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Title: Physiological markers of future outcomes: Three experiments on subconscious psi perception during concurrent performance of a guessing task

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Abstract

Physiological responses to arousing (vs. calm) stimuli arriving 3-7 seconds in the future have been described in peer-reviewed journals using five different physiological measures in at least four different laboratories. However, only a handful of these have used tasks in which participants must perform conscious guessing at targets. In order to eventually improve performance at intuitive guessing, understanding the mechanisms of physiological presentiment effects during the performance of behavioral guessing tasks is critical.

To address this gap in knowledge, we performed three experiments. Our hypothesis for all three experiments was that two measures of autonomic state, heart pulse period or inter-beat-interval (IBI) and skin conductance (SC), would both show distinct and significantly different patterns associated with future correct vs. incorrect guesses in a guessing task. In the first two experiments we show that at the group level, significant differences in heart period are observed, such that IBI is higher preceding a correct guess than an incorrect guess. However, at least at the group level, there was no SC difference associated with correctness or incorrectness of a future guess in either of the two experiments. The third experiment found no significant anticipatory effects. Finally, an exploratory analysis comparing data from all females to all males across the four experiments showed that while at the group level SC was not responsive to correctness of future guesses in any experiment, a robust sex difference in SC anticipatory responses exists, in which males have increased skin conductance preceding correct vs. incorrect guesses, while females show the reverse pattern.

None of the significant effects in any of the experiments or the post-hoc sex difference analysis could be explained by expectation bias. Reasons for the lack of a significant effect in the third experiment are discussed. Overall, the results support the hypothesis.

Introduction

Physiological responses to arousing (vs. calm) stimuli arriving 3-7 seconds in the future have been described in peer-reviewed journals using five different physiological measures (skin conductance, heart rate, blood volume, EEG, fMRI) in at least four different laboratories (D. Radin, 1997; D. Bierman and H. Scholte, 2002; B. McDonough et al., 2002; S. Spottiswoode and E. May, 2003; R. McCraty et al., 2004a, b; D. Radin, 2004; E. C. May et al., 2005; D. Radin and E. Lobach, 2007; D. Radin and A. Borges, 2009). Similar to these presentiment studies is a smaller set of studies reporting heart rate and EEG differences associated with targets vs. non-targets in behavioral guessing tasks (B. McDonough et al., 2002; L. Sartori et al., 2004; P. Tressoldi et al., 2005; P. Tressoldi et al., 2009). The series of experiments presented here were motivated by a desire to expand our understanding of the physiological anticipatory responses in such a guessing task.

In the present series of experiments, we set out to test the hypothesis that two measures of autonomic state, heart inter-beat-interval (IBI) and skin conductance (SC), would both show distinct patterns associated with future correct vs. incorrect guesses when individuals are asked to predict the identity of future visual stimuli.

Methods: Experiment One

Experimental Design

No formal protocol was written before the experiment began, although a general outline of the conditions was written in a laboratory notebook, and the protocol was discussed and agreed upon orally among the authors, two of whom are skeptics (MG and SS). The number of trials of the guessing task and all other procedural details were predetermined; however the analysis methods were altered from the analyses originally performed, based on advice from several colleagues.

Behavioral and physiological data were examined and reported upon after 20 participants had performed the experiment[1], and significant result was found. At that point, colleagues suggested that we normalize the physiology traces to reduce noise, and the second and third authors suggested we apply this new analysis to all 40 subjects who performed the experiment by June 2009. The new analysis, using normalized traces, was not performed until after data from all 40 participants had been gathered. The number of participants was determined by the number of undergraduates who registered for the experiment in Winter and Spring quarters of 2009.

Participants

Between January 2009 and June 2009, we collected behavioral and physiological data from a group of 40 Northwestern University undergraduates (18-21 years old; 24 female) who each participated in a 1.5 to 2-hour session in which they performed three tasks. Physiological data were available for 39 of the 40 participants (one male was removed). The first and third of these tasks examined remote-stare detection as described previously (J. Mossbridge et al., 2009); the present paper only describes results from the second task that was performed, the target-guessing task.

Participants were pre-screened via a written question: "How would you rate your confidence that psychic phenomena, including telepathy and precognition, are real and scientifically verifiable? Please answer on a scale from 0 to 5, with 0 rated as "No Confidence" and 5 as "Complete Confidence." We selected only individuals who rated their confidence as "3" or above on this scale.

Task

In each trial of 25 trials of the guessing task, participants were presented with four photographs in each of the four corners of the computer monitor. These photographs were selected without replacement from a set of 100 images consisting of the 100 least arousing photos in the

[1] Note that an earlier report (Mossbridge et al. 2009) includes 19 participants that are included in the experiments described in the present paper. After submitting that paper, we added 20 more subjects to the first experiment and altered our method of analysis (see Data Analysis for details). Thus, any meta-analysis should include the data described here and not those in the 2009 report.

International Affective Picture System database (P. J. Lang et al., 2005), as ranked by adult female observers. Four novel photographs were presented on each trial. Each participant was asked to use the mouse to click on the image that they felt would be the one later selected by the computer as the "target" image. Immediately after the participant clicked on an image, all images disappeared from the screen. The software then randomly selected one of the four photographs as the target image (with an equal probability for any of the four targets), and a full-screen version of this target image was immediately displayed for 8 seconds, followed by a delay (blank screen) of 10 seconds before the next four images were displayed (Figure 1).

Procedure

Each participant first completed consent forms, then discussed the purpose of the study with the experimenter (JM). The experimenter told each participant that they were selected for this study due to their conviction that psi phenomena could be verified scientifically, and that the experimenter shared this conviction. They were told that the purpose of this study was to replicate previous findings from other laboratories, and to shed light on the physiological underpinnings of psi perception and perceptual learning of psi tasks. Prior to the first trial of the guessing task, there was a 135-second relaxation period to allow the participant's skin conductance and pulse periods to settle to baseline values. Before leaving the room, the experimenter told the participant to use this time to relax and get ready for the first trial.

Apparatus for Gathering Behavioral Data

Software for the guessing task was written by the experimenter (JM) in Matlab 7.4 (2007a, The Mathworks, MA) and is available upon request. The software used independent calls to an Alea 1 True Random Number Generator (Araneus, Finland) for each selection of a target image. This hardware-based USB random number generator has passed many tests of statistical randomness, including the Die Hard series of tests.

The program was run on a Dell PC (Intel Core 2 Duo processor) running the Microsoft Windows XP operating system. This PC, in the experimenter's room, was attached to a flat screen monitor in the participant's testing room (both monitors from Acer). The mouse used by the participant for behavioral responding was connected to this same PC.

Apparatus for Gathering Physiological Data

We used Biograph Infiniti software Version 3.1.5 (Thought Technology Ltd., NY) to gather skin conductance and inter-beat interval data. This software was run on an HP laptop with an Intel Celera M processor, using the Microsoft Windows XP operating system. This laptop remained in the room with the subject at all times, but when the software had started to gather data, the top of the laptop was closed almost entirely, so the participant would not be distracted the screen. If the participant did for some reason see the screen, no information about the behavioral aspects of any condition would have been available.

