ANOMALOUS UNCONSCIOUS EMOTIONAL RESPONSES: EVIDENCE FOR A REVERSAL OF THE ARROW OF TIME [1]

Dick J. Bierman
University of Utrecht & University of Amsterdam
Dean I. Radin
Interval Research Corporation, Palo Alto, USA

1. Introduction

The idea that psychic ("psi") effects manifest primarily at an unconscious level has been popular throughout the history of parapsychology. In an elegant experiment in the early 1970s, John Hartwell, then at Utrecht University, measured the brainwave known as Contingent Negative Variation (CNV) after a warning signal but before a randomly selected picture of a face was displayed (Hartwell, 1978). CNV is usually associated with anticipatory processes, especially as a "readiness to respond" indicator. The subjects in Hartwell's studies were asked to respond with one of two buttons depending on the gender of the face on a picture.

The warning stimulus was sometimes informative, i.e., the subject was able to *infer* from the warning stimulus the gender of the face on the upcoming picture. In those trials a mean CNV was observed that clearly differed for male and female faces. In the other case the warning stimulus was uninformative, and it was hoped that the CNV still would indicate what type of picture was about to be shown. Such a finding would have suggested that in one way or another the subject had unconscious knowledge of the nearby future.

Given the large effort invested in this study, the results of Hartwell's experiment were disappointing. No significant CNV effect was found for the uninformative warning stimulus. In hindsight, Hartwell's method was probably too insensitive. The power of his design was such that it required the differential effect in the uniformed (anomalous) condition to be at least 30% of the differential effect found in the informed condition. Also he used stimuli with very low emotional content (male and female faces).

Nearly 20 years elapsed before the idea of using physiology to detect unconscious precognitive information was re-examined. Radin (1997) monitored the sympathetic and parasympathetic behavior of the autonomic nervous system with skin conductance, heart rate and fingertip blood volume measurements. Radin's subjects were asked to look at a computer monitor and press a button to start a trial. As illustrated in Figure 1, the button press caused the display of a blank screen for five seconds, then a randomly selected calm or emotional picture was shown for three seconds, and this was followed by ten seconds of a blank screen. In three studies, he found significant differences in autonomic physiology, most notably skin conductance, preceding the exposure of emotional vs. calm pictures. Radin examined a number of possible normal explanations and concluded that they did not apply.

---

[1] This article is adapted from talks presented by the first author at the 1997 Parapsychological Association Convention (Brighton UK), and by the second author at the 1996 Parapsychological Association Convention (San Diego, CA, USA). The article appeared in: Stuart Hameroff, Alfred Kaszniak, and David Chalmers (Eds) Toward a Science of

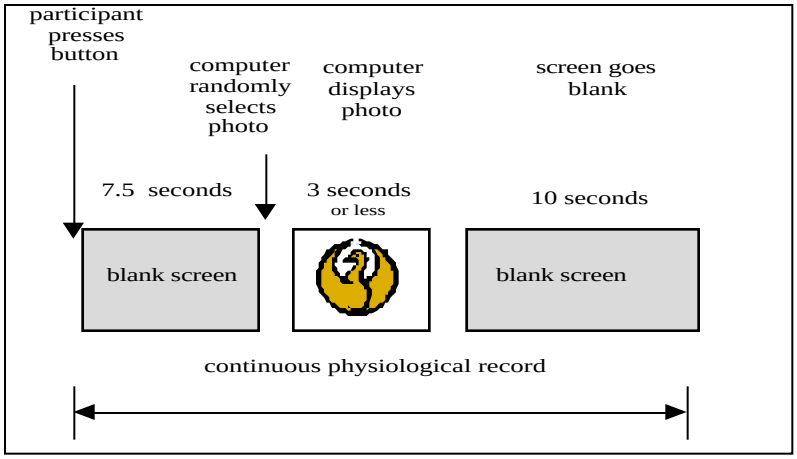

Figure 1. Illustration of method used by Radin (1997).

One potential normal explanation, the effect of anticipatory strategies, was not discussed in Radin (1997). Such a strategy is as follows: Subjects who participate in this type of experiment slowly become aware that every few trials an emotional picture will be displayed. They may therefore begin to build up (generally incorrect) expectations about the emotional categories of upcoming pictures (i.e., calm or emotional). Following the Gambler's Fallacy, their degree of expectation may increase after each calm picture and may decrease after an emotional picture. Superficially, it appears that this might result in a mean anticipatory presponse which is smaller for calm stimuli than for emotional stimuli, and this in turn might account for the presentiment effect described by Radin (1996).

This possible explanation of the differences in presponse was later modeled through two computer simulations independently written by the authors, and by a third independent colleague. It turned out that the effect as described above only emerges when randomization is conducted without replacement, and therefore it could not explain Radin's original results (as he used randomization with replacement). Thus Radin's findings suggested a genuine, replicable psi effect with an unusually large signal-to-noise ratio.

When the first author heard about these results, he thought they were "too good to be true," and therefore decided to replicate the experiments in his laboratory using the same procedures and picture material, but completely different software, hardware, and randomization procedures. He reasoned that if the effects could be replicated under these conditions, it would make any explanation in terms of technical artifacts or inappropriate randomization less likely.

2. Procedure

A participant sits in a comfortable chair in a dimly lit room. The index and middle finger of the left hand are connected to a skin conductance measurement device. In the instructions, the experimenter emphasizes that the subject should try to experience each trial anew. After the instructions and one or more demonstration trials, the experimenter leaves the room and the participant starts the first trial at will by pressing a key on the keyboard. After 7.5 seconds[2], a period that we call the *fore-period*, a randomly chosen picture, either calm or highly emotional, is displayed for a specific exposure time (for randomization details see Appendix 1). Before, during and after exposure the skin conductance is sampled by the computer at 5 samples per second (see Figure 1).

---

2 Radin used 5 seconds for practical

Study 1: This was a straightforward replication of the experiments reported by Radin (1997), with the following modifications. Rather than selecting pictures uniformly at random from the target pool, pictures were organized in three sets with different ratios of calm to emotional pictures. The target set was chosen randomly at the beginning of each experiment such that even the ratio was unknown to the experimenter. Then the pictures in the set were shuffled and presented in the shuffled order. All pictures in the set were presented.

