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When orienting and anticipation dissociate — a case for scoring electrodermal responses in multiple latency windows in studies of human fear conditioning

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ABSTRACT

Electrodermal activity in studies of human fear conditioning is often scored by distinguishing two electrodermal responses occurring during the conditional stimulus–unconditional stimulus interval. These responses, known as first interval responding (FIR) and second interval responding (SIR), are reported to be differentially sensitive to the effects of orienting and anticipation. Recently, the FIR/SIR scoring convention has been questioned, with some arguing in favor of scoring a single response within the entire conditional stimulus–unconditional stimulus interval (entire interval responding, EIR). EIR can be advantageous in practical terms but may fail to capture experimental effects when manipulations produce dissociations between orienting and anticipation. As an illustration, we rescored the data reported by Luck and Lipp (2015b) using both FIR/SIR and EIR scoring techniques and provide evidence that the EIR scoring technique fails to detect the effects of instructed extinction, an experimental manipulation which produces a dissociation between orienting and anticipation. Thus, using a technique that scores electrodermal response indices of fear conditioning in multiple latency windows is recommended.

Electrodermal activity has been a popular and widely reported autonomic index of conditional responding since the early studies of human fear conditioning. Since the 1960s, with the advent of using long conditional stimulus–unconditional stimulus intervals (CS–US interval) of six seconds or more, most researchers have agreed that separate response components can be observed during the CS–US interval, leading to the development of scoring techniques aimed at identifying and separating these components (Boucsein, 2012). The existence of multiple electrodermal responses is well accepted, but there is less agreement as to whether these responses reflect distinct psychological processes and whether information is lost if they are combined during scoring (Öhman, 1983; Pineles et al., 2009).

Following calls to standardize the reporting of electrodermal activity in psychological research, Prokasy and Kumpfer (1973) reviewed the then extant literature on electrodermal activity as a measure of conditioning and argued in favor of distinguishing multiple responses during a CS–US interval of sufficient duration (usually 6 s or more). A first component (first interval response, FIR) was said to emerge within 1–4 s of CS onset and a second component (second interval response, SIR) shortly after this, depending on the duration of the CS–US interval (within 4–7 s for a 6 s CS–US interval and 4–9 s for an 8 s CS–US interval). The FIR, was argued to be more sensitive to orienting elicited by CS onset while the SIR was said to be more sensitive to anticipation of the US (Öhman, 1983). A response to the US (third interval response, TIR) is scored within 1–4 s after the onset of the US. These scoring intervals are applied, regardless of whether the US onset occurs during the CS or coincides with the CS offset (delay conditioning) or whether there is a time gap between CS offset and the US onset (trace conditioning). Prokasy and Kumpfer maintained that both first and second interval responses were sensitive to associative learning, but that their separation was justified on the basis that experimental manipulations did not always affect both components in the same manner (Prokasy and Ebel, 1967), and that first and second interval responding were statistically independent (Prokasy and Ebel, 1967; Prokasy et al., 1973).

The use of separate latency windows when scoring electrodermal responses can be questioned on pragmatic and theoretical grounds. Scoring in multiple latency windows is time consuming and not easily automatized, and reporting results for two response components may be cumbersome and lengthen a report without adding additional information. Moreover, the separation of the response components can be difficult in the case of overlapping responses, rendering the scoring method subjective and potentially open to bias. On theoretical grounds, studies have frequently failed to support the notion that the two response components reflect dissociable psychological processes, yielding

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parallel results for FIR and SIR. Pineles et al. (2009) examined a selection of fear conditioning experiments which scored electrodermal responses in multiple latency windows and argued that, almost always, evidence for conditioning is found in both response components. They argued that separating response components may not be justified and provided evidence for this by rescoring the electrodermal responses obtained from a large differential fear conditioning study (N = 287) using both a FIR/SIR component approach and an approach that scored a single response component, the entire interval response (EIR). The EIR was defined as the difference between skin conductance baseline (defined as the average skin conductance level 2 s before CS onset) and the peak skin conductance value observed anywhere within the CS–US interval of eight seconds (but before the onset of the unconditional response). The results were largely comparable across FIR, SIR, and EIR, however, although the FIR and EIR had similar effect sizes, SIR effect sizes were smaller. Indices of differential conditioning, difference scores between CS+ (CS paired with the US) and CS− (CS presented alone), between EIR and FIR were highly correlated, but correlations with SIR were not so robust.