Adhesive single-use Ag/AgCl electrodes (11 mm in diameter) were snapped to leads from a skin conductance sensor (SC-Flex/Pro, Thought Technology, Ltd.) and attached to the second and third fingers of the non-dominant hand. The sensor used a constant voltage of 0.5V between the electrodes to measure the conductance. No electrode gel was used (see Discussion for commentary on this and other EDA-related issues). A blood volume pulse sensor (BVP-Flex/Pro, Thought Technology, Ltd.) was attached to the fourth finger of the non-dominant hand; this BVP sensor provided peak-to-peak amplitude data from which pulse periods or inter-beat intervals (IBI) were calculated. All attachments were reinforced with breathable medical tape. The skin conductance and blood volume pulse sensors were connected to a Procomp Infiniti Encoder (Thought Technology, Ltd.), which was connected via a USB port to the HP laptop running the physiology software. The encoder applied a 5^{th} order Butterworth anti-aliasing filter (64Hz) to all incoming signals. Skin

conductance and inter-beat interval data were gathered throughout the experiment. Room temperature was kept at approximately 70° F.

To mark the timing of behavioral events for later physiological analysis, the software sent an auditory click to a voltage isolator (Thought Technology, Ltd.). This pulse was interpreted as a voltage deviation, which was communicated via a lead attached to the Procomp Encoder, and recorded by the Biograph Infiniti software. One event-marking pulse was sent immediately prior to the display of the target image.

Continuous skin conductance and inter-beat interval data for each participant were sampled at 256 Hz, re-sampled at 32 Hz, and saved on a USB flash drive for later analysis on a MacBook laptop. The experimenter (JM) wrote physiology data analysis software in Matlab 7.6.0 (R2008a, The Mathworks, MA), available upon request. When analyzing inter-beat interval data, the software removed instances of inter-beat intervals longer than 1300 ms (heart rates below 46 BPM) and shorter than 400 ms (heart rates above 150 BPM), and replaced these values with the most recent inter-beat interval within that range. To avoid "data picking" due to experimenter bias, no other artifact-removal process was performed.

Data Analysis

The independent variable was correct vs. incorrect performance on each trial; the dependent variables were average change in inter-beat interval (IBI) and skin conductance (SC) during the 10-second period preceding feedback. Before analysis, the IBI data were corrected for a period lag imposed by the physiology recording software using a simple algorithm (G. Reyes del Paso and J. Vila, 1998). IBI data were normalized by subtracting from each data point in each 10-second observation period the mean of the unique IBI values in the two seconds immediately preceding the observation period. For SC data, the mean of the 1-second period preceding the 10-second observation period was used as the normalization value. These normalization procedures were

instituted upon the advice of colleagues after data from the first 19 subjects was presented (Mossbridge et al., 2009). For each of the IBI and SC measures, one mean based on all pre-feedback data on correct trials and another mean based on all pre-feedback data on incorrect trials was calculated for each participant (Figure 2). To obtain these means, we performed a two-step averaging process. First, a grand mean time series for correct trials and another grand mean time series for incorrect trials was obtained by averaging, at each of the 320 data points (10 seconds at 32 Hz sampling rate), all other data points from correct or incorrect trials (as appropriate) at that data position in the observation period. Second, we collapsed these grand mean time series by averaging all 320 data points across them, to provide four collapsed means: mean IBI preceding correct trials, mean IBI preceding incorrect trials, mean SC preceding correct trials, and mean SC preceding incorrect trials. For IBI, these means were based on unique values only; these were not weighted averages. Though grand mean time series data were used to understand the time course of the effect, all statistical analyses were done on the collapsed means.

The hypothesis was tested using two-tailed within-subject planned t-tests at $a=0.05$; all t-tests were preceded by Shapiro-Wilk and Kolmogorov-Smirnov tests of normality, and all dependent variables passed these tests at $a=0.05$. Further, as a control for potential arousal effects resulting from previous "correct" feedback, we planned to use the same two analyses to examine the same physiology data grouped according to the correctness of the previous trial. The hypothesis would only be supported if any effects found in IBI or SC data were not found when the same data were sorted according to the correctness of the previous trial. Finally, where there were significant effects, we planned an expectation bias analysis consisting of a linear regression of the mean dependent variable on correct trials showing the significant effect on the number of contiguous incorrect trials preceding a correct trial ($a=0.05$).

Results: Experiment one

A significant difference between inter-beat interval (IBI) data from correct vs. incorrect trials revealed a presentiment-like response; this difference *preceded* the display of the feedback. Figure 3 shows the group mean of the mean normalized physiology traces, while Figure 4 (left column) shows the collapsed averages of normalized pulse period data recorded during the 10-second pre-feedback period. Mean normalized IBI values on correct trials were significantly longer than those on incorrect trials (mean IBI correct: 12.7 ms, mean IBI incorrect: 1.4 ms; t_{38}=2.18, p=0.035, d=0.35). At the group level, collapsed averages of normalized electrodermal data recorded during this period were not significantly dependent on the correctness of the trial (data not shown; SC correct: 0.076 uS, SC incorrect: 0.043 uS, t_{38}=-0.85, p=0.400).

Because the feedback on previous trials could reasonably be expected to affect physiological responses to current trials, our confirmatory analyses included re-examination of the same data, this time sorted by whether the previous trial had been correct or incorrect. For this control analysis based on the correctness of previous trials, paired t-tests on mean normalized IBI and SC data from the 10-second pre-feedback period were again not significant (both ps > 0.382; Figure 4, right column, shows normalized IBI means on previous trials). Thus the small but significant difference observed in IBI data on correct vs. incorrect trials does not reflect a carryover effect from the previous trial.

It is also possible that the differences in IBI observed here were caused by expectation bias (e.g., J. Dalkvist et al., 2002). To explain these data, IBI preceding the feedback would have to increase with each consecutive incorrect trial, then reset to baseline after a correct trial. To determine whether this was the case, we used a planned linear regression analysis of the mean normalized IBI values for all correct trials from all participants on the number of contiguous

incorrect trials preceding each correct trial. This regression was not significant (adjusted r^2=0.005 p=0.160), suggesting that expectation bias is not a reasonable explanation for these results.

Methods: Experiment two

Experimental Design

To attempt to replicate and extend the findings of the first experiment, we analyzed data that we had previously gathered for another purpose. Except for those details described below, all methods were the same as in experiment one.

Participants

Fifteen participants (all female, 25-60 years old) were recruited via word-of-mouth to participate in an intensive study of learning on psi tasks. On the first day of training, these subjects performed the same guessing task as in experiment one.

Task

The guessing task used exactly the same procedure as in experiment one.

Procedure

Instead of the guessing task being preceded by a remote-stare detection task (as in experiment one), here the subjects performed 10 minutes of a biofeedback task focused on heart rhythms (EmWave PC, Heartmath). They were told to breathe deeply, imagining breathing through their heart area, and to remember a joyful time in their lives as they performed the task. After 10 minutes were complete, SC and IBI recording apparatus was attached and they performed the guessing task.

Another difference from the first experiment was that after these subjects performed two more hours of testing on various psi tasks, they were given a "retrocausal review" of the correct targets in the guessing task. This retrocausal review consisted of 10-second displays of each of the

correct targets, shown one after another on their monitor. Participants were asked to send the targets "back in time" to themselves.

