ORIGINAL RESEARCH

Electrophysiology of Intuition: Pre-stimulus Responses in Group and Individual Participants Using a Roulette Paradigm

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The authors completed the ICMJE Form for Disclosure of Potential Conflicts of Interest and had no conflicts to report.

ABSTRACT

This study used electrophysiological measures of pre-stimulus effects that can occur prior to an unknown future event as an indicator of nonlocal intuition. Intuition in this context is considered as a process by which information normally outside the range of conscious awareness is detected at the cellular level by the heart, the brain, and the autonomic nervous system. This study extends the findings of previous experiments demonstrating that aspects of our physiology can respond to an emotionally engaging stimulus before it is actually experienced. The study evaluated a revised version of a roulette protocol, which included two pre-stimulus segments and included an analysis of the individual participant's data over eight separate trials in addition to a group-level analysis. We also assessed the potential effects of the moon phase on the pre-stimulus response outcomes and participant winning and amount won ratios.

Data were collected under controlled laboratory conditions from 13 participants in 8 separate sessions using a modified version of a gambling paradigm protocol based on roulette. Half of the experimental sessions were conducted during the full moon phase and half during the new moon phase. Within each trial a total of three segments of physiological data were assessed. There were two separate pre-stimulus periods, pre-bet (4 sec) and post-bet (12 sec), and a post-result period (6 sec). Participants were told that they were participating in a gambling experiment and were given an initial starting kitty and told they could keep any winnings over the course of 26 trials for each of the eight sessions. The physiological measures included the electrocardiogram (ECG), from which cardiac inter-beat-intervals (heart rate variability, HRV) were derived, and skin conductance. Before the participants participated in the first session, they completed the Cognitive Styles Index questionnaire, which assesses analytical vs intuitive styles.

Overall, the results indicate that the revised protocol provides an effective objective measure for detecting a pre-stimulus response, which reflects a type of nonlocal intuition. We found significant differences between the win and loss responses in the aggregated physiological waveform data during both pre-stimulus segments, which provides important information about nonlocal intuition. On average, we detected a significant pre-stimulus response starting around 18 seconds prior to participants knowing the future outcome. Interestingly, there was not a strong overall relationship between the pre-stimulus responses and the amount of money the participants won or lost. We also found a significant difference in both pre-stimulus periods during the full moon phase but not in the new moon phase.

The results suggest that the protocol is a reliable means of prompting physiological detection of pre-stimulus effects and can be used in future studies investigating aspects of nonlocal intuition. The findings also suggest that if participants had been able to become more attuned to their internal physiological responses, they would have performed much better on the betting choices they made.

INTRODUCTION

Although not yet well understood, intuition is a familiar facet of experience that can be a powerful transforming mediator that can inform and potentially redirect the path of an individual's life. Intuitive perception is commonly acknowledged to play an important role in business decisions and entrepreneurship, learning, creativity, medical diagnosis, healing, spiritual growth, and overall well-being.[1,2] Yet despite its presence in informing such diverse aspects of individual and collective life, intuition is poorly understood and largely remains a scientific mystery. Along with other scientists who deem these phenomena worthy of rigorous investigation, we believe that intuitive perception involves the heart, brain, and nervous system's connection to a field of information beyond normal conscious awareness.[3-10] Our previous studies suggest that no matter how intuitive information is initially introduced into the psychophysiological systems, once received, it is processed in the same way that information obtained through the familiar sensory systems is processed.[10] A number of pattern-recognition and dual processing models have been developed to explain how internal implicit processes are involved in intuitive perceptions.[8,11-14]

Although this study is among the latest in a line of studies that provides evidence of perception of future information, most scientists still regard such findings as anomalous. The majority of studies view intuitive perception solely as the result of implicit memories and past experience and confine intuition to a function of the unconscious mind accessing existing but forgotten information stored in the brain.[1,15-19] From this perspective, awareness is thought to be restricted to perceptions of present sensory input intermingled with memories of the past. As discussed in more detail in another article in this issue, we propose there are three types or categories of intuition: implicit knowledge, energetic sensitivity, and nonlocal.[20]

It has been suggested that the capacity to receive and process information about nonlocal events appears to be a property of all physical and biological organization and is likely due to the inherent interconnectedness of everything in the universe.[4,5,7] There is now a large body of rigorous experimental research dating back more than 70 years documenting nonlocal intuitive perception in rigorous scientific experiments showing that it *cannot* be explained by flaws in experimental design or research methods, statistical techniques, chance, or selective reporting of results.[21] For example, Bem conducted a meta-analysis of nine experiments in the area of precognition (conscious cognitive awareness) and premonition (affective apprehension) of a future event that could not otherwise be anticipated through any known sensory process and found significant results in eight of the nine studies with respect to pre-stimulus responses in more than 1000 subjects, indicating a possible retroactive influence of the stimulus.[22] Mossbridge also recently concluded a meta-analysis of 26 physiologically based studies that found a clear physiological pre-stimulus effect of what appeared to be unpredictable stimuli, despite the fact there was no known explanation available for this finding.[23]

One important conclusion from these studies is that intuitive perception of a future event is related to the degree of emotional significance of that event.[24,25] Moreover, the response to and processing of pre-stimulus information about a future event is not confined to the brain alone. Instead, the evidence suggests that the heart responds first, followed by the brain and possibly other organs in the body, and all are involved together in responding to nonlocal intuitive information.[10,25]

The first studies we are aware of that examined changes in brain activity that preceded an unknown stimulus were conducted by Levin and Kennedy in the mid-70s.[26] They observed a significantly larger contingent negative variation (CNV), which is a slow brainwave potential associated with anticipation, expectancy, or cortical priming, just before subjects were presented a target stimulus. Warren et al also found significant differences in event-related potentials (ERP) between target and non-target stimuli presented during forcedchoice precognition tasks.[27] Don et al extended these ERP findings in a series of gambling studies in which they found enhanced negativity in the ERPs was widely distributed across the scalp in response to future targets.[28,29] The authors concluded from these studies that the ERP effect was an indicator of "unconscious precognition" since the study's participants' overt guessing accuracy did not differ from chance expectations. More recently, several groups have explored physiological predictors of future events by investigating whether the autonomic nervous system could respond to randomly selected future emotional stimuli.[30,31] Radin designed elegant experiments to evoke an emotional response using randomly selected emotionally arousing or calming photographs, with measures of skin conductance level (SCL) and photoplethysmographic measures of heart rate and blood volume.[21,24] Comparison of SCL response between emotional and calm trials showed a significantly greater change in electrodermal activity around 5 seconds before a future emotionally arousing picture than before an emotionally neutral or calm picture. These results have since been replicated,[25,32-35] and a follow-up study using functional magnetic resonance imaging found brain activation in regions near the amygdala (which handles the processing of strong emotions such as fear and rage) *before* emotional pictures were shown but not before the calm pictures were shown.[35] Consistent findings across previous studies indicate that the body typically responds to a future emotionally arousing stimulus 4 to 7 seconds prior to experiencing the stimulus; however, this is likely limited by the experimental protocol. It has also been shown that intuitive perception of a future event is related to the degree of emotional significance one has in the outcome of the event.[25]

