*s > .10).

**Self-report measures**

Cell means and standard errors appear in Table 9.

**Table 9.** Cell means and standard errors (in parentheses) of self-report measures.

<table>
<thead>
<tr>
<th>Suboptimal prime</th>
<th>Easy task</th>
<th>Difficult task</th>
<th>Optimal prime</th>
<th>Easy task</th>
<th>Difficult task</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Happiness prime</td>
<td>Sadness prime</td>
<td>Happiness prime</td>
<td>Sadness prime</td>
<td>Happiness prime</td>
</tr>
<tr>
<td>Response accuracy</td>
<td>72.66 (2.64)</td>
<td>71.31 (2.82)</td>
<td>69.45 (3.72)</td>
<td>77.81 (2.85)</td>
<td>70.86 (2.79)</td>
</tr>
<tr>
<td>Reaction time</td>
<td>2700.73 (49.87)</td>
<td>2719.32 (52.09)</td>
<td>2786.27 (53.07)</td>
<td>2720.98 (70.10)</td>
<td>2690.05 (84.21)</td>
</tr>
<tr>
<td>Pre-task mood</td>
<td>20.47 (0.84)</td>
<td>20.79 (1.11)</td>
<td>20.93 (0.80)</td>
<td>20.81 (1.09)</td>
<td>22.39 (0.87)</td>
</tr>
<tr>
<td>Post-task mood</td>
<td>18.00 (1.12)</td>
<td>16.84 (1.14)</td>
<td>14.33 (1.52)</td>
<td>18.38 (0.96)</td>
<td>17.56 (1.12)</td>
</tr>
<tr>
<td>Subjective demand</td>
<td>3.61 (0.25)</td>
<td>4.12 (0.26)</td>
<td>4.40 (0.29)</td>
<td>3.38 (0.23)</td>
<td>3.94 (0.33)</td>
</tr>
</tbody>
</table>

*Note.* Cell *n*s ranging from 14 to 19. Measurement units were % for response accuracy, milliseconds for reaction times, sum scores for mood, and mean ratings (ranging from 1 to 7) for demand and ability ratings.
Mood

Given the high inter-correlations of the ratings of positive and inverted negative affect UWIST scale items, we created mood sum scores for the pre-task (Cronbach’s α = .76) and post-task (Cronbach’s α = .71) mood measures. A 2 (prime) × 2 (difficulty) × 2 (prime presentation) × 2 (time) mixed-model ANOVA revealed a significant time main effect, F(1, 126) = 112.60, p < .001, ηp² = .47 (pre-task M = 21.07, SE = 0.34, post-task M = 16.65, SE = 0.40), which was qualified by a significant four-way interaction, F(1, 126) = 8.47, p = .004, ηp² = .06, in absence of other significant effects (ps > .10). To decompose this four-way interaction, we ran separate 2 (prime) × 2 (difficulty) × 2 (prime presentation) ANOVAs of the pre-task and post-task mood scores. While the three-way interaction was not reliable for the pre-task mood scores (p = .509), it was significant for the post-task scores, F(1, 120) = 5.99, p = .016, ηp² = .05. We further decomposed this interaction and ran focused interaction contrasts, which revealed a significant prime × difficulty interaction in the suboptimal-prime condition F(1, 126) = 5.23, p = .024, ηp² = .04, but not in the optimal-prime condition (p = .243). Additional cell contrasts between the sadness-prime and happiness-prime cells in the suboptimal-prime condition revealed no significant difference when the task was easy (p = .456), but a significant effect when the task was difficult, t(126) = 2.43, p = .017, ηp² = .06. The mood scores in the happiness-prime cell were lower than in the sadness-prime cell. In the optimal prime condition, the contrasts did neither find significant differences between the sadness-prime and happiness-prime cells in the easy (p = .641) nor in the difficult condition (p = .246). Moreover, the prime main effect in the three-way ANOVA was not significant (p = .605). It is obvious that these findings do not provide evidence for the possibility that the affect primes influenced participants’ conscious moods in a prime-congruent way.

Subjective demand-index

Given high correlations (Cronbach’s α = .75) between the ratings of subjective task difficulty, invested effort, and the subjective capability to succeed (inversed), we created a subjective demand-index by averaging these ratings. A 2 (prime) × 2 (difficulty) × 2 (prime presentation) ANOVA revealed a significant three-way interaction, F(1, 126) = 8.41, p = .013, ηp² = .05. We decomposed this interaction by running the focused interaction contrast analysis for each of the prime presentation conditions. The prime × difficulty interaction was significant in the suboptimal prime condition, F(1, 126) = 7.44, p = .007, ηp² = .06: in the easy condition, subjective demand did not differ significantly between the happiness-prime and sadness-prime conditions (p = .183). In the difficult condition, ratings were significantly higher in the happiness-prime condition than in the sadness prime condition, t(126) = 2.48, p = .015, η² = .05. In the optimal prime condition, the prime × difficulty interaction was not significant (p = .405).

Discussion

The present study provides first evidence for differential effects of implicit versus explicit affect cues on effort-related cardiac response and suggests that affect primes have their systematic influence on effort-mobilization without eliciting emotional feelings. Suboptimally presented sadness and happiness cues moderated the effect of objective task difficulty on cardiac PEP response as predicted by the IAPE model (Gendolla, 2012) and found in previous studies (Freydefont et al., 2012a; Silvestrini & Gendolla, 2011b). Most relevant, when the affect cues were presented optimally, the affect primes also moderated the effect of objective task difficulty,
but the direction of this effect was opposite to the direction of the effect in the suboptimal prime condition. That is, optimal prime presentation reversed the effect of suboptimally presented affect primes. This is interpretable as a prime contrast effect on effort-related cardiac response in the optimal prime condition where the primes’ content was explicitly visible. Moreover, there was no evidence that the optimal or suboptimal primes induced conscious affect in terms of prime-congruent mood changes, but there was evidence for a prime contrast effect on effort mobilization. These results support the psychological reactance hypothesis (J. W. Brehm, 1966; S. S. Brehm & Brehm, 1981), according to which affect primes lose their effect due to a correction process when their content becomes explicit, as outlined above. Accordingly, clearly visible primes are hints for the participants that their feelings should be manipulated, meaning a restriction of freedom. The result is a behavior correction effects in order to counteract the restriction of freedom, resulting in the observed prime contrast effect on cardiac PEP response.

The significant prime × difficulty interaction effect on PEP reactivity in the suboptimal prime condition replicates previous findings (see also Freydefont et al., 2012a; Silvestrini & Gendolla, 2011b). In the easy condition, the descriptive values of the PEP response show stronger reactivity in the sadness-prime condition than in happiness-prime condition. The IAPE model (Gendolla, 2012) explains and predicts this by higher experienced task demand in the sadness-prime condition, because sadness is associated with difficulty while happiness is associated with ease. The affect primes make the ease vs. difficulty concept accessible, which in turn influences the level of experienced task demand and corresponding effort. In the difficult task, this leads to the experience of being over-challenged in the sadness-prime condition, resulting in low effort due to disengagement. Consequently, effort is high in the happiness-prime condition, where task demand is experienced as high but feasible. Although the prime × difficulty cross-over interaction contrast was significant and the PEP response pattern corresponded to our hypothesis for the suboptimal prime condition, focused cell comparisons were only significant in the difficult condition. However, our previous studies have also found significant prime effects in easy task conditions. For the present study, the lack of a significant prime effect in the easy condition could be explained in terms of too low objective task difficulty, leaving little room for the affect primes to influence subjective demand during performance. The arithmetic task we have administered in the present study was new—we have never used it before and the original task version (Bijleveld et al., 2010) was not difficulty-manipulated. Although we have applied pre-tests to calibrate the easy and difficult levels, it is very likely that the easy version of the task was easier than anticipated.

In the optimal-prime condition, the prime effects were reversed, speaking for the reactance hypothesis. This is an important finding because it indicates that affect primes have to be processed implicitly to have their anticipated effect on effort-related cardiac response. If optimally presented primes induced affective states—which would be more likely than for suboptimally presented primes, because the optimal primes lead to more accessible affective information—we would have expected effects corresponding to those of conscious moods on mental effort (Gendolla, Brinkmann, et al., 2012 for reviews; see Gendolla & Brinkmann, 2005). However, the effects found were opposite. These findings lend further support to the IAPE model idea that effort mobilization is automatically influenced when affective cues are implicitly processed during task performance and that suboptimally presented affect primes have this effect without inducing explicit affect (Gendolla, 2012).

