An emotional learning paradigm to investigate relevance detection

COPPIN, Géraldine

Abstract

A critical finding supporting the fear module theory (Öhman & Mineka, 2001) is the result according to which, during fear conditioning, resistance to extinction of enhanced SCRs is found towards pictures of evolutionary fear-relevant stimuli, but not towards pictures of fear-irrelevant stimuli (Öhman, Eriksson & Olofsson, 1975). The aim of the current research project was to test an alternative hypothesis, namely that the resistance to extinction is not specific to evolutionary fear-relevant stimuli but to all stimuli that are appraised as self-relevant to the organism. Therefore, in the current experiment, we established a positive conditioning procedure, and assessed the resistance to extinction for positive relevant stimuli and compared it to the positive conditioning of neutral stimuli. Our results showed a physiological response to an unconditioned positive stimulus and a change in arousal before and after the conditioning for the two conditioned stimuli. These findings are discussed in relation to emotional learning for relevant stimuli. Moreover, possible future investigations are suggested.

Reference


Available at: http://archive-ouverte.unige.ch/unige:1411

Disclaimer: layout of this document may differ from the published version.
Master’s thesis

An emotional learning paradigm to investigate relevance detection

Coppin Geraldine
coppin6@etu.unige.ch 0033 6 18 42 07 16

Under the direction of Sander David
Collaborators: Brosch Tobias, Delplanque Sylvain

Maîtrise universitaire en psychologie
2008
Abstract

A critical finding supporting the fear module theory (Öhman & Mineka, 2001) is the result according to which, during fear conditioning, resistance to extinction of enhanced SCRs is found towards pictures of evolutionary fear-relevant stimuli, but not towards pictures of fear-irrelevant stimuli (Öhman, Eriksson & Olofsson, 1975). The aim of the current research project was to test an alternative hypothesis, namely that the resistance to extinction is not specific to evolutionary fear-relevant stimuli but to all stimuli that are appraised as self-relevant to the organism. Therefore, in the current experiment, we established a positive conditioning procedure, and assessed the resistance to extinction for positive relevant stimuli and compared it to the positive conditioning of neutral stimuli. Our results showed a physiological response to an unconditioned positive stimulus and a change in arousal before and after the conditioning for the two conditioned stimuli. These findings are discussed in relation to emotional learning for relevant stimuli. Moreover, possible future investigations are suggested.

Keywords: Emotion; Positive conditioning; Fear module; Relevance; Skin conductance resistance; Baby

« Bébé. Créature difforme à l'âge, au sexe et à la condition indéterminés, hautement remarquable par la violence des sympathies et des antipathies qu'elle provoque chez les autres »
(Ambrose Bierce, Extrait de Le dictionnaire du diable)

« Lorsque le premier bébé rit pour la première fois, son rire se brisa en un million de morceaux, et ils sautèrent un peu partout. Ce fut l’origine des fées. »
(James Barrie, Peter Pan)
Abbreviations:
CS: Conditioned Stimulus
CSneu-hab: Neutral conditioned stimulus never paired with US (during habituation)
CSneu-acq: Neutral conditioned stimulus never paired with US (during acquisition)
CSneu-ext: Neutral conditioned stimulus never paired with US (during extinction)
CSneu+hab: Neutral conditioned stimulus paired with US (during habituation)
CSneu+acq: Neutral conditioned stimulus paired with US (during acquisition)
CSneu+ext: Neutral conditioned stimulus paired with US (during extinction)
CSpos-hab: Positive conditioned stimulus never paired with US (during habituation)
CSpos-acq: Positive conditioned stimulus never paired with US (during acquisition)
CSpos-ext: Positive conditioned stimulus never paired with US (during extinction)
CSpos+hab: Positive conditioned stimulus paired with US (during habituation)
CSpos+acq: Positive conditioned stimulus paired with US (during acquisition)
CSpos+ext: Positive conditioned stimulus paired with US (during extinction)
EC: Evaluative Conditioning
SCR: Skin Conductance Response
UCR: Unconditioned Response
US: Unconditioned Stimulus
PLAN:

1. Introduction

1.1. An evolved module of fear and fear learning

1.1.1. Seligman’s theory of the preparedness of phobias

1.1.2. Supports of the fear module’s theory

1.1.3. The amygdala as a fear module

1.2. An emotional learning for relevant stimuli, including fear-relevant stimuli, but not limited to them

1.2.1. Appraisal models of emotion

1.2.2. Criticisms of fear module’s theory

1.2.3. The amygdala as a “relevance detector”

1.3. An attempt to test the idea of a possible emotional learning for relevant positive stimuli

1.3.1. What is Evaluative Conditioning?

1.3.1.1. Definition of Evaluative Conditioning
1.3.1.2. Specificities of Evaluative Conditioning

1.3.2. Skin Conductance Resistance as an indicator of fear and relevance learning

1.3.3. Relevant findings in the literature

1.3.4. Aim of the experiment and hypotheses

2. Method

2.1. Participants and stimuli

2.2. Procedure and date analysis

3. Results

3.1. Behavioral results

3.1.1. Subjective ratings of pleasantness

3.1.2. Subjective ratings of arousal

3.2 Results for Skin Conductance Response

3.2.1. Main effects

3.2.2. Interaction effects
3.2.3. Test of our hypothesis

3.2.4. Other results

4. Discussion

References

Appendix

Acknowledgements
1. Introduction

As underlined by Olsson and Phelps (2007), “Learning about potentially harmful stimuli and events is critical in shaping adaptative behavior in a rapidly changing environment”. Evolutionary survival is increased if an organism can detect quickly potential threats. It is probably because of the critical nature of this feature for survival that many works had been lead on the detection and learning of fear stimuli. Researchers like Öhman and Mineka (2001) had proposed an evolved module for fear elicitation and fear learning, described as “a relavitely independent behavioral, mental, and neural system that is specifically tailored to help solve adaptative problems prompted by potentially life-threatening situations in the ecology of our distant forefathers” (p. 484). Nowadays, “Fear provides the most thoroughly examined neurobiological mechanism of emotional learning (Schiller & Phelps, in press).