Extending and building on Radin's protocol, we added measures of brain response (EEG) and heart rhythm activity (ECG) and found not only that both the brain and heart received the pre-stimulus information some 4-5 seconds before a future emotional picture was randomly selected by the computer but that the heart received this information about 1.5 seconds before the brain received it.[10] A number of studies have since found evidence of the heart's role in reflecting future or distant events.[2,36-41] Using a combination of cortical-evoked potentials and heartbeat-evoked potentials, these studies also found that when the participants were in the physiological coherence mode prior to the trials, the afferent input from the heart and cardiovascular system modulated changes in the brain's electrical activity, especially at the frontal areas of the brain. In other words, participants were more attuned to information from the heart when in a coherent state prior to participating in the experimental protocol. Therefore, being in a state of psychophysiological coherence is expected to enhance intuitive ability.[10]

RESEARCH DESIGN AND METHODS

The primary goals of this study were to: (1) test a revised version of experimental protocol using a gambling paradigm based on roulette; (2) conduct analysis of the pre-stimulus response patterns within participant grand averages and in group level averages; (3) assess two pre-stimulus segments as opposed to one, as was done in previous studies; (4) assess the potential effects of the phase of the moon on the pre-stimulus

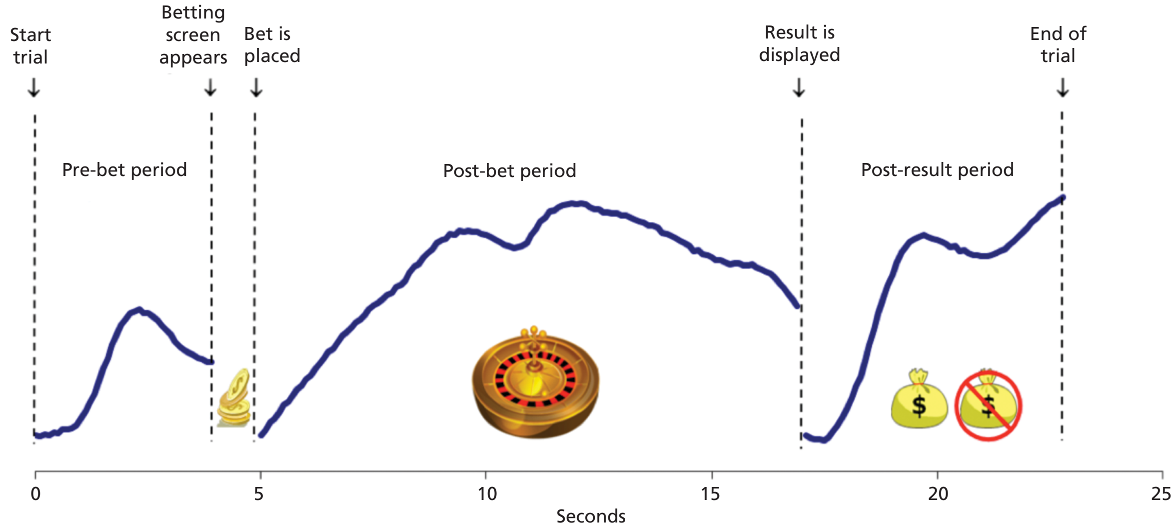

Figure 1 Experimental protocol. In the pre-bet segment, the participant clicks a computer mouse to start the trial. After a delay of 4 seconds, the betting screen appears. In the betting segment, the participant selects the bet amount to be wagered and makes a decision of red or black. This segment does not have a pre-determined time frame and depends on the time the participant takes to make a decision. The post-bet segment begins when the red/black choice is made. Six seconds after the red/black choice is made, the sound of a roulette wheel is triggered, which lasts for an additional 6 seconds, (ie, the post-bet segment total time is 12 seconds). In the post-result segment, the result of the trial, whether the participant won or lost the bet according to if his or her bet matches the random number generator's generated outcome, is determined and displayed on the screen. The result is then added to or subtracted from the running tally of wins and losses across trials, which is displayed for 6 seconds on the bottom left-hand side of the computer screen so that the participant knows whether he or she is winning or losing and by how much.

responses; (5) assess the potential relationships between physiological measures and participant winnings and losses; and (6) determine if cognitive style, as assessed by the Cognitive Style Index (CSI), was associated with physiological or win/loss outcomes.

After obtaining informed consent, data were collected from 13 participants (9 male, 4 female, mean age 48 y, range 20-59 y) in eight separate sessions over a 2-month period with approximately 2 weeks between sessions. Each session contained 26 trials. In a counter-balanced order, four of the sessions were conducted during the full moon phase and the other four during the new moon phase (±3 days). The experiments took place under controlled laboratory conditions. Prior to the first session, participants completed the CSI questionnaire, which assesses analytical vs intuitive styles.

The experimental protocol was a revised version of the protocol designed by McCraty and Atkinson first used in studies with repeat entrepreneurs. The protocol uses a gambling paradigm based on roulette wherein the participants are required to choose a bet amount and then choose (bet on) either red or black. In the revised version, a second pre-stimulus segment was added that allowed us to examine the period prior to placing the bet on red or black. The choice of red or black is then compared to the post-trial result, the randomly determined future outcome (Figure 1). Participants were told that they were participating in a gambling experiment and they were encouraged to win as much as possible over the course of 26 trials and would be able to keep any winnings, which were given to them in cash at the end of each session. In order to determine if the potential amount of winning was a significant factor in the emotional engagement of the participant in the study, the dollar amount in the starting kitty was $5 for one sub-group and $20 for a second sub-group. In the group with a starting kitty of $5, participants had the option of choosing from four bet amounts, $0.05, $0.10, $0.25 and $0.50. The sub-group with the starting kitty of $20 had the option of choosing from bet amounts of $ 0.25, $0.50, $1.00 and $2.00. The participants in both groups had the same starting and betting amount options for their sub-group throughout each of their eight sessions.