There may be situations, however, in which experimental manipulations do produce meaningful dissociations between first and second interval responding, to which an EIR approach may be insensitive. One such case with significant empirical support is observed in studies of instructed extinction. During instructed extinction, one group of participants is informed after the completion of acquisition training that US presentations will cease, while the control group is interrupted in a similar manner but not informed about the changes to the CS–US contingency. Instructed extinction has been reliably shown to eliminate differential responding to CS+ and CS− at the very beginning of extinction. This conclusion, however, is often based solely on evidence from the SIR, as for the FIR instructed extinction effects are often masked by sensitization of the orienting reflex in the control group. Luck and Lipp (2015a, 2015b) and Rowles, et al, (2012) report that differential SIR is immediately eliminated following instructed extinction in the instruction group, while differential SIR remains intact at the beginning of extinction in the control group. In contrast, differential FIR was eliminated in both groups at the beginning of extinction. Closer inspection suggests that in the instruction group differential responding is eliminated due to a decrease in responding to CS+, but in the control group differential responding is eliminated due to an increase in responding to the CS−. This latter finding is interpreted to reflect sensitization of the orienting reflex caused by the interruption by the experimenter in the control group, an effect which is not seen in the instruction group as this group is provided with additional safety information.

Even though both differential FIR and SIR are eliminated after instructed extinction in the experimental group, it is crucial that evidence of intact differential responding be present in the control group to attribute the effect to the content of the instructions rather than to the fact that the experimental stimulus sequence was interrupted. Given the amplitude of the FIR tends to be larger than that of the SIR, we would predict that the EIR would reflect a response pattern similar to that seen for the FIR, and therefore would not allow for the detection of instructed extinction effects. If the EIR approach indeed fails to detect instructed extinction effects, one might wonder whether the findings from one particular fear conditioning paradigm are sufficient to warrant a preference for the FIR/SIR scoring technique. We would argue, however, that it is not always possible to predict a-priori when a dissociation between orienting and US anticipation will occur and important information could be missed if an EIR approach is not sensitive to such dissociations.

In order to examine whether effects of instructed extinction can be reflected in electrodermal responses scored using the entire interval scoring technique we applied the FIR/SIR and the entire interval scoring technique to the data reported by Luck and Lipp (2015b). This study compared two instruction groups (US electrode attached and US electrode removed) with a non-instructed control group, measuring electrodermal responding and conditional stimulus valence evaluations. As the focus of the current paper is on the electrodermal data, not the effect of instructed extinction, the reader is referred to Luck and Lipp (2015b) for details about the conditional stimulus valence measure, the effect of removal/attachment of the US electrode, and a more comprehensive discussion of instructed extinction.

1. Method

1.1. Participants

Seventy-eight (47 female) undergraduate students, aged between 17 and 50 years ($M = 22.28$ years), volunteered participation. The participants were compensated with course credit or monetary compensation and the procedures were approved by the Curtin University ethics review board. The participants were randomly assigned to either the control ($n = 24$), the instruction (electrode-on) group ($n = 30$), or the instruction (electrode-off) group ($n = 24$). The larger number of participants in the electrode-on group is due to the replacement of participants who failed to believe the instructions. One participant's electrodermal responses were lost due to problems with the recording device.

1.2. Apparatus/stimuli

Color pictures of four Caucasian, male adults [NimStim database: images M_NE_C: models 20, 21, 32, 31, Tottenham et al. (2009)] displaying neutral facial expressions were used as the conditional stimuli (CS). The pictures were 506 × 650 pixels in size and were presented on a 24 in. color LCD screen for 6 s. Counter-balancing was conducted across participants, varying three factors — the faces used in the experiment, the face used as CS+/CS−, and the nature of the first trial (CS+/CS−). The trial sequence was arranged in a pseudo-random order, such that a CS+ or CS− was not presented on more than two consecutive trials. The unconditional stimulus (US) was a 200 ms electrotactile stimulus, pulsed at 50 Hz and delivered by a Grass SD9 Stimulator to the participant's preferred forearm.

Electrodermal activity was recorded with two 8 mm Ag/AgCl electrodes filled with an isotonic gel and DC amplified at a gain of 5 μSiemens per Volt. A Biopac MP150 system, using AcqKnowledge Version 3.9.1 at a sampling frequency of 1000 Hz was used to record the electrodermal responding data, and DMDX 4.0.3.0 software (Forster and Forster, 2003) was used to control the stimulus presentation and timing.

1.3. Procedure

After washing their hands and providing informed consent the participants were seated in front of a monitor in a separate cubicle of the laboratory. The electrodermal electrodes were attached to the thenar and hypothenar prominences of their non-dominant hand. The US electrode was attached to their dominant forearm and the participants underwent a shock work up procedure to set the intensity of the electrotactile stimulus to a level they experienced as subjectively unpleasant but not painful. After the work-up procedure, the participants were asked to relax and watch a blank computer screen while a three minute baseline of their electrodermal activity was recorded. After this baseline, participants were informed that they would view faces on the screen and that they should pay attention and evaluate the faces as pleasant or unpleasant. The conditioning sequence, which consisted of habituation, acquisition, and extinction phases was started. During habituation, both CS+ and CS− were presented a total of four times to allow for the habituation of orienting responses. Acquisition, which followed habituation immediately, involved eight presentations of the CS+ and the CS−, with the offset of the CS+ coinciding with the onset of the US in a 100% reinforcement schedule, while the CS− was presented alone. For example, on a given trial