Also, rather than using different exposure times between studies like those reported in Radin's (1997) studies, we introduced this variable as a within-subject variable. There were always two possible exposure times, each randomly selected with a probability of 0.5.

Study 2: This study employed subjects who were not completely informed about the nature of the task. They were told that 10 control pictures would be presented to establish a baseline for their physiological behavior. According to this cover story, the experiment would begin after establishment of this baseline.[3] However, unbeknownst to the subjects a single emotional picture would be presented randomly between the third and tenth trial. For about half of the subjects this emotional picture was erotic and for the other half the emotional picture was violent.

Study 3: After Study 2, the (same) subjects were now completely informed about the fact that there would occasionally be emotional pictures, and thus the subjects were expected to use anticipation strategies similar to those potentially used by subjects in Study 1. Study 3 used only one ratio (one emotional to two calms) between emotional and calm targets, and it used only 48 pictures from the original pool of 120. These 48 pictures were selected on the basis of their stronger observed effects in Study 1.

2. 1 Stimulus material

The stimulus material was identical to the set of pictures used by Radin (1997). It consisted of 80 calm pictures, like scenes of the ocean or forest, and 40 emotional pictures of a violent or erotic nature. This set of pictures was slightly updated by the student experimenter in Study 1. She adjusted the set for cultural differences between the United States and The Netherlands, most notably by replacing some of the erotic pictures that would not be perceived as very arousing in Europe with more emotional pictures. A snapshot review of the updated set and other information on this study is available through the Web at www.psy.uva.nl/emo_int.1.

For Studies 2 and 3, a subset of the 120 pictures of the basic set was used. This selection was based on a qualitative evaluation of the response effect of each of the pictures used in Study 1. For the emotional categories “violent” and “erotic,” the most arousing pictures were selected while for the calm category a random selection was made. In the category “violent” we included decorative body piercings, including genital piercings. The erotic pictures were of both homosexual and heterosexual nature. We did not make an effort to study any differential effects between these two sub-categories.

[3] The University of Amsterdam human subjects committee approved this minor use of

2. 2 Subjects

Subjects in all studies were recruited from the circle of friends or acquaintances of the experimenters. In the first study these were 16 health care professionals following a course in Therapeutic Touch. In the second and third study most subjects were students at the University of Amsterdam. Seven of the 32 participants in studies 2 and 3 rated themselves as skeptical about the existence of paranormal phenomena.

2.3 Dependent variables

The dependent variable in both studies was the behavior of the skin conductance during the 7.5 seconds preceding the stimulus (the fore-period). To avoid the problem of multiple analyses, and of evaluating data from non-normal distributions and with strong auto-correlations between samples, we defined the dependent variable ***P*** as the mean value of the samples between 4 seconds and 6 seconds after the subject initiated the trial (which is indicated as the critical interval in Figure 2), as compared to the mean values based on samples between 0.6 and 1.6 seconds after the subject initiated the trial.[4]

2.4 Independent variables

The following independent variables were used:

a. *Type of stimulus (StimType)*; For each study this within-subject variable had two values: calm and emotional. In the category emotional we discerned two sub-categories: violent and erotic. In study 2a the type of stimulus was a between-subject variable.

b. *Exposure time (Exp.Time)*; For each study this within-subject variable had two levels.

c. *Subject variables* (Ss-X). The gender of the subjects may be an important variable because in normal research on the physiology of emotions gender-typical effects have been reported (Greenwald et al, 1989).

d. *Ratio* between calm and emotional targets (Study 1 only).

3. Hypothesis and exploratory analyses

Because these three studies were primarily conducted to validate the earlier results obtained by Radin (1997), the major relevant hypothesis was that skin conductance before the exposure of emotional pictures would be significantly greater than before calm pictures. We also decided to explore potential differences between different classes of emotional pictures and the effects of exposure time.

Finally we planned secondary analyses to examine sequential effects (Study 1 only). This was done because in the studies reported here a "randomization without replacement" scheme was used.

- We explored the differential effects for calm and emotional pictures matched for sequential position.
- We explored the effects on the presponse pattern distribution for different emotional to calm ratios.

---

[4] Bierman (1997) originally used a slightly different interval, but new theoretical insights suggested shifting the critical interval to one second earlier (see the later discussion on time-

4. Results of Study 1

4.1 Subjects

In study 1, 16 subjects were tested in the period between Oct. 4 and Nov. 14 1996. Three were male, and 13 female. Their age ranged from 22 to 57.

4.2 Calm vs. Emotional effect

Each subject contributed 40 trials, so the total data set consisted of 16* 40 = 640 trials of skin conductance, or more precisely, Galvanic Skin Response (GSR) data.[5] Of these 640 trials, 428 had calm stimuli and 212 had emotional stimuli. For each trial the difference between the first sample and the remaining samples were calculated, resulting in curves showing the *change* in skin conductance from the moment the button was pressed to start each trial. Figure 2 shows the mean response for change in skin conductance for all calm and emotional trials.

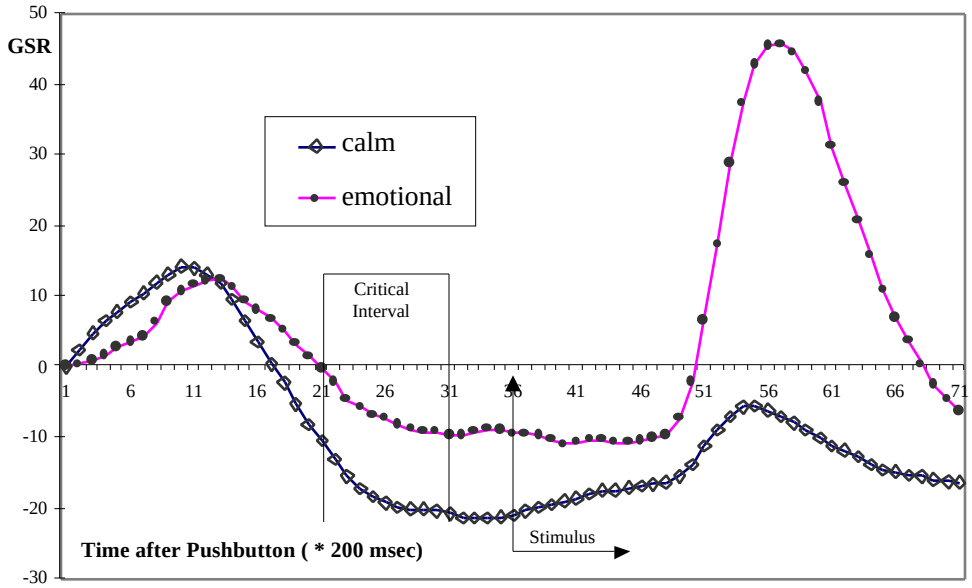

Figure 2: Mean galvanic skin response (GSR) as a function of sample number (time) for the two stimulus categories, calm and emotional. Stimulus presentation starts at sample 37. The critical interval where the presponse P was hypothesized to occur is also indicated.