Among the cardiovascular activity indices assessed in the present study, only PEP reactivity—the most sensitive noninvasive index of beta-adrenergic sympathetic impact on the heart (Kelsey, 2011)—showed the significant three-way interaction effect of affect primes, task diffi-
The patterns of SBP and DBP responses corresponded to the PEP effects, but the three-way interaction was not significant there, meaning that the manipulation had weaker effects on theses indices. However, the discrepancy between effects on cardiac PEP and blood pressure is not surprising because PEP is the purest index of beta-adrenergic sympathetic impact among the assessed cardiovascular activity indices. Therefore, PEP is the prime measure of effort (Kelsey, 2011; Obrist, 1981; Wright, 1996), although cardiac contractility has also a systematic impact on blood pressure, especially on SBP by its impact on cardiac output. Numerous studies have found significant effort-related effects on SBP reactivity (see Gendolla & Richter, 2010; Wright & Kirby, 2001 for reviews). But it is to note that blood pressure is also influenced by peripheral vascular resistance and can be masked by it. That is, predicted effects on PEP in absence of accompanying effects on blood pressure are not surprising. The reason to assess PEP is its higher sensitivity for manipulations of task difficulty (Richter et al., 2008). Also the lack of effects on HR is not problematic. HR is determined by the independent influences of the sympathetic and parasympathetic nervous systems and should only reflect effort mobilization to the degree to which HR is determined by sympathetic arousal rather than parasympathetic withdrawal. In cognitive tasks, which usually elicit rather small changes in HR, parasympathetic withdrawal is more likely (cf. Berntson, Cacioppo, & Quigley, 1993). Most relevant, we have not found evidence for PEP effects and simultaneous decreases in blood pressure or HR. Therefore the present PEP effects can hardly be explained by pre- or afterload effects, allowing the conclusion that they were caused by beta-adrenergic impact (see Sherwood et al., 1990).

In the present study, effects on the measure of subjective demand assessed after the task only partially corresponded to the pattern one could anticipate according to the IAPE model (Gendolla, 2012). According to this theory, affect primes influence perceived task demand which in turn determines the amount of mobilized effort according to the principles of motivational intensity theory (J. W. Brehm & Self, 1989). Previous studies found evidence for this idea (Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013; Silvestrini & Gendolla, 2011b). Accordingly, one could expect lower demand ratings in the happiness-prime/easy condition than in the sadness-prime/easy condition. This was also what we found. However, when the task was difficult, one could again expect higher demand ratings in the sadness-prime condition than in the happiness-prime condition. Surprisingly, these ratings were reversed: demand was rated as higher in the happiness-prime than in the sadness-prime cell. In the optimal-prime condition, effects on subjective demand were not significant. However, it is important to note that the IAPE model posits that affect primes have a systematic impact on experienced task demand during task performance, i.e. when effort is mobilized. But the task demand ratings in the present study were assessed after performance, and it is known that retrospective judgments can suffer from a number of biases (see Robinson & Clore, 2002). Given the previous evidence for affect primes effects on subjective demand, we can only attribute the effect in the suboptimal-prime/difficult condition to chance. Most important is that our main dependent variable assessing effort—cardiac PEP—showed the expected effect. This can be hardly explained by higher experienced demand in the happiness-prime/difficult condition than in the sadness-prime cell. Assessing subjective demand during task performance is barely possible with self-report measures. Consequently, we have to leave it for future studies to test for implicit associations between implicit affect and the difficulty and ease concepts, posited by the IAPE model, using appropriate methods (see De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009).

Our task performance measures—response accuracy and reaction times—did not reveal any significant effects. Even if some of our lab’s previous studies found performance effects that corresponded to effort-related cardiovascular response (e.g., Gendolla & Silvestrini, 2010, 2011;
Lasauskaite et al., 2013), it is of note that we had not predicted any manipulation effects on response accuracy or reaction speed. Even if some researchers consider speed and accuracy as indicators of effort (e.g., Bijleveld et al., 2010), it should be noted that effort and performance can be dissociated. Effort is the mobilization of resources for instrumental behavior, while performance is the outcome of behavior. Performance depends on more variables than effort—at least ability and strategy use are important additional factors (Locke & Latham, 1990). Thus, in short, there is no direct link between mental effort and task performance and thus a lack of performance effects in correspondence to effort is hardly surprising.

Finally, it is of note that our mood measures did not provide any evidence that the happiness and sadness primes might have induced conscious happiness- or sadness-related states. Neither the results in the suboptimal nor in the optimal prime presentation condition speak for the possibility that the primes induced emotional feelings in a prime-congruent way. Also our previous studies did not find any evidence that suboptimal affect primes induced emotional feelings (Freydefont et al., 2012a; Freydefont & Gendolla, 2012; Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013; Silvestrini & Gendolla, 2011a, 2011b). This lack of evidence for prime effects on conscious affect go along with one of the main ideas of the IAPE model, according to which it is not necessary for the affect primes to induce conscious affect to have influence on mental effort. It is sufficient to activate emotion knowledge about the typical performance ease or difficulty of different emotional states, which is then used for the subjective task demand appraisals in the context of cognitive challenge (e.g., Lasauskaite et al., 2013).

To summarize, the results of the present study demonstrate differential effects of suboptimally versus optimally presented affect primes on effort-related cardiac response. Our findings do, on the one hand, replicate the previously found combined effect of suboptimally presented affect primes and objective task difficulty on effort mobilization (Freydefont et al., 2012a; Silvestrini & Gendolla, 2011b). Most relevant, the present study found that optimally presented affect primes turn this effect on its head, reflecting prime-contrast effects on effort-related cardiac response, speaking for the idea that explicit affective cues can elicit reactance (J. W. Brehm, 1966) rather than inducing prime-congruent conscious affect. To conclude, the present results lend further support to the IAPE model (Gendolla, 2012) idea that effort mobilization is automatically influenced by implicitly processed affective cues and that suboptimally presented affect primes have this effect without inducing explicit affect (Gendolla, 2012).
Chapter 5. Implicit sadness-difficulty and happiness-ease associations

Abstract

The present experiment tested the idea of implicit associations between happiness and the performance ease concept, and between sadness and the performance difficulty concept. The study applied a sequential priming paradigm: participants categorized facial expressions as positive or negative. These targets were preceded by suboptimally presented ease- or difficulty-related words or neutral non-words as primes. As predicted, the experiment revealed that reaction times in the sequential priming task increased from congruent (ease/happiness and difficulty/sadness) to incongruent (ease/sadness and difficulty/happiness) trials. The neutral prime control condition fell in between. The findings provide evidence for implicit associative links of happiness with ease and sadness with difficulty, as posited by the implicit-affect-primes-effort model (Gendolla, 2012).

Introduction

A recent series of studies has revealed replicated evidence that suboptimally presented affective stimuli that are processed during task performance systematically influence effort mobilization, operationalized as cardiac response (e.g., Freydefont et al., 2012a; Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013). Participants who processed sadness primes during a cognitive task mobilized more resources than participants who processed happiness or anger primes. According to the implicit-affect-primes-effort (IAPE) model (Gendolla, 2012)—the theoretical framework guiding this research—this systematic impact of affect primes on effort mobilization

\[8\] This chapter is based on Lasauskaite, R., Gendolla, G. H. E., Bolmont, M., & Freydefont, L. (2012). Evidence for implicit happiness-ease and sadness-difficulty associations. Manuscript in preparation. The mentioned manuscript reports two studies, one of which is based on research conducted for the Master thesis by Mylène Bolmont. For ethical reasons this study is not reported in this doctoral thesis as it has already served for obtaining another scientific degree.
is explained by their impact on experienced task demand. Affect primes are supposed to activate mental representations of affective states (i.e. implicit affect) and accessible and applicable knowledge in terms of features of the affect concept can then influence behavior.

Given that resource mobilization is guided by the general principle of energy conservation (J. W. Brehm & Self, 1989), especially accessible information about performance ease or difficulty is applicable to the self-regulation of effort mobilization. The IAPE model suggests that people have acquired knowledge about performance ease and performance difficulty as typical features of different affective states. Rendering this knowledge accessible results in experiences of lower or higher subjective demand, which influences effort, because people mobilize resources in proportion to subjective demand as long as success is possible and justified (J. W. Brehm & Self, 1989; see Gendolla, Wright, et al., 2012 for a recent review). Some affect primes like happiness and anger activate the ease concept, while others like sadness or fear activate the difficulty concept as features of their mental representation. That way, different affect primes have different systematic effects on effort mobilization due to their impact on subjective task demand. That is, the core idea of the IAPE model is that of the existence of implicit associative links between individuals’ representations of different affective states and performance ease or difficulty.