Results: Experiment two

As in experiment one, collapsed averages of normalized pulse period data recorded during the 10-second pre-feedback period on correct trials were significantly longer than those on incorrect trials [Figure 5 shows group mean physiology traces; Figure 6 (left column) shows collapsed means, mean IBI correct: 16.3 ms, mean IBI incorrect: 5.3 ms; t_{14}=2.48, p=0.026, d=0.64]. Again, at the group level, skin conductance was not significantly dependent on the future correctness of the trial (data not shown; SC correct: 0.054 uS, SC incorrect: -0.024 uS, t_{14}=-0.72, p=0.483). Re-sorting the same data based on correctness or incorrectness of the previous trial revealed that the IBI differences were not due to a prolonged response to the previous trial's feedback (both $ps > 0.170$; Figure 6, right column shows mean normalized IBI). Finally, linear regression of the mean normalized IBI values for all correct trials from all participants in the second experiment on the number of contiguous incorrect trials preceding each correct trial revealed no evidence to support an expectation bias (adjusted r^2=0.003 p=0.264). Together, the results of the second experiment support the IBI component of the hypothesis.

Methods: Experiment three

Experimental Design

The effect size of the IBI anticipatory response in second experiment was almost twice that of the first experiment, and one major difference between the two experiments was the preceding biofeedback task performed by participants in the second experiment. Although there were other differences between the experiments (e.g., gender ratio of participants, age of participants, and use

of a "retrocausal review") we performed a third confirmatory experiment with a secondary goal of determining whether the biofeedback task used in the second experiment was the parameter that increased the effect size.

Participants

Between January 2010 and March 2010, we collected behavioral and physiological data from a group of 30 Northwestern University undergraduates (17-22 years old; 15 female) who each participated in a 45-minute to 1-hour session in which they performed the biofeedback task and the target-guessing task. In order to determine whether the biofeedback task was critical for the IBI effect, half of the subjects (15) listened to the music accompanying the biofeedback software but did not perform the task, while the other half listened to the music and performed the task. All subjects felt very relaxed at the end of the 10-minute period. However, there were no differences on any measure between the two groups, so all data shown here are combined across the two groups.

Task

The target-guessing task was the same as in experiments one and two, except the delay between the offset of the feedback and the onset of the next stimulus was increased to 15 seconds.

Procedure

The procedure was as in experiment two except as already described, but there was no retrocausal review.

Results: Experiment three

Unlike in the first two experiments, in the third experiment, collapsed averages of normalized pulse period data recorded during the 10-second pre-feedback period on correct trials were no different than those on incorrect trials [Figure 7 shows group mean physiology traces; Figure 8 (left column) shows collapsed means; mean IBI correct: -0.60 ms, mean IBI incorrect: -

0.83 ms; t_{29}=0.04, p=0.971]. Again, at the group level, skin conductance was not significantly dependent on the future correctness of the trial (data not shown; SC correct: 0.07 uS, SC incorrect: 0.02 uS, t_{29}=1.00, p=0.363). Re-sorting the same data based on correctness or incorrectness of the previous trial revealed that the lack of IBI and SC differences could have been confounded due to an apparent response to the previous trial's feedback, although this response was not significant for either IBI or SC (IBI t_{29}=-1.45, p=0.159; SC t_{29}=1.65, p=0.110; Figure 8, right column shows mean normalized IBIs). The results of the third experiment may suggest that either relaxing to music or performing a biofeedback task before the target-guessing task may obliterate any IBI anticipatory effect. Alternatively, they could indicate that for the undergraduate population, the performance of the target-guessing task (as in the first experiment) without a preceding psi task could bias them to become physiologically over-invested in the previous trial's correctness. It is worth noting that in an earlier report including 19 of the 40 subjects in experiment one (Mossbridge et al. 2009), on the first psi task performed by the participants, the previous trial's correctness significantly affected anticipatory IBI effects in the following trial. Thus, differences in participant profiles or the presence of the retrocausal review in experiment two and not in experiment one may have been responsible for the differing results of experiments two and three.

Post-hoc sex difference analysis

Because other laboratories have reported sex differences in presentiment responses (D. Bierman and H. Scholte, 2002; R. McCraty et al., 2004a, b; D. Radin and A. Borges, 2009), and the present IBI anticipatory results seem related to presentiment, we performed a post-hoc sex difference analysis to determine whether sex differences were present in our data. To increase the power of these analyses, we combined the 84 participants from experiments 1-3 for whom

physiology data was available, resulting in comparisons between data from 54 females and 30 males.

The results of this analysis revealed a qualitative difference in IBI anticipatory effect, and a quantitative difference in SC anticipatory effects. As for the IBI data, the anticipation of females was between -7 and -4 seconds before feedback, while for males the anticipation period was between -4 and -1 seconds before (Figure 9, top panels). Further, the collapsed means of normalized SC data revealed a statistically significant effect of sex: in women, normalized SC showed a significant decrease before a correct vs. incorrect guess (data not shown; Table 4; t_{53}=-2.58, p=0.013, d=0.35), while for men, SC showed a trend toward an increase in normalized SC before a correct vs. incorrect guess (data not shown; t_{29}=1.47, p=0.161). An expectation analysis using the linear regression method already described was not significant for the female data (adjusted r^2=-0.001, p=0.319), but it was significant for the male data (adjusted r^2=0.025, p=0.022). To eliminate expectation bias, we re-analyzed the data by performing a between-subjects sex difference analysis on the collapsed means of normalized SC data from *only the first trial* performed by each subject (Figure 10 shows mean physiology traces). Because there were no preceding trials, no expectation bias could have been induced by past performance on the task. This analysis revealed a trend toward a decrease in normalized SC preceding correct vs. incorrect guess on the first trial in women, though this difference only occurred in the first four seconds of the observation period and was swamped in the collapsed means (Figure 11, top panel; t_{52}=-0.59, p=0.555). There was a sustained significant increase in normalized SC before a correct vs. incorrect guess in men (Figure 11, bottom panel; t_{28}=4.02, p=0.0004, d=1.49). A between-subjects ANOVA on these data revealed a significant interaction between sex and correctness on the first trial (F_{80}=8.90, p=0.003, η_p^2=0.10). These data suggest that there are both qualitative and quantitative sex differences in anticipatory the

physiological effects obtained during the performance of a target-guessing task, and that these differences cannot be explained by expectation bias.

Discussion

Our hypothesis for all three experiments was that two measures of autonomic state, heart inter-beat-interval (IBI) and skin conductance (SC), would both show distinct and significant patterns associated with future correct vs. incorrect guesses in a guessing task. The results of the first two experiments supported half of our hypothesis: at the group level, there were significant anticipatory effects for IBI but not SC. The results of the third experiment did not support the hypothesis, though the data suggest that there could have been some influence of responses to previous trials that might have confounded any anticipatory effects. That such an effect did not occur in the second experiment, where the target-guessing task was the first psi task to be performed, may be due to the relative maturity of the participants in that experiment (note the lack of differential post-feedback responsiveness in Figure 5). Finally, post-hoc sex difference analyses revealed anticipatory SC effects in opposing directions for the sexes, strongly supporting our hypothesis. Taken together, these data, which cannot be explained by expectation bias, suggest that information about future events can affect both heart pulse periods and skin conductance.