The formal statistical test consisted of calculating the presponse ***P*** according to the definition given in the section on dependent variables, then performing a Mann Whitney U test on those scores preceding calm vs. emotional stimuli. The resulting z-score was $z = 2.4$ with a corresponding $p = 0.016$, thus the hypothesis was confirmed.

[5] GSR in this context refers to phasic (changing) physiological measures rather than tonic

4.3 Violent vs. Erotic effect

Figure 3 shows the mean presponse pattern for erotic pictures and for violent pictures.[6]

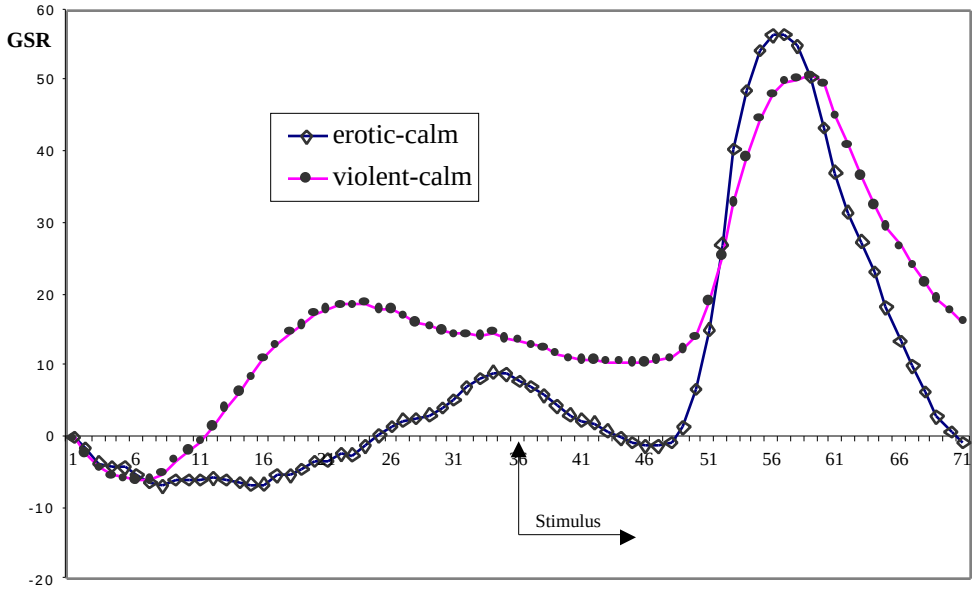

Figure 3. Mean GSR vs. time for erotic and violent stimuli, both as compared to the mean GSR for calm stimuli.

From Figure 3 it appears as though the violent presponse is faster and larger in magnitude than the erotic presponse. A comparison of the independent variable ***P*** for the two types of pictures yields a (Mann-Whitney U) z-value of 1.65 (p = 0.10). The results for the violent presponse alone are quite significant (z = 2.94; p = 0.003)

4.4. Exposure time effect

In Figure 4 the average difference in presponse between emotional and calm is given for long (3000 msec) and short (400 msec) exposures. Although the differences are both in the predicted direction, the differences when formally tested are only suggestively significant (Mann Whitney U: z-value = 1.72, p = 0.085).

[6] The

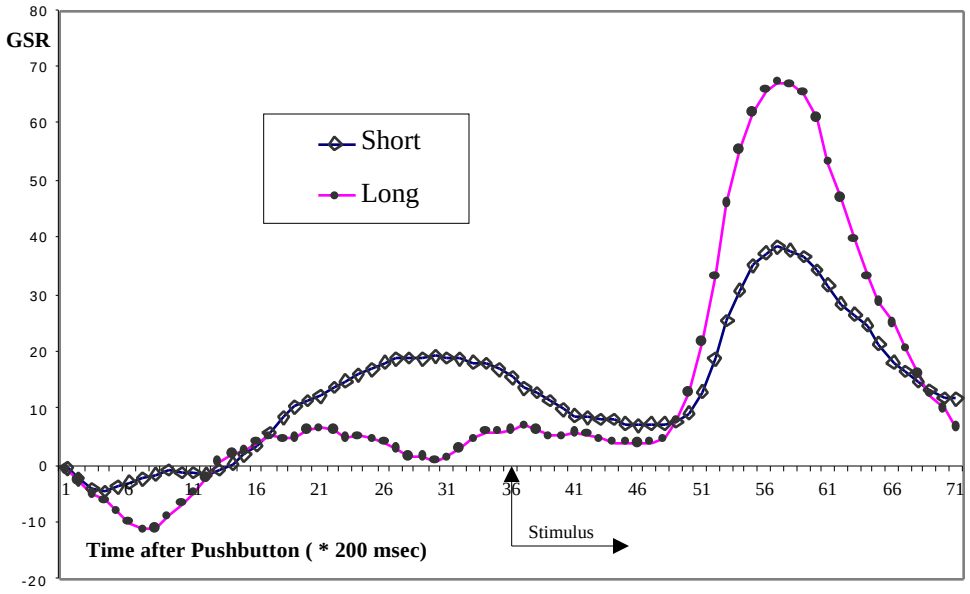

Figure 4: The average difference in presponse between emotional and calm trials for two different exposure times in Study 1.

4.5 Secondary analysis

A number of secondary analysis were conducted to test for sequential explanations. No evidence was found for such an explanation. (See Appendix 2 for more details.)

5. Results of Study 2

5.1 Subjects

32 subjects, 16 males and 16 females, were tested from Feb. 17, 1997 through March 4, 1997. Their ages ranged from 19 to 36.