In support of the IAPE model logic, some of our studies have found that participants who processed sadness primes during task performance rated subjective task demand indeed as higher than participants who processed happiness (or anger) primes (Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013; Silvestrini & Gendolla, 2011b). But although all of our published studies revealed the predicted affect prime effects on effort mobilization, some of those experiments did not find significant prime effects on post-performance ratings of subjective demand (Freydefont et al., 2012a; Freydefont & Gendolla, 2012; Silvestrini & Gendolla, 2011a). One can argue that zero-effects, like nonsignificant prime effects on demand ratings, are hardly interpretable and may be ignored. But also for the obtained significant affect prime effects on subjective demand evaluations it is to note that those ratings were retrospective judgments, which are very vulnerable for a number of biases (Robinson & Clore, 2002). Most relevant, the IAPE model posits that affect primes influence subjective task demand directly during performance. This is hardly assessable with self-report measures for which it would be necessary to interrupt task performance. Thus, more direct measures of associative links between implicit sadness and difficulty and between implicit happiness and ease are called for (see De Houwer et al., 2009; Nosek, Hawkins, & Frazier, 2011 for overviews).

The present research addressed this issue by assessing implicit links between individuals’ representations of two types of affect and the concepts of ease and difficulty which are central for the IAPE model explanation for affect prime effects on effort mobilization. We did so by applying a sequential priming paradigm (see Wentura & Degner, 2010), in which the presentation of one stimulus—the prime—facilitates (or impairs) the accessibility and thus the categorization of a following stimulus—the target—to the degree to which the stimuli-related concepts are associated (or dissociated) in memory. Referring to affective stimuli, sequential priming has been frequently applied for assessing the implicit evaluation of target stimuli (see Klauer & Musch, 2003 for a review). For example, Hermans, De Houwer, and Eelen (1994) used a variant of the sequential priming paradigm and found that target words were faster categorized as positive or negative if they were preceded by a prime word of the same valence (i.e. congruent trials). By contrast, categorizations were slower when the target words were preceded by a prime of the opposite valence (i.e. incongruent trials). These findings fit the automatic evaluations model (see Fazio, 2001 for a review), which posits that the presentation of a stimulus can auto-
matically activate its associated evaluation in memory. However, sequential priming with affective stimuli can assess more than the implicit evaluation of target stimuli by activating the representation of an affect category and assessing the degree of assimilation of target words. Sequential priming can assess any existing implicit association between primes and targets. One way to assess the strength of associative links between affect categories and other concepts is to invert the order of affective stimulus and the target. That is, one can use the non-affective concept as prime and the affective stimulus as target to assess the associative link between both concepts.

In the present research, we applied sequential priming to assess if there are implicit associative links between two emotion categories—sadness and happiness—and the concepts of performance ease and difficulty. We did so to examine the idea that performance ease is part of the emotion knowledge about happiness and that performance difficulty is part of the emotion knowledge about sadness (see Niedenthal, 2008). To test this idea, we administered ease- and difficulty-related words as primes and sadness- and happiness-related stimuli as targets. If the IAPE model logic about implicit associative links of sadness with difficulty and of happiness with ease is correct, response times for correct target categorization should be faster in congruent trials (ease/happiness and difficulty/sadness) compared to incongruent trials (ease/sadness and difficulty/happiness) with the neutral prime control condition falling in between.

Method

Participants and design

Forty first-year psychology students (36 women) participated for course credit. Seven students were not native French speakers and consequently excluded from the analysis, leaving $n = 33$ participants as final sample (average age 20 years). The design was 3 (prime: ease, neutral, difficulty) × 2 (target: happy, sad) × 2 (block: block 1, block 2) within-persons.

Stimuli and randomization

Based on a pretest, we selected 4 ease-related French words (translation: easy, evident, relaxed, simple) and 4 difficulty-related words (translation: difficulty, complex, complicated, testing) as primes, and created 4 neutral primes by jumbling the letters of prime words (aina, sornel, sempale, epreviens\(^9\)). Targets were six pictures of sad and six pictures of happy facial expressions of three women (no. 16, 22, 31) and three men (no. 10, 46, 71) taken from the Radboud Faces Database (RaFD). The chosen happiness and sadness expressions had the highest emotion recognition scores in the database validation study (Langner et al., 2010). One experimental block consisted of 144 trials, i.e. all possible combinations of 12 primes × 12 targets, which were pseudo-randomized: the same prime and the same target were not presented successively.

\(^9\)French words that were originally used as ease-related prime words: aisé, evident, relax, simple; difficulty-related prime words: ardu, complexe, compliqué, éprouvant.
Implicit sadness-difficulty and happiness-ease associations

Procedure

The study was run in individual sessions. After having obtained signed consent, participants had to correctly categorize as quickly as possible if the target faces expressed a rather positive or rather negative emotional state by pressing respective response keys. Each of the two blocks, which were separated by a 30 sec. break, took about 10 minutes. Trials started with a fixation cross (500 ms), followed by a prime word (52 ms), which was backward-masked with a series of "X" letters (133 ms). Then a target picture appeared for maximally 1500 ms during which participants had to respond. After the response, the message "response entered" appeared for 2000 ms minus participants’ response time. The inter-trial interval varied between 500 and 1500 ms. Consequently, the blocks had the same duration for all participants, regardless of their response speed. The task was preceded by 16 training trials with correctness feedback, consisting of neutral primes and other sadness and happiness expressions as targets than those presented in the main task. No feedback was given during the main task.

Results

Response times

Due to a skewed distribution, we analyzed square root transformed response times of correct target categorizations but report, for the sake of easier interpretation, results in milliseconds. Response time scores for congruent, incongruent, and neutral control trials were created as in the first study.

Congruency effects

A contrast × block ANOVA revealed the expected significant linear contrast main effect, $F(1, 32) = 4.907, p = .034, \eta^2_p = .133$. As depicted in Figure 9, reaction times linearly and symmetrically increased from congruent ($M = 599.17, SE = 15.38$) to incongruent trials ($M = 606.69, SE = 15.41$) with the neutral control condition ($M = 602.94, SE = 15.08$) falling in between.

Neither the orthogonal quadratic contrast ($p = .983$), nor any block main effects or contrast × block interactions ($ps > .168$) approached significance. This reflects a significant sequential priming effect: congruent trial composed of difficulty-related primes and sadness-related targets and ease-related primes and happiness-related targets were faster processed than incongruent trials, consisting of difficulty-related primes and happiness-related targets and ease-related primes and sadness-related targets.
Figure 9. Average response times in congruent (ease/happiness and difficulty/sadness) vs. neutral (non-word/happiness and non-word/happiness) vs. incongruent (ease/sadness and difficulty/happiness) sequential priming task trials (in milliseconds). Error bars indicated standard errors of the means.

Decomposed prime × target analysis

To test if the above-discussed sequential priming effect was carried by specific prime-target configurations, we further analyzed the response times with a 3 (prime) × 2 (target) × 2 (block) repeated measures ANOVA. This analysis revealed again a target main effect, $F(1,32) = 11.63, p = .002, \eta^2_p = .267$. Participants generally categorized happiness targets faster ($M = 594.74, SE = 15.47$) than sadness targets ($M = 611.13, SE = 15.25$). More relevant, the prime × target interaction was also significant, $F(2,31) = 3.34, p = .048, \eta^2_p = .177$. As expected, participants categorized happiness targets faster in the ease-prime condition ($M = 591.74, SE = 15.76$) than in the difficulty-prime condition ($M = 598.06, SE = 16.03$), with the neutral prime condition falling in between these two conditions ($M = 594.41, SE = 15.26$). By contrast, categorization of sadness targets was faster in the difficulty-prime condition ($M = 606.61, SE = 15.86$) than in the ease-prime condition ($M = 615.32, SE = 15.39$). The neutral-prime condition fell in between ($M = 611.47, SE = 15.65$). The prime × target × block interaction was not significant ($p = .501$).

We decomposed the prime × target interaction by calculating difference scores and subtracted response times for happiness targets from those for sadness targets. The categorization speed advantage for happiness targets decreased again linearly and symmetrically from the ease-prime ($M = 20.50, SE = 4.41$) via the neutral-prime ($M = 13.38, SE = 6.20$) to the difficulty-prime condition ($M = 7.91, SE = 6.59$), as evident in a significant linear contrast, $F(1,32) = 4.90, p = .034, \eta^2_p = .133$. The orthogonal quadratic effect was not significant ($p = .878$).