The experimental protocol software was written in C++ using the .Net Framework, which was run on a Windows 98 PC computer (Microsoft Corp, Redmond, Washington). A Biopac MP30 data acquisition system was used to continuously record SCLs and the ECG at sample rate of 500 Hertz. For SCL, disposable electrodes were attached to the pads of the index and second fingers of the non-dominant hand. The ECG was obtained using disposable electrodes attached in a modified V5 location to maximize the R wave of the ECG. The hardware-based True Random Number Generator (TRNG) used to determine the outcomes of the protocol was an Arneus Alea 1 (Turku, Finland), which provides high-quality, unbiased, uncorrelated random numbers that pass a number of stringent statistical tests, including Diehard and NIST, and connects to the experimental control computer via a USB port.

The Cognitive Style Index (CSI) is a 38-item questionnaire designed to assess cognitive and learning styles. Each item has "true," "uncertain," and "false" response options. Scores of 2, 1, or 0 are assigned to each response with the direction of scoring dependent on the polarity of the item. The closer the total scores to the maximum of 76, the more "analytical" the style of the respondent. The closer to zero, the more "intuitive" is the style of the respondent.

Within each of the 26 trials, three segments of the physiological data were assessed (the win/loss response). There are two separate pre-stimulus periods, pre-bet (4 seconds) and post-bet (12 seconds), followed by the post-result segment (6 seconds). The post-result period is important because it can be used to validate the emotional engagement of the participant when he or she discovers whether the bet was won or lost. A trial is initiated by pressing the start button when ready. After a 4-second delay, the participant is prompted to place a bet. Following a second delay (12 seconds), the results are shown. This procedure was repeated 26 times at each of the eight sessions. The timing of participant mouse clicks to initiate a trial and place bets and the timing of result presentation were recorded in the data stream so the start and end of all trial segments could be precisely determined.

In the experimental sessions, participants were seated in a comfortable chair. A computer monitor was located approximately one meter in front of the participant at eye level, and the participant clicked a computer mouse when ready to initiate each trial. At the start of each session, there was a 4-minute period for recording baseline physiological data. Once the instructions were read, the participant completed the experiment alone (ie, the experimenter was not present).

DATA ANALYSIS

The pre- and post-stimulus responses from each of the 8 sessions were analyzed as a group and at the individual participant level. The physiological data was analyzed by response to winning and losing and the response to the red and black independent of winning or losing. The data were also examined by the four possible physiological response outcomes—winning by betting on red, losing by betting on red, winning by betting on black, losing by betting on black—as well as by gender, cognitive style, and moon phase. Data processing and statistical analysis were performed using DADiSP (DSP Development Corp, Newton, Mass) and SPSS (International Business Machines Corp, Armonk, New York) software. Physiological data for 11 of the 104 (13 x 8) sessions conducted were not used because two of the files were not saved correctly and were lost. Nine files could not be used due to participant movements or electrode contact problems.

Skin Conductance Levels

Because measurements focused on how the physiological measures changed from the start of when each segment was initiated, all data points in each trial segment were transformed into a percentage difference score relative to the SCL value at the time the participant pressed the mouse button to initiate the given trial segment (button press). To compute the percentage difference score (D), the first data point for each trial segment was subtracted from each of the following data points in the series. Each data point in the trial segment was then divided by the value of the first data point in the trial segment to yield the percentage difference series in which the first point is always zero.

Heart Rate Variability

Inter-beat-interval (IBI) data were derived from the ECG data, which was used for HRV analysis. All aberrant beats and artifacts were removed from the records. A computer algorithm eliminated intervals that varied by more than 30% of the mean of the previous four intervals, and any remaining artifacts were removed during second-stage editing by an experienced technician who visually inspected the records. A regularly spaced time series was derived from the succession of normal RR intervals by linear interpolation of the irregularly spaced series and then resampled at 10 samples per second.

Win Ratio

The win ratio is the percentage of trials won by betting correctly on one of two randomly determined outcome colors (red or black) relative to the total number of trials. The ratio is calculated by dividing the number of winning bets by the total number of 26 trials in each of the eight sessions.

Amount Won Ratio

The amount won ratio is the percentage of the total dollar amount won in each session relative to the initial starting dollar amount. At the end of the session, the final amount that was either won or lost (ending total minus starting amount) is divided by the starting dollar amount to arrive at the amount won ratio.

Statistics

To reduce the possibility of false-positive findings, a decision was made to use a random permutation analysis (RPA) procedure for data analysis, following Radin's and our previous studies.[24,25] Because it controls for autocorrelations inherent to physiological signals and their underlying non-normal distributions,[42] RPA was used to determine the statistical significance of the differences between win and loss response waveforms and to determine statistical significance of the response difference between TRNG-selected red and black outcomes, regardless of whether the participant won or not based on the color on which they bet.

Both SCL and HRV were analyzed during the pre-bet, post-bet, and post-result segments. Applied separately to each segment of the SCL and HRV data, RPA generates one standard deviate, or Z score, per participant for each segment in each session.[43] The RPA random distribution was constructed from 1,000,000 permutations.

Because the win and amount won ratios lacked normal distributions, nonparametric tests were chosen to test for between- and within-group differences for

Table 1 Overall SCL and HRV Results and Summary for All Participants Over Eight Sessions

All Participants (N=13), All Sessions (N=93)

	Pre Bet			Post Bet			After Result		
	Zsum	Stouffer z	*P* <	Zsum	Stouffer z	*P* <	Zsum	Stouffer z	*P* <
Bet-dependent—Win/Loss Difference									
SCL	–5.70	–.59	NS	–2.61	–0.27	NS	43.41	4.50	.001
HRV	27.69	2.87	.01	18.83	1.95	.05	–42.09	–4.36	.001
Bet-independent—RNG/Red-Black Difference									
SCL	–12.37	–1.28	NS	–12.49	–1.29	NS	–9.35	–0.97	NS
HRV	–16.07	–1.67	.05	–23.25	–2.41	.01	3.03	.31	NS

Abbreviations: HRV, heart rate variability; NS, not significant; RNG, random number generator; SCL, skin conductance level.

these two variables. The Wilcoxon Signed Ranks exact test was used to test for within-group differences for the two ratios during new and full moon phases. The Mann-Whitney U test was used to test between-group effects of the ratios between males and females, low- and high-scoring CSI groups, and between the two groups with different starting kitty amounts. The binomial test with a test proportion of 0.5 was used for the analysis of the binary win (1) lose (0) outcomes for individual participants betting records. Spearman's rank correlation was used to test for relationships between win ratios and individuals for win-lose difference Z scores in the pre-bet, post-bet, and after result win-loss difference Z scores.