5.2 Calm vs. Emotional effect

Each subject had only one emotional exposure, randomly preceded by between 3 to 9 calm exposures. Figure 5 shows the difference between the mean physiological records of 32 emotional exposures and the mean of 184 calm exposures. This curve shows the same trend as seen before: A rise in presponse before emotional targets as compared to before calm targets. However, the formal test yielded a non-significant z-score for the difference between calm and emotional stimuli of z = 0.43 (of course, the statistical power in Study 2 was considerably less than that in Study 1).

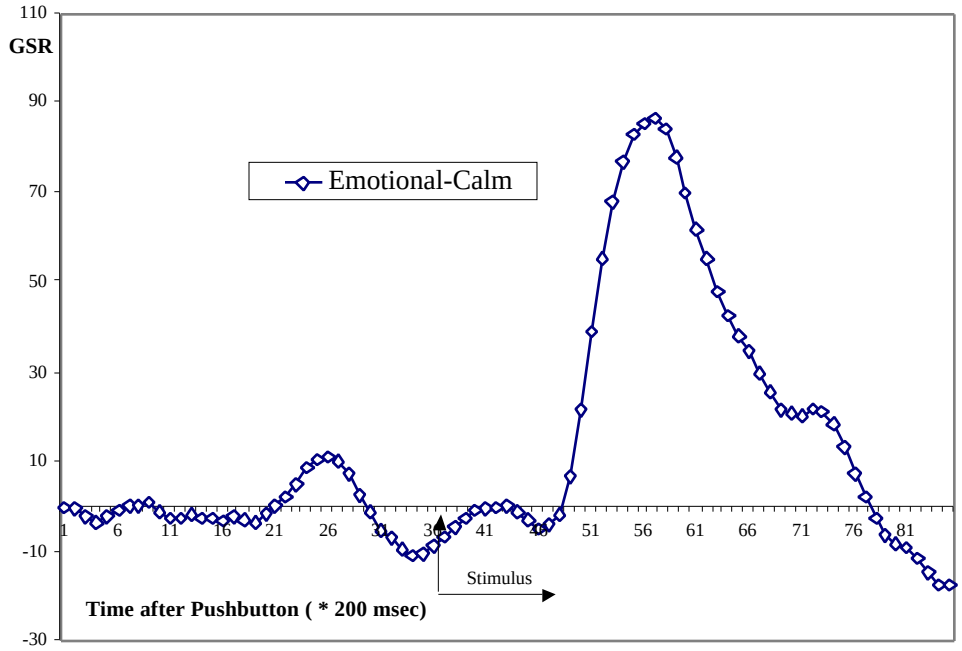

Figure 5: Difference between calm and emotional exposures in Study 2.

4.3 Violent vs. erotic effect

Figure 6 shows the mean physiological record in cases of exposure of erotic vs. violent pictures in Study 2. The over-all pattern was again similar to the pattern found in Study 1. The maximum value for violent exposures occurred sooner than for erotic exposures. There also appears to be an interesting "symmetry" between the presponse and response curves, especially for the erotic exposures. The formal statistical test yielded a non-significant z-score for the difference between erotic and violent pictures of z = 0.57.

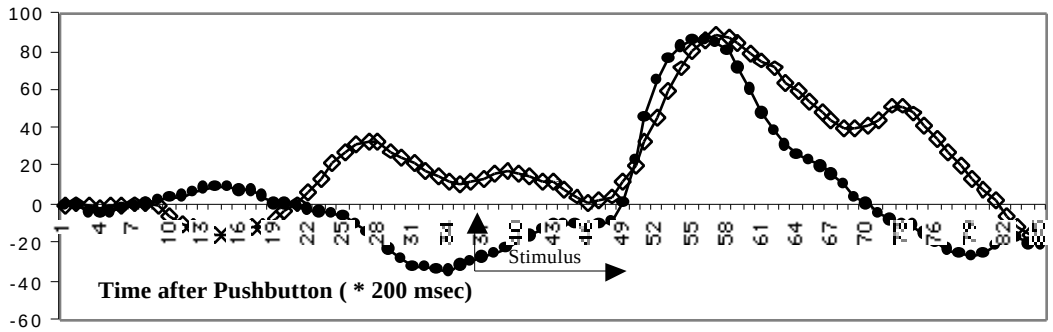

Figure 6: Mean GSR for erotic vs. violent stimuli, both corrected with the mean GSR for calm stimuli.

5.4 Exposure time effect

Figure 7 shows the difference between calm and emotional targets according the two exposure times. In contrast with the findings of Study 1, it appears that the shorter exposure time did not have a presponse at all. It should be noted that in Study 1 the shortest exposure time was 600 msec while in this study it was 400 msec. The formal statistical test yielded a non-significant z-score for the difference between the two exposure times of z = 0.67.

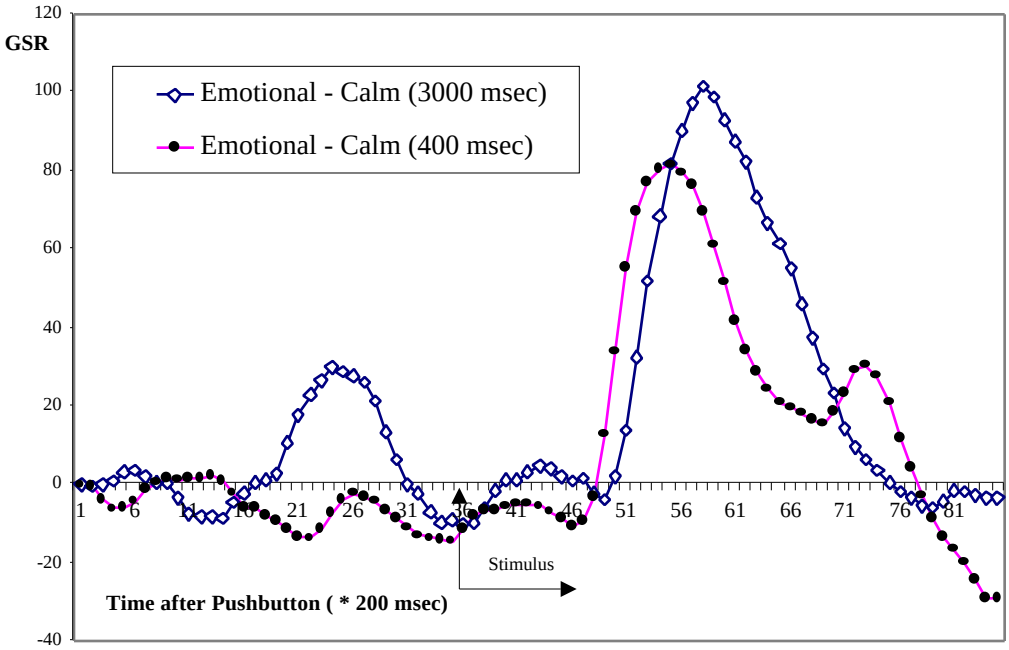

Figure 7: Mean GSR for emotional minus calm stimuli for two exposure times.