Although behavior was not amongst the dependent variables, it is worth noting that behavioral performance was not above change for any experiment, adding to the mounting evidence that conscious psi perceptual performance is not easily demonstrated.

In contrast to the behavioral data, the physiological data presented here may offer some insight into the mechanisms of performance on target-guessing tasks. These effects are intriguing to us for two reasons: 1) their existence suggests that such responses can be obtained during the performance of different behavioral tasks, 2) IBI anticipatory effects did not differ in direction

across sexes, but SC anticipatory effects did, and 3) these sex difference effects differ from those in the literature. To the first point, the current anticipatory effects, evoked not by future arousing vs. non-arousing stimuli but instead by upcoming feedback about task performance, should be replicable in other behavioral tasks offering trial-by-trial feedback, assuming that participants are motivated enough to be aroused when trials are correct and that participants perform enough trials to extinguish the arousal arising from correct performance on a previous trial. To the second point, for both males and females, normalized IBI values for both males and females in the period preceding feedback on correct trials were longer than those on incorrect trials, but during the same time period, normalized SC values for males on correct trials were higher than those on correct trials, and the reverse was true for females. One potential explanation for the opposing direction of SC anticipatory responses between the sexes is that for women, whose IBI anticipation precedes that of men, these effects do not foreshadow the feedback, but instead reflect the decision process. Another possibility is that one of the sexes is influencing the target using psychokinesis, while the other is using precognition or retrocausation. To the final point, the sex differences obtained here seem to differ from those already described in other reports of anticipatory physiological effects (D. Bierman and H. Scholte, 2002; R. McCraty et al., 2004a, b; D. Radin and A. Borges, 2009). In those reports, females showed an effect that males did not show; here, males and females both showed effects that were in opposing directions. At the very least, these results suggest that future examinations of anticipatory physiological effects should include a sex difference analysis to avoid missing any opposing effects that are "washed out" at the group level.

It is worth noting that some of the methods used to record electrodermal data in this experiment differed from those conventionally used in the parapsychology field. For example, although several rigorous analyses of electrodermal recording methodology have suggested that electrode gel is necessary during the recording of SC data (S. Schmidt and H. Walach, 2000; S.

Schmidt et al., 2001), the manufacturer of the equipment used in this study suggests that gel should not be used unless necessary (e.g. to increase low skin conductance values). Second, athough the electrodes were surrounded by an adhesive collar, breathable tape was used to further secure electrodes to the fingers, and some authors have suggested that the use of such tape could introduce mechanical artifacts into the SC signal (S. Schmidt and H. Walach, 2000; S. Schmidt et al., 2001). To guard against such artifacts, participants were instructed not to move their hand during recording, and the electrode leads were taped to the table. If some artifacts did occur, however, they would have been randomly distributed throughout the recording, and therefore would not have contributed to any consistent effects. On the other hand, many elements of the electrodermal measurement methodology were conventional. The electrode type and size used here (Ag/AgCl electrodes 11 mm in diameter), the finger placement, and the constant voltage of 0.5V used here are methodological choices that are either considered adequate or recommended by most authors (D. C. Fowles et al.; S. Schmidt and H. Walach, 2000; S. Schmidt et al., 2001). Further, the analytical approach we used, including the use of t-tests and ANOVAs in statistical analyses, are also recommended above several other common methods of analysis (S. Schmidt et al., 2001). For these reasons and those cited above, we consider the present skin conductance data to be sound.

The present experiments, performed in an independent perceptual neuroscience laboratory in a mainstream scientific context, provide replications of already existing reports on presentiment, and offer novel avenues for the investigation of the parameters affecting performance on guessing tasks.

References

Bierman D, Scholte H (2002) A fMRI Brain Imaging study of presentiment Journal of ISLIS 20:380-389.

Dalkvist J, Westerlund J, Bierman D (2002) A computational expectation bias as revealed by simulations of presentiment experiments. Proceedings of the 45th Annual Convention of the Parapsychological Association:62-79.

Fowles DC, Christie MJ, Edelberg R, Grings WW, Lykken DT, Venables PH Publication Recommendation for Electrodermal Measurements. Psychophysiology 18:8p.

Lang PJ, Bradley MM, Cuthbert BN (2005) International affective picture system (IAPS): Affective ratings of pictures and instruction manual. . Technical Report A-6 University of Florida, Gainesville, FL

May EC, Paulinyi T, Vassy Z (2005) Anomalous Anticipatory Skin Conductance Response to Acoustic Stimuli: Experimental Results and Speculation About a Mechanism. Journal of Alternative & Complementary Medicine 11:8p.

McCraty R, Atkinson M, Bradley RT (2004a) Electrophysiological Evidence of Intuition: Part 2. A System-Wide Process? Journal of Alternative & Complementary Medicine 10:12p.

McCraty R, Atkinson M, Bradley RT (2004b) Electrophysiological Evidence of Intuition:Part 1. The Surprising Role of the Heart. Journal of Alternative & Complementary Medicine 10:11p.

McDonough B, Don N, Watson C (2002) Differential Event-Related Potentials to Targets and Decoys in a Guessing Task. Journal of Scientific Exploration 16:187-206.

Mossbridge J, Grabowecky M, Suzuki S (2009) Evidence for Subconscious but not Conscious Psi in Remote Stare Detection and Precognition Tasks. . Proceedings of the 52th Annual Convention of the Parapsychological Association:12-13.

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

Radin D (2004) Electrodermal presentiments of future emotions. Journal of Scientific Exploration 18:253-273.

Radin D, Lobach E (2007) Toward understanding the placebo effect: Investigating a possible retrocausal factor. Journal of Alternative and Complementary Medicine 13:733-739.

Radin D, Borges A (2009) Intuition through time: what does the seer see? Explore 5:200-211.

Reyes del Paso G, Vila J (1998) The continuing problem of incorrect heart rate estimation in psychophysiological studies: an off-line solution for cardio tachometer users. Biological Psychology 48:269-279.

Sartori L, Massaccessi S, Martinell M, Tressoldi P (2004) Physiological correlates of ESP: heart rate differences between targets and nontargets. Journal of Parapsychology 68:351-360.

Schmidt S, Walach H (2000) Electrodermal activity (EDA) -- State-of-the-art measurement and techniques for parapsychological purposes. Journal of Parapsychology 64:139-163.

Schmidt S, Schnieder R, Binder M, Burkle D, Walach H (2001) Investigating methodological issues in EDA-DMILS: Results from a pilot study. Journal of Parapsychology:59-82.

Spottiswoode S, May E (2003) Skin conductance prestimulus response: Analyses, artifacts and a pilot study. Journal of Scientific Exploration 17:617-641.

Tressoldi P, Marinelli M, Massaccessi S, Sartori L (2005) Heart rate differences between targets and non-targets in intuitivate tasks. Human Physiology 31:6446-6650.

Tressoldi P, Martinelli M, Zaccaria E, Massaccessi S (2009) Implicit intuition: How heart rate can contribute to predict future events. Journal of the Society for Psychical Research 73.