RESULTS

Group Analysis

Table 1 shows the RPA results of the physiological data for all participants across all sessions, and Figure 2 shows the grand averages of the SCL and HRV waveforms in the bet-dependent context. The bet-dependent context looks at the difference in physiological waveforms between winning and losing regardless of what color was bet on. There were significant findings in both of the pre-stimulus periods for the HRV win/loss responses. In the pre-bet segment, before the participants had made their betting choice, there was a significant ($P<.01$) difference in the win/loss response and in the post-bet segment ($P<.05$). There were no signifi-

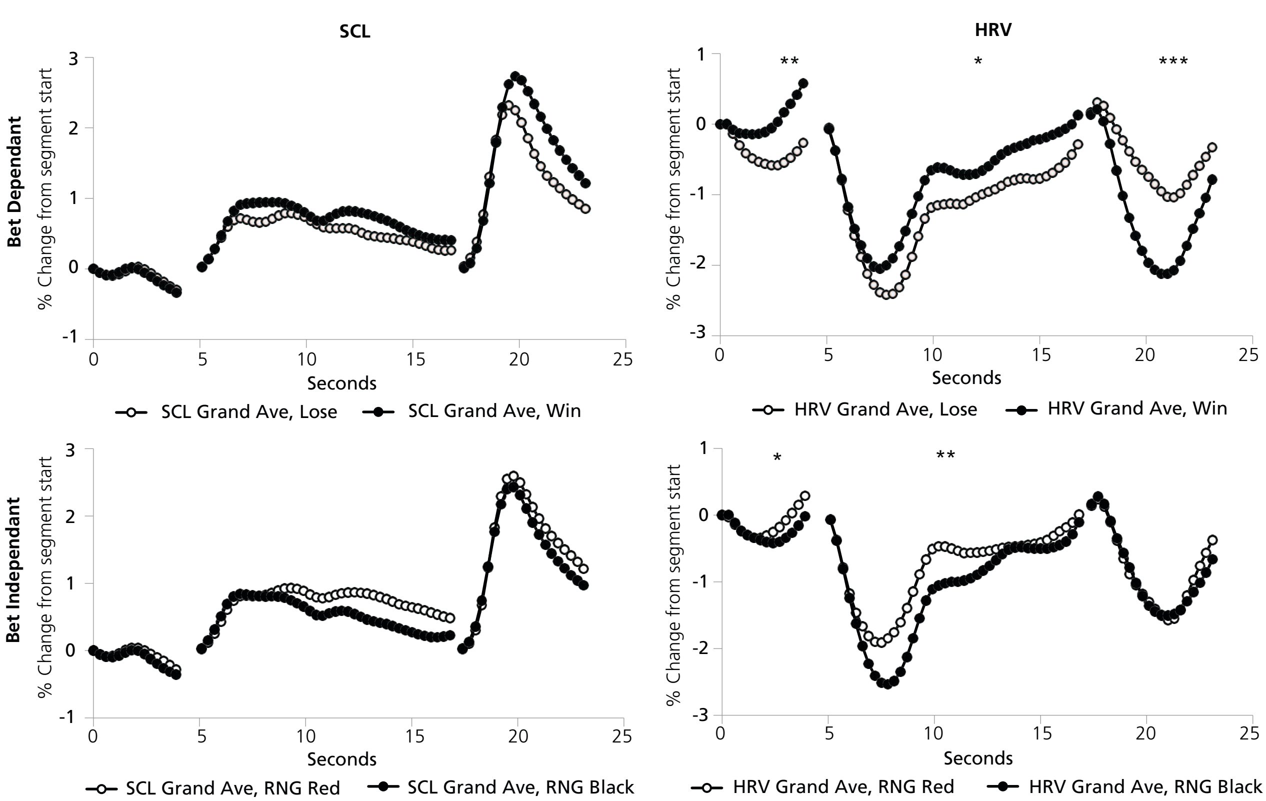

Figure 2 The grand averages for the bet-dependent SCL and HRV win/loss waveforms and bet-independent red/black random number generator (RNG) result response for all 13 participants across all 8 trials for the 3 segments of the experiment: the pre-bet, post-bet period and post-result periods. The top half of the figure shows the bet-dependent skin conductance level (SCL) and heart rate variability (HRV) response to winning or losing. The lower half shows bet-independent response to the red and black RNG-determined outcome.