6. Results of Study 3

6.1 Subjects

These were identical to Study 2.

6.2 Calm vs. emotional effects

Figure 8 shows the over-all results of Study 3. The presponse is clearly visible but although the power is even slightly higher than in Study 1 the difference between calm and emotional stimuli is not significant (z = 0.9).

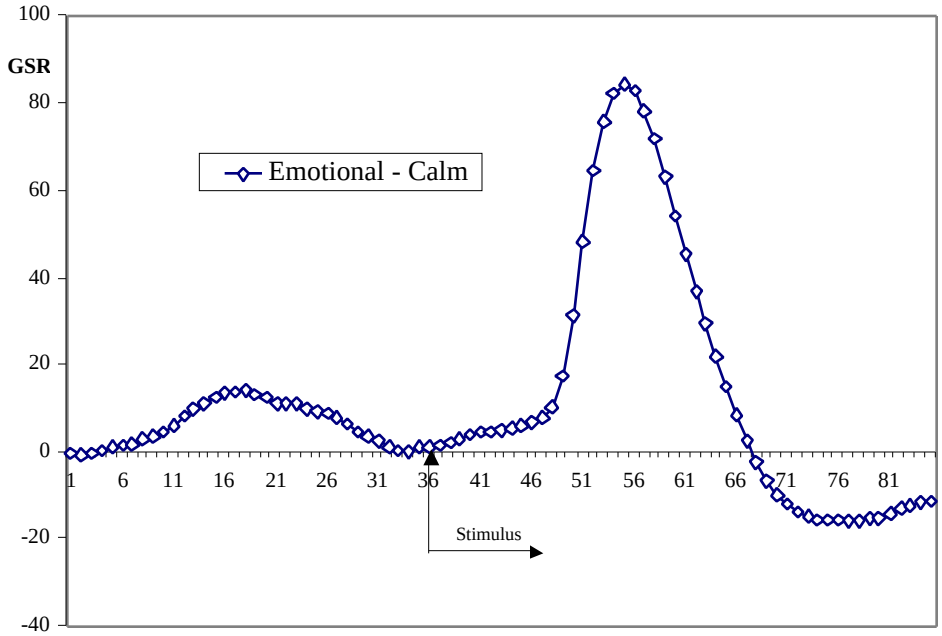

Figure 8: Mean GSR for emotional minus calm stimuli for Study 3.

6.3 Erotic vs. violent effects

Figure 9 possibly shows an earlier presponse for violent than for erotic stimuli. The formal test however only deals with the magnitude of the effects during the critical period and hence do not show a significant effect (z = 0.14).

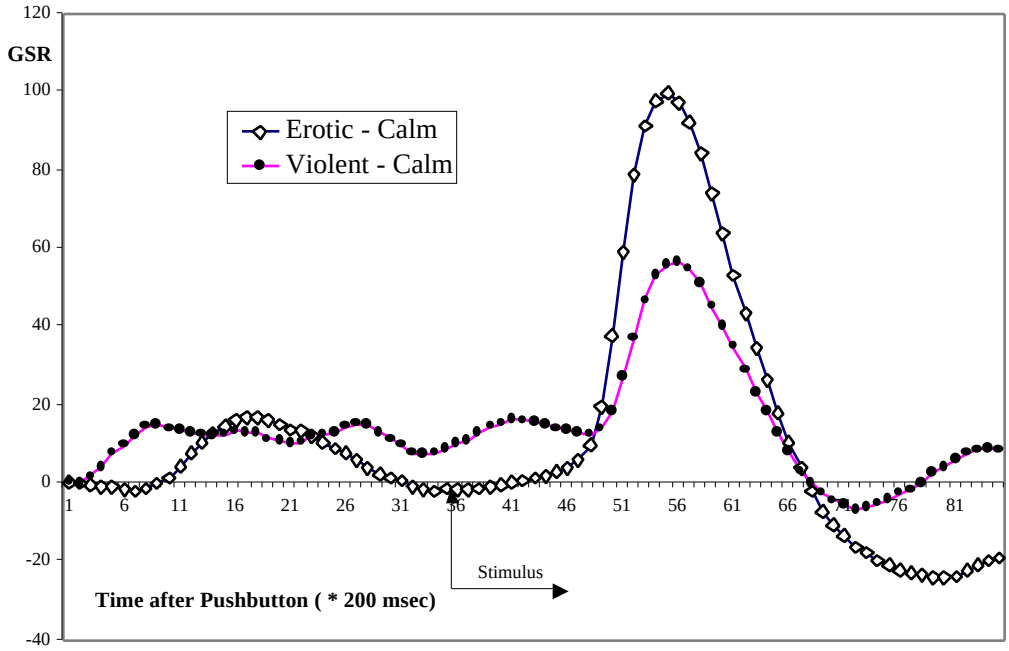

Figure 9: Mean GSR for erotic vs. violent targets in Study 3.

6.4 Exposure time effects.

Figure 10 displays the mean GSR for emotional stimuli for short and long exposure times. The Mann Whitney U test yields a z-score of 0.55.