But can we consider that only fear stimuli’s facilitated detection and learning have an advantage in an evolutionary meaning? A person that can detect food when he or she is hungry will clearly have enhanced chances of survival. In the same way, Brosch, Sander, Pourtois and Scherer (2008) underlined that “The care that parents provide for their newborn children is important for reproductive success and has high adaptive value” (p.364), and newborns are therefore relevant for the survival of the species, even they are not (generally) consider as fear stimuli.

The aim of the present study was precisely to show that a general appraisal mechanism based on relevance detection (independently of valence) could explain a facilitated learning for relevant stimuli, including fear-relevant stimuli, but not limited to them.

In the first part of the introduction, we will begin by Seligman’s works about the acquisition of phobias, which play an important role for the understanding of the theory of the fear module (Öhman & Mineka, 2001) that we will expose after, as well as the experimental evidences for this theory. We will discuss in particular the postulated function of the amygdala in this framework.
Contrary to the idea of the fear module, in the framework of the appraisal models of emotion, the idea that organisms could better learn associations for relevant stimuli, rather that only fear-relevant stimuli, as it was the case in the theory of the fear module, is defended. We will see arguments against fear module’s theory and present how the amygdala can be seen in this alternative explanation, offering a general mechanism and not simply a modularity hypothesis.

Then, we will briefly review some literature directly linked to our experimental design, about the evaluative conditioning and a peripheral indicator for fear and relevance learning: skin conductance resistance. We will also present some research that used a positive conditioning, and the lessons that we can draw from this for our experimental design.

As a conclusion of this theoretical part, we will go back to the aim of the experiment, as well as the hypotheses that we can do according to fear module’s hypothesis and according to appraisal models of emotion.

In the second part, we will present in details the method of the experiment.

In the third part, we will present our results.

Finally, we will discuss its impact and interpretation and what further experiments it could give rise to.

1.1. An evolved module of fear and fear learning

1.1.1. Seligman’s theory of the preparedness of phobias

According to Seligman (1971) (cited by Davey, 1995), associative learning is not an arbitrary process. Indeed, the ease with which learned associations can be formed will depend on biological predispositions shaped by the specialised evolutionary history of a species. Using this definition, he suggested that an organism can be either prepared, nonprepared or contraprepared for learning, the preparedness being a predisposition to learn an association. He supposed that fear-relevant stimuli are prepared stimuli and that "phobias are highly prepared to be learned by humans" (Seligman, 1971, p.312, cited by Davey, 1995).
1.1.2. Supports of the fear module’s theory

Even if the idea of a “fear module” has its origin in the work of Seligman, it is really Öhman and Mineka (2001) who formalized this notion. These authors proposed an evolved module for fear elicitation and fear learning that comprised four characteristics: selectivity with regard to input, that is the fear module would be sensitive to “stimuli that have been correlated with threatening encounters in the evolutionary past” (Öhman & Mineka, 2001, p. 485); automaticity, namely the fear module would be directly elicited by stimuli; encapsulation, since the fear module would be relatively impenetrable to other modules not directly linked to it; and a special neural circuitry, organized around the amygdala. Like most of the research which addressed the first characteristic of the module, we will focus on it too, but also evoke the underlying neural circuitry.

According to Öhman and Mineka (2001), a critical finding supporting the fear module theory is the resistance to extinction of enhanced Skin Conductance Resistance (SCRs) towards pictures of fear-relevant animals (snakes and spiders) that had been paired with an electric shock, but not towards fear-irrelevant stimuli (flowers and mushrooms) that had been paired with an electric shock during fear conditioning (whereas there were no differences in rate or degree of acquisition between fear-relevant and fear-irrelevant stimuli; Öhman et al., 1976, mentionned by Hugdahl & Johnsen, 1989).

Moreover, results from masking paradigms (Öhman & Soares, 1993) were seen as a support of the hypothesis that suggests that non-conscious processes are sufficient to active responses to fear-relevant stimuli. In a differential conditioning paradigm, Öhman and Soares (1993) exposed normal subjects to fear-irrelevant or fear-relevant stimuli, giving notice of an electric shock. During the extinction phase (where the Unconditioned Stimulus, US, was omitted), and for half of the subjects, these stimuli were presented backwardly masked. The authors reported differential SCRs to the masked conditioning stimuli only for subjects conditioned to fear-relevant stimuli.
It is also interesting to underline another result of Öhman and Soares (1993): phobic subjects, relative to normal subjects, produced increased SCRs to phobic pictures than to neutral pictures, even when the pictures were backwardly masked and could not be perceived consciously.

Furthermore, in visual search tasks, the search of fear-relevant stimuli was unaffected by the location of the target in the display and by the number of distractors (Öhman, Flykt & Esteves, 2001). It was not the case for the fear-irrelevant stimuli. These results conducted the authors to suggest parallel search for fear-relevant stimuli and serial search for fear-irrelevant stimuli.

The figure 1 can be viewed as a schematic representation of the relations between different systems postulated by Öhman and colleagues.

![Figure 1: Schematic representation of the fear module and its hypothetical relations with other cognitive, physiological and behavioral systems.](image)

In Öhman and Wiens (2004).

These experimental results are used by Öhman and colleagues as a support for their proposal of an evolved fear module. This is all the more important since the idea of a common evolutionnary origin has been given support by Mineka, Davidson, Cook and Keir (1984), who showed an observational conditioning of snake fear in rhesus monkeys.
As regards to the special neural circuitry postulated by the authors, it is interesting to examine the function that they attributed to the amygdala. We will at first present this structure and then, we will examine the function that the fear module’s theory attributed to it.

1.1.3. The amygdala as a fear module

The amygdala (or corpus amygdaloideum), almond-shaped groups of neurons, is a limbic structure, located deep within the medial temporal lobe of the brain in complex vertebrates, including humans.

The regions described as amygdala correspond to several nuclei with distinct functional traits: the basolateral complex, the centromedial nucleus and the cortical nucleus. The last one is involved in the sense of smell and receive inputs from the olfactory bulb and the olfactory cortex. Moreover, a part of the basolateral complex receives input from the sensory systems, including the auditive and visual cortices. Moreover, we can note that the importance of the afferences and the efferences of the amygdala should reveal a crucial role for the organism.

As underlined by Ledoux (2003), the amygdala was part of the MacLean’s limbic system theory. However, it did not stand out as an especially importance until 1956 when Weiskrantz showed disruptions of fear responses to previously fear stimuli by animals suffering from the Kluver and Bucy syndrome, pathology due to the dysfunctioning of amygdala.