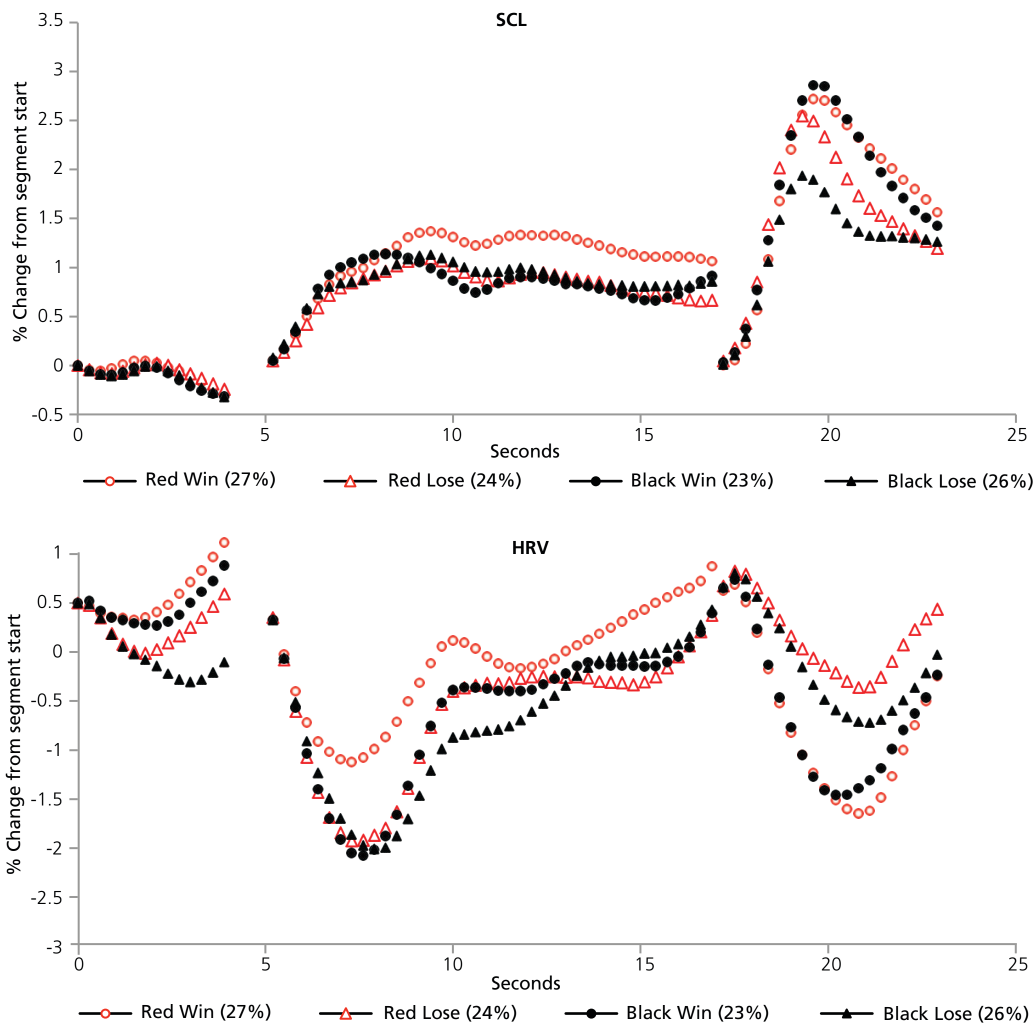

Figure 3 Presents the grand averages for winning and losing on red as well as winning and losing on black. The chart legend also shows the percentage of the 2623 usable trial waveforms that make the 4 waveform types.

Abbreviations: HRV, heart rate variability; SCL, skin conductance level.

cant differences for the SCL in either of the pre-stimulus segments. As expected, there was a significant difference between the win/loss response waveforms in the post-result segment for both the SCL ($P<.001$) and HRV ($P<.001$) measures, which indicates that the participants were emotionally engaged in the experiment.

In the bet-independent context, a similar pattern was observed in the physiological responses to the TRNG-selected outcome (red or black). In this context, we are looking at the difference in physiological waveforms between a red or black outcome, independent of winning or losing. In both of the pre-stimulus segments (pre-bet and post-bet) the HRV waveforms were significantly different at $P<.05$ and $P<.01$. Skin conductance was not significantly different for either of the pre-stimulus segments. The bet-independent analysis found no significant differences in either SCL or HRV in the post-result segment. This is likely due to the mixing of winning and losing bets that were placed on both red and black.

In Figure 2, it can be seen that a greater shortening of the RR interval (HRV), indicating an increase in heart rate, starts to occur in the post-bet segment on losing trials about *10 seconds prior* to the outcome result being displayed. This is consistent with the shorter RR intervals for losing trials in the pre-bet segments that begins almost immediately after the button press, which is, on average, 18 seconds prior to knowing the outcome of the trial.

Figure 3 displays the SCL and HRV waveforms for the four possible physiological response outcomes, winning or losing on red and winning or losing on black. Interestingly, the winning and losing on black response HRV waveforms have an overall lower mean offset than their red counterpart, indicating that there may be differences in the four types of pre-stimulus responses (win, lose, or betting on red or black).

WITHIN PARTICIPANTS ANALYSIS

To address the question of the occurrence of the pre-stimulus response across the eight experimental sessions within individual participants, individual session Z scores were combined using Stouffer Z method

Table 2 Individual Participants, Individual Session Z Scores Combined Using Stouffer z Method to Provide an Overall Assessment of the Response to Winning and Losing

Win/Lose RPA of All Sessions (N=8) by Participant

	Pre Bet			Post Bet			After Result		
Participant	**Zsum**	**Stouffer z**	***P*** **<**	**Zsum**	**Stouffer z**	***P*** **<**	**Zsum**	**Stouffer z**	***P*** **<**
Skin Conductance Level									
1	3.33	1.26	NS	2.01	0.76	NS	3.03	1.15	NS
2	0.82	0.29	NS	0.75	0.26	NS	4.15	1.47	NS
3	–3.01	–1.06	NS	–1.19	–0.42	NS	7.72	2.73	.01
4	–2.81	–1.15	NS	–0.36	–0.15	NS	–8.03	–3.28	.001
5	–2.17	–0.88	NS	0.51	0.21	NS	0.08	0.03	NS
6	1.03	0.37	NS	–2.07	–0.73	NS	12.61	4.46	.001
7	–3.86	–1.37	NS	–2.77	–0.98	NS	1.81	0.64	NS
8	3.99	1.63	.05	2.84	1.16	NS	4.96	2.02	.05
9	–4.24	–1.73	.05	–5.03	–2.06	.05	–0.17	–0.07	NS
10	–1.05	–0.37	NS	3.65	1.29	NS	1.48	0.52	NS
11	–2.98	–1.06	NS	1.40	0.50	NS	13.70	4.84	.001
12	2.54	1.04	NS	–0.65	–0.26	NS	–4.97	–2.03	.05
13	2.72	0.96	NS	–1.70	–0.60	NS	7.05	2.49	.01
Heart Rate Variability									
1	–1.44	–0.54	NS	3.11	1.17	NS	4.09	1.54	NS
2	3.22	1.14	NS	3.67	1.30	NS	–9.71	–3.43	.001
3	2.17	0.77	NS	–0.84	–0.30	NS	–5.17	–1.83	.05
4	2.60	1.06	NS	0.35	0.14	NS	3.47	1.42	NS
5	2.54	1.03	NS	0.78	0.32	NS	–3.59	–1.47	NS
6	–1.61	–0.57	NS	1.29	0.45	NS	–5.89	–2.08	.05
7	3.67	1.30	NS	0.02	0.01	NS	–3.16	–1.12	NS
8	5.09	2.08	.05	2.88	1.18	NS	–2.05	–0.84	NS
9	1.94	0.79	NS	2.01	0.82	NS	–1.99	–0.81	NS
10	3.22	1.14	NS	–2.04	–0.72	NS	–7.07	–2.50	.01
11	–4.17	–1.47	NS	6.49	2.30	.05	–6.19	–2.19	.05
12	2.68	1.09	NS	0.77	0.31	NS	–2.78	–1.13	NS
13	7.77	2.75	.01	0.34	0.12	NS	–2.05	–0.72	NS

Abbreviations: NS, not significant; RPA, random permutation analysis.

to provide an overall assessment of the response. Win-lose (bet-independent) results are shown in Table 2 and an example of one participant's waveforms is shown in Figure 4. Three of the 13 participants had significant overall pre-bet response patterns in either SCL or HRV, and one had significant pre-bet response patterns in both SCL and HRV ($P<.05$) to winning and losing. One additional participant had a significant overall post-bet HRV response pattern ($P<.05$).