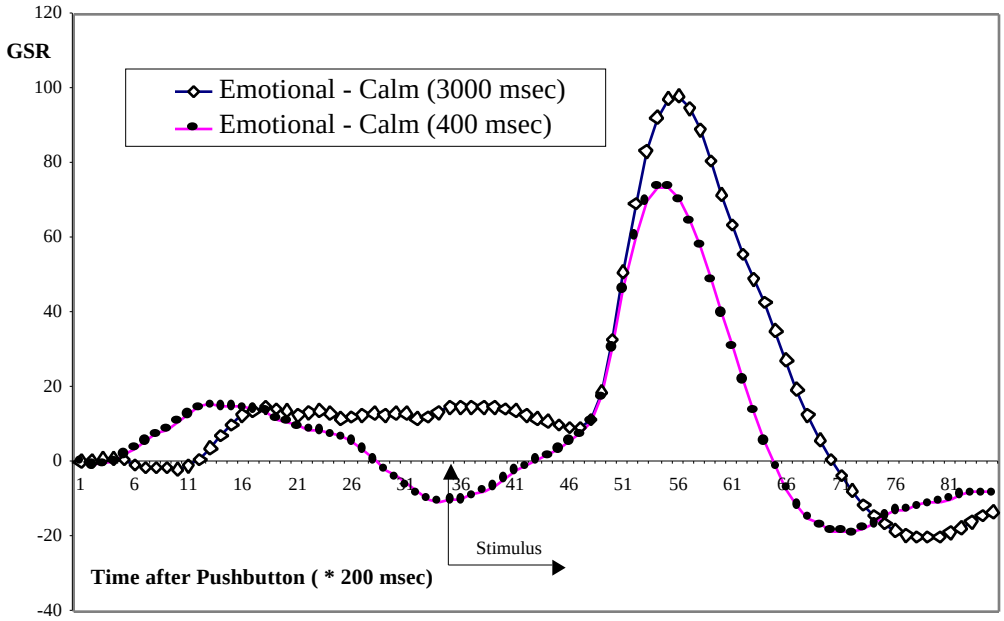

Figure 10: Mean GSR for emotional minus calm pictures for two exposure times.

7. Discussion

Table 1 provides a summary of the three studies. The effect of a larger presponse for succeeding emotional pictures than for succeeding calm pictures is consistent through the three studies. We have calculated an effect size measure (the difference in mean ranks for the two conditions that are compared, normalized by the over-all mean rank, in terms of *percent*) to allow us to quantitatively compare the results of the different studies.

Study	*Study1*	*Study2*	*Study3*	*Combined*	*p-value*
Emotional-calm z-score	2.4	0.43	0.9	2.16	0.016
Effect size emotional-calm	+11.3%	+4.7%	+4.4%		
Erotic-violent z-score	-1.65	0.57	0.14	-0.54	n.s.
Effect size erotic-violent	-13.5%	+12.7%	+1.4%		
Short-long exposure z	1.72	-0.67	0.55	0.92	n.s.
Effect size short-long	+13.7%	-13.9%	+4.7%		

Table 1: A review of the results. Positive values mean that the first condition of the two that are compared had the largest effect.

While the emotional vs. calm presponse effect is positive in all three studies, the effect size is only a third as large in Studies 2 and 3. This reduction may be due to the use of different

subject populations, but in any case, the combined result confirms the earlier findings of Radin (1997).

The results of the comparison between violent and erotic stimuli in tabular form are more confusing. The direction of the difference is not consistent across the studies, and apart from the different subject populations, the choice of the dependent variable may be questioned. In future research, it seems more advisable to use a dependent variable that reflects the specific presponse patterns expected (e.g., early vs. late phase of the presponse).

An interpretation of the exposure times findings is also difficult because there were three different times used in these studies. It appears that an exposure time of 600 msec is better than 3000 msec, but an exposure time of 400 msecs is inferior. It should be noted that for 400 msec exposures, the subjects do not always recognize the emotional contents of the pictures. Thus, in that condition they may not always consciously (or even unconsciously) experience an emotion.

Examining possible artifacts

Radin (1997) has adequately treated a number of potential normal explanations of the effect. The current replication, using completely different hardware and software, does strengthen the conclusion that the results are not due to technical artifacts.

The major (and maybe only) source of normal explanations remaining after Radin's original analyses is the hypothesis that subjects developed anticipatory strategies that resulted in different anticipatory physiology preceding calm or emotional pictures. At first glance this seems to be a real possibility. However, the current results do not support this idea because the presponse effect does not depend on the ratio between calm and emotional targets in any systematic way. We would expect some systematic relationship to exist if anticipation strategies were indeed based upon the Gambler's Fallacy.

There are three further arguments against an explanation in terms of normal anticipatory strategies. The first is that we find suggestive internal effects that can not easily be explained by this type of strategies. For example, the differences observed between erotic and violent emotional stimuli would require an anticipatory strategy (i.e., a probabilistic strategy) able to discriminate both between upcoming calm and emotional targets and between two types of emotional pictures. This seems most unlikely given that the subjects were blind both to the ratios between calm and emotional targets, and to the content of the emotional targets.

Secondly, sequential presentation histories starting with one emotional, followed by one, two or three calms always have a larger presponse before a final emotional in comparison with a final calm picture. Thus the effect is basically independent of presentation orders. Presentation orders starting with two or more consecutive emotional pictures and with larger lags are too infrequent to analyze.

The final argument is that computer simulations of anticipatory strategies, using the same emotional to calm target ratios and the same number of exposures used in the current studies, do not show the expected main calm vs. emotional effects. It does turn out that these simulations are sensitive for the type of randomization used. If we used a random selection *with* replacement of the targets, then the simulation effects were nil. However, if we used a random shuffling scheme *without* replacement then the effects ranged between 0% and 10%. This was a surprise because the reasoning as sketched in the introduction has such a direct appeal.

The following anticipatory strategies were tested:

a) Increase anticipation by 1 unit after each calm target, and reset anticipation to 1 after each emotional target.

b) Double the anticipation after each calm target (to a maximum of 500) and reset the anticipation after each emotional target to either half of the previous value, or 1.

The simulated effects in the open-deck situation were never larger than 2% while the observed experimental effects in Studies 1 and 2 were generally larger than 10%. However, these analyses are by no means exhaustive and there may be less plausible statistical anticipation models that may result in larger differences. The major point in favor of the psi hypothesis is that there are no indications in the real data that support any of these sequential strategy models.

Is this effect an instance of macroscopic time symmetry?