According to Adolphs (1999), the amygdala, for humans like for animals, plays a crucial role in the eliciting of behaviors and in the recovery of knowledges in response to biologically salient stimuli, in particular, those signalling a possible threat.

According to Öhman and colleagues, the fear module is centred on the amygdala. “Basically, the fear module is a device for activating defensive behaviour and associated psychophysiological responses and emotional feelings to threatening stimuli” (Öhman & Mineka, 2001, p.485). More recently, Öhman (2005), after a review of literature about the role of amygdala in fear also concluded that “fear stimuli engage a subcortical network of structures that
is centered on the amygdala” (p. 957). One important result reported by Öhman and colleagues as evidence for this point of view is the role of the amygdala in human fear conditioning (see for example the experiments of Büchel, Dolan, Armony & Friston, 1998; Büchel, Dolan, Armony & Friston, 1999; LaBar, Gatenby, Gore, Ledoux & Phelps, 1998; Morris, Öhman & Dolan, 1998, confirming the hypothesis of the amygdalar involvement). Moreover, neuroimaging studies showed the role of the amygdala in the processing of fearful faces (see for instance Morris et al., 1996, reporting a differential response in this structure to fearful and happy facial expressions), as well as the study of the lesions affecting the amygdala in patients (for example, see Adolphs et al., 1999). Moreover, many studies had showed that damage to the amygdala interfered with the acquisition and expression of conditioned fear (see Ledoux, 2000).

Therefore, it is clear that amygdala is implicated in human fear and fear conditioning. But is it really its only function?

1.2. An emotional learning for relevant stimuli, including fear-relevant stimuli, but not limited to them

1.2.1. Appraisal models of emotion

Frijda (1986) considered that « emotions are elicited by significant events » and that events are significant “when they touch upon one or more of the concerns of the subject” (p.6). He also considered that “emotions result from the encounter between an event and a concern to which that event is relevant and to which it owes its emotional impact” (p.333) and that “behind every occurrence of emotion there is relevance for a concern” (p.354).

One of his contributions to the study of emotion is this notion of concern, defined as a “disposition to desire occurrence or nonoccurrence of a given kind of situations” (p.335).

In a recent book, Frijda (2006) wrote that “concerns, in emotion theory, cover the dispositional sources of emotions: major motives, interests, and affective sensitivities of an individual. The term thus refers to the dispositional and motivational background of emotions. No concern, no emotion: only when an event is appraised as favoring or threatening satisfaction of at
least one of an individual’s concerns will an emotion arise. Such interconnection of motivation and emotion is a core tenet of most current emotion theories.”

He considered therefore the emotions as “action readiness changes in response to events relevant to the individual’s concerns” and that they “based upon relevance evaluations of these events; these are expressed in “feelings” or in the experienced relevance of events” (Frijda, 1986, p.371).

Despite the evident popularity of the view of Ekman on basic emotions, the appraisal theories of emotion dominate the field of how the emotions are generated and differentiated. The major contribution of these theories is to specify a standard set of criteria that are supposed to underlie the appraisal process of emotion. In fact, the central assumption of the appraisal theorists is that the evaluation of the circumstances plays a central role in the elicitation and differentiation of emotions. As an event unfolds, the individual concerned would evaluate its significance on a number of criteria such as pertinence of the consequences to one's well-being, conduciveness or obstructiveness for one's plans and goals, and the ability to cope with such consequences. These models postulated that the organisms constantly scan their environment to detect pertinent and significant stimuli. We can note that the notions of concerns and relevance are quite similar.

In the model of Scherer (2005), relevance detection is considered as a first selective filter that a stimulus or event needs to pass to merit further processing (Sander, Grandjean & Scherer, 2005). As illustrated by the figure 2, this check can be decomposed in novelty check (which is crucial because the novelty detection alerts the organism to potentially significant stimuli: novel events may signal dangers or opportunities), intrinsic pleasantness check and goal/need relevance check.

In the framework of this model, emotion is defined as “an episode of interrelated, synchronised changes in the states of all or most of the five organismic subsystems in response to the evaluation of an external or internal stimulus event as relevant to the major concerns of the organism” (Scherer, 2005).
1.2.2. Criticisms of fear module’s theory

Some experimental findings are clearly in opposition with the theory of a fear module. First, Flykt (1999) reported similar patterns of extinction for ontogenetic fear-relevant stimuli and for phylogenetic fear-relevant stimuli. In a backward masking paradigm, he showed identical masking effects for fear-relevant phylogenetic and ontogenetic stimuli. Thus, both cultural and biological fear-relevant stimuli are effective in automatically eliciting fear responses. Similary, Hugdahl and Johnsen (1989) observed that the resistance to extinction for a slide of a gun pointed towards the subject (that is an ontogenetic fear-relevant stimulus) with noise as US was not different from the resistance to extinction for a slide of a snake (a phylogenetic fear-relevant stimulus) with shock as US.

Furthermore, Brosch and Sharma (2005) reported a visual detection task in which ontogenetic threatening stimuli, like phylogenetic stimuli, showed little differences in search
times as the number of distractors is increased. This finding is inconsistent with an exclusive preattentive processing for phylogenetic fear-relevant stimuli.

In this way, it seems that the validity of a fear module can be questioned by the findings of no special status of phylogenetic compared with ontogenetic stimuli (Flykt, 1999; Hugdahl & Johnsen, 1989). We can also note that Öhman and Mineka (2001) themselves admitted that “under certain conditions (...) the fear module may also be activated by fear-irrelevant stimuli” (p.515). Thus, only the fear relevance, confounded factor with the time of appearance in the evolutionary history in Öhman and colleagues’ studies, appeared as important.

Moreover, the results of Silvert and colleagues (2004) showed that the autonomic system can be differentially activated by unrecognised emotionally negative and neutral words, stimuli that are not biologically prepared. They represent threat in a verbal manner and do not present simple physical features related to fear, what is in contrast with Öhman’s proposal.