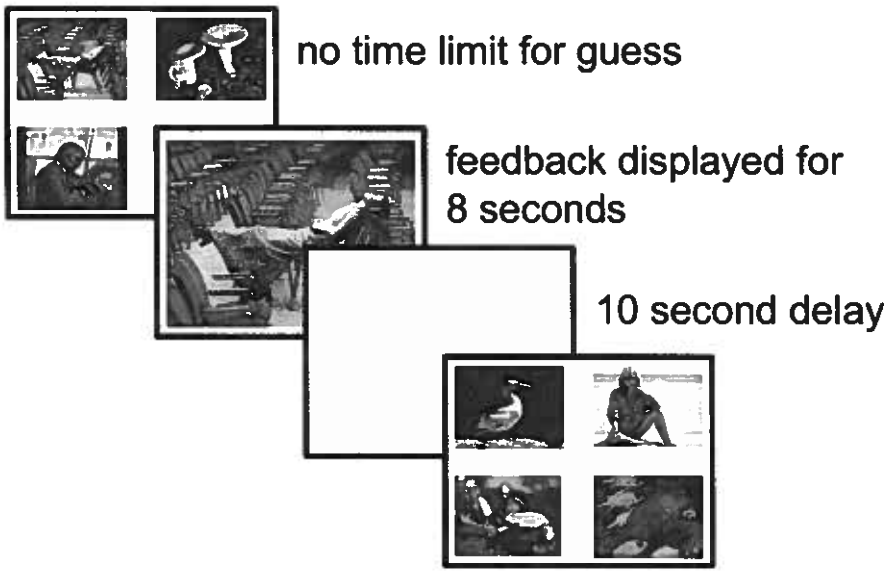

Figure 1: The target-guessing task
Four novel but unemotional images were displayed on each of 25 trials. The subject's task was to guess which image would be displayed after s/he used a mouse to click on one of the images. There was no deadline for the decision, but once the subject selected an image, the target image was selected at random by the hardware random-number generator and immediately displayed for 8 seconds. This feedback period was followed by a 10-second delay consisting of a blank screen, after which the next four images were displayed.

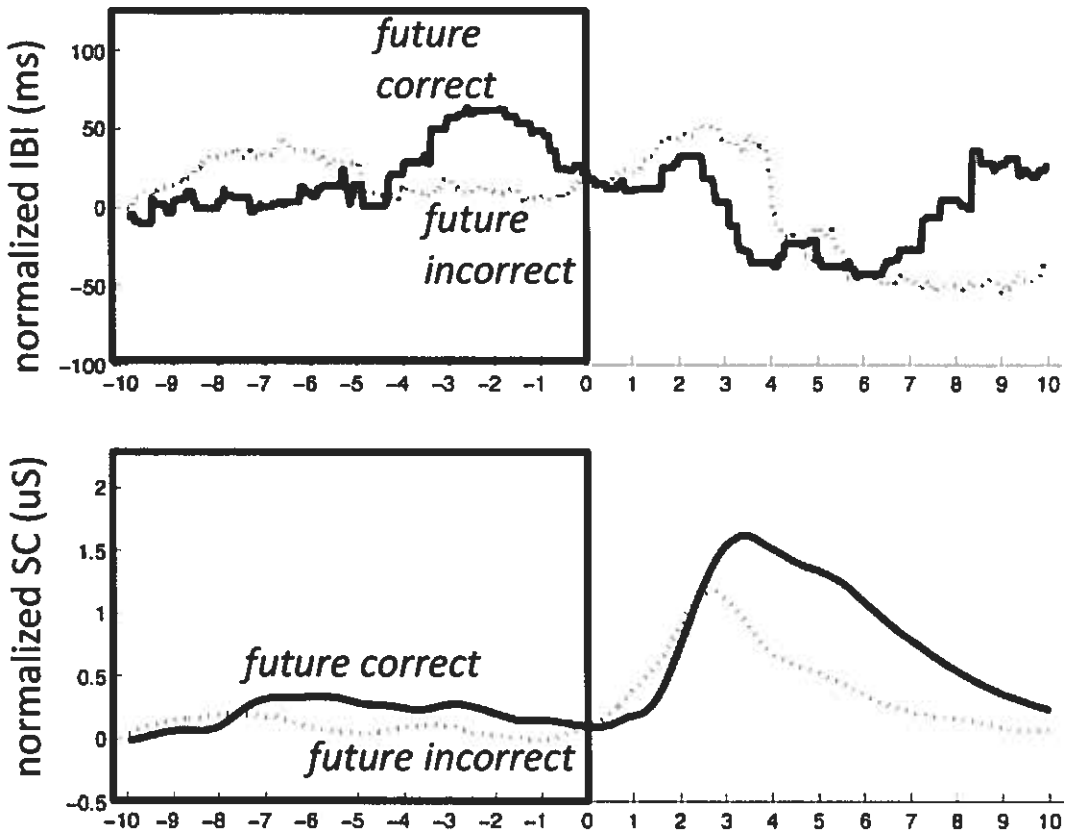

Figure 2: Example of dependent variables for one participant
Traces show normalized time series centered at the onset of feedback (0 ms) for a single participant on a single trial. For each participant, normalized physiology traces were first averaged point-by-point over all correct and all incorrect trials to obtain four grand mean traces. Top: normalized inter-beat interval traces for correct (darker line) vs. incorrect (lighter line) trials. Bottom: normalized skin conductance traces for correct (darker line) vs. incorrect (lighter line) trials. To obtain dependent variables used for statistical analyses, these four traces were each collapsed over time by averaging across each trace data from -10 to 0 ms (the pre-determined pre-feedback observation period), resulting in four collapsed means of pre-feedback values. Data shown are from a male participant in the third experiment.

