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Review

Peripheral physiological responses to subliminally presented negative affective stimuli: A systematic review

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ABSTRACT

Negative affective information may be presented outside of awareness and change physiological activity. By increasing peripheral physiological activity, subliminally presented negative affective information may contribute to the development of disease. The current systematic review evaluated 65 studies in which negative affective stimuli were presented subliminally to a healthy sample while cardiovascular, electrodermal, electromyographical, hormonal, or immunological activity was measured. Overall, 41% of the tested contrasts indicated significant increases due to negative affective stimuli compared to control stimuli. These effects were most pronounced in fear-conditioning studies measuring skin conductance response amplitude and priming studies measuring systolic blood pressure. However, across the included studies the methodology varied substantially and the number of contrasts per physiological parameter was limited. Thus, although some evidence exists that subliminally presented negative affective stimuli can induce adverse peripheral physiological changes, this has not yet been addressed sufficiently.

Can information that occurs outside of awareness affect perception, motivation, decisions, and emotions? Research addressing this question is flourishing in various fields within psychology, including organizational (e.g., Uhlmann et al., 2012), emotion (e.g., Zajonc, 1980), clinical (e.g., Jones, Vilensky, Vasey, & Fazio, 2013), cognitive (Kihlstrom, 1987), and social psychology (e.g., Bargh & Chartrand, 1999; Fazio, 2001). Surprisingly, the potential role of unconscious processes in the relationship between negative affective information and health has remained understudied. In psychosomatic research, the limits of conscious awareness have long been of interest and explored (Lane, 2008). For example in the 1930s, a psychoanalytic approach was used to address unconscious emotional conflict in the etiology of hypertension (Alexander, 1939), but experimental tests of this particular method failed to provide supportive evidence (Lane, 2008). Notwithstanding, the possible adverse influence of negative affective information outside of awareness on physiological systems is consistent with current theoretical insights (Brosschot, 2010; Brosschot, Verkuil, & Thayer, 2010; Brown, 2004; Damasio, 1994; Lane, 2008). However, experimental evidence is still scarce. Given that several studies indeed showed that unconscious processes influence the experience of emotions (e.g., Dannlowski et al., 2006; Murphy & Zajonc, 1993) and behavior (e.g., Aarts, Custers, & Marien, 2008; Cohen, Moyal, Lichtenstein-Vidne, & Henik, 2016) it seems crucial to examine whether physiological parameters can be affected by negative affective stimuli when these are presented outside of awareness.

In fact, the quest for evidence of this kind appears to have a long history. In the early days of psychological research, Jung (1907) and Peterson and Jung (1907) performed several studies regarding the effect of word-associations on galvanic skin responses (GSRs). In these studies they would repeatedly read out a list of neutral words to participants that had to verbalize whatever associated word came to mind. The researchers observed that participants gave different verbal responses to some of the same words and, importantly, that the GSRs were larger than what they had seen before. Notably, this was one of the first psychophysiological experiments and not much was known about the electrodermal response at the time. An in-depth interview with the participants on these words revealed personal affective associations and that the changes in verbal responses had been unintentional. It was concluded that the GSR was able to detect affective associations with neutral words. The different verbal responses and GSRs together were assumed to be a new method to measure an attempt of the mind to prohibit further conscious processing of something that was considered harmful to the self and was referred to as the *psycho-physical galvanic reflex*. Although the authors faced considerable methodological restrictions using the electrodermal response, it seems that these findings are the first (published) displays of the physiological changes that

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involuntarily accompany an affective state. Later, McGinnies (1949) was able to display negative affective words below threshold of awareness using a tachistoscope at an interval of 10 ms. He found larger GSRs to the affective words compared to the neutral words, which was interpreted as evidence for *perceptual defense*: a distortion of perception to protect the individual from unpleasant experiences. Moreover, Lazarus and McCleary (1951) provided evidence that after a conditioning procedure individuals were able to discriminate between stimuli of different affective valence before conscious recognition as indicated with changes in GSR, which was referred to as *subception*. Notably, the results of these studies have been largely discussed in light of the *repression hypothesis* as they were believed to indicate that individuals tend to reject and keep something out of consciousness when it may negatively affect one's wellbeing. These experimental researchers were pioneers and gave way to find ostensibly more objective evidence of physiological effects of subliminal negative affective information. The research instigated fierce criticism from peers, who performed what we would now call observational studies, and, as a result of the zeitgeist, may have been overlooked in their importance (for a historical discussion the reader is referred to Mackinnon and Dukes, 1962).

More recently, influential evidence of the effects of subliminally presented negative affective stimuli on physiology is offered by neuroscience studies that have found amygdala activation in response to fear-inducing stimuli that were presented below threshold of awareness (e.g., Critchley, Mathias, & Dolan, 2002; LeDoux, 2000; Pessoa, 2005). These findings suggest physiological arousal can be elicited using this type of stimulus presentation and support the earlier findings with GSR that differences in affective valence of stimuli can be determined even when these are presented outside of awareness. However, far less studies seem to have addressed peripheral physiological parameters, such as blood pressure or cortisol. Considering the potential relevance of unconscious processes in psychosomatic research, the aim of the current study was to provide a systematic review of the evidence for the physiological effects of subliminally presented negative affective stimuli from different fields within psychology.