Formally the laws of physics are time-symmetric. In practical terms, this time symmetry is observed in classical mechanics but not in thermodynamics, where Boltzmann's second law forces the systems toward increasingly higher states of entropy. In a lucid book on time symmetry, Huw Price analyses this problem and concludes that the standard "explanation" based upon probabilistic arguments is incorrect (as Boltzmann himself also realized) (Price, 1996).

In an analysis of the asymmetry observed in radiation (electromagnetic theory), Price suggests that the asymmetry is caused by the spatial arrangements of absorbers and emitters. Absorbers tend to be non-coherent and transmitters tend to be coherent. According to Price this results in a destructive interference of the "advanced" waves. Thus we rarely observe back-action in nature unless we have a coherent absorbing system. We speculate that consciousness may be such a system. One could for instance propose that microtubules form such a special spatial arrangement of a multi particle 'absorber' (Hameroff & Penrose, 1996). Another argument for our speculation is that ongoing presentiment experiments, where the exposure times are shortened and the attention of the subject is directed away from the picture in order to increase unconscious impact (Murphy & Zajonc, 1993), do not show any anomalous effect. It appears therefore that conscious emotional experience in necessary for the 'time-symmetry' to occur.

Price shows also that when allowing for time-symmetry in quantum physics all of the puzzling paradoxes related to the measurement problem, such as non-locality, disappear.

Price's analysis of the problem of lost time-symmetry suggests a continuation of these types of experiments using experienced meditators. On the other hand, there are some suggestions in the present data, and in data of ongoing experiments, that a *conscious* emotional experience may be required to elicit the presentiment effect. I.e. if the meditator is too experienced and succeeds in completely blocking the target picture out of his or her awareness, the presentiment effect may disappear. Interestingly, our speculation about consciousness as a coherent absorbing system fits in with folklore about the relationship between meditation and the occurrence of psi-phenomena. It is said that on the path toward control of one's consciousness, at some point psi-phenomena just naturally appear. It is also said that one should not pay attention to these phenomena, because that would only frustrate further progress in meditation performance.

Within this admittedly speculative framework, the expected point of symmetry on the time axis is *not* at the time of stimulus onset, but rather at the start of the conscious experience, which may be around 500 msec later. Therefore the peak of the presponse is not expected around 3.5 seconds before the stimulus onset (where it would be if it was a mirror image of the response with symmetry point at stimulus onset), but rather about 2.5 seconds before stimulus onset. This fits in well with the specification of the dependent variable in section 2.3.

8. Conclusion

Human physiology changes in predictable ways in anticipation of and after exposure to emotional visual stimuli. In a series of experiments reported by Radin (1997), it was found that even when stimuli were adequately randomized, so that the upcoming stimuli could not be inferred, that anticipatory responses (as measured by changes in skin conductance) before exposure to emotional pictures were significantly larger than before exposure to calm pictures.

The results of three new experiments, the first and third close replications and the second a conceptual replication of Radin's studies, confirm what was called a "presentiment" or pre-feeling effect: The anticipation or "presponse" preceding emotional pictures in these studies, measured again as changes in skin conductance, was greater than the presponse preceding calm pictures. One of the three studies had an independently significant over-all effect (Mann-Whitney U: $z = 2.4$; $p = 0.008$, one tailed), and the compound score for the three studies pooled was significant ($z = 2.16$; $p < 0.016$, one tailed). Examination of the data suggest different presponse patterns for specific categories of stimuli, e.g., violent vs. erotic pictures.

Sequential response patterns and other possible artifacts were examined as a possible normal causal explanation of the data, but it is concluded that these data only seem explicable as a form of "backaction" or retro-causal effect due to conscious experience. Backaction was discussed in the light of the role of time-symmetry in physics. It was speculated that consciousness plays the role of a highly coherent absorber and is therefore responsible for constructive "backaction" rather than destructive retro-causal effects which are thought to arise from non-coherent absorbers.

Acknowledgements

Dagmar van der Neut was the experimenter in the first study. She was a continuous source of improvements and ideas. Also Rens Wezelman's stimulating discussions and uncanny insights were and continue to be instrumental in the success of the research program. The Parapsychological Institute offered hospitality for the carrying out of Study I.

References

Bierman, D.J. & Radin, D.I. (1997). Anomalous Anticipatory Response on Randomized Future Conditions, *Perceptual and Motor Skills*, **84**, pp. 689-690.

Hartwell , J. (1978). CNV as an index of precognitive information. *European Journal of Parapsychology*, **2**, pp.83-103.

Hameroff, S.R. and Penrose, R. (1996). Conscious events as orchestrated spacetime selections. *Journal of Consciousness Studies* 3 (1), pp. 36-53.

Murphy, T.S. & Zajonc, R.B. (1993). Affect, Cognition, and Awareness: Affective priming with Optimal and Suboptimal Stimulus Exposure. *Journal of Personality and Social Psychology*, 64, 5, pp. 723-739.

Price, H. (1996) Time's arrow and Archimedes Point: new directions for the physics of time. Oxford University Press. ISBN: 0-19-510095-6

Radin, D. I. (1997). Unconscious perception of future emotions: An experiment in presentiment. *Journal of Scientific Exploration*, **11** (2), 163-180.

Appendix 1: *Randomization details.*

Proper randomization of the presentation order is a critical element in this experiment because the participant must not be able to infer anything about the upcoming future stimuli. Thus, the stimulus-arrays were shuffled using a pseudorandom generator based upon the standard random function in the CodeWarrior C programming environment (CodeWarrior for Macintosh, version 8.). Sources for this software are available over the Internet. It should be remarked that this randomization procedure is performed at the start of the presentation of the first trial, and therefore an interpretation of the results in terms of clairvoyance rather than precognition is allowed. (http://www.psy.uva.nl/emo_int.1)

Appendix 2: *Secondary analyses in Study 1*

A.1 Ratio effect

To evaluate the effect of different ratios between calm and emotional stimuli, an ANOVA was performed using *stimulus category* and *ratio* as factors, and the ***P***-score as dependent variable. Given the non-normality of the ***P***-score distribution this turns out to be a slightly conservative approach. The results showed that the mean presponse for all stimuli, calms and emotional targets was heavily influenced by *ratio* ($F= 15.36$, $df=2$, $p<0.0001$). This is due to the fact that *ratio* is a between-subject variable and subjects differ enormously with respect to psychophysiological responsiveness. However, the interaction with *stimulus category* was not significant, suggesting that the ratio of emotional to calm targets was of no influence on the calm vs. emotional presponse effect.