For another key process in the cognitive functioning: attention, like for learning, it is long-admitted that the emotional significance of a stimulus can influence attention process (James, 1890). Nevertheless, according to Öhman and Mineka (2001), whereas the fear-relevant stimuli benefit of prioritized attention resources; positive stimuli do not. On the contrary, appraisal theories of emotion sustain that relevant stimuli, independently of their positive or negative valence, are allocated increased amounts of attention and processing resources. Brosch and colleagues (2008) underlined that most of the literature seem to show attention capture by only negative emotional stimuli. But these studies suffer from a range of problems and therefore do not constitute a clear evidence to the proposition of a fear module. Moreover, negative emotional stimuli are not the only kind of stimuli that could capture attention.

The study of Brosch, Sander and Scherer (2007) showed, using pictures of human infants displaying the Kindchenschema (Lorenz, 1943), considering young offspring as a biologically relevant stimuli, that this type of stimuli are allocated additional attentional resources, suggesting that these stimuli are processed in priority, and so, important for the organism.

In fact, Lorenz (1943) postulated that “humans respond with emotions and behavior patterns of parental care to a number of configurational key stimuli that can easily be analyzed”
like a high and slightly bulging forehead, large eyes or rounded cheeks (see figure 3 for illustration). Moreover, Brosch and colleagues (2007) emphasized that the degree of kindchenschema in faces is correlated with positive attributions such as cuteness, fondness or honesty (Berry & McArthur, 1985).

Figure 3: An illustration of the kindchenschema in different species (at left).

In Lorenz (1943), The foundations of ethology

In another study, Brosch and colleagues (2008) found an early attention capture by both positive (baby faces) and negative (anger faces) emotional stimuli. For the authors, their results support the idea of “a common early and possibly automatic appraisal check of relevance detection that would modulate attentional resources allocated to negative, including fear-related and positive stimuli that are highly relevant for the organism.” (p.368)

Therefore, baby faces displaying a kindchenschema, positive biologically significant stimuli, seem to be stimuli of a particular interest.
Beyond these different experimental results, we can also argue for a broader function of the amygdala than the one proposed by the hypothesis of a fear module.

1.2.3. The amygdala as a “relevance detector”

Sander and colleagues (2003) reviewed evidence according to which aversive, but not specifically fear-relevant stimuli, evoke amygdala response. In addition, not only the amygdala exhibits an activation for negative stimuli in general, but Sander and colleagues (2003) pointed out the fact that the amygdala activation was also correlated with the processing of positive events in several studies. Moreover, they emphasized that the amygdala activation was also revealed by experiments that did not manipulate the emotional value of stimuli but still used biologically relevant information. Consequently, they concluded, leaning on the criteria of an experimental perspective for the demonstration of a functional specificity of brain activity and its link to a particular cognitive mechanism, that the amygdala is specific to the processing of fear-related stimuli. Thus, they pinpointed one major problem of Ohman’s theory of a fear module. It seems that the amygdala is concerned with processing and labelling relevant stimuli that include, but are not restricted to, fear-related stimuli (Sander et al., 2003). Furthermore, Zald (2003) sustained that the amygdala responses are modulated notably by the current motivational value of stimuli. Therefore, Sander and colleagues (2003) sustained that in the fear conditioning paradigms, the neutral stimulus associated with the fear event activates the amygdala not because it has acquired a frightening meaning, but because it becomes, as the CS, highly relevant in signalling the presence of a potential threat.

Sergerie, Chochol and Armony (2008) conducted a meta-analysis of functional neuroimaging studies of visual emotional perception that reported amygdala activation and showed that the amygdala responded to both positive and negative stimuli. Similarly, Coppin and Sander (2008) reviewed studies of olfactory and gustative perception that reported amygdala activation and showed that valence or arousal did not seem to be the appropriate features to understand the computational profile of this structure. They argued that the relevance of stimuli was the major characteristic allowing to explain results like amygdala activation to own’s name
during sleep (Portas, Krakow, Allen, Josephs, Armony and Frith, 2000) or a correlation between this activation to happy faces and extraversion (Canli, Sivers, Whitfield, Gotlib and Gabriel, 2002).

1.2. An attempt to test idea of a possible emotional learning for relevant positive stimuli

Facing the different contradictions that we raised, we conducted an experiment likely to clarify what it is the most important for a facilitated learning: the nature fear-relevant or highly relevant of stimuli, independently of their valence. We realized a positive conditioning that could be seen as an evaluative conditioning and as a classical conditioning.

1.2.1. What is Evaluative Conditioning?

1.2.1.1. Definition of Evaluative Conditioning

According to Todrank (2005), the Evaluative Conditioning (EC) is “a form of Pavlovian conditioning in which the Conditioned Response (CR) is a change in preference or liking for the Conditioned Stimulus (CS)”, it “applies Pavlovian conditioning principles to the acquisition and modification of human likes and dislikes”. In the same way, De Houwer and colleagues (2001) wrote that EC “refers to changes in the liking of a stimulus that are due to the fact that the stimulus has been paired with other, positive or negative stimuli.”

In this study, we will focus more specifically on the pairing between a CS and a positive stimulus.

1.2.1.2. Specificities of Evaluative Conditioning

Classical conditioning paradigm is the procedure used in Öhman and colleagues’ studies. Baeyens, Eelen and Crombez (1995) suggested that distinct processes are engaged in classical and evaluative conditioning, a view not unanimously shared.
In fact, in another paper, Baeyens and De Houwer (1995) underlined that two findings characterizing the EC are particularly important. Firstly, it does not seem necessary that the subject is consciously aware of the US-CS contingencies in order to establish evaluative shifts. Secondly, the EC is resistant to extinction. These two characteristics are important to keep in mind for the understanding of the methodology of our experience, described later.

Nevertheless, the claim that evaluative learning is resistant to extinction is highly controversial. This is not a fact without importance, because it could have methodological consequences. In fact, it is possible to think that the evaluative learning has a slow extinction rate. Field and Davey (1999) sustained that the EC effects obtained in a number of studies are not due to associative learning. In addition, they claimed that the special characteristics of the EC, that we have just evoked, were probably nonassociative artifacts of the EC paradigm. However, this is in contradiction with the recent findings of Vansteenwegen and colleagues (2006) corroborating the idea that EC is resistant to extinction. Similarly, Diaz, Ruiz and Baeyens (2005) concluded, as to their results, that they provided evidence that EC is resistant to extinction and suggested an interpretation of EC as a qualitatively distinct form of associative learning.