Response accuracy

Participants responded correctly and without exceeding the response time window in $M = 97.54\% (SE = 0.50)$ of the trials. Neither a 3 (congruency) × 2 (block) ANOVA ($ps > .17$), nor a 3 (prime) × 2 (target) × 2 (block) ANOVA found any significant effects on response accuracy ($ps > .08$).
Discussion

Using a sequential priming paradigm, the present experiment supports the idea of existing implicit associative links between individuals’ representations of sadness and the concept of performance difficulty as well as between representations of happiness and the performance ease.

The present study was based on the IAPE model (Gendolla, 2012) that explains how implicit affect influences mental effort. Accordingly, affect primes activate mental representation of affective states (i.e. implicit affect), which in turn render associated knowledge about performance ease vs. difficulty accessible. This activated knowledge is applicable in achievement situations, because task performance needs resources and resource mobilization is guided by an energy conservation principle (J. W. Brehm & Self, 1989). People avoid mobilizing more resources than necessary and therefore look for hints about task demand (see Gendolla, Wright, et al., 2012 for a recent review). According to the IAPE model, implicit affect can inform about subjective demand, because it activates representations of performance ease or difficulty. The present study provides support for this hypothesis.

Additionally to the predicted congruency effects, the present experiment found a significant target main effect: happiness-related target stimuli were categorized faster than sadness-related targets. Although we had not predicted higher general accessibility of the happiness concepts, this main effect is not surprising. In accordance with the afore mentioned density hypothesis (Unkelbach, Fiedler, Bayer, Stegmüller, & Danner, 2008), according to which positive information is represented in higher density than negative information, other studies have found that positive stimuli are faster recognized than negative stimuli. Research on the recognition of facial expressions of emotions has, for example, revealed that happiness expressions are faster recognized than negative stimuli. Research on the recognition of facial expressions of emotions has, for example, revealed that happiness expressions are faster recognized than sadness, anger, disgust, or even neutral expressions (see Kiritu & Endo, 1995; Leppänen & Hietanen, 2003). Concerning faces, it has been argued that this “happy face recognition advantage” occurs primarily at cognitive processing states (Leppänen, Tenhunen, & Hietanen, 2003) and that it may reflect a higher-level asymmetry in the recognition and categorization of emotionally positive and negative signals in general. However, the target main effect in the present studies did not interfere with our predictions about implicit associations between sadness and difficulty and between happiness and ease. As evident in the calculated differences in categorization speed of happiness-related and sadness-related targets in the three prime conditions, this higher accessibility of the happiness concept merely added a constant to the expected sequential priming effect.

In contrast to the here reported study, our experiments on the impact of affect primes on mental effort (e.g., Freydefont et al., 2012a; Gendolla & Silvestrini, 2011; Lasauskaite et al., 2013; Silvestrini & Gendolla, 2011b), administered affective stimuli as primes and not as targets. In fact, in our effort-priming paradigm there are no targets—the administered tasks do not apply sequential priming. Rather, we have assessed prime effects on general cognitive performance. However, it may be surprising that we have not used affective stimuli as primes and ease- and difficulty-related words as targets in the present studies. The reason for this is twofold. (1) Using affective stimuli as primes may result in assessment of implicit evaluations of target stimuli rather than assessment of the mere implicit prime-target (or target-prime) association. Affective stimuli are usually used as primes to activate an evaluative category (positive or negative) and assessing the degree of assimilation of target stimuli to those categories in order to assess the targets’ implicit evaluation, e.g. as a measure of implicit attitudes (see Fazio, 2001). Using non-affective stimuli as primes can prevent this, because non-affective primes should activate a se-
mantic category rather than an evaluation. (2) Sequential priming needs target stimuli that are easy to categorize in order to assess implicit associations between primes and targets. It appears that categorizing the valence of stimuli is the easiest and least ambiguous categorization (e.g., Murphy & Zajonc, 1993; Zajonc, 1980). Maybe because of this, categorizing the valence of target stimuli appears to be the most frequently applied task in sequential priming (see Klauer & Musch, 2003)—in fact researchers have just recently started to ask participants for other, emotion-specific rather than valence-specific categorizations (e.g., Rohr, Degner, & Wentura, 2012). However, associative links between two concepts exist—by definition—in both ways. Consequently, assessing the link between non-affective primes and affective target stimuli is an appropriate measure of the associative strength between both concepts.

The here presented study investigated the implicit associative links of sadness with difficulty and happiness with ease. However, it is of note that representations of more than these two types of affect are relevant for the IAPE model (Gendolla, 2012). In fact, the model makes predictions for any type of implicit affect that is linked to representations of performance difficulty and performance ease. Prominent examples are anger and fear. As found in our studies on implicit affect influences on mental effort, anger primes result in lower task demand than sadness primes (e.g., Gendolla & Silvestrini, 2011). Therefore, anger should be associatively linked to ease. By contrast, fear is associated with experiences of low coping potential (Lerner & Keltner, 2001). Therefore, it should be associatively linked to difficulty. However, the present experiment is the one of the first studies that tested the idea that implicit affect is systematically linked to the ease vs. difficulty concepts. We leave it to futures studies to test the implicit associative links between more types of implicit affect and performance ease and difficulty.
Chapter 6. General discussion

The present thesis aimed to investigate the informational value carried by implicitly processed sadness and happiness primes in their influence on mental effort, as proposed by the IAPE model (Gendolla, 2012). This model explains how implicit affect influences mental effort—operationalized as cardiovascular reactivity—through its effects on subjective demand in the context of task performance. Each of the four studies of this thesis addressed some aspect of this process. In summary, the present research brought evidence for nonaffective ease and difficulty feelings induced by affect primes (Study 1), speak against induced emotional feelings (Studies 2 and 3), and demonstrated implicit associative links between sadness and difficulty and between happiness and ease (Study 4). In this chapter, the findings and alternative explanations are integrally discussed. Finally, some ideas for possible future research are brought to attention and limitations are considered.

Main results

Stronger effort-related cardiac PEP reactivity was found in the sadness than in the happiness prime conditions of the first two studies (chapters 2 and 3), whereas affect primes moderated task difficulty effects on effort in the third study. Most important, the here presented experiments extended the research on the IAPE model by clarifying the role of nonaffective ease or difficulty feelings and the role of affective states. Moreover, evidence for implicit links between sadness and difficulty and between happiness and ease concepts was found.

Prime effects on effort

The IAPE model (Gendolla, 2012) predicts that, as long as success is possible and justified, implicit sadness leads to high effort whereas implicit happiness leads low effort through implicit effects’ influence on experienced demand. In Studies 1 and 2, replicating previous findings (Gendolla & Silvestrini, 2011; Silvestrini & Gendolla, 2011a), effort-related cardiac PEP reactivity was stronger in the sadness-prime condition than in the happiness-prime condition. According to the IAPE model, this effect is explained by affect primes’ influence on task demand appraisals: primes automatically activate sadness- and happiness-related knowledge that, among other information, includes information about performance difficulty (for sadness primes) or ease (for happiness primes) that is typical in those states. This information then serves as indication for experienced task demand that determines mobilized effort: high experienced demand leads to high mobilized effort while low experienced demand leads to low mobi-
lized effort. In short, in first two studies, sadness-primes led to high effort while happiness-primes led to low effort.

Most relevant, in order to demonstrate the importance of experienced demand, the first study employed a discounting paradigm and revealed evidence that nonaffective feelings of performance ease or difficulty play a role in affect primes’ effect on effort. Informing participants that task presentation properties might influence their sense of task difficulty or ease diminished the effect of higher effort in the sadness-prime condition, as evident in focused cell comparisons. In sum, the results of the first study of this thesis brought evidence for the role of nonaffective feelings of performance ease or difficulty and supported the mechanism proposed by the IAPE model.

Following the logic of the IAPE model, affect primes moderate task difficulty effects on mental effort (Silvestrini & Gendolla, 2011b). Study 3 demonstrated that effort-related cardiac PEP reactivity was stronger in a sadness-prime condition than in a happiness-prime condition when the task was easy, but weaker than in the happiness-prime condition when the task was difficult. This moderating effect was again explained by prime influences on experienced task demand. More specifically, when the task was easy, sadness primes activated sadness-related knowledge including information about performance difficulty. Integrating this information into the evaluative judgment about task demand led to higher experienced task demand and thus higher effort than happiness-primes. However, when the task was difficult, sadness-primes led to experienced task demand that was higher than justified and thus the person disengaged (low effort). By contrast, the task seemed difficult but feasible in the happiness-prime condition and participants remained engaged (high effort). Thus, implicit affect moderated task difficulty effects on effort: implicit sadness led to higher effort than implicit happiness when the task was easy, but to lower effort than implicit happiness when the task was difficult.