In the analysis of the bet-independent (RNG determined red-black outcome) results for the individual participants, two additional participants had significant pre-bet difference to the TRNG-selected red-black outcome. One of these had a significant difference in the SCL response ($P<.05$) and the other in the HRV waveforms ($P<.05$). Three of the participants had significant post-bet differences, two in SCL ($P<.01$) and one in the HRV waveforms ($P<.01$) (data not shown).

This is another potential pathway to influence the betting outcome. It is interesting to note that one of these two had the second highest cumulative win ratio and the other had the second lowest. Of the two pre-stimulus segments, the response in the pre-bet period has the potential ability to influence the betting outcome because it occurs before the actual bet is placed. One of the three participants with an overall significant pre-bet response had the third highest cumulative win ratio, and one of the others had the third lowest.

The binary win (1) lose (0) outcome was assessed using the binomial test with a test proportion of 0.5. In the first analysis, the win-lose results for each individual participant from all trials across all sessions was

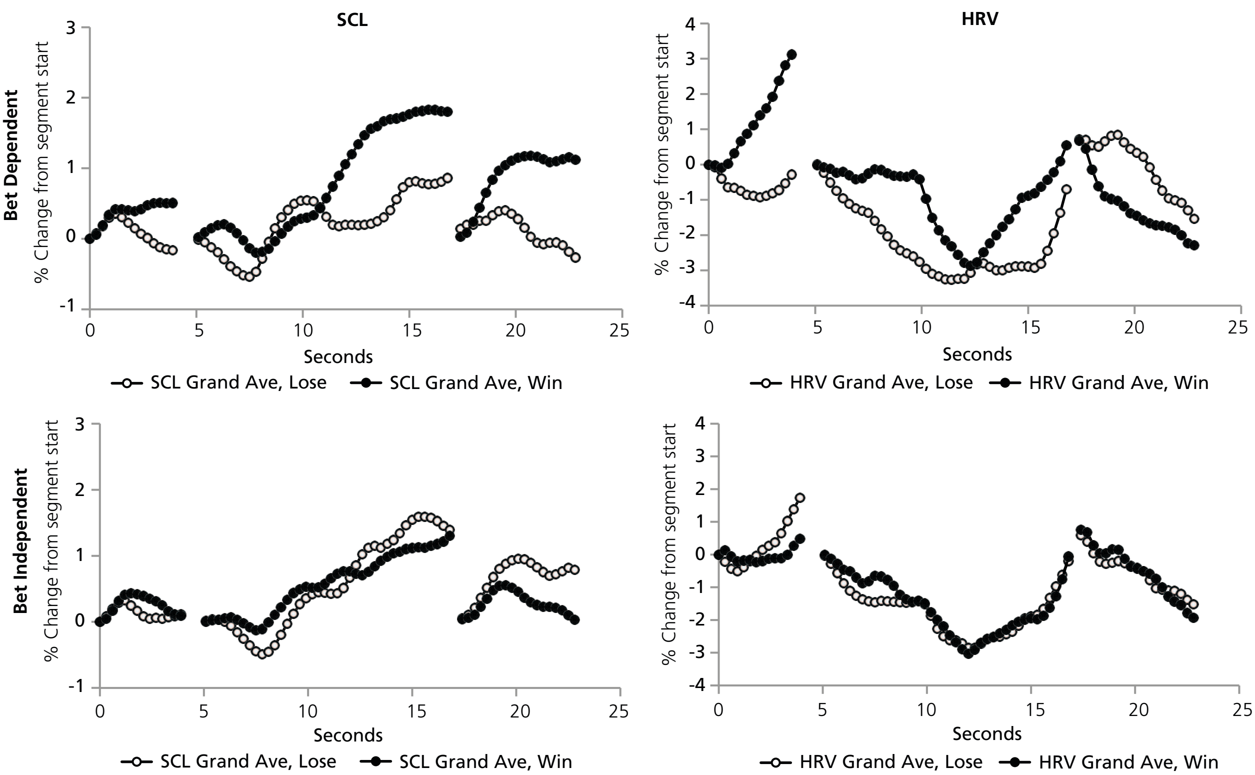

Figure 4 Example of one participant's 8-session Grand Average.
Abbreviations: HRV, heart rate variability; RNG, random number generator; SCL, skin conductance level.

assessed. One of the participant's win-loss records was found to be significant.

The Spearman's rank correlations, between Win ratios and individual win-loss difference Z scores for the pre-bet, post-bet, and post-result phases, found significant correlations between the win ratio and the SCL post-bet win-loss difference (.218, $P<.05$) and between the HRV post-bet win-loss difference (.279, $P<.01$).

FULL AND NEW MOON PHASE ANALYSIS

To address the question of potential relationships between the moon phase and the magnitude or occurrence of the pre-stimulus response, full moon and new moon trials were grouped separately. Individual session Z scores within each of the groupings were combined using the Stouffer Z method to provide an overall assessment of the moon phase response. The results are shown in Table 3. There was a significant difference in the HRV win/loss waveforms during both the pre-bet ($P<.01$) and post-bet ($P<.05$) segments during the full moon phase and no significant difference during the new moon phase. SCL win/loss response was not significant in either of the pre-stimulus segments during either moon phase. As expected, there were significant differences in all post-result win/loss HRV waveforms for both the full moon ($P<.001$) and new moon phase ($P<.01$) and for the SCL waveforms during the full ($P<.01$) and new moon ($P<.001$).

The Wilcoxon signed-rank test was used to compare roulette win ratios and the amount won ratio between

Table 3 Summary of Sessions by Moon Phase

All Participants by Moon Phase

		Pre Bet			Post Bet			After Result		
	Sessions	Zsum	Stouffer z	*P* <	Zsum	Stouffer z	*P* <	Zsum	Stouffer z	*P* <
Skin Conductance Level										
New	45	–5.20	–0.78	NS	–7.50	–1.12	NS	27.24	4.06	.001
Full	48	–0.50	–0.07	NS	4.89	0.71	NS	16.17	2.33	.01
Heart Rate Variability										
New	45	6.72	1.00	NS	7.40	1.10	NS	–20.00	–2.98	.01
Full	48	20.97	3.03	.01	11.43	1.65	.05	–22.09	–3.19	.001

Abbreviation: NS, not significant.