Moreover, in a recent review, Martin-Soelch, Linthicum and Ernst (2007) wrote that the fundamental difference between classical and evaluative conditioning resides in the nature of the US. In classical conditioning, the US is biologically significant and elicits a physiological reflex. According to De Houwer and colleagues (2001), EC typically uses second-order CS as US or US that are not biologically relevant.

Importantly, Martin-Soelch and colleagues (2007) emphasized that most EC studies found a similar learning effect for pleasant and unpleasant US at the level of (dis)liking change. However, Rozin and colleagues (1998) reported a learning effect only for aversive taste US, and not for positive. This observation could be related to the difficulty in finding pleasant taste stimuli which are liked as intensely as the unpleasant stimuli are disliked. In fact, find appetitive stimuli than can elicit a physiological activation similar to the one elicited by the painful or fear stimuli used in aversive conditioning is not easy. Nevertheless, Martin-Soelch and colleagues
(2007) reemphasize “the paucity of work dedicated to understanding the mechanisms underlying appetitive conditioning in humans, and the potentially critical importance of this process in the genesis of psychiatric disorders” (p.437). We will come back to this point in our discussion.

1.2.2. Skin Conductance Resistance as an indicator of fear and relevance learning

We will discuss below the link between the physiological function modulated by the autonomic system, recorded during our experiment (SCR), and potential concurrent emotional events. Then, we will address the highly debated question of the existence of autonomic nervous system response patterns specifics to some (basic) emotions. Importantly, Williams and colleagues (2005) showed that there is a coupling between amygdala responses and skin conductance in response to fear stimuli.

It is a rather well-established notion that the SCR, a change in the ability of the skin to conduct electricity, is more arousal-related than valence-related. Thus, for example, Amrhein, Mühlberger, Pauli and Wiedemann (2004) wrote that “SCR was found to be a reliable indicator of arousal (e.g. Bradley et al., 1993)” (p. 232). Similarly, Sanchez-Navarro and colleagues (2006) wrote that “SCR depends on the arousal level of the affective stimuli, with the most arousing pictures evoking the largest SCRs” (p. 146).

Another idea is that aversive motivation could be assessed via SCR (Fowles, 1987). Thus, as we saw, the resistance to extinction of enhanced SCRs towards pictures of fear-relevant stimuli, but not towards pictures of fear-irrelevant stimuli is the main support of the proposal of Öhman and Mineka (2001). But, as already mentioned, Cuthbert and colleagues (2000) obtained increased SCRs for the presentation of positive (and negative) stimuli, raising the question of a possible link between SCR and positive stimuli.

In fact, in the study of Hermann and colleagues (2000), a variation of SCR in an appetitive conditioning procedure cannot be found but this investigation suffers from a range of problems. According to Fowles (1987), the failure of SCR to respond to appetitive stimuli could
be the reflect of a ceiling effect due to excessive responding during the task. In fact, “it is possible that SCR is generally insensitive to our experimental manipulations during our task, due to the large amount of responding associated with performing the task - i.e., a ceiling effect may preclude responding to appetitive motivational manipulations. » (Fowles, 1987, p. 386).

The findings of Amrhein and colleagues (2004), who found that SCR elicited by neutral pictures was significantly smaller than for the pleasant or unpleasant pictures but failed to find a difference between positive and negative pictures, give support to this idea. In their paradigm, participants saw affective pictures (from the International Affective Picture System) for eight seconds, more precisely, 22 pleasant pictures, 22 neutral pictures and 22 unpleasant pictures were used (their content was not precised, except for 5 pleasant pictures: attractive nudes of the opposite sex). Moreover, it seems that a study of Hamrick (Hamrick, 1974, mentionned by Andreassi, 1995) also supports this relation. This author studied the effects of erotic and neutral stimuli on SCR, HR and subjective ratings of females. He found significant increase in SCR (and decrease in HR) to the erotic stimuli. Moreover, the changes in SCR and HR to these stimuli were accompanied by subjective ratings that indicated positive affective reactions. More recently, Karama and colleagues (2002) showed that a significantly greater number of discrete increases in skin conductance during the erotic condition than during both neutral and baseline conditions, for male participants only. In a study where SCR was recorded, Lane and colleagues (1997) showed set of pictures previously demonstrated to elicit pleasant (including babies), unpleasant emotion to women. SCR was larger when viewing unpleasant or pleasant materials compared to neutral pictures.

Even if the links between SCR and valence and/or arousal are quite hard to specify in a clear-cut way, these two measures seem of particular interest for the purposes of our study.

1.2.3. Relevant findings in the literature

It is important to keep in mind the results of Todrank and colleagues (1995), who used positive evaluative conditioning with odours and pictures of faces, and showed that the establishment of the association was strongly reinforced by making conceptual couples of
pictures and smells. Moreover, Hugdahl and Johnsen (1989) showed that the use of a noise as US for slides of guns yielded a superior acquisition and resistance to extinction compared with the use of a shock as US. So, although Van Reekum, Van Den Berg and Frijda (1999) showed that it is possible to change the hedonic evaluation of neutral stimuli by the combination of a CS and a non-congruent US, we made the choice of using a CS and a US that is semantically related. In fact, in the experiments of Öhman and colleagues, we could not consider that an electric shock and a flower could be semantically related whereas a spider sting or a snake bite could evoke an electric shock. Given our choice to be the closest as possible to the Öhman’s studies and the fact that we were not in a cross-modal paradigm (like Van Reekum et al., 1999), we used a laugh of babies as US.

We can note that Hermann and colleagues (2000) have already tried to establish an appetitive conditioning procedure by combining pictures of faces with odours of vanilla (positive) and rotten yeast (disgust) but only few markers showed variation, and SCR was not one of them. Moreover, no subjective changes in the valence of the CS occurred in this experiment. Nevertheless, their study suffered from a range of problems: too many valence ratings during the procedure, a positive US not very strong (in consequence, the subjects did not even produce an Unconditioned Response (UCR) towards the US, which is necessary for a conditioning) and furthermore, there is not congruence between the US and the CS.