Besides the effects of suboptimal (implicit) affect stimuli, Study 3 also tested the effects of optimally presented (explicit) affect stimuli on mental effort. The results revealed that in the optimal prime condition the effects on effort mobilization were opposite to those in the suboptimal prime condition. These results support the psychological reactance hypothesis (J. W. Brehm, 1966): Due to a correction process, optimally presented affect primes had opposite effects on cardiac reactivity than suboptimal primes. Clearly visible primes provided participants with the feeling to be manipulated and elicited reactance that led to behavior correction effects in order to restore freedom.

To sum up, three studies demonstrated systematic prime effects and a moderating effect of implicit affect on objective task difficulty’s effect on effort-related cardiac PEP response. In addition, Study 1 brought evidence that prime effects are carried by subjective demand. Taken together, these results supported the predictions of the IAPE model and replicated and extended previous findings.

**Prime effects on experienced demand**

According to the IAPE model (Gendolla, 2012), affect primes influence mental effort through their effects on experienced demand: The higher perceived demand, the higher is effort, as long as success is possible and justified. This prime effect, as discussed above, was diminished by providing an external source for nonaffective difficulty or ease feelings in Study 1. Affect prime effects on self-reported demand were expected to accompany the affect prime effects on effort-related cardiac reactivity. Through the experiments of this thesis, the prime effects on subjective task demand were, however, not consistent. In Study 1, although primes had effects
on cardiac PEP reactivity, there was no evidence that they affected perceived task difficulty or capability. In Study 2, however, the primes had effects on averaged task demand-related ratings (difficulty, inversed capability, and effort) that correspond to cardiac PEP reactivity: Participants found the concentration task more demanding when presented with sadness-primes than when presented with happiness-primes. Thus, the results of the Study 2 go along with the predictions of the IAPE model and speak for the idea that mobilized effort is proportional to perceived task demand. Finally, the demand ratings of the Study 3 only partially reflected the predictions. In the suboptimal prime presentation condition, when the task was easy, task difficulty ratings were, as expected, higher in the sadness-prime than in the happiness prime condition. In the difficult task, the ratings were higher for the happiness-prime condition compared to the sadness-prime condition while they were actually expected to be higher in accordance with the higher mobilized effort. In sum, although the IAPE model predicts that effort is determined by experienced demand as long as success is possible and justified, the self-report measures of task demand were not consistent. However, verbal ratings were not primary measures in testing the predictions of the IAPE model because they have certain limitations.

The fact that the results on those ratings were not consistent across the studies—neither in this thesis nor in previous research of our lab (see Gendolla, 2012 for a review)—and were ambiguous is not very surprising if one considers limitations of self-report measures in the context of the IAPE model. First, the null results of the first study cannot be interpreted as evidence for the absence of effects. Second, retrospective self-report measures are known to be biased (Robinson & Clore, 2002) and thus not reliable. Mainly for this reason, verbal measures are not main measures in this research. Third, according to the IAPE model, the primes should have their effects on perceived difficulty during the task. Therefore, the implicit affect cues are integrated into task trials. Thus, retrospective measures were not accurate in the sense that they did not reflect the processes that were happening during task performance when people were exposed to the affect primes. The post-task demand ratings assessed remembered experiences. Thus, taking into account these limitations, it is neither surprising nor problematic that the effects on perceived task demand were not consistent.

Investigating the role of experienced demand in the implicit affect's influence on effort, the results of the first study have a critical role. As discussed above, they demonstrated that providing a cue for a possible manipulation of demand experiences diminished the prime effect. This experimental effect provides more conclusive evidence for prime effects on nonaffective feelings of difficulty or ease than self-report measures assessed after task performance.

Relating prime effects to implicit associations

Besides verbal task demand reports and evidence for feelings of difficulty or ease, the Study 4 provided evidence for the idea of the IAPE model that sadness and happiness primes activate affect-related knowledge that includes information about performance difficulty and ease. More specifically, the results of this study demonstrated that sadness is related to difficulty and that happiness is related to ease. Within a sequential priming paradigm, participants recognized sad or happy facial expressions faster when they were coupled with a congruent ease or difficulty prime-word (sadness/difficulty and happiness/ease) than when they were coupled with an incongruent prime-word (sadness/ease and happiness/difficulty) with neutral trials in between (sadness/non-word and happiness/non-word). In conclusion, the results of this behavioral study support the idea of the IAPE model that sadness-stimuli are associated with difficulty-related information while happiness-stimuli are associated with ease-related information.
Affect primes and mood

The experimental paradigm of the first three studies included measures of possible mood changes due to prime effects on consciously experienced affective states. The question of explicit affective states is important because, first, the IAPE model posits that implicit affect cues influence effort without inducing explicit affective states. Second, even if the effects of conscious affective states (e.g., moods; see Gendolla, 2000) on mental effort correspond to those of implicit affect, the proposed mechanism is different from that posited in the IAPE model. Moods as subjective affective states have their effects due to their informational impact on evaluative judgments, because people base those judgments on their subjective affective state (Abele, 1995; Gendolla, 2000): a task seems to be more difficult in a sad mood than in a happy mood. The IAPE model predicts that affect primes have their effect on effort without conscious emotional feelings. No study of this thesis found evidence that sadness or happiness primes influenced affective experiences in a prime-congruent way.

In light of this reasoning, the second study focused on possibly induced emotional feelings by affect primes not only by measuring mood changes throughout the experiment, but by applying a discounting paradigm. This paradigm allows testing the possible role of emotional feelings: affective states, if attributed to an external source, loose their informational value (Clore, 1992). The results revealed that the prime effects remained when participants received the information that “flickers” appearing in the context of the task might influence their emotional state—the procedure that normally leads to diminished mood effects on effort (Gendolla & Krüsken, 2002b). These results speak for the idea of the IAPE model that implicit affect has its effects on effort without inducing conscious emotional feelings.

To further develop the question of the possible role of explicit affective states in prime influences on effort, the Study 3 manipulated the presentation time of the prime stimuli (suboptimal/brief versus optimal/long). If the affect primes induce affective states, a long prime presentation should lead to stronger reactions because longer presented primes have higher potential to induce conscious affective reactions. In addition, if this is true, prime-congruent mood changes were expected. However, the results showed opposite effects of optimal prime presentation on effort than those of suboptimally presented primes. Moreover, the mood measures did not reveal any prime-congruent changes in affective experiences. As discussed above, the results were interpreted as supporting the psychological reactance theory (J. W. Brehm, 1966). In conclusion, the findings of this experiment speak against the idea that affect primes might induce affective states and go along with the idea that affect primes have their effect on effort through activated specific affect-related knowledge, as predicted by the IAPE model.

Effort-related cardiovascular reactivity

Cardiac PEP was the main indicator of effort (Kelsey, 2011; Richter et al., 2008) in the here discussed studies and, as expected, reflected the predicted effects of affect primes, discounting manipulations, task difficulty, and prime presentation in all three experiments. Together with cardiac PEP, we also assessed blood pressure and HR. In first two studies, no significant effects appeared on blood pressure and HR measures. In Study 3, blood pressure measures showed prime × task difficulty interaction effects in a prime × task difficulty × prime presentation design. However, the found effects were not interpretable as prime-congruent effects. In
sum, the effort effects predicted by the IAPE model were well reflected in cardiac PEP reactivity, while no relevant effects were observed on blood pressure or HR reactivity.

Blood pressure and HR were mainly measured in order to be able to control for possible preload and afterload effects on cardiac PEP (Sherwood et al., 1990). Decreases in cardiac PEP were accompanied by general increases in blood pressure and HR. Thus, PEP reactivity could be interpreted as being caused by beta-adrenergic impact on the heart that reflected effort (Kelsey, 2011; Wright, 1996).

**Effort and task performance**

Some researchers consider task performance measures—response time and accuracy—to be indicators of mental effort (e.g., Bijleveld et al., 2010). In Studies 1 and 3 of this thesis, we did not find any effects of affect primes or task difficulty on task performance. In Study 2, primes had effects on reaction times, which corresponded to the effects on effort-related cardiac response: participants were faster and showed stronger cardiac PEP reactivity when presented with sadness-primes than when presented with happiness-primes. These results reflect a link between effort and performance. However, the IAPE model (Gendolla, 2012) does not make any predictions about prime effects on task performance measures. As discussed at the beginning of this thesis, effort is defined as the mobilization of resources in order to carry out instrumental behavior (J. W. Brehm & Self, 1989). Task performance is the outcome of this behavior. Moreover, the link between effort and performance is complex: performance depends not only on effort but also on ability and strategies (Locke & Latham, 1990). Thus, a link between effort and performance can be found but it is not predicted.