A.2 Matching for sequential position

In the previous analyses, the means of the presponses were calculated independently of the sequential position of the specific stimulus. Thus, the average of the calm presponses was composed of presponses of calm trials that were preceded by another calm trial, but also of calm trials that were preceded by an emotional trial. This pooling of trials with different sequential positions may have resulted in artifacts as described in the Introduction section.

One solution to this problem is to compare trials only if they have an identical sequential history. The trials in Study 1 were therefore broken down according to their sequential history. We compared the last calm and emotional targets with the following histories:

lag1: Emotional-Calm vs. Emotional-Emotional

lag2: Emotional-Calm-Calm vs. Emotional-Calm-Emotional

lag3: Emotional-Calm-Calm-Calm vs. Emotional-Calm-Calm-Emotional

lag4: Emotional-Calm-Calm-Calm-Calm vs. Emotional-Calm-Calm-Calm-Emotional

The results for the different lags are graphically presented in Figure 11.

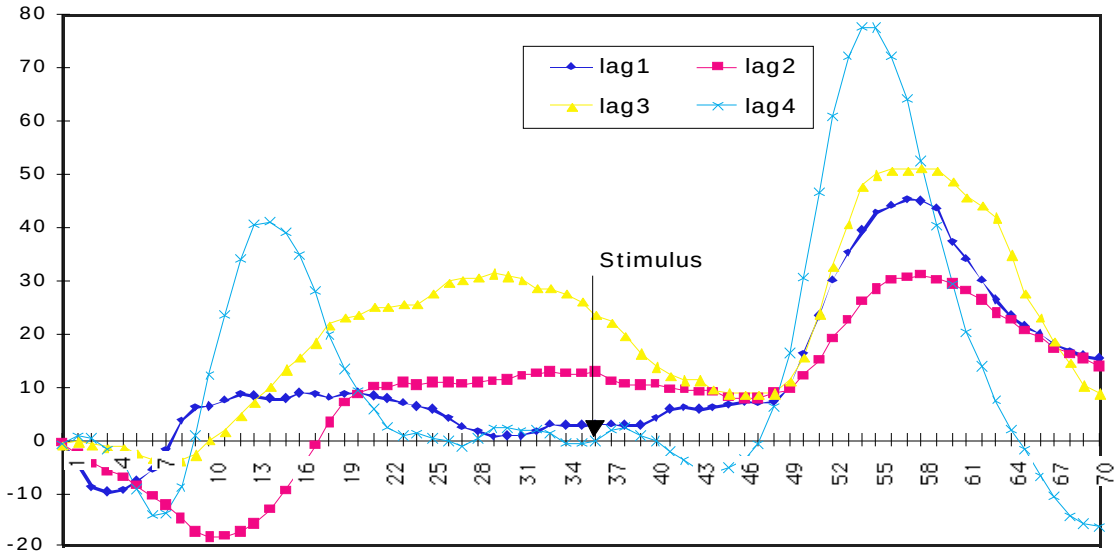

Figure 11. Differences between mean presponse for emotional minus calm stimuli, with matched sequential histories.

It can be seen that although there are different wave-forms for the different time lags, the over-all picture shows that the presponse prior to emotional targets is larger than prior to calm targets. Separate Mann-Whitney U tests, shown in Table 2, yield the following z scores:

Lag	z-score	Ncalms	Nemotionals
1	0.30	146	77
2	1.74	96	46
3	2.86*	59	34
4	1.15	42	16

Table 2. Mann-Whitney U tests for different sequential lags.

Lags beyond 4 also shown a positive z-score. A weighted sum of the four different lag analyses is shown in Figure 12. This is basically identical to the result shown in Figure 2. This indicates that the presponse effect does not depend on the sequence of calm and emotional targets.

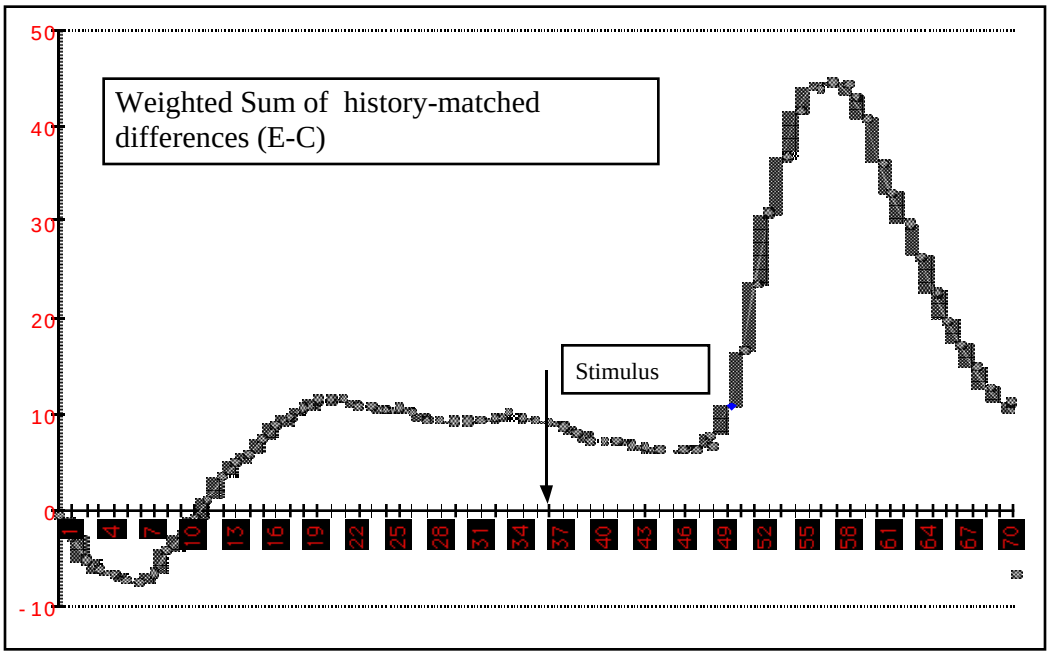

Figure 12: Weighted sum of presponse differences for emotional minus calm targets, over 4 different sequential histories.