1.2.4. Aim of the experiment and hypothesis

McNally (1987), after an extensive and thorough review of the existing empirical data up to 1987, wrote that “the evidence most consistent with the theory (of preparedness) is the enhanced resistance to extinction of electrodermal responses established to fear-relevant stimuli” (p.283). Therefore, a stronger positive conditioning towards positive relevant picture stimuli than towards neutral ones could be a strong argument towards a general relevance check, proposed by the appraisal model of emotions. More precisely, we conducted an experiment in which we assessed the resistance to extinction of positive relevant and neutral stimuli with the intention of obtaining an argument comparable to the most critical result supporting the fear module’s theory. So, our
theoretical hypothesis is that the relevance of stimuli, independently of valence, rather than merely the phylogenetic fear-relevance, could be seen as accountable for the strength of the positive conditioning that we established. Our operational hypothesis is that the resistance to extinction for positive stimuli will be enhanced compared to neutral stimuli in a Pavlovian positive conditioning.

In a classical conditioning, participants were exposed to fear-relevant (typically snakes and spiders) or fear-irrelevant stimuli as CSs, with shock as US. One CS (called the CS+) is consistently paired with the US, whereas one CS (called CS-) is never paired with a shock. Typically, SCR is used as dependent variable.

Cuthbert and colleagues (2000) obtained increased SCRs for the presentation of positive (and negative) stimuli with long stimulus presentation times (6000 ms), the temporal delay that we therefore used in this experiment.

Taking these different results into account, we established a positive conditioning procedure measuring one kind of autonomic marker: SCR. We used sounds of high potency and relevance as positive US, semantically congruent to CS. The strength of the positive stimulus was examined by the fact that it must elicit a UCR. Finally, we used long stimulus presentation time (6000 ms).

In the next section, we will specify in details the method used in this experiment.
2. Method

2.1. Participants and stimuli

Participants

Sixty participants were recruited on the premises of the University of Geneva. All the participants were women (mean age of the 46 participants of interest: 22.1 years, 38 right-handed) in order to avoid possible effects due to hormonal differences between males and females. Hormonal differences obviously exist between females according to the period of the menstrual cycle, that is why we questioned them about it. We excluded mothers, pregnant women and a participant who didn’t know if she was pregnant or not. The data of one participant who cannot have her period due to genetic problems was also removed of the analysis. Moreover, data from one female had to be excluded due to her impossibility to direct her attention to the task. Seven participants had to be excluded due to problems in the recording of physiological measure. So, 46 participants remained for the analyses. All participants had normal or corrected-to-normal vision.

Stimuli

Our experimental design required the use of five stimuli: positive face 1, positive face 2, neutral face 1, neutral face 2 (see appendix) and two positive sounds. We used baby faces as positive faces, adult face as neutral faces and baby’s laughs as positive sounds. The baby faces were evaluated as very attractive by infants from 5 to 15 months in the study of Van Duuren, Kendell-Scott and Stark (2003). The adult faces come from the KDEF (Karolinska Directed Emotional Faces).

The images had a size of 20X25 cm on the screen for participants who were placed approximately at 60 cm of the screen.

The experiment was presented on using E-Prime software (Psychology Software Tools, Pittsburgh, USA; www.pstnet.com/eprime).
2.2. Procedure and data analysis

Procedure

After having signed an informed consent form, participants were seated in a comfortable chair. They were instructed to pay attention to the different pictures that they will see on the screen and to avoid moving in order not to disturb the physiological recordings.

Prior to the conditioning procedure, participants were attached to electrodes measuring SCR. Skin conductance was recorded from two electrodes placed on the medial phalanges of the second and third finger of the non-dominant hand.

Each trial started with a fixation cross presented for one second. Each stimulus was presented for 5 seconds with an interstimulus interval ranging between 10 and 20 seconds. During the initial habituation phase, participants saw 4 non-reinforced presentations of each stimulus. During the subsequent acquisition phase, they saw each CS 6 times. The CS+ was consistently paired with the US, whereas the CS- was never paired with the US. So, the acquisition phase unfolded as follows:

CS pos+: positive face 1 + positive sound
CS pos-: positive face 2 + no sound
CS neu+: neutral face 1 + positive sound
CS neu-: neutral face 2 + no sound

Finally, the extinction phase included 6 non-reinforced presentations of each CS. In total, participants were presented 72 trials.

Each stimulus served as both CS+ and CS- counterbalanced across participants. The order of presentation within each phase was randomized.

Participants indicated their rating of pleasantness and arousal after the first presentation of each picture and sound and at the end of the experiment on continuous scales of 7 cm, from “not pleasant at all” to “very pleasant” and from “not arousing at all” to “very arousing”. For the sounds, they also had to indicate the annoyance along the experiment in a continuous scale of 7 cm from “not annoying at all” to “very annoying”. After the experiment, they completed questionnaires. The questions were about their age, their laterality, if they had kids, if they are
pregnant, and if they had children in their circle. Moreover, they had to quantify their desire to have children in general and in a close future in a continuous scale of 7 cm, from “not important at all” to “very important”. We also interrogated them about their menstrual cycle in order to know in which phase they were, and if they were taken birth control pill. Finally, they were debriefed.

In all the subjective scales, a value of 3.5 represented a mean or “neutral” rating.

Data analysis

SCR was measured for each trial as the peak-to-peak amplitude difference in skin conductance to the largest response (in micro siemens, µS) in the 1 to 3 seconds window following stimulus onset. The minimal response criterion was 0.02 µS (see Dawson, Schell & Filion, 1990; Boucsein, 1992 for the choice of the temporal window and the minimal response criterion). The raw SCR scores were transformed to log (SCR+1), and scaled according to each participant’s mean unconditioned response (see Olsson, Ebert, Banaji & Phelps, 2005).

Data were analyzed using a repeated measures analysis of variance (ANOVA) with the factor of valence (neutral, positive), of phase (habituation, acquisition, extinction) and of conditioning (-,+).
3. Results

3.1. Behavioral results

3.1.1. Subjective rating of pleasantness

![Mean subjective rating of the pleasantness before and after conditioning](image)

Figure 4: Mean evaluation of the pleasantness before (during habituation) and after (during extinction) the conditioning

Before conditioning (during habituation), statistical analyses showed that neither the two neutral pictures nor the two positive pictures were significantly different from each other (both F<1). There was a significant difference between the mean evaluation of pleasantness of the two neutral pictures and the mean evaluation of pleasantness of the two positive pictures
(F(1.45)=218.91, p<0.001), the pictures of babies were rated more pleasant (mean of 5.82) than the pictures of adults (mean of 2.43).