**Alternative explanations**

In this section, the results of the present studies are discussed in light of other approaches which might seem to be relevant for explaining the effects of implicit affect on motivation. The first one is proposed by Aarts and Custers (Aarts, 2007; Custers & Aarts, 2010) and is concerned with masked stimuli’s influences on goal pursuit. The second one is the embodiment approach (Niedenthal, 2007) that proposes that all cognitive and affective processes are linked to bodily reactions.

**Goal priming**

Aarts and Custers (Aarts, 2007; Custers & Aarts, 2010) proposed a model of nonconscious goal pursuit according to which positive affect is an implicit motivator and thus should increase motivation, i.e., energy for resource mobilization, or motivational intensity. According to this model, positive affective valence of goal representations leads to motivated goal-directed behavior. This happens because the positive valence of a goal gives a signal that the accessible goal is worth to be pursued. In one of the studies by Aarts (2007), participants who were previously subliminally primed with a goal of socializing performed faster in a mouse-clicking task with a possibility to win tickets for a party than those who were not primed with the goal of socializing. The authors interpreted working faster as working harder. In short, according to this model, a goal association with positive affect leads to working harder.

Following the logic of the nonconscious goal pursuit model, in the experiments of this thesis we should have expected higher performance (thus higher motivational intensity) in the
happiness-prime conditions compared to the sadness-prime conditions, because positive affect should lead to increased motivational intensity. However, in the first and third studies, there were no prime effects on task performance. Performance effects in the second study of this thesis were even opposite to this prediction: participants were faster in the implicit sadness condition than in the implicit happiness condition. In addition, Aarts and Custers do not distinguish between motivation and performance – working faster is considered as working harder. Nevertheless, this model can hardly explain the found affect prime effects on cardiac reactivity in our studies. These effects were also opposite to the possible predictions of Aarts and Custers model: we found higher effort in the implicit sadness condition than in the implicit happiness condition. Finally, the goal pursuit model by Aarts and Custers and the IAPE model by Gendolla differ conceptually: experimental settings constructed to test the IAPE model do not involve goals that are associated with certain affects. Thus, the nonconscious goal pursuit model cannot explain the effects of the experiments of this thesis.

**Embodiment**

The embodiment perspective (see Niedenthal, 2007 for a review) posits that perceiving or thinking about an emotion involves the “re-experiencing” of the specific emotion which includes perceptual and motoric processes. Thus, this approach deals with affect perception and with physiological reactions and for this reason it seems to be relevant to be discussed in the present research, which includes affect stimuli. According to the embodiment approach, sadness and happiness primes presented during the experiment should lead to simulations of sadness and happiness emotions. Consequently, physiological reactions in the sadness-prime condition should correspond to reactions experienced during sadness whereas physiological reactions in the happiness-prime condition should correspond to reactions experienced during happiness. However, physiological reactivity patterns obtained in our experiments were opposite to the physiological patterns that are typical for the specific affects: non-crying sadness is related to decreases in sympathetic withdrawal and thus decreases in HR, SBP, SBP, and MAP, while happiness is related to increases in cardiac activity (see Kreibig, 2010 for a review) Also, the embodiment approach is not concerned with effects on motivation. For these reasons, the IAPE model is much more appropriate in the context of the present experiments.

**Limitations**

Although the presented findings revealed important evidence for the mechanism proposed by the IAPE model, this research also carries several limitations. These limitations concern possible confounds of affect-related effects versus valence effects and the generalizability of prime effects.

The effects found in this work using prime stimuli of specific emotions—sadness and happiness—cannot be a priori distinguished from those of affect valence. The implicit associations between sadness and difficulty and between happiness and ease found in Study 4 are discussable. In that study, difficulty-related prime words might have facilitated recognition of sad faces because they are in general negatively valenced while ease-related prime words might have facilitated the recognition of happy faces, because they are in general positively valenced. Following this logic, the found effect could be interpreted as a simple affective priming effect (Fazio, 2001) and therefore future research should focus on testing implicit links between con-
cepts of ease/difficulty and other emotions in order to demonstrate that the effects found in Study 4 were rather due to the implicit links predicted by the IAPE model. Moreover, recent research by our lab (Freydefont et al., 2012a; Freydefont & Gendolla, 2012; Gendolla & Silvestrini, 2011) demonstrated that anger effects on effort mobilization correspond to those of happiness. Thus, it is important to test the links between difficulty and ease concepts and other emotions than sadness or happiness in the future research.

Another limitation concerns the priming stimuli: In all studies, we used the same averaged facial expressions from the AKDEF database (Lundqvist & Litton, 1998) to manipulate implicit affect. Although the IAPE model does not specify the type of affect cues, the results of this thesis do not provide generalized evidence of implicit affect on mental effort. The found effects should be replicated with other affect prime stimuli. These limitations are expected to be addressed in future research.

**Outlook**

The discussed limitations of the here reported studies bring us to the last section to suggest some ideas for possible future research. First, the predictions concerning the mechanisms proposed by the IAPE model (Gendolla, 2012) should be tested with a wider range of affect stimuli: (1) other kinds of stimuli than averaged emotional facial expressions and (2) stimuli representing other emotions than sadness and happiness. We expect replication of the here presented results with different kinds of stimuli – possibly emotion words (which might be problematic because word stimuli are higher order and the semantic processes are slower; Carr, McCauley, Sperber, & Parmelee, 1982), or other pictures of facial expressions in order to be able to generalize the effects. Second, studies using wider ranges of affect-cues than sadness- or happiness-related should be conducted. It is equally interesting and important to test the effects predicted by the IAPE model for other affects, for instance, fear or anger. Those two affects would be both classified as negative, but the predictions for fear and anger in the IAPE model are opposite. This way, implicit associations between fear and difficulty and between anger and ease would support the idea of the IAPE model about specific implicit affect influences on effort mobilization beyond affect valence and would extend and complement the results of Study 4.

Another suggestion for possible future research aims at refining the idea of the IAPE model that affect cues activate affect-related information – the first of four levels of the proposed mechanism in the model. The question then arises, which stimuli presentation properties lead to automatic activation of affect-related information and thus to effects on effort mobilization. Future research should aim at systematic investigating: (1) effects on effort of averaged facial expressions, photos of facial expressions, words and other possible prime stimuli (see, e.g., Freydefont, Gendolla, & Silvestrini, 2012b). (2) More tests of the role of prime presentation time are needed—which is also addressed in Study 3 (also see, e.g., Barbot & Kouider, 2012)—by possibly using material that allows higher temporal resolution for the prime presentation. (3) Different masking possibilities: masking duration, masking stimuli (e.g., neutral facial expression as mask; Maxwell & Davidson, 2004). Investigating those issues would allow refining the mechanism behind implicit affect by defining criteria for presentation of affect cues.
Conclusions

The results of the studies conducted in the context of the present thesis contribute to better understanding the impact of implicit factors on motivational processes. In the context of the IAPE model (Gendolla, 2012), which explains how implicit affect influences mental effort mobilization, the results of the present research provided evidence for the critical roles of non-affective feelings of performance ease or difficulty, but not for the involvement of explicit affective states. Furthermore, it was shown that implicit but not explicit affective cues influence on effort mobilization. Finally, the results also speak for the existence of implicit associations between the sadness and performance difficulty concepts and between the happiness and performance ease concepts. Taken together, the present research supports the ideas outlined in the IAPE model.
Résumé

Introduction


Théorie de l’intensité motivationnelle

Le modèle IAPE est basé sur la théorie de l’intensité motivationnelle de Brehm (1989). L’intensité motivationnelle, ou effort, est définie comme mobilisation des ressources pour effectuer un comportement instrumental (Gendolla & Wright, 2009). La théorie se base sur le principe de la conservation de l’énergie. Selon ce principe, nous évitons de gaspiller nos ressources et investissons seulement ce qui est nécessaire. Basée sur ce principe, la théorie de l’intensité motivationnelle prédit que l’effort est déterminé par la difficulté de la tâche aussi longtemps que la réussite est possible et justifiée : l’effort augmente avec la difficulté jusqu’à ce qu’elle devienne impossible ou à un point où la personne ne veut plus s’engager. Différents facteurs, comme, par exemple, l’humeur (Gendolla, 2000) ou la perception de ces propres capacités (Wright, 1998), peuvent rendre la tâche plus difficile ou plus facile.