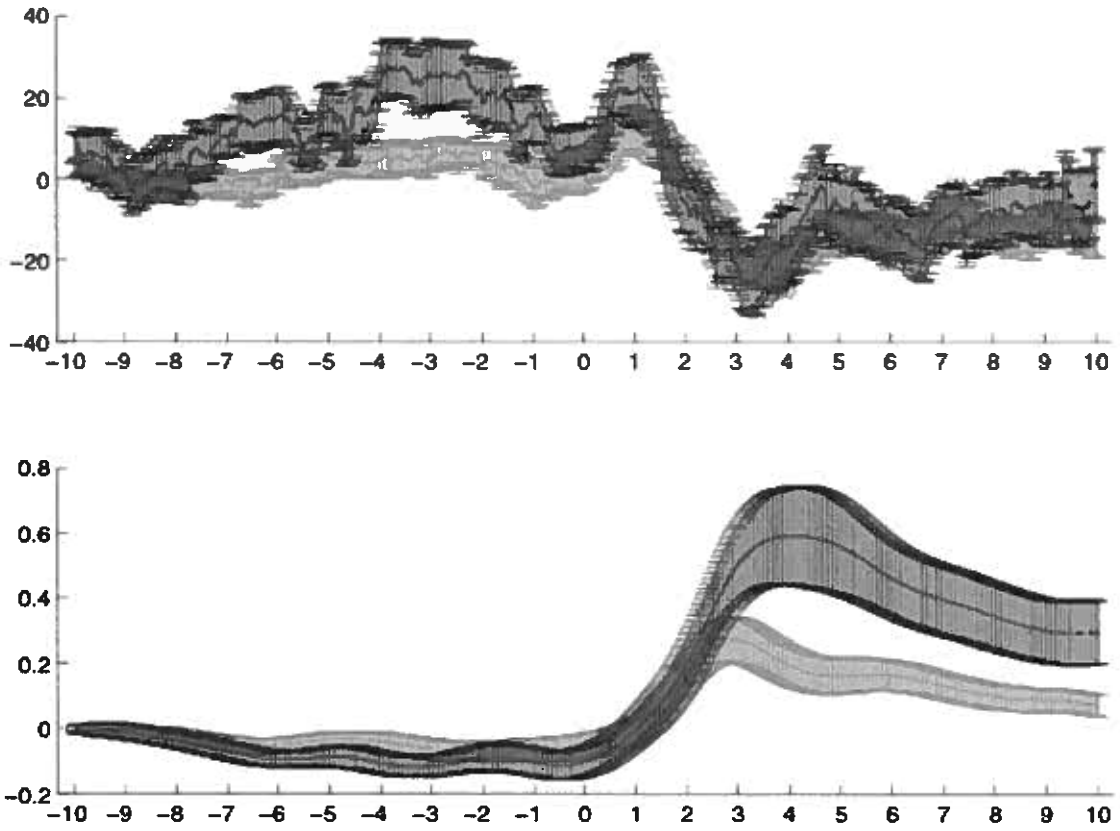

Figure 3: Group mean traces: Experiment 1
Group averages of normalized pulse period (top) and normalized skin conductance (bottom) traces centered on the onset of the feedback image (0 ms); data from experiment 1. The mean trace for correct trials is black and for incorrect trials is red. Standard error bars were calculated for each point.

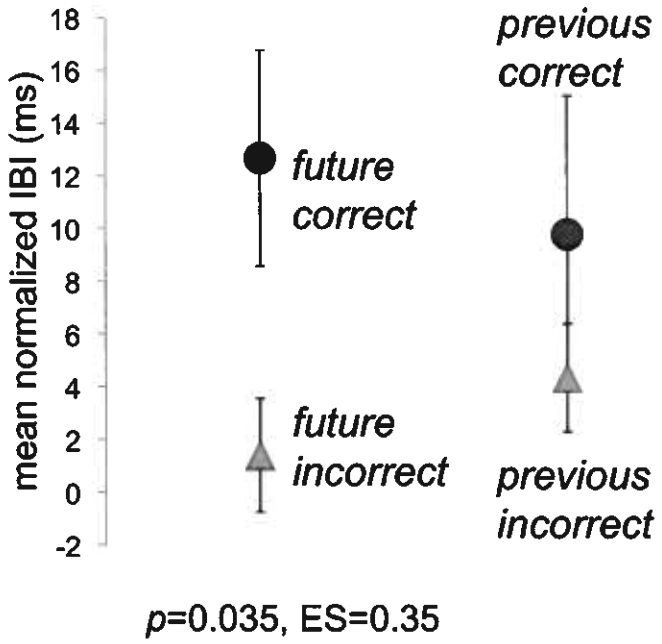

Figure 4: IBI means: Experiment 1
Group averages of normalized pulse periods averaged across the 10 seconds preceding the onset of feedback; data from experiment 1. These data were either sorted according to correctness on the current trial (left; black = correct, red=incorrect) or, as a control, correctness on the previous trial (right). ES (effect size) gives the value of d. Error bars are within-subject standard errors.

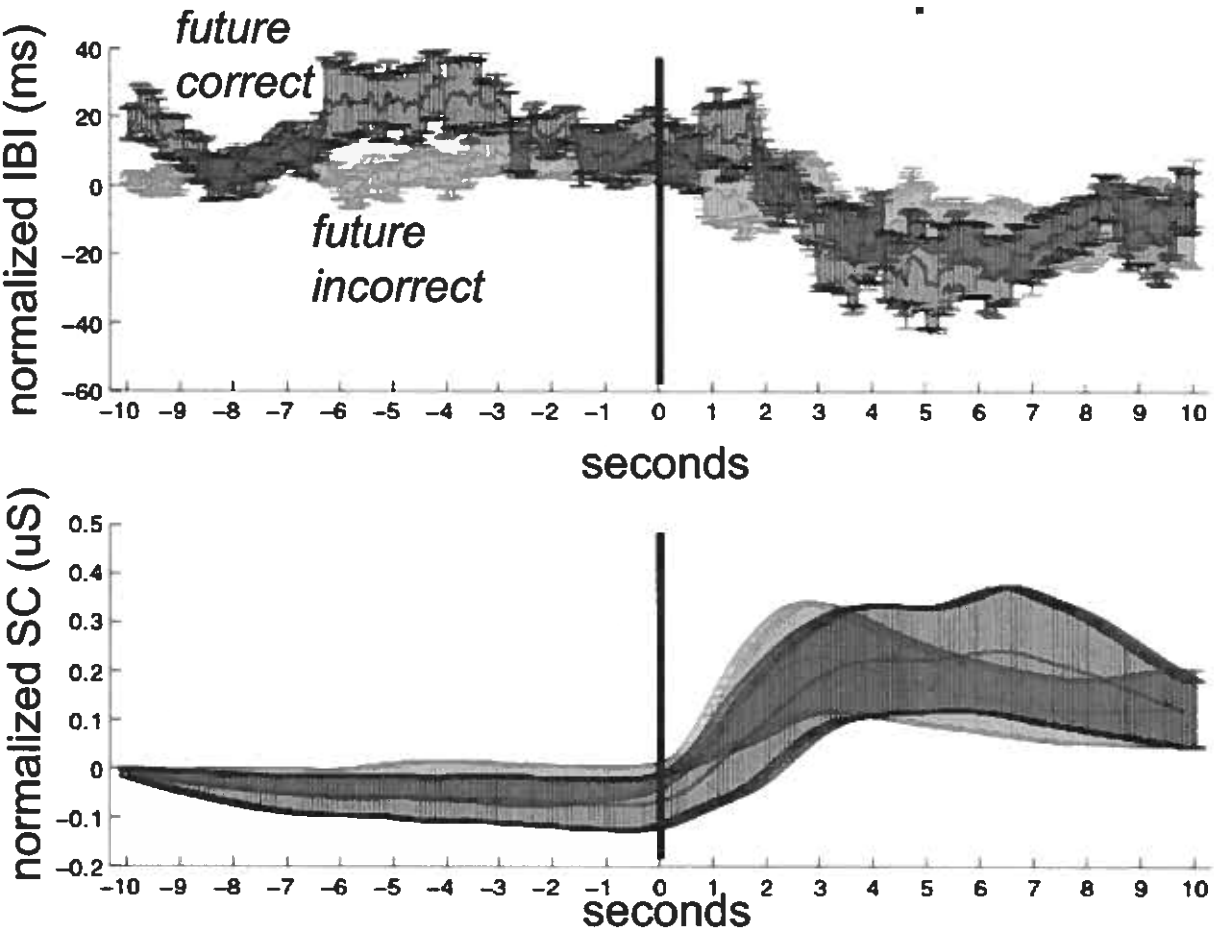

Figure 5: Group mean traces: Experiment 2
Group averages of normalized pulse period (top) and normalized skin conductance (bottom) traces centered on the onset of the feedback image (0 ms); data from experiment 2. The mean trace for correct trials is black and for incorrect trials is red. Standard error bars were calculated for each point.