Similarly, after conditioning (during extinction), statistical analyses showed that neither the two neutral pictures nor the two positive pictures were significantly different from each other (both F<1). There was a significant difference between the mean evaluation of pleasantness of the two neutral pictures and the mean evaluation of pleasantness of the two positive pictures (F(1.45)=207.1, p<0.001), the pictures of babies were rated more pleasant (mean of 5.74) than the pictures of adults (mean of 2.49).

For each kind of stimulus, there was no significant difference in the mean evaluation of the pleasantness before and after conditioning (CSneu-: F<1; CSneu+: F<1; CSpos-: F(1.45)=1.94, p>0.18; CSpos+: F<1).

The mean evaluation of the US before the conditioning was 5.09. It was not significantly different from the mean evaluation after the conditioning (mean of 5.30, F(1.45)=1.35, p<0.26). We can note that the mean annoyance of the US at the end of the experiment was 2.14.

3.1.2. Subjective rating of arousal
Before conditioning (during habituation), statistical analyses showed that neither the two neutral pictures nor the two positive pictures were significantly different from each other (F(1,45)=1.78, p>0.18 and F(1,45)=2.28, p>0.14 respectively). There was a significant difference between the mean evaluation of arousal of the two neutral pictures and the mean evaluation of arousal of the two positive pictures (F(1,45)=14,7124, p<0.0004), the pictures of babies (mean of 2.79) were rated less arousing than the pictures of adults (mean of 3.78).

After conditioning (during extinction), statistical analyses showed that the two neutral pictures were not significantly different from each other (F<1). This time, the two positive pictures were significantly different from each other (F(1,45)=9.1637, p<0.005), the CSpos+ was rated more arousing (mean of 3.82) than the CSpos- (mean of 2.89). There was no significant difference between the mean evaluation of arousal of the two neutral pictures and the mean evaluation of arousal of the two positive pictures (F(1,45)=0.15, p>0.69).

For the two non-conditioned stimuli, there was no significant differences in the mean evaluation of the arousal before and after conditioning (CSneu-: F(1,45)=1.83, p>0.18 ; CSpos-:
F(1,45)=1.26, p>0.26). For the CSpos+, arousal was significantly enhanced after the conditioning (mean of 3.82, whereas the mean evaluation during habituation was 2.99) (F(1,45)=11.412, p<0.0016). Contrary to the CSpos+, the arousal of the CSneu+ was significantly decreased after the conditioning (mean of 3.47, whereas the mean evaluation during habituation was 3.87) (F(1,45)=6.09, p<0.018).

The mean evaluation of the US before the conditioning was 4.99. It was not significantly different of the mean evaluation after the conditioning (mean of 4.75, F(1,45)=1.45, p>0.23).

3.2 Results Skin Conductance Resistance

3.2.1. Main effects

The SCR was stronger for the conditioned stimuli paired with US (mean of 0.934) than the conditioned stimuli never paired with US (mean of 0.635) (F(1,45)=5.0613, p<0.029).

There was also a main effect of the phase (mean for habituation: 0.63, mean for acquisition: 0.634, mean for extinction: 0.305) (F(2,90)=6.1037, p<0.003).

There was no significant difference in the strength of the SCR according to the valence (F(1,45)=1.41, p>0.24).

3.2.2. Interaction effects
The interaction conditioning * phase was statistically significant (F(2, 90) = 5.9972, p < 0.004). Bonferroni follow-up tests showed that there was no difference between CS+ and CS- during habituation and during extinction. But there was a significant difference between CSpos-acq and CSpos+acq (p < 0.005), and between CSneu-acq and CSneu+acq (p < 0.002), whereas there was no difference between CSpos+acq and CSneu+acq.
There was a tendency to the interaction valence*phase ($F(2,90)=2.4058$, $p<0.096$). Neither the interaction valence*conditioning nor the interaction valence*conditioning*phase were significant (both $F<1$).

The response to positive stimuli during habituation was more important than the response to neutral stimuli during habituation ($F(1,45)=3.6588$, $p<0.063$).

*Figure 7: Interaction valence*phase*
3.2.3. Tests of our hypothesis

![Mean SCR for the different stimuli and for the different phases](image)

Figure 10: Mean log (SCR+1)/Mean response during habituation to the US for the different pictures during the different phases

We had the hypothesis that the resistance to extinction for the CSpos+ will be enhanced compared to the CSneu+. But the mean response to CSpos+ext was not more important than the mean response to CSneu+ext (F(1,45)=1.92, p>0.17). Moreover, difference between (CSpos+acq – CSpos+ext) and (CSneu+acq – CSneu+ext) was not statistically different (F(1,45)=1.16, p>0.28).

The analyses of Olsson and colleagues (2005) were performed for each participant by subtracting the means for CS- from the means for CS+ for the same stimulus category. The difference between (CSpos+ext – CSpos-ext) and (CSneu+ext – CSneu-ext) was not significant (F(1,45)=2.39, p>0.12).

There was no difference between (CSpos+acq – CSpos-acq) and (CSneu+acq – CSneu-acq) (F<1).
3.2.4. Other results

The mean response to the US1 was significantly more important than the mean response to the US2 (F(1,45) = 14.16, p<0.0005).

There was a positive correlation of 0.30 (p<0.05) between the desire to be mother soon and the response to the CSpos+acq. There was a negative correlation of 0.32 (p<0.05) between the desire to be mother soon and the response to the CSneu+ext.
4. Discussion

In this experiment, we investigated whether it was necessary to postulate the existence of a fear module to explain the results concerning the facilitated learning for fear-relevant stimuli. We established a positive conditioning procedure, and found a significant response to our US; a baby laughs. It was quite cheerful because contrary to aversive conditioning, appetitive conditioning had rarely been studied in humans and as Martin-Soelch, Linthicum and Ernst (2007) said, “this gap may be explained by the difficulty to find in humans suitable appetitive stimuli that can elicit physiological responses similar to those elicited by aversive stimuli.” (p. 427).

Unfortunately, we could not find the enhanced resistance to extinction to positive stimuli that we expected. The more relevant test for our hypothesis gave a p value of 0.12, with results in the expected direction. But as sustained by Rozin and colleagues (1998), “EC study results do not constitute a homogenous set of weakly supportive studies. Rather, there is a group of studies which vary from no net effect to substantial effects.” (p. 413).