Mobilisation de l’effort et réactivité cardiaque

Dans le cadre de cette thèse, l’effort a été opérationnalisé comme l’influence sympathique beta-adrénergique sur le cœur. Wright (1996) a intégré la théorie de l’intensité de la motivation avec l’approche de Obrist (1981) sur l’active coping et proposé que la réactivité cardiaque est proportionnelle à la difficulté de la tâche aussi longtemps que la réussite est possible et justifiée (Wright, 1996). Selon cet approche, la meilleure mesure non-invasive de l’effort est la réactivité cardiaque, surtout la période de pré-éjection (PEP ; la période de temps entre le début de la dépolarisation ventriculaire gauche et l’ouverture de la valvule aortique). Ainsi pour les études présentées dans cette thèse l’effort a été mesuré comme la réactivité de la PEP. Les changements de la pression sanguine systolique et diastolique ainsi que la fréquence cardiaque ont été mesurés pour vérifier les effets possibles de preload et afterload.
Modèle implicit-affect-primes-effort

Le modèle implicit-affect-primes-effort (IAPE; Gendolla, 2012) explique comment les affects implicites influencent la mobilisation de l’effort. L’affect implicite est défini comme l’activation automatique de représentations mentales d’expériences affectives. Parmi ces représentations, les connaissances sur la difficulté ou la facilité de la performance sont également activées. Par exemple, les amorces de la tristesse ou la peur activent les concepts liés à la difficulté de la performance ; les amorces de la joie ou la colère activent les concepts liés à la facilité de la performance (ex. Gendolla & Silvestrini, 2011). Dans le contexte de la performance d’une tâche cognitive la personne intègre toute l’information disponible pour déterminer l’exigence de la tâche afin d’adapter le niveau d’effort à investir. Les amorces affectives implicites contribuent à l’évaluation de la difficulté. De cette façon, les amorces de tristesse ou de peur déterminent la difficulté de la tâche perçue comme plus élevée alors que les amorces de joie ou de colère déterminent la difficulté de la tâche comme moins élevée ou plus facile. Donc, selon le modèle IAPE, les personnes à qui l’on présente des amorces de tristesse ou de peur vont investir plus d’effort et vont se désengager dans les niveaux plus difficiles de la tâche. Les personnes confrontées à des amorces de joie ou de colère vont investir moins d’effort et vont rester engagées dans les niveaux plus difficiles de la tâche. Le modèle prédit aussi que les amorces affectives implicites influencent la difficulté perçue, et par conséquent l’effort, sans pour autant induire de sentiments émotionnels.

Les effets de l’affect implicite sur la mobilisation de l’effort

Pour tester les prédictions du modèle IAPE (Gendolla, 2012), un paradigme développé par Gendolla et Silvestrini (2011) est utilisé. Typiquement, la session commence avec une phase de repos qui consiste d’un film neutre d’une durée de 8 minutes. Pendant cette phase d’habituation les mesures physiologiques sont prises afin de mesurer la baseline. Ensuite, les participants exécutent une tâche cognitive avec les amorces affectives intégrées dans chaque essai de la tâche. 1/3 des amorces sont affectives (tristes ou joyeuses dans les expériences de cette thèse), 2/3 des amorces sont neutres (la meilleure proportion selon Silvestrini & Gendolla, 2011a). Des images moyennes d’expressions émotionnelles (Lundqvist & Litton, 1998) d’hommes et de femmes ont été utilisées comme amorces. À la fin de la session les participants répondent à quelques questions finales, sont débriefés et reçoivent leur crédit ou rémunération.

Une série d’expériences a testé les effets prédits par le modèle IAPE. Les études de Gendolla et Silvestrini (2011; Silvestrini & Gendolla, 2011a) ont montré que les participants mobilisent plus d’effort quand ils sont présentés avec des amorces de tristesse pour l’exécution d’une tâche cognitive que quand ils sont présentés avec des amorces de joie ou de colère. Les amorces affectives activent automatiquement la connaissance liée à la difficulté ou la facilité de la performance et cela influence la difficulté subjective de la tâche et l’effort investi. De plus, les évaluations subjectives de la difficulté de la tâche ont été plus hautes dans la condition de tristesse que dans les conditions de joie ou de colère et cela correspond au pattern de la réactivité cardiaque.

L’affect implicite modère les effets de la difficulté objective de la tâche. Dans l’étude de Silvestrini et Gendolla (2011b), les participants ont mobilisés plus d’effort, mesuré en tant que réactivité cardiaque, dans la condition de l’amorce lié à la tristesse que dans la condition de joie quand la tâche était facile. Par contre, quand la tâche était difficile, cet effet était inverse : plus d’effort était mobilisé dans la condition de joie car pour la condition de la tristesse la tâche était
évaluée comme trop difficile et les participants se sont désengagés (mobilisation de l'effort basse). Dans l’étude de Freydefont, Gendolla et Silvestrini (2012a) des effets correspondants ont été montrés pour les amorces liés à la tristesse et colère.

**Objectifs de cette thèse**

L’objectif de cette thèse était d’investiguer les mécanismes prédits par le modèle IAPE à propos de l’influence des affects implicites sur la mobilisation de l’effort. Le modèle IAPE postule que :

- Les amorces affectives influencent l’effort par les sentiments non-émotionnels de difficulté ou facilité ;
- Les amorces affectives influencent l’effort sans sentiments émotionnelles conscients ;
- Le concept de tristesse est implicitement lié au concept de difficulté ; le concept de joie est implicitement lié au concept de facilité.

Ces mécanismes proposés par le modèle IAPE ont été testés dans quatre études.

**Le rôle des sentiments non-émotionnels de difficulté et de facilité**

Le but de cette expérience était d’investiguer le rôle des sentiments non-affectifs de difficulté et de facilité. Les sentiments non-affectifs, selon Clore (1992), sont les sentiments cognitifs qui en soi n’ont pas de la valence. Par exemples se sentir rassuré, se sentir confus, ou encore avoir faim. Dans le contexte d’une tâche cognitive, un sentiment de difficulté d’une performance devrait résulter à un effort plus élevé et un sentiment de facilité d’une performance devrait résulter à un effort moins élevé. Pour tester le rôle des sentiments de difficulté et facilité, nous avons appliqué le paradigme du discounting (Winkielman et al., 1997). Selon ce paradigme, un indice concernant une possible manipulation du sentiment de difficulté ou facilité devrait éliminer l’effet de l’amorce sur l’effort car les sentiments seront attribués à la source externe et ne vont plus influencer la perception de l’exigence de la tâche. Les participants ont effectué une tâche cognitive avec des amorces tristes ou joyeuses intégrés. La moitié des participants ont reçu un indice indiquant que la manière dont la tâche est présentée sur l’écran peut influencer leur sentiment sur la difficulté ou la facilité de la tâche. Cette manipulation devrait éliminer l’effet de l’effort plus grand dans la condition de tristesse que dans la condition de joie (voir Gendolla & Krüsken, 2002b) opérationnalisée en tant que la PEP cardiaque. Les résultats ont confirmés les prédictions : sans présentation de l’indice, les participants ont mobilisé plus d’effort dans la condition de tristesse que dans la condition de joie. Cependant, avec présentation de l’indice, il n’y avait pas de différence entre les conditions de tristesse et de joie. Pour conclure, cette étude a donné une évidence que les amorces d’affect induisent des sentiments non-affectifs sur la difficulté ou la facilité de la performance qui, à son tour, influencent la mobilisation de l’effort.
Rôle des sentiments explicites

Dans cette étude nous avons investigué le rôle potentiel des sentiments émotionnels dans l’impact systématique des stimuli implicites sur la mobilisation de l’effort mental. Nous avons appliqué le paradigme de discounting. Si les amorces induisent des sentiments émotionnels, un indice concernant la manipulation possible des sentiments devrait éliminer l’effet de l’effort plus haut dans la condition de tristesse que dans la condition de joie car les participants vont attribuer leurs sentiments à une source externe et ne plus les utiliser pour évaluer l’exigence de la tâche. Les participants ont travaillé sur une tâche d’attention pendant laquelle ils voyaient des amorces contenant des expressions de tristesse versus joie présentées de manière suboptimale. Avant la tâche, la moitié des participants ont reçu une indication que les flickers présentés pendant la tâche peuvent avoir une influence affective. L’effet prévu de cette manipulation était une réduction de l’impact des sentiments conscients sur la mobilisation des ressources. L’effort était mesuré en tant que réactivité de la PEP. Comme anticipé, les participants qui étaient présentés avec les amorces de tristesse ont mis plus d’effort que les participants présentés avec les amorces de joie. Dans la condition de l’indice, l’effet de l’amorce sur l’effort n’a pas été éliminé mais la réactivité cardiaque était généralement plus forte. Cet effet est interprété comme un poids cognitif plus important et ainsi la difficulté était plus élevée. Ce qui résulte à un effort plus important. Les résultats de cette étude n’ont pas amené d’évidence pour les sentiments émotionnels induits par les amorces.

