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Electrophysiological Evidence of Intuition: Part 1. The Surprising Role of the Heart

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ABSTRACT

Objectives: This study aims to contribute to a scientific understanding of intuition, a process by which information normally outside the range of conscious awareness is perceived by the psychophysiological systems. The first objective, presented in two empirical papers (Part 1 and Part 2), was to replicate and extend the results of previous experiments demonstrating that the body can respond to an emotionally arousing stimulus seconds before it is actually experienced. The second objective, to be presented in a third paper (Part 3), is to develop a theory that explains how the body receives and processes information involved in intuitive perception.

Design: The study used a counterbalanced crossover design, in which 30 calm and 15 emotionally arousing pictures were presented to 26 participants under two experimental conditions: a baseline condition of normal psychophysiologic function and a condition of physiological coherence. Primary measures included: skin conductance; the electroencephalogram (EEG), from which cortical event-related potentials and heartbeat-evoked potentials were derived; and the electrocardiogram (ECG), from which cardiac decelerations/accelerations were derived. These measures were used to investigate where and when in the brain and body intuitive information is processed.

Results: The study's results are presented in two parts. The main findings in relation to the heart's role in intuitive perception presented here are: (1) surprisingly, the heart appears to receive and respond to intuitive information; (2) a significantly greater heart rate deceleration occurred prior to future emotional stimuli compared to calm stimuli; (3) there were significant gender differences in the processing of prestimulus information. Part 2 will present results indicating where in the brain intuitive information is processed and data showing that prestimulus information from the heart is communicated to the brain. It also presents evidence that females are more attuned to intuitive information from the heart.

Conclusions: Overall, we have independently replicated and extended previous research documenting prestimulus responses. It appears that the heart is involved in the processing and decoding of intuitive information. Once the prestimulus information is received in the psychophysiologic systems, it appears to be processed in the same way as conventional sensory input. This study presents compelling evidence that the body's perceptual apparatus is continuously scanning the future. To account for the results presented in Parts 1 and 2, Part 3 will develop a theory based on holographic principles explaining how intuitive perception accesses a field of energy into which information about future events is spectrally enfolded.

INTRODUCTION

Most people at some time have experienced "intuitive" perceptions about distant objects or future events that later turned out to be correct. In many cases, these perceptions are really cognitive inferences, extrapolations based on forgotten memories of prior experience that seep into consciousness (Sarbin et al., 1960). However, there are instances

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when so-called "gut feelings" or "intuitive insights" are found to be valid and related to circumstances so unique that these intuitions do not seem explicable on the basis of prior experience. It is postulated that such intuitive perception involves connection to a field of information beyond normal conscious awareness (Loye, 1983).

The Concise Oxford Dictionary (1964) defines intuition as "immediate apprehension by the mind without reasoning, immediate apprehension by a sense, and immediate insight."* Roberto Assagioli (1971) observes that intuition is "a synthetic function in the sense that it apprehends the totality of a given situation or psychological reality. It does not work from the part to the whole—but apprehends a totality directly in its living existence." In these terms, intuition is defined as a process by which information normally outside the range of cognitive processes is immediately sensed and perceived in the body and mind as certainty of knowledge or feeling about the totality of a thing distant or yet to happen. The "thing" can be an object, entity, or event in the material world, or an intellectual construct, such as a thought or idea. Often the feeling of certainty is absolute—the intuition is experienced as beyond question or doubt—and the feeling can encompass positive emotions, such as optimism and excitement, or negative emotions such as dread, fear, or terror. This experience of an immediate, total sense of the thing as a whole is quite unlike the informational processing experience of normal awareness. In normal awareness, the contents of the mind are updated incrementally, as the moment-by-moment sequences of sensory experience unfold.

Within this context, our study investigated the temporal dimension of intuition: the proposition that the body's psychophysiologic systems receive and process information about a future event before the event actually happens. We present compelling electrophysiological evidence that shows, under controlled experimental conditions, that both the brain and the heart process information about the emotionality of a stimulus before this stimulus is presented to research participants.

Although ours is among the latest in a long line of studies that document phenomena involving perception of future information (see below), most scientists regard such findings as anomalous. Even among those who study it, intuitive perception is viewed largely as the result of past experience. Thus, most recent work sees intuition as a function of the unconscious mind accessing existing information within the brain from forgotten experience (Agor, 1984; Eisenhardt and Zbaracki, 1992; Hogarth, 2001; Laughlin, 1997; Myers, 2002; Torff and Sternberg, 2001).

*As defined here, intuition may appear similar to the concept of precognition: "a form of extrasensory perception involving foreknowledge of a future event" (*McGraw-Hill Dictionary of Scientific and Technical Terms*, 1994). However, in light of our empirical results, we develop a distinction between these two concepts in Part 2.

This viewpoint stems from the common assumption in neuropsychology that conscious awareness, memory, and unconscious perception are emergent properties of the brain and nervous system alone. It is believed that the mind is emergent from the brain, and therefore subject to the same physical constraints as all biologic systems, in which time is believed to flow from the past to the future. From this perspective, awareness is thought to be restricted to perceptions of present sensory input, intermingled with memories of the past.

The dilemma over intuition (whether it is based on memory of past experiences or involves actual perception of some thing apart in space or ahead in time) is comparable, in many respects, to the dilemma of physics in the early twentieth century. A number of now famous "anomalous" experiments in quantum physics repeatedly demonstrated that the subatomic world is a domain in which there is virtually instantaneous "communication" of information between particles separated by vast regions of space, and in which particles act is if they have "knowledge" of events before these events actually happen. Although this defied explanation by classical physics, these phenomena of nonlocal communication are now accepted as established scientific fact (Aczel, 2002; Nadeau and Kafatos, 1999; Penrose, 1989), and have led to the revolutionary understanding that such space/time-defying communication of information is the result of the inherently interconnected nature of the quantum world (Bekenstein, 2003; Bohm and Hiley, 1993; Nadeau and Kafatos, 1999).

In the same way that nonlocal communication was once regarded as anomalous in physics, evidence of intuition to this point has been largely marginalized by science. Yet, in our view, the rigorous investigation of this phenomenon has potential to yield a fundamental shift in scientific understanding—even transforming the way we view ourselves in relation to the world. Thus, this study aims to contribute to the development of a scientific explanation for intuition, in an effort to enlarge scientific understanding of human perception: of how the body receives and processes information about objects or events distant in space or ahead in time. Central to this endeavor is the description of how information about future events is communicated to and processed by the sensory perception system.

For the purposes of presentation, this work has been divided into three publications. The first two publications are empirical and describe an experiment conducted to determine where and when in the body information about a future event is registered and processed. This experiment was designed to replicate and extend the results of previous electrophysiological studies of the prestimulus response by adding measures of brain and heart activity well suited to investigate information processing. Part 1, presented here, reports results on skin conductance and heart rate decelerations/accelerations. Part 2, to be published in the next issue of this *Journal*, reports results on measures of brain activity and on the interaction between the heart and brain in processing information about a future stimulus. Part 3, a forthcoming work, develops a theory to explain intuitive perception. This theory draws on the principles of holographic organization to describe how the body is connected, via sensory perception, to a field of energy that spectrally enfolds information about future events.

Previous research

The notion that intuitive perception is purely a function of the unconscious mind accessing forgotten prior experience has been challenged by several recent studies. Using rigorous experimental protocols, these studies have shown that the body often responds to a future emotionally arousing stimulus 4 to 7 seconds prior to experiencing the stimulus (Bierman, 2000; Radin, 1997b, 2003; Spottiswoode and May, 2003).

A number of studies examining the brain's prestimulus response (to be reviewed in Part 2) have demonstrated significant differences in event-related potentials[†] before presentation of the target stimuli compared to nontarget stimuli (Don et al., 1998; McDonough et al., 2002; Warren et al., 1992a, 1992b). Recently, researchers have also explored physiologic predictors of future events by investigating whether the human autonomic nervous system can unconsciously respond to randomly selected future emotional stimuli. Radin (1997a, 1997b) designed experiments to evoke an emotional response using randomly selected emotionally arousing or calming photographs.[‡] Indicators of autonomic activity included skin conductance level (SCL) and photoplethysmographic measures of heart rate and blood volume. Comparison of SCL response between emotional and calm trials showed a significantly greater change in electrodermal activity approximately 5 seconds before a future emotional picture than before a future calm picture. These results have since been replicated (Bierman and Radin, 1997; Bierman, 2000; Bierman and Scholte, 2002; Radin, 2003).[§] A further study, using a free-running protocol,[‖] also found significant skin conductance changes in the pre-stimulus period (Spottiswoode and May, 2003).

[†]Event-related potentials are voltage fluctuations that are associated in time with some physical, mental, or emotional occurrence. These potentials can be recorded from the scalp and extracted from the ongoing EEG by means of filtering and signal averaging.

[‡]The research subjects were instructed to press a computer mouse button to begin each trial. After the button-press the computer screen remains blank for 5 seconds, and then an image randomly selected from one of the two picture sets is shown for 3 seconds. This is followed by a blank screen for 10 seconds. At the end of this period, a message appears on the screen stating that when ready, the participant can press the mouse button to begin the next trial.

[§]Bem DJ. Precognitive habituation: Replicable evidence for a process of anomalous cognition. Unpublished manuscript, 2003.

[‖]The participants did not press a button and were completely unaware of when an audio startle stimulus would be randomly presented.

Operationally, an important implication of these studies' findings, for our research purpose, is that the prestimulus response to a future event is related to the degree of emotionality of that event. In short, we can hypothesize that the greater the emotional significance of a future stimulus, the larger will be the physiologic response prior to experiencing the stimulus.

RESEARCH DESIGN AND METHODS

We adopted Radin's (1997b) basic experimental protocol while including additional measures of brain and heart activity well suited to investigate information processing. This was done to determine where and when in the brain and body information about the future event was registered and processed. In addition to SCL, we included the electrocardiogram (ECG) for heart rate variability (beat-to-beat decelerations/accelerations) measurement. A 19-channel electroencephalogram (EEG) for cortical event-related potential and heartbeat-evoked potential measurements was also included; details of these measurements and results will be provided in Part 2. These measures have all been used to index specific aspects of sensory information processing, and can be interpreted according to well-established operational criteria (see Discussion).

This study utilized a counterbalanced crossover design with two experimental conditions.[¶] Each research subject participated in the protocol twice: once in his/her baseline psychophysiological state (condition 1), and once after having maintained a physiologically coherent state for 15 minutes prior to participation in the session (condition 2) (Fig. 1). The post-physiological coherence condition was included to test the hypothesis that an enhanced prestimulus response is related to the maintenance of a state of physiological coherence.

We previously introduced the term *physiological coherence* in documenting a physiologic mode frequently associated with sustained positive emotions. This mode encompasses distinct but related physiologic phenomena including entrainment, resonance, and synchronization, which reflect more efficient and harmonious interactions among the body's subsystems (McCraty and Childre, 2002, 2004; Tiller et al., 1996). Correlates of physiologic coherence include: increased synchronization between the two branches of the autonomic nervous system, a shift in autonomic balance toward increased parasympathetic activity, increased heart–brain synchronization, increased vascular resonance, and entrainment between diverse physiologic

[¶]The counterbalanced design was necessary to control for exposure effects. Half the participants completed the experimental protocol in condition 1 first, whereas the other half completed the protocol in condition 2 first.

	Stimulus Conditions	
Experimental Conditions	Calm	Emotional
1. Baseline psychophysiological mode	30 trials	15 trials
2. Post-physiological coherence mode	30 trials	15 trials

FIG. 1. Research design.

oscillatory systems. The coherent mode is reflected by a smooth, sine wave-like pattern in the heart rhythms and a narrow-band, high-amplitude peak in the low frequency range of the heart rate variability power spectrum, at a frequency of about 0.1 Hz (Tiller et al., 1996).

We have previously found that increased heart rhythm coherence correlates with significant improvements in performance on tasks requiring attentional focus and subtle discrimination (McCraty, 2002; McCraty and Atkinson, 2003), which may be important elements of the intuitive effect studied here.

Participants

Twenty-six (26) adult participants, 11 males, 15 females, ranging in ages from 28–56 (mean age, 45), were recruited from e-mail notices to people who had prior training in the HeartMath emotional management techniques, which facilitate the self-generation and maintenance of the physiological coherence mode (McCraty and Childre, 2002). Participants were in good health and had normal or corrected-to-normal vision. All participants gave informed consent.

Testing procedure

The two testing sessions were scheduled 2 weeks apart, with the order of the two experimental conditions randomly assigned for each participant. To test participants in their baseline psychophysiologic mode (condition 1), they were instructed not to engage in any meditative practices or practice of the HeartMath techniques on the testing day. To test participants in the physiological coherence mode (condition 2), participants practiced the Heart Lock-In emotional restructuring technique for 15 minutes before beginning the session. The Heart Lock-In technique, which combines intentional heart focus with the self-generation of a genuine positive emotion, such as appreciation or care, has been previously shown to induce development and maintenance of the physiological coherence mode (for details of this technique, see Childre and Martin, 1999; McCraty and Childre, 2002).

In the experimental sessions, each participant was seated in a comfortable chair in a sound-attenuated testing room, temperature-regulated to approximately 72°F. A video monitor was located approximately 1 meter in front of the participant at eye level, and a computer mouse was attached to the arm of the chair for the participant to click when ready to initiate each trial.

To record SCL, surface silver–silver chloride electrodes were attached to the pads of the participant's nondominant hand on the index and second fingers. An isotonic skin conductance electrode gel was used to improve electrical contact. The signal was amplified by a Grass model 7P122G DC amplifier (Grass, West Warwick, RI).

The ECG was measured using a lead-one configuration. A Grass model 7P6C ECG amplifier was used to detect the signals. A photoplethysmographic sensor was attached to the left earlobe to determine when the blood pressure wave reached the brain.

Each participant was fitted with an electrode cap for recording of the EEG (details will be presented in Part 2). Respiration was also measured with a respiration belt placed around the chest.

Stimulus presentation was controlled by a program written by David Joffe in Microsoft Visual C++ 5.0 (Microsoft Corporation, Redmond, WA). The stimulus control program generated a TTL pulse on one of the parallel port channels each time the participant pressed the mouse button to initiate the subsequent trial, and a second TTL pulse on a separate parallel port channel at the exact moment the stimulus image was presented on the video screen. The TTL timing signals were continuously collected throughout the session together with the physiologic data using a Data Translations DT3016 32-channel, 16-bit data acquisition board (Data Translation, Inc., Marboro, MA) and Capital Equipment Corp. TestPoint version 3.4a software (Capital Equipment Corp., Billerica, MA). Data acquisition occurred at a rate of 256 samples per second.

Participants were told that they were participating in a study to test their response to different types of emotionally stimulating photographs, and were unaware of the study's true purpose. They were instructed to press the mouse button when ready to begin each trial. After "button press," the monitor remained blank for 6 seconds, after which the computer randomly selected a photo and displayed it for 3 seconds (as illustrated in Fig. 2). A blank screen followed for 10 seconds. After this cool-down period, a message appeared on the monitor, instructing participants to begin the next trial when ready. At the beginning of each experimental session, the stimulus control software's pseudorandom number generator was reseeded with the subject's number followed by the current date as a six-digit number.

After a demonstration trial to familiarize the participant with the process, the experimenter left the room. Each participant viewed 45 pictures in each of the two sessions; each session consisted of 30 calm pictures and 15 emotional pictures selected from the International Affective Picture System (IAPS). This 2:1 ratio was used to avoid physiologic habituation to the emotional pictures (Boucsein, 1992).[#]

[#]Radin DI. Evidence for an anomalous anticipatory effect in the autonomic nervous system. Unpublished manuscript, 2002.

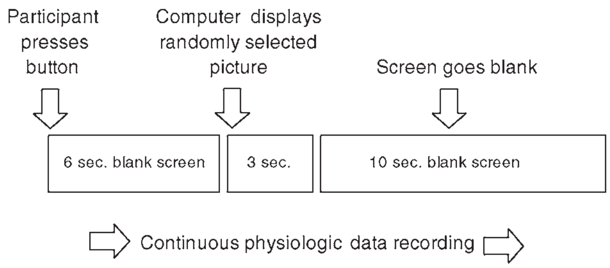

FIG. 2. Experimental protocol.

Data from a total of 2340 trials were collected across the two sessions for all participants.

Stimulus photos were selected based on ratings of arousal level determined by the IAPS. Calm pictures were randomly selected from a pool of 60 images with the lowest arousal ratings; these included landscapes, seascapes, fruit, trees, animals, and common household objects. Emotional pictures were randomly selected from a pool of 30 images with the highest arousal ratings; these portrayed a range of erotic, violent, and emotionally stimulating subjects. All pictures were digitally displayed in color, at 600 × 800 screen resolution, on a 17-inch monitor. If, during a session, a given picture was randomly selected twice, another picture of similar emotionality was selected in its place; thus, no photos were repeated within a session.

Data and statistical analysis

Data editing was blind to stimulus category (calm or emotional targets). Data processing and statistical analysis used DADISP 4.1 (DSP Development Corp., Newton, MA), MATLAB 6.1 (The MathWorks, Inc., Natick, MA), and SPSS 8.0 (SPSS, Inc., Chicago, IL) software.

Skin conductance measures. To reduce the data generated by sampling at 256 samples per second, the low-frequency skin conductance channel was resampled at 8 samples per second. Because measurement focused on how the physiology changed from the moment a given trial was initiated, each sample in each trial was transformed into a percentage difference score relative to the *baseline* SCL value at the moment the participant pressed the button to initiate the given trial ("button press"). To compute the percentage difference score (D), the first data point in each trial was subtracted from each of the 152 points (19 seconds × 8 samples per seconds) in the series. Then each point in the series was divided by the original value of the first data point of the series to yield the percentage difference series, in which the first point is always zero.

Heart rate variability. The ECG data used for heart rate variability (HRV) analysis were all normal sinus intervals. 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 8 samples per second.

Statistics for SCL and HRV. To reduce the possibility of false-positive findings, a deliberate decision was made to use statistically conservative procedures for data analysis. Therefore, randomized permutation analysis (RPA) was used to determine statistical significance of the differences between emotional and calm curves during the prestimulus period, because it controls for autocorrelations inherent to physiologic signals and their underlying non-normal distributions (Blair and Karniski, 1993). Applied separately to each individual's SCL and HRV data, RPA generates two standard deviates, or z scores, per person: $z$pre, the differential prestimulus value, and $z$post, the differential poststimulus value (Good, 1994; Hjorth, 1994; Radin, 1997b).

Operationally, RPA involved the following: The stimulus output from each individual's experimental session of 45 trials was a random sequence of 30 calm and 15 emotional targets. For each trial, we computed percentage difference scores (D), as described above. Then for each of the 152 samples we calculated the mean of the D values for the 15 emotional trials and the mean D for the 30 calm trials. These mean difference values are labeled D_E and D_C. Next we computed the difference between each of the 152 D_E and 152 D_C values during the 6-second pre-stimulus period (i.e., $d = D_E - D_C$), and summed these differences, $\sum d_o$, where this expression denotes the observed summed difference.

Then we randomized the original calm and emotional target classifications to create 30 new "pseudo-calm" and 15 new "pseudo-emotional" trials, while keeping the data in their original form and retaining the original ratio of 30 calm to 15 emotional trials. We then processed the data exactly as before, creating mean emotional and mean calm curves, calculating the difference between the two curves, and computing a summed difference value, $\sum d$.

Next we repeated this process 2000 times to construct a distribution of randomly permuted $\sum d$ values. After each new permuted value was generated, we updated the mean (m) and the standard deviation (s) of the distribution along with a standard normal deviate measure, $z = (\sum d - m)/s$. This z score (calculated using the mean and standard deviation from the 2000 randomized summed differences) is a statistical measure of the difference between emotional and calm physiologic responses, and was computed separately for the prestimulus and poststimulus response periods. These z scores were combined, using the Stouffer z method, to provide an overall measure of the prestimulus differential or poststimulus orienting response across subjects (Rosenthal, 1978).

RESULTS

Univariate analysis

Skin conductance level. The results of the RPA of the 6-second prestimulus period (*z*pre) for all subjects revealed no significant findings in SCL in either of the two experimental conditions (Table 1 and Fig. 3). The expected upward anticipatory trend is observed for both types of future stimulus. In the poststimulus data, there is a large upward slope for the emotional photos, indicating sympathetic nervous system activation.

In both conditions the SCL response to the emotional photos was significantly greater than to the calm photos (condition 1: $z$post = 7.27, $p < 0.001$; condition 2: $z$post = 6.89; $p < 0.001$).

Heart rate variability. In contrast to the SCL findings, the HRV data did show significant differences between the calm and emotional trials in condition 1 ($z$pre = −3.19, p = 0.001) (Table 1 and Fig. 4), although there were no significant HRV differences in condition 2. In condition 1, the HRV curves for the calm and emotional photos clearly diverge, starting around 4.5 seconds prior to the stimulus.

Regression analysis. To confirm the expected relationship between the perceived emotionality of the stimulus and the prestimulus response, each participant's maximum prestimulus and poststimulus SCL percent difference values from both calm and emotional session average waveforms were analyzed using linear regression. A significant relationship was found between the maximum prestimulus SCL value and the maximum poststimulus SCL value in both experimental conditions (condition 1, $R^2 = 0.342$, $p < 0.001$; condition 2, $R^2 = 0.253$, $p < 0.001$).

We also tested for an expectancy artifact related to photo sequence. If present, the pre-stimulus SCL response would increase as the number of sequential calm trials increased, due to growing anticipation of the next emotional stimulus. There was no expectancy effect in the regression results ($R^2 = 0.0004$, $p = 0.379$). We tested for the same expectancy artifact in the HRV data and also found no effect ($R^2 = 0.00002$, $p = 0.875$).

Bivariate analysis

Analysis by gender. Results showed that neither the females nor males evidenced a significant difference in SCL levels between the calm and emotional trials in the prestimulus period (Table 1).

By contrast, both males and females had significant differences in HRV between the calm and emotional trials in condition 1 (females $z$pre = −2.66, p = 0.004; males $z$pre = −1.82, p = 0.03). However, in condition 2 the females demonstrated a significant HRV difference ($z$pre = −2.26, p = 0.01), whereas the males did not (Table 1).

DISCUSSION

This study's purpose was to independently replicate and extend previous experiments demonstrating that the body can respond to an emotional stimulus prior to experiencing the future stimulus. While confirming this finding overall, we were unable to replicate the skin conductance results. This lack of skin conductance evidence is likely due to a different subject population than was used in the Radin studies. In a poststudy conversation, Dr. Radin informed us that he had excluded experienced meditators because he had found they do not have the expected skin conductance response (D.I. Radin, personal communication, November 2002). Our population consisted of individuals who not only had previous experience with meditation, but were also experienced practitioners of the HeartMath emotional management tools who could enter the physiological coherence mode at will. Thus, we have replicated Radin's unpublished

Table 1. Skin Conductance Level and Heart Rate Variability Data

	Prestimulus				*Poststimulus*			
	Condition 1		*Condition 2*		*Condition 1*		*Condition 2*	
	z *pre*	p *(1-tail)*	z *pre*	p *(1-tail)*	z *post*	p *(1-tail)*	z *post*	p *(1-tail)*
All Subjects								
SCL	0.59	ns	0.76	ns	7.27	0.000	6.89	0.000
HRV	−3.19	0.001	−1.33	ns	−3.64	0.000	−3.24	0.001
Females								
SCL	−0.08	ns	0.97	ns	5.70	0.000	6.18	0.000
HRV	−2.66	0.004	−2.26	0.01	−3.08	0.001	−3.69	0.000
Males								
SCL	1.00	ns	0.04	ns	4.52	0.000	3.38	0.000
HRV	−1.82	0.03	0.49	ns	−2.02	0.02	−0.77	ns

SCL, skin conductance level; HRV, heart rate variability; ns, not significant.

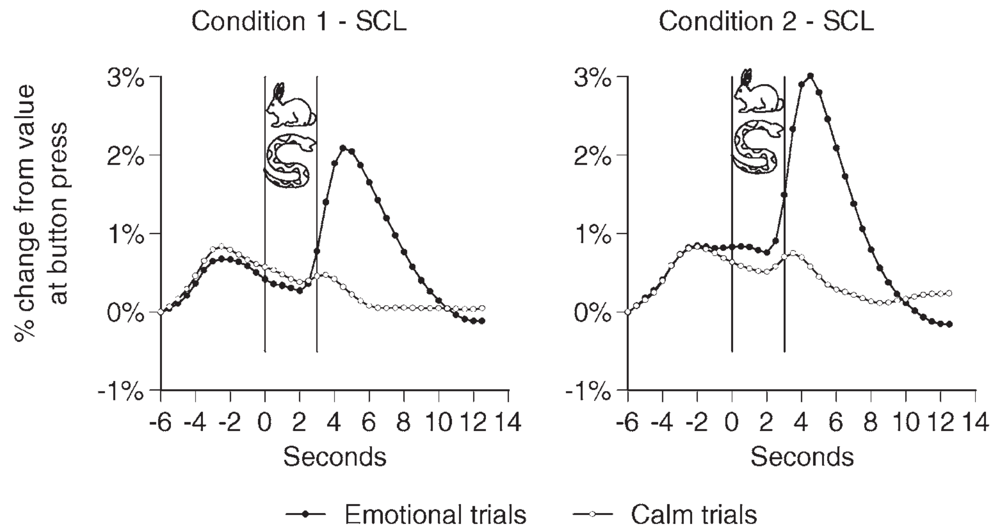

FIG. 3. Mean skin conductance level (SCL) response for the group as a whole (n = 26) for calm versus emotional trials. Data are shown for experimental condition 1 (baseline psychophysiologic mode) and condition 2 (postphysiological coherence). The "0" time point denotes stimulus onset. There were no significant differences in the prestimulus SCL response to future calm versus emotional stimuli in either experimental condition.

observations and have also found a likely physiologic explanation for them. Event-related potential data relevant to this will be presented in Part 2.

Our working premise is that no matter how intuitive information is initially introduced into the psychophysiologic systems, once received it is processed in the same way as information obtained through the familiar sensory systems. Although, to our knowledge, this is the first study to examine beat-to-beat changes in heart rate in the context of "intuitive" information processing, there is a substantial body of literature discussing the interpretation of cardiac decelerations/accelerations in relation to the processing of sensory information (Jennings and van der Molen, 2002; Lacey and Lacey, 1974; van der Molen et al., 1985, 1987; Van der Veen et al., 2001). During a typical anticipatory (prestimulus) period, a triphasic heart response curve is usually observed—an initial deceleration, followed by a small accelerative component, and then a larger deceleration. However,

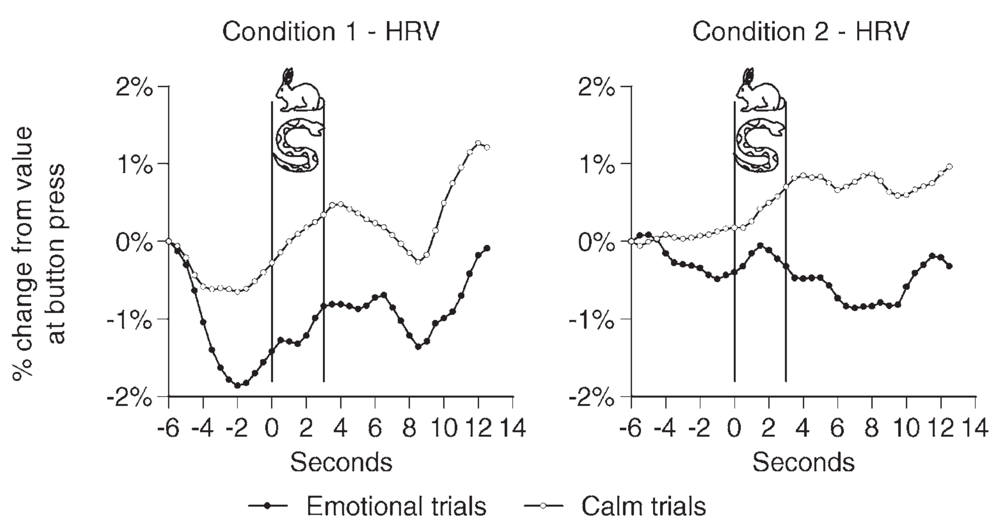

FIG. 4. Mean heart rate variability (HRV) response for the group as a whole (n = 26) for calm versus emotional trials. Data are shown for experimental condition 1 (baseline psychophysiologic mode) and condition 2 (postphysiologic coherence). The "0" time point denotes stimulus onset. Significant differences (p = 0.01) in the prestimulus response to calm versus emotional stimuli were observed in condition 1, where the HRV curves for the calm and emotional photos begin to diverge approximately 4.5 seconds prior to the participants viewing the photos.

when the individual is preparing for a known noxious stimulus, the accelerative component is wiped out and the response curve is characterized, instead, by a strong decelerative trend throughout the foreperiod (van der Molen et al., 1987). Interestingly, this pattern is consistent with our prestimulus HRV result, as shown in Figure 4. In other words, the body seems to process the unknown stimulus in the same way it does when the future stimulus is known.

Interpreting the processing of intuitive information within the classical framework just described, our HRV data indicate that, on average, the informational input to the heart regarding the future emotional stimulus occurred about 4.75 seconds before the stimulus was actually presented. This is where the slope of the deceleration curve for the emotional trials clearly starts to diverge from the slope for the calm trials.

A system-wide process?

We have presented compelling evidence that the heart plays a surprising role in the processing of prestimulus information. More evidence for this important point will be presented in Part 2, where we will show that while both the heart and the brain are directly involved, there is evidence that the heart may receive the pre-stimulus information before the brain. This suggests that, instead of being localized to the brain alone, the apprehension of information pertaining to future emotional events is a system-wide process involving the heart and the brain, and even the body as a whole.

The observed deceleration in heart rate, indicating a shift in informational content, is usually interpreted as the result of an increase in parasympathetic outflow controlled solely by the brain. However, it is also possible that the deceleration originated within the heart itself, and that the resulting change in afferent neural signals to the brain either signaled the brain about the future event, or facilitated its processing of the intuitive information, or both.

This possibility is also corroborated by recent work in neurocardiology, which has established that the heart is a sensory organ and an information encoding and processing center with an extensive intrinsic nervous system, enabling it to learn, remember, and make functional decisions independent of the cranial brain. The heart's intrinsic nervous system not only makes adjustments to the heart's rhythmic activity on a beat-to-beat basis, but can even override inputs from the sympathetic and parasympathetic nervous systems (Armour and Ardell, 1994; Armour, 2003). Moreover, there is substantial evidence that patterns of cardiac afferent neurological input to the brain not only affect cardiovascular regulation, but also influence higher brain centers involved in perception and emotional processing (Frysinger and Harper, 1990; McCraty and Childre, 2004; Sandman et al., 1982). For instance, extensive experimental data have documented that cardiac afferent input modulates a wide range of processes such as reaction times (Lacey and Lacey, 1974), pain perception (Randich and Gebhart, 1992), hormone production (Drinkhill and Mary, 1989), electrocortical activity, and cognitive functions (Rau et al., 1993; Sandman et al., 1982; van der Molen et al., 1985).

In short, in light of the heart's extensive involvement in so many different psychophysiological functions and systems, it may not be so surprising after all that the heart is also involved in the processing of intuitive information.

Correlates of intuition

Reviewing the results of our bivariate analysis of skin conductance and HRV offers some initial evidence on the relationship between gender and the body's prestimulus response in the two experimental conditions. Although there was not a significant skin conductance response for either gender, for HRV the males showed a prestimulus response only in the baseline physiologic mode, whereas the females had a significant response in both the baseline and coherent modes. It is possible that the target photos may have been perceived differently by the two genders. In fact the HRV data from condition 2 (data not shown) suggest that overall, males enjoyed the emotionally arousing stimuli while the females did not. It is also possible that once emotionally centered after Heart Lock-In, the males were less emotionally responsive to stimuli. More extensive evidence on differences in relation to gender and the two experimental conditions will be presented in Part 2.

Potential sources of spuriousness

There are a number of sources of potential artifacts that we have examined and ruled out as an explanation for the intuitive effect observed here. These and other factors have been examined in depth by other researchers (Bierman and Scholte, 2002; Radin, 1997b, 2003; Spottiswoode and May, 2003) and were carefully considered in the design and execution of our experiments.

Sensory or statistical cueing and participant anticipation effects. To eliminate the effects of participant anticipation and prior exposure, subjects were not informed of the true purpose of the experiment, and their participation in the two sessions was spaced 2 weeks apart. To avoid sensory cueing resulting from sounds generated by the hard disk's retrieval of the upcoming photo, the target photos were not retrieved from the hard disk until after the physiologic data from the prestimulus time period had already been recorded. To avoid statistical cueing from a nonrandom presentation of the photos, the randomness of the sequence of photos was checked before administration and verified as adequately random. To check for a participant expectancy effect related to the number of sequential calm trials (Radin, 2003; Spottiswoode and May, 2003), we analyzed the data for evidence of such an effect and found none; thus, participant anticipation could not account for the prestimulus effects observed.

Measurement, data collection, or data analysis artifacts. To avoid these kinds of operational artifacts, the electrophysiological data representing the prestimulus response were already recorded in the computer's memory before the target was displayed. A second source of potential spuriousness here concerns the type of random number generator used—pseudorandom number generators versus hardware-based random number generators. However, several research groups have now used both types of random number generators and found that the type used made no difference in the study outcomes (Radin, 2003).[§]

The software was designed to annotate all physiologic data in real time and mark current conditions of the session to insure correct synchronization with external events. To avoid violations of the distributional assumptions associated with parametric statistical tests, nonparametric randomized permutation analysis was used to evaluate results. Overall, it is unlikely that the hardware, software, or data collection mechanisms employed are sources of systematic bias that might explain our observed results. If any unknown operational or analysis artifacts were present, they would have affected the emotional and calm trials alike.

Participant or experimenter fraud. To protect against participant fraud, the study's purpose, technical procedures, and access information to the databases were kept confidential. The data collection computer is not connected to the Internet, and cannot be accessed from outside the laboratory. Moreover, no unauthorized personnel had access to the laboratory. Participant fraud based on unauthorized body movements during the experiments is a nonissue because these body movements generate false data signals that are readily identifiable. Experimenter fraud, such as deliberate deception or misrepresentation of the data, did not occur, as corroborated by this study's replication of the basic findings of several other independent research groups.

Limitations

This study has several limitations. First, most participants had previous experience in meditation and all currently practiced the HeartMath 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. For comparative purposes, the same physiologic measures should be studied in a population of individuals who do not have experience in emotional self-management practices. Another limitation is that the emotional stimuli may not have been as effective in eliciting responses in the male participants. This may be compounded by the tendency of photographic stimuli to elicit idiosyncratic responses (e.g., a picture with high emotional affectivity to one participant may have low affectivity to another), which reduces the potential contrast between arousing and calming stimuli and introduces an unwanted source of variance in the data. Also, the perceived emotional valence of the stimuli likely varied among participants, particularly across genders. Future studies should address these issues, as it is possible that positive stimuli of high emotionality will elicit different prestimulus responses than negative emotional stimuli. Finally, there is the issue that the research design used for this study introduces a conscious anticipation effect, in that it requires that the subject press a button in order to initiate a trial. Although this does not appear to be a source of spurious results, this design does not allow for the intuitive effect to be generated and detected in relation to spontaneous future stimuli. This is an issue for future research investigating intuition in more natural settings.

CONCLUSIONS

This report has presented a portion of the results from a larger study of intuitive perception investigating how the body receives and processes prestimulus information about a future event. Overall, we have replicated the general finding of previous studies by providing further evidence of a physiologic response to a future emotional stimulus occurring before the stimulus is actually experienced.

Our main findings reported here in Part 1 of this work are: (1) the heart appears to receive and respond to intuitive information; (2) a significantly greater heart rate deceleration occurred prior to future emotional stimuli compared to calm stimuli; (3) there were significant gender differences in the processing of prestimulus information. Part 2 (to be published in the next issue of this *Journal*) presents results on measures of brain activity and on the interaction between the heart and brain in processing prestimulus information.

Of greatest significance here is our major finding: namely, the electrophysiological evidence that the heart is directly involved in the processing of information about a future emotional stimulus seconds before the body actually experiences the stimulus. To our knowledge, this is the first study to measure heart rate decelerations/accelerations in connection with intuitive perception, and this finding thus constitutes a significant addition to previous research on intuition. What is truly surprising about this result is the fact that the heart appears to play a direct role in the perception of future events; at the very least it implies that the brain does not act alone in this regard. If verified by future studies, this is an important finding that may open the door to an enlarged scientific understanding of the heart's role in human perception, consciousness, and behavior.

Also significant is our related finding that once the prestimulus information is received, it appears to be processed in the same way as conventional sensory input. Thus, while other aspects of the phenomenon of intuitive perception may require a new explanatory framework (to be discussed in Part 3), the body's processing of information about future external events appears interpretable within a classical physiologic information processing context.

In closing, although our finding that the heart is involved in intuitive perception may be surprising from one perspective, it is worth noting that in virtually all human cultures, ancient and modern, the heart has long been regarded as a conduit to a source of information and wisdom beyond normal awareness. Thus, our data may be seen as providing scientific evidence for an intuitive capacity that humankind has known and used for many millennia.

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REFERENCES

Aczel AD. Entanglement: The Greatest Mystery in Physics. New York: Four Walls Eight Windows, 2002.

Agor W. Intuitive Management: Integrating Left and Right Brain Skills. New Jersey: Prentice Hall, 1984.

Armour JA. Neurocardiology—Anatomical and functional principles. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 03-011, 2003.

Armour JA, Ardell JL, eds. Neurocardiology. New York: Oxford University Press, 1994.

Assagioli R. Psychosynthesis. New York: Viking, 1971:27.

Bekenstein JD. Information in the holographic universe. Sci Am 2003;289:58–65.

Bierman DJ. Anomalous baseline effects in mainstream emotion research using psychophysiological variables. Proceedings of Presented Papers: The 43rd Annual Convention of the Parapsychological Association, 2000:34–47.

Bierman DJ, Radin DI. Anomalous anticipatory response to randomized future conditions. Percept Mot Skills 1997;84:689–690.

Bierman DJ, Scholte HS. Anomalous anticipatory brain activation preceding exposure of emotional and neutral pictures. Presented at Toward a Science of Consciousness IV, Tuscon, AZ, 2002.

Blair RC, Karniski W. An alternative method for significance testing of waveform difference potentials. Psychophysiol 1993;30: 518–524.

Bohm D, Hiley BJ. The Undivided Universe. London: Routledge, 1993.

Boucsein W. Electrodermal Activity. New York: Plenum Press, 1992.

Childre D, Martin H. The HeartMath Solution. San Francisco: HarperSanFrancisco, 1999.

The Concise Oxford Dictionary of Current English. Oxford, England: Oxford University Press, 1964.

Don NS, McDonough BE, Warren CA. Event-related brain potential (ERP) indicators of unconscious psi: A replication using subjects unselected for psi. J Parapsychol 1998;62:127–145.

Drinkhill MJ, Mary DA. The effect of stimulation of the atrial receptors on plasma cortisol level in the dog