As Öhman and his collaborators, we found no differences in rate or degree of acquisition between positive and neutral stimuli. But interestingly, we found that the subjective arousal was significantly enhanced after the conditioning for the CSpos+, whereas the subjective arousal of the CSneu+ was significantly decreased after the conditioning. Importantly, there was no difference in the arousal before and after conditioning for the two non-conditioned stimuli. Therefore, at a subjective level, the conditioning had effects, even after the phase of extinction.

It is not really easy to interpret this result. According to Duffy (1962), arousal “describes a condition conceived to vary in a continuum from a low point in sleep to high point in extreme effort or intense excitement” (p. 5). Clearly, the accent is put on the physiological level. Nevertheless, the measurement of arousal is not straightforward and in addition to the direct physiological measures of arousal are measures of self report of arousal, that show general effects with durations from a few minutes to a few hours (Revelle & Loftus, 1992). Thayer (1989) showed that self report measures of arousal seem to reflect the general factor of many of the finer grain physiological measures and according to Revelle and Loftus (1992), self reports are a
powerful device for assessing arousal state. Our change in subjective arousal before and after conditioning for the two conditioned stimuli could be therefore reflecting a change in several physiological systems.

Thus, only one physiological measure, SCR, given its blurry link with arousal, is clearly insufficient. It could be interesting in the future to include others physiological measures, like the pupil’s response. In fact, Bradley, Miccoli, Escrig and Lang (in press) showed recently that this measure reflects emotional arousal (associated with increased sympathetic activity) during affective picture viewing.

One possible explanation to the enhanced arousal for the CSpos+ and the decreased arousal for the CSneu+ after the conditioning is to consider that the CSneu were not neutral; in fact, the subjective pleasantness of these stimuli was more negative than neutral. It was not so surprising because the two adult faces have direct gaze, what lead to more anger and joy attributions (Adams & Kleck, 2005), and many participants reported negative feeling about these pictures (“it appears like pictures taken in jail”, “they look aggressive”). Thus, we could hypothesize that the decreased arousal for the CSneu+ reflect the decreased perceived threat of this picture, and in consequence its decreased relevance due to its association with positive sound. To the contrary, the increased arousal for CSpos+ could reflect the increased relevance of this stimulus. Further experiments are obviously needed to confirm this supposition.

Another interesting result is the positive correlation between the desire to be mother soon and the response to the CSpos+acq, even it is moderate, it invites to pay attention to individual features. In fact, it could be interesting to conduct this experiment with pregnant women or women that have babies in order to see if the important relevance of babies in this population could influence the response to these stimuli. Similarly, consider the influence of attachment patterns and menstrual cycle could be a track to explore.

Another population that could be interesting for the future is phobic people. In fact, Schneider and Spanagel (2008) showed in rats that a neutral odor previously paired with a positive emotional context was an effective stimulus for attenuating a defensive response to a sudden loud noise (starle response). The positive conditioning, beyond its potentially critical
importance in the genesis of psychiatric disorders (Martin-Soelch et al., 2006), could be also important in the treatment of this pathology.

A third interesting population could be children. Recently, Lobue and DeLoache (2008) showed that young children shared the propensity of adults for particularly rapid visual detection of snakes. According to the researchers, the existence of this tendency in young children lends important support to theories positing the existence in humans of an evolved bias for the detection of evolutionarily relevant threat stimuli. But Blanchette (2006) emphasized that evolutionary-relevant (snakes, spiders…) and modern (guns, syringes…) threats led to a similar quicker response in a visual search paradigm. Moreover, Brosch and colleagues (2007) showed an early attention capture by positive (baby faces) emotional stimuli in human adults. It could be very interesting to investigate if a similar bias to positive relevant stimuli could be seen in young children and if a modulation similar to the one found by Brosch and colleagues (2008) could be showed for P1 time-locked to target onset.

Regarding the cerebral underpinnings of positive conditioning, Martin-Soelch and colleagues (2006) suggested that a circuitry involving amygdala, anterior cingulate, orbitofrontal cortex and striatum (and certainly more regions) could be involved in appetitive conditioning.

If we stay at a cerebral level, we can note that Larson and colleagues (2006) showed a differential pattern of amygdala activation between phobics and non phobics subjects during the presentation of phobia-relevant pictures. They interpreted this differential pattern within the framework of the « vigilance-avoidance » model of anxiety (Amir & Foa, 2001). This framework suggests that when phobic individuals perceive a threatening stimulus, they have a strong immediate fear response and then quickly avert their attention. We proposed that these results could be reinterpreted within the framework of appraisal models of emotion and were in agreement with the hypothesis of the function of the amygdala as a relevance detector (Sander et al., 2003). Thus, the differential pattern of amygdala activation in Larson’s study may be the result of a differential relevance of those stimuli for phobics and non phobics participants. Would this pattern change after a positive conditioning similar to the one used by Schneider and Spanagel (2008)?
In conclusion, even if our main hypothesis was not confirmed, this experiment brings interesting evidences: SCR to babies is more important than SCR to adults before any conditioning, a baby laugh could activate physiological response, the subjective arousal changes before and after a positive conditioning and it seems to be a link between relevance of babies and physiological response. We did not analyze yet another physiological data, heart rate, that we also measured during the experiment. There are many questions that could be investigated in the future. Interests are theoretical as well as clinical. A particular attention should be clearly paid to the measurement of arousal. As Schiller and Phelps (in press) said “Although emotional learning entails more than learning about fear, this model system provides a starting point for understanding the complex means by which emotional responses can be acquired”. This quote called studies about emotional learning, not restricted to fear learning, to be developed in the future.
References:


Appendix

Appendix 1: Picture of the baby 1

Appendix 2: Picture of the baby 2

Appendix 3: Picture of the adult 1

Appendix 4: Picture of the adult 2
Acknowledgements

I would like to deeply thank David Sander for his pedagogic support and his helpful comments. His capacity to combine critique with an immediate empathy and encouragements command respect.

I would also like to thank Tobias Brosch whose enthusiasm and capacity to explain things clearly and simply helped to make the difficult stages of this work fun for me.

I am indebted to Sylvain Delplanque for providing a stimulating environment in which I learn a lot of new practical abilities and for his statistical help.

I would also like to thank the members of the University of Geneva who gave me an external point of view about my research.