Table 4 Summary of Sessions by Moon Phase and Participant

	Full Moon (52 sessions)		New Moon (52 sessions)	
Subject no.	Win ratio	Amount won ratio	Win ratio	Amount won ratio
1	50%	–3%	50%	–10%
2	47%	–22%	42%	–36%
3	52%	9%	45%	–20%
4	54%	3%	39%	–29%
5	54%	18%	48%	10%
6	56%	30%	50%	0%
7	50%	–12%	41%	–48%
8	58%	18%	48%	–1%
9	48%	–13%	47%	–19%
10	56%	6%	49%	2%
11	43%	–37%	57%	36%
12	52%	4%	53%	15%
13	54%	14%	54%	11%
Average	51.8%	1.3%	48%	–6.9%

full and new moon sessions. Each participant's new and full moon win ratios were consecutively paired: for example, the first new moon session with the first full moon session and the second new moon session with second full moon session, etc, for a total of four, new/full moon pairs for each participant. The overall win ratio was significantly higher ($Z=-2.2$, $P<.05$) during the full moon period, but the amount won ratio did not differ significantly between moon phases (Table 4).

GENDER ANALYSIS

To address the question of potential differences between the occurrence of pre-stimulus responses and gender, we also grouped and analyzed the individual's trials by gender using the same Stouffer Z method described above (Table 5). The two groups appear to parallel each other with significant differences in the HRV win/loss waveforms in the pre-bet segment for males ($P<.05$) and for females ($P<.01$). There were no significant differences in the post-bet segment. In the post-result segment, the males displayed a significant response in SCL levels ($P<.001$), while the women did not. Both men ($P<.001$) and women ($P<.05$) had significant differences in HRV waveforms. The Mann-Whitney U test was used to test for difference between males and females on the average win ratio (50% for males, 49% for females) and the amount won ratio (males –1%, females –6%). There were no significant differences between males and females.

COGNITIVE STYLE

To address the question of a potential relationship between cognitive style and the occurrence of pre-stimulus responses, we grouped the participants by high and low CSI scores. The group with the three highest CSI scores (more analytical, mean CSI score 46.7) and the three lowest CSI scores (more intuitive, mean CSI score 24.7) were used in the analysis. Individual session Z scores of the two groups were combined using the Stouffer Z method. The results of the analysis are shown in Table 6. In the group scoring highest in analytical style, the only significant difference was in the pre-bet segment for the HRV win/loss waveforms ($P<.01$). In the more intuitive-style group (lower CSI), the only significant finding was in the post-bet segment of the SCL win/loss response ($P<.01$). The nonparametric Mann-Whitney U test was used to compare the two groups on winning ratio and the amount won ratio and found that neither were significantly different between the groups with high and low CSI scores.

STARTING KITTY AMOUNTS

As discussed in the methods section, the starting kitty and potential bet amounts were higher for half of the participants. Group 1 started each trial with $5 in the initial kitty and Group 2 with $20. This was done to determine if participants' emotional engagement was influenced by the potential to win a greater amount of money. The potential bet amounts were proportional to the starting kitty amount in both groups to maintain comparability between the amount won ratio in the two groups. For the analysis between the groups, individuals' trial session Z scores were combined using the Stouffer Z method to provide an overall assessment of the win/loss waveforms for both groups (Table 7). The

Table 5 Random Permutation Analysis by Gender

Gender Response Across All Sessions (Males N=9, sessions= 67 and Females N=4, sessions=26)

	Pre Bet			Post Bet			After Result		
	Zsum	Stouffer z	*P* <	Zsum	Stouffer z	*P* <	Zsum	Stouffer z	*P* <
Skin Conductance Level									
Male	–10.24	–1.25	NS	–5.19	–0.63	NS	47.31	5.78	.001
Female	4.54	0.89	NS	2.58	0.51	NS	–3.90	–0.76	NS
Heart Rate Variability									
Male	14.09	1.72	.05	11.16	1.36	NS	–31.03	–3.79	.001
Female	13.60	2.67	.01	7.67	1.50	NS	–11.06	–2.17	.05

Abbreviation: NS, not significant.

Table 6 Cognitive Styles for Analytical and Intuitive Participants

Cognative Styles Index: High (N=3) and Low (N=3) Scoring Participants (24 sessions)

	Pre Bet			Post Bet			After Result		
	Zsum	**Stouffer z**	***P*** **<**	**Zsum**	**Stouffer z**	***P*** **<**	**Zsum**	**Stouffer z**	***P*** **<**
Skin Conductance Level									
Intuitive	–6.22	–1.33	NS	–8.29	–1.77	0.05	20.16	4.30	.001
Analitical	2.49	0.51	NS	2.70	0.55	NS	12.67	2.59	.01
Heart Rate Variability									
Intuitive	2.50	0.53	NS	2.45	0.52	NS	–13.06	–2.78	.01
Analitical	14.22	2.90	.01	1.98	0.40	NS	–18.82	–3.84	.001

Abbreviation: NS, not significant.

Table 7 Analysis by Group With Different Starting Amounts and Maximum Bet Amount

All Participants by Betting Amount Group

		Pre Bet			Post Bet			After Result		
	Sessions	**Zsum**	**Stouffer z**	***P*** **<**	**Zsum**	**Stouffer z**	***P*** **<**	**Zsum**	**Stouffer z**	***P*** **<**
Skin Conductance Level										
Group 1	43	–2.80	–0.43	NS	–0.36	–0.05	NS	19.55	2.98	.01
Group 2	50	–2.90	–0.41	NS	–2.25	–0.32	NS	23.86	3.37	.001
Heart Rate Variability										
Group 1	43	7.48	1.14	NS	8.35	1.27	NS	–16.80	–2.56	.01
Group 2	50	20.21	2.86	.01	10.48	1.48	NS	–25.29	–3.58	.001

Group 1 Started with $5 and max bet was $0.50.
Group 2 started with $20 and max bet was $2.00.
Abbreviation: NS, not significant.

only significant finding in the pre-stimulus periods was in Group 2, in the pre-bet segment. There was a significant difference in the win/loss response for the HRV (P<.01). This greater pre-bet response result could be due to the larger financial risks being taken; however, no significant differences were found between the win or amount won ratios between these two groups using the Mann-Whitney U test.

DISCUSSION

The primary goals of this study were to test the revised version of the roulette protocol in which we added a second pre-stimulus segment and to examine the pre-stimulus response patterns within participant grand averages in addition to the group-level analysis. We also assessed the potential effects of the moon phase on the pre-stimulus outcomes.

Overall, the results indicate that the revised roulette protocol provides an effective objective measure for detecting a pre-stimulus response, which reflects a type of nonlocal intuition. The significant differences between the win and loss response in the aggregated physiological data during both pre-stimulus segments appear valid and robust, as confirmed by the random permutation analysis, which is an appropriate statistical procedure. The heart rhythm measures (HRV) were especially successful in detecting pre-stimulus responses in both pre-stimulus segments, which is consistent with other studies, suggesting the heart is especially involved in reflecting nonlocal information.