This systematic review focused on studies that manipulated awareness of negative affective stimuli. In experimental designs, awareness is usually manipulated by presenting a stimulus below the threshold of awareness, i.e., subliminally, typically followed (and often preceded) by an irrelevant different stimulus, i.e., mask (e.g., Bargh & Chartrand, 2000; Marcel, 1983; Tamietto & De Gelder, 2010; Wiens & Öhman, 2007). Typically, this subliminal manipulation has been applied to two paradigms: priming with stimuli with an innate affective valence (e.g., Van den Bussche, Van den Noortgate, & Reynvoet, 2009), from here on referred to as 'priming studies', and priming with fear-conditioned stimuli (e.g., Wiens & Öhman, 2007), from here on referred to as 'fear-conditioning studies'. The mechanism underlying the first paradigm, priming, is believed to be the activation of cognitive representations of the prime content, which is reflected in a change in a variety of behavioral responses such as reaction times to targets (Fazio, 2001). In addition to behavioral responses, physiological responses have also been found to be influenced by subliminal affective primes (e.g., Hull, Slone, Meteyer, & Matthews, 2002). In fear-conditioning, an association between an unconditioned stimulus (US), such as a shock or a loud noise, that automatically elicits a response (i.e., unconditioned conditioned response, UCS) and a novel stimulus is formed. The result is a conditioned response (CR) to the now conditioned stimulus (CS+). In contrast, the stimuli that are not combined with a US are referred to as CS−. The participant is assumed to learn to differentiate between the CS+ and CS−. Presentation of the CS+ is expected to elicit a physiological response that is similar to presentation of the US alone, as if it was the negative experience itself (e.g., Öhman & Mineka, 2001). The advantage of fear-conditioning over priming is that it offers more control over the specific affective associations with the stimulus.

Theoretically, the subliminal presentation of negative affective stimuli in experimental paradigms activates unconscious negative affectivity and should result in measurable changes in physiological activity (Brosschot, 2010; Brosschot et al., 2010; Lane, 2008). Since the dysregulation of adaptive peripheral physiological activity is assumed to be the final step in the relation between psychological negative affect and adverse health outcomes (e.g., McEwen, 1998b), we only included studies using peripheral physiological parameters. Most of these parameters are believed to be more directly involved in increased somatic health risks than central nervous system parameters. For example stronger responses of systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate variability (HRV) to mental stress were found to be predictive of cardiovascular (CV) disease risk and other health-related outcomes (e.g., Chida & Steptoe, 2010; Malik et al., 1996; Thayer, Yamamoto, & Brosschot, 2010). Furthermore, chronically elevated cortisol increases vulnerability for disease states, for example through immunosuppression and numerous other pathophysiological effects (McEwen, 1998a). As described, results generally confirm that subliminally presented stimuli affect the brain (e.g., Critchley et al., 2002; LeDoux, 2000; Pessoa, 2005), but this central activity does not necessarily provide information on peripheral activity. Moreover, findings regarding central activity have already been substantially elaborated on elsewhere (e.g., Brooks et al., 2012; Gianaros & Wager, 2015). In contrast, results on peripheral activity have scarcely been addressed and the potential health risks have not been evaluated. Thus, we focused on the peripheral physiological parameters that indicate physiological changes within the organism: CV and electrodermal (EDA) parameters of autonomic activity, musculoskeletal, i.e., electromyographical (EMG), hormonal, and immunological parameters. Additionally, by including only studies that tested a healthy population we attempted to elucidate the more general mechanisms that theoretically precede physical illnesses.

Searching the literature for research on the main concepts of this study, i.e., 'unconscious' is considerably hindered by a lack of consensus on terminology, (see also Brosschot et al., 2010; Eriksen, 1960; Merikle, 1984). To overcome this issue we paid special attention to building a comprehensive keyword profile in an attempt to find all relevant studies. The complex method of building this profile is explained in detail in the method section. Basically, we systematically expanded an initial simple keyword profile with a large set of new keywords. Possible relevant keywords for 'unconscious' were for example alternatives such as 'subconscious' and 'without awareness'. A comprehensive and systematically built topic-specific profile increases the degree of certainty in finding all relevant articles. Moreover, it ensures replicability across databases and researchers while facilitating updates with exactly the same search profile over time.

Furthermore, we addressed two methodological issues regarding subliminal stimulus presentation. First, as pointed out by Eriksen (1960) and Merikle (1984), to obtain valid results regarding the effects of subliminally presented stimuli, a check of awareness of the presented stimuli is required to ensure that the stimuli are indeed not consciously perceived. Moreover, verbal report of awareness is subjective and objective measures of (non)awareness should be used (Merikle, 1984). However, when recognition is reported using an objective measure, it implies that a participant has also consciously perceived (or processed) the stimulus, which is not necessarily true (Merikle, Smilek, & Eastwood, 2001). To overcome this conundrum, we have extracted information on the type of awareness check without ascribing any value to the specific type of check. Second, changes in physiology after subliminal presentation of stimuli may be a consequence of the procedure itself, for example by seeing flashes on the screen or the use of masks that might have been arousing in some way. We addressed this by selecting studies with adequate control stimuli, i.e., stimuli that had no negative affective connotation, that were presented in the same way as the negative affective stimulus, either in between or within-group designs.