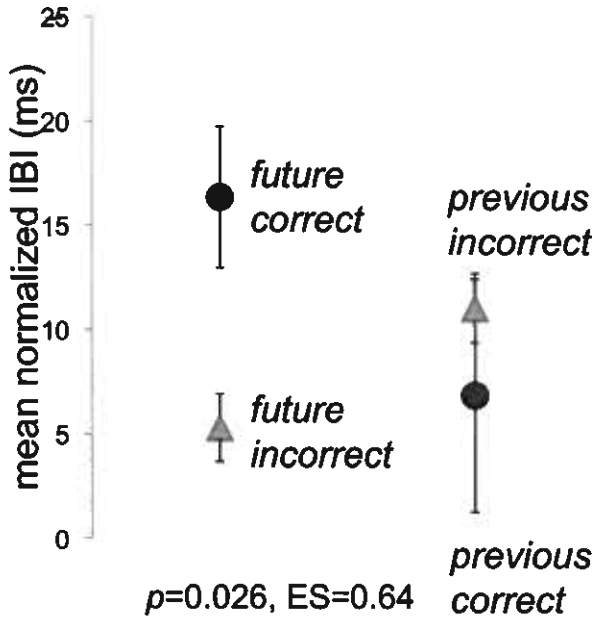

Figure 6: IBI means: Experiment 2
Group averages of normalized pulse periods averaged across the 10 seconds preceding the onset of feedback; data from experiment 2. These data were either sorted according to correctness on the current trial (left; black = correct, red=incorrect) or, as a control, correctness on the previous trial (right). ES (effect size) gives the value of d. Error bars are within-subject standard errors.

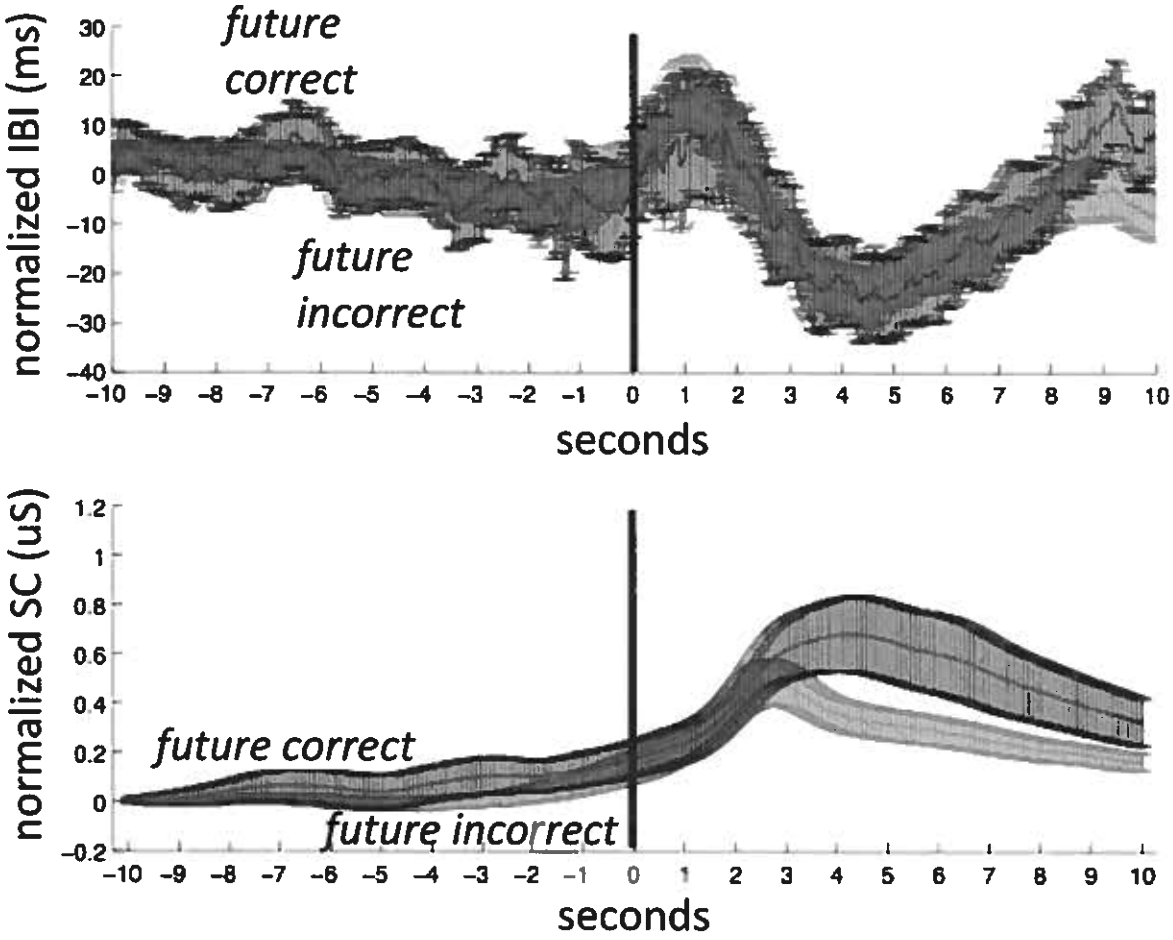

Figure 7: Group mean traces: Experiment 3
Group averages of normalized pulse period (top) and normalized skin conductance (bottom) traces centered on the onset of the feedback image (0 ms); data from experiment 3. The mean trace for correct trials is black and for incorrect trials is red. Standard error bars were calculated for each point.

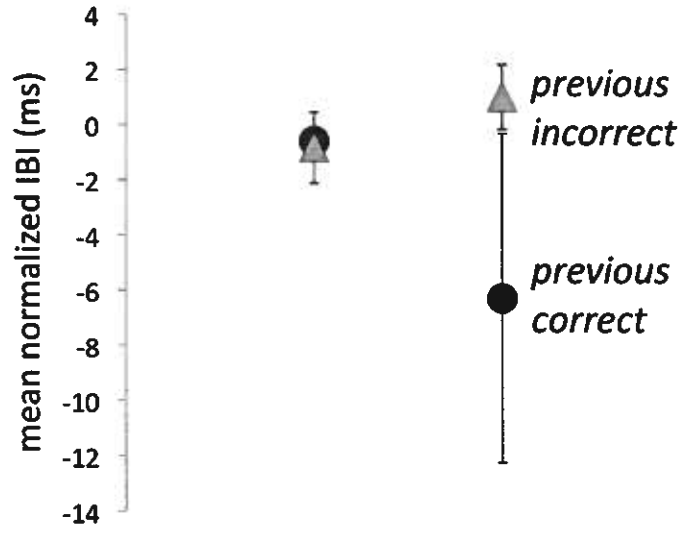

Figure 8: IBI means: Experiment 3
Group averages of normalized pulse periods averaged across the 10 seconds preceding the onset of feedback; data from experiment 3. These data were either sorted according to correctness on the current trial (left; black = correct, red=incorrect) or, as a control, correctness on the previous trial (right). Error bars are within-subject standard errors.