The addition of the pre-bet (pre-stimulus) segment, which is the period prior to the appearance of the betting screen, provides additional information about nonlocal intuition. The results showed that an increase in interbeat interval (IBI) length (heart rate de-acceleration) in the pre-bet segment was predictive of winning trials and the divergence in the win/loss curve begins almost immediately after starting the trials. On average, this effect occurred around 18 seconds prior to knowing the future outcome. While the time, 18 seconds, is substantially earlier than found in previous research—typically 4 to 7 seconds, these results indicate that the timing of accessing the intuitive information regarding the unknown future outcome is likely a function of the experimental protocol. How much earlier the HRV waveforms can predict the outcomes of a future event will require further investigation. This finding is especially noteworthy as foreknowledge in the pre-bet period has the potential to influence and change the outcome because it occurs before the actual bet is placed.

The 12-second post-bet period that begins after the bet amount is wagered and the red/black choice is made also had significant results of the HRV waveforms with the response starting around *12 to 14 seconds before* the future result was made known to the participants. Interestingly, in the HRV waveforms, the IBIs in win response were shorter than the IBIs in the losing response, while the opposite was true for the bet-independent responses. This finding is puzzling and challenging to understand. When looking at Figure 3, particularly during the first seconds of the post-bet segment, there was a lesser IBI shortening when the participants won betting on red than when winning by betting on black. However, the difference between losing on red and losing on black in the same period were nearly identical. In fact, the winning on black and losing on red or black were all nearly the same, leaving the winning on red standing alone, possibly implying that color may play a role in nonlocal perception.

As far as we know, this was the first electrophysiological study that analyzed the pre-stimulus response at the individual level. The results of individual participants across the eight sessions found that some, but not all, participants, maintained relatively consistent and significant win/loss pre-stimulus response patterns, as indicated by waveforms in the within-participant grand averages (individual participant data from all eight sessions). This is an interesting finding since there is evidence from prior studies that observed effects in repeated trials involving nonlocal information/interaction tended to decline in later trials.[44]

In the analysis of the bet-independent red-black outcome, two participants had significant overall prebet responses. Awareness of one's internal physiological responses during the period has a real potential to positively improve the choice (bet) and outcome. Interestingly, one of these participants had the second-highest cumulative win ratio and the other had the second lowest. We have seen other examples in a previous study of repeat entrepreneurs where a participant had very poor outcomes in the cognitively directed choices they made yet had strong pre-stimulus physiological responses.[45] This may indicate they are unconsciously inverting or misreading the internal physiological signals or that baseline patterns to which the pre-stimulus signals are compared require resetting. These internal baseline processes are discussed in more detail in another article in this issue.[20]

The findings in the analysis of the individual participants lead to several considerations. It appears that group-level outcomes provide stronger pre-stimulus results. We have previously suggested that measuring the pre-stimulus response in small groups would provide a more stable and reliable outcome indicator for almost any inquiry that can be formulated in a binary format such as red or black or yes or no, etc.[46] An innovative study in this issue has tested this hypothesis and confirmed that significantly greater pre-stimulus waveform responses are obtained in pairs of participants as compared to single participant per-stimulus responses.[41] The results of this and other studies also show that if the participants were more attuned to their internal physiological responses, which clearly show a better than chance ability to predict the future outcome than the cognitive level choices that are made in the context of this study, they would have won more money. Previous research has shown that when participants shift into a more coherent physiological state prior to engaging in the data collection, a significantly different cardiac afferent signal can be detected at the frontal cortex as well as other brain regions in the pre-stimulus period.[10] This suggests that learning to attune to and become more conscious of the internal physiological signals, especially the afferent signals from the heart, is an important factor in increasing one's access to nonlocal intuitive information.

The findings that the HRV win/loss response during both the pre-bet and post-bet segments during the full moon phase but not the new moon phase and that the win ratio was also higher at full moon are also intriguing and are consistent with others findings. For example, Puharich observed increases in the strength of telepathic effects in the 1960s.[47] Krippner also noticed increased nonlocal perception abilities in the 1970s.[48] More recently, significant solar and full moon phase effects in a large database of psychokinesis experiments were found, and the author suggests that the moon's interaction with the earth's magnetosphere during the moon's passage through the magneto-tail in full moon times may explain the observed effects.[49]

In regard to the analysis of the groups with the highest and lowest cognitive-style scores, it is interesting that the only significant difference was in the prebet segment for the HRV waveforms in the group scoring high in analytical style, although there were no significant differences between the groups. This instrument was used because of its use in previous studies using the single pre-stimulus version of the protocol.

LIMITATIONS

This study has several limitations. First and most important was the small sample size of 13 participants. It would also be advantageous in future studies to use a protocol that is faster moving and allows the participants to perform a greater number of trials in a session. Larger sample sizes will be required to determine if and how individuals might be unconsciously or consciously interpreting these physiological responses to influence their betting choices and whether sensitivity to these signals can be developed or increased. Of further interest is understanding whether some people invert the interpretation of the physiological signals and become good losers. Another potential limitation is that most of the participants had previous experience in meditation and self-regulation techniques. This background could have affected their responsiveness to the future stimuli so that the results may not necessarily be characteristic of the general population. Finally, there is the issue that the research design used for this study introduces a conscious anticipation effect, in that it requires the subject to press a button in order to initiate a trial. To reduce the effects of participant anticipation, subjects were not informed of the true purpose of the experiment. Although this does not appear to be an issue, this design does not allow for the pre-stimulus effect to be generated and detected in relation to spontaneous future stimuli as opposed to participant-initiated trials.

CONCLUSIONS

The primary purpose of the study was to evaluate a revised version of the roulette protocol which included two pre-stimulus segments and to conduct within-participant analysis in addition to the traditional group-level analysis. We also assessed the potential effects of the moon phase on the pre-stimulus response outcomes. Overall, the results indicate that the revised protocol provides an effective objective measure for detecting a pre-stimulus response, which reflects a type of nonlocal intuition. We found significant differences between the win and loss response in the aggregated physiological data during both pre-stimulus segments, indicating that the second pre-stimulus segment provides additional information about nonlocal intuition. On average, we detected a significant pre-stimulus response starting around 18 seconds prior to knowing the future outcome. Interestingly, there was not a strong overall relationship between the pre-stimulus responses and the amount of money the participant won or lost. This suggests that if participants had been able to become more attuned to their internal physiological responses, they would have performed much better on the betting choices that were made. We also demonstrated a significant relationship between both pre-stimulus periods and the moon phase. Overall, the results suggest that the revised roulette protocol is a reliable means of prompting physiological detection of pre-stimulus effects and can be used in future studies investigating aspects of nonlocal intuition.

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