Amorçage suboptimal versus optimal

Le but de cette expérience était de tester l’idée du modèle IAPE que les amorces ont un effet sur la mobilisation de l’effort quand ils sont implicites mais pas explicites. Pour tester cette prédiction, nous avons contrasté un amorçage suboptimal (brève durée) à un amorçage optimal (durée plus longue). L’effet de contraste qui était attendu dans la condition de la présentation optimale des amorces correspond à la théorie de la réactance (J. W. Brehm, 1966). Les amorces qui sont bien visibles donnent un sentiment d’être manipulé et donc de restriction de liberté. Cela résulte à une réactance et correction du comportement afin de reconstituer sa liberté. Pour cette raison le pattern opposé est prédit dans la condition de présentation optimale des amorces. Les participants ont effectué une tâche arithmétique soit facile soit difficile avec des amorces de tristesse ou de joie intégrés dans chaque essai. Les amorces étaient présentées brièvement (suboptimal) ou plus longtemps (optimal). Dans la condition de la durée suboptimale, les résultats correspondent aux prédictions et répliquent l’effet déjà démontré par Silvestrini et Gendolla (2011b): l’effort était plus important dans la condition de joie que dans la condition de tristesse quand la tâche était facile. Quand la tâche était difficile, le pattern était inversé : plus d’effort était investi dans la condition de joie mais moins dans la condition de tristesse car la tâche était évaluée comme trop difficile et les participants se sont désengagés. Dans la condition de la présentation optimale des amorces, le pattern était inversé en comparaison avec la condition de la présentation suboptimale (l’interaction triple était significative). Pour conclure, les amorces et la difficulté de la tâche ont des effets additifs sur l’intensité de l’effort, comme prédit par le modèle IAPE. Mais surtout, ces effets peuvent être démontrés seulement si les amorces sont implicites. Si les amorces sont présentées de manière explicite, les effets sur l’effort sont opposés grâce à la réactance psychologique.
Les associations implicites tristesse-difficulté et joie-facilité

La dernière étude présentée dans cette thèse a testé la prédiction du modèle IAPE que les amorces de la tristesse et de la joie ont un effet sur l’effort en activant automatiquement l’information liée à la difficulté ou la facilité. Pour tester ces prédicitions nous avons utilisé un paradigme d’amorçage séquentiel. La tâche des participants était d’identifier correctement et le plus vite que possible si l’expression du visage apparaissant sur l’écran était plutôt triste ou joyeux. Chaque image cible était précédée par un mot d’amorçage. Les mots étaient soit liés à la facilité, soit à la difficulté, ou encore des non-mots neutres. Si le concept de tristesse est lié au concept de la difficulté et le concept de la joie est lié au concept de la facilité, les participants devraient répondre plus rapidement dans les essais congruents (difficulté-tristesse et facilité-joie) et plus lentement dans les essais incongruents (difficulté-joie et facilité-tristesse) que dans les essais neutres (neutre-tristesse et neutre-joie). Les résultats ont soutenu l’hypothèse (le contraste linéaire était significatif). Pour conclure, cette étude confirme la prédiction du modèle IAPE que les amorces de la tristesse ou de la joie influencent l’effort en activant l’information liée à la difficulté ou facilité.

Discussion générale

Le but de cette thèse était d’investiguer les mécanismes prédits par le modèle IAPE (Gendolla, 2012). Quatre études ont adressé différents aspects de ce modèle.

Les résultats principaux

Trois des études présentées dans cette thèse se concentraient sur les effets de la tristesse implicite et de la joie implicite sur la mobilisation de l’effort, mesurée comme réactivité cardiaque. Nous avons répliqué l’effet de l’effort plus important dans la condition de tristesse que dans la condition de joie. Mais surtout, nous avons montré que l’affect implicite a un effet à cause de son influence sur l’évaluation subjective de la tâche (étude 1), sans induction de sentiments émotionnels (étude 2). De plus, les effets prédits par le modèle IAPE sont valables seulement si les amorces sont présentées de manière suboptimale (présentation brève), mais pas optimale (présentation plus longue) (étude 3). Finalement, nous avons montré que la tristesse est liée au concept de difficulté et que la joie est liée au concept de facilité (étude 4).

Dans toutes les trois études de cette thèse qui ont utilisé les mesures cardiovasculaires, seul les effets de la PEP correspondent aux effets prédits par le modèle IAPE (Gendolla, 2012). La PEP reflète les changements de l’influence sympathique beta-adrénergique sur le cœur et est considéré comme la mesure la plus sensible de l’effort. Les effets sur les autres mesures cardiovasculaires – pression sanguine systolique et diastolique et la fréquence cardiaque – n’étaient pas significatifs.

Les mesures rapportées sur la difficulté de la tâche n’étaient pas conséquents. Dans l’étude 1, il n’y avait pas d’effet significatif sur la difficulté subjective. Par contre, dans l’étude 2, les effets sur la difficulté rapportée correspondent aux effets sur la PEP. Dans l’étude 3, les effets sur la difficulté subjective ne correspondent pas aux effets sur la PEP dans la condition difficile. Le modèle IAPE prédit que les amorces influencent la mobilisation de l’effort par ces effets sur la difficulté subjective. Cette divergence observée dans l’étude 3 n’est pas surprenante car la difficulté est jugée pendant la performance quand la personne exécute la tâche alors que les mesures
sur la difficulté subjective sont prises après la tâche alors elles sont rétrospectives et ne reflètent pas l’exigence ressentie lors de la tâche. Pour cette raison les mesures rapportées de la difficulté subjective n’étaient pas considérées comme des mesures principales de l’effort.

Les mesures de la performance correspondaient aux effets sur la PEP dans l’étude 2 : les participants étaient plus rapides et ont mobilisé plus d’effort dans la condition de tristesse que dans la condition de joie. Dans les études 1 et 3, les amorces de tristesse et de joie n’ont pas eu d’effets significatifs sur la performance. Même si certains chercheurs opérationnalisent l’effort comme performance, nous ne confondons pas la mobilisation de ressources pour réaliser certain comportement ou l’effort avec les résultats de ce comportement ou la performance. Pour cette raison, le modèle IAPE ne prédit pas d’effets de l’affect implicite sur la performance.

**Limitations et perspectives**

Malgré des résultats importants en investiguant les mécanismes du modèle IAPE, la recherche de cette thèse porte plusieurs limitations. Premièrement, l’affect implicite dans les expériences de cette thèse concernait seulement la tristesse et la joie. Pourtant, les effets peuvent être interprétés comme liés à la valence des émotions et pas comme un lien entre les émotions et concepts de difficulté et facilité. Pour cette raison il serait nécessaire d’effectuer des études qui impliquent non seulement affect implicite de tristesse et de joie mais aussi, par exemple, la colère et la peur. Deuxièmement, dans les études sur l’effort présentées dans cette thèse, seulement les stimuli de la base de données AKDEF (Lundqvist & Litton, 1998) ont été utilisés. Il faudra également démontrer que les effets présentés dans cette thèse son généralisables sur les autres sortes de stimuli, par exemple, des images d’expressions émotionnelles, des mots liés aux émotions, etc.

**Conclusions**

Les résultats des études de cette thèse contribuent à une meilleure compréhension de l’influence des facteurs implicites sur les processus motivationnels. Dans le contexte du modèle IAPE (Gendolla, 2012) qui explique comment l’affect implicite influence la mobilisation de l’effort mental, les résultats de cette recherche apportent des évidences sur le rôle critique des sentiments non-affectifs de difficulté ou de facilité de la performance, mais pas pour une implication de l’état affectif explicite. De plus, nous avons montré que le modèle IAPE prédit les effets de l’amorçage implicite mais pas explicite. Finalement, les résultats montrent une évidence pour un lien implicite entre tristesse et difficulté ainsi qu’entre joie et facilité. Donc la recherche de cette thèse soutien les idées du modèle IAPE.
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