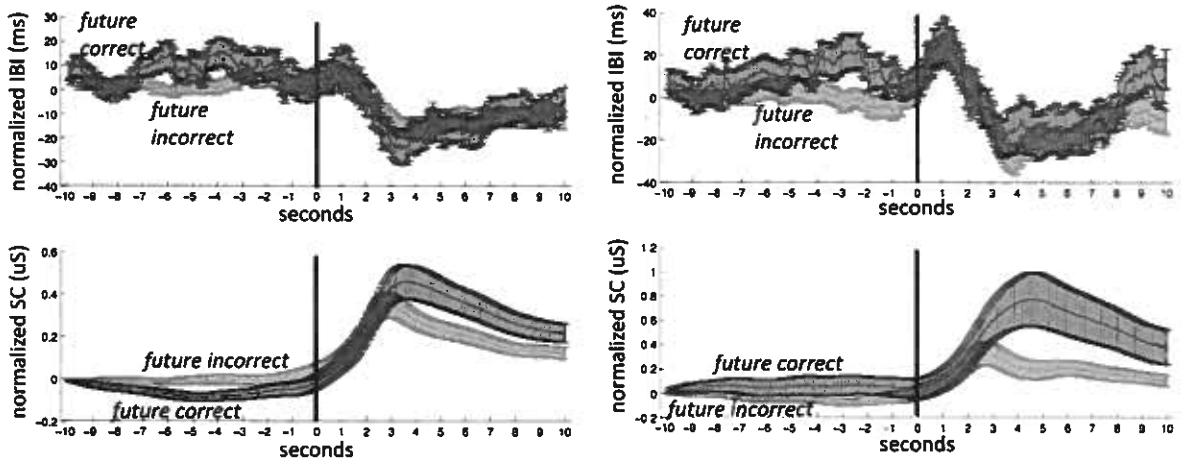

Figure 9: Group mean traces: Post-hoc sex difference analysis
Group averages of normalized pulse period (top) and normalized skin conductance (bottom) traces centered on the onset of the feedback image (0 ms). Left: data from all 54 females; right: data from all 30 males. The mean trace for correct trials is black and for incorrect trials is red. Standard error bars were calculated for each point.

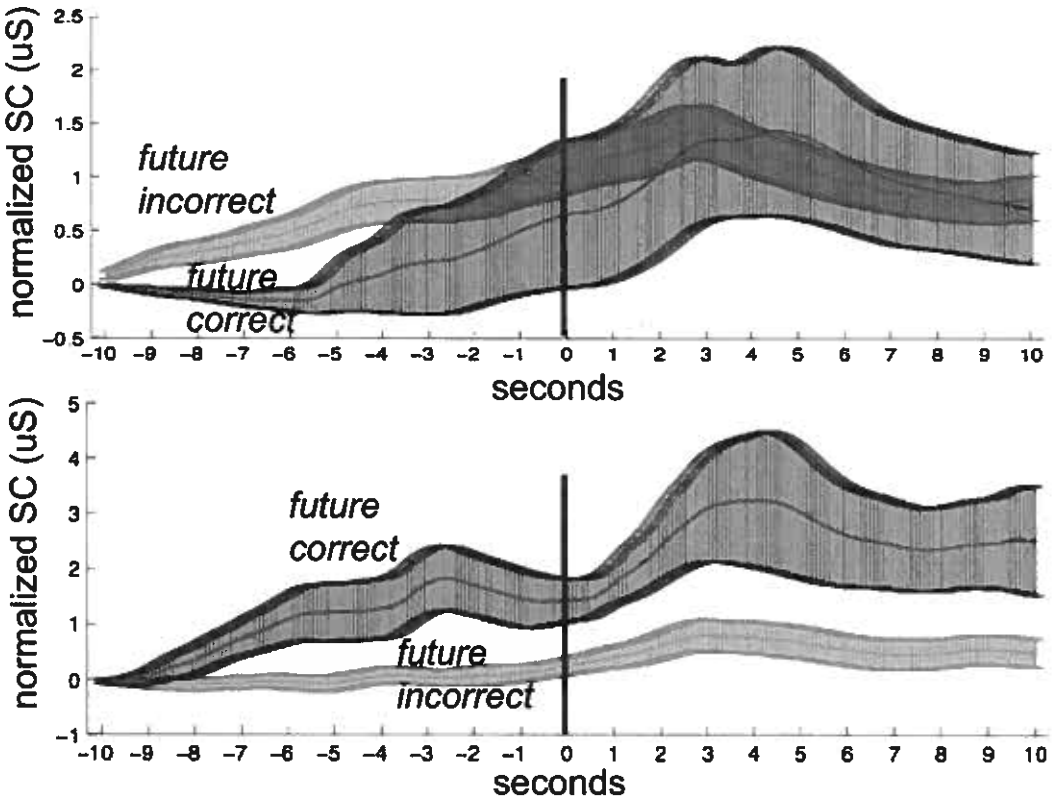

Figure 10: Group mean traces of first trials only: Post-hoc sex difference analysis
Group averages of normalized skin conductance traces from only the first trial for each participant, centered on the onset of the feedback image (0 ms). Top: data from all 54 females; bottom: data from all 30 males. The mean trace for correct trials is black and for incorrect trials is red. Standard error bars were calculated for each point.

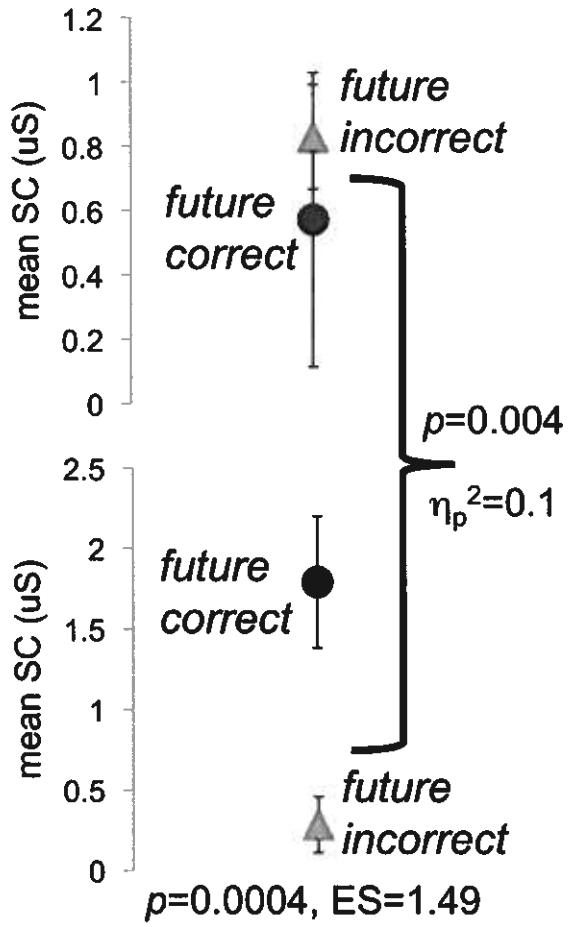

Figure 11: SC means for first trials only: Post-hoc sex difference analysis
Group averages of normalized skin conductance averaged across the 10 seconds preceding the onset of feedback. Top: data from all 54 females; bottom: data from all 30 males. These data were sorted according to correctness on the current trial (black = correct, red=incorrect). ES (effect size) gives the value of d. Error bars are between-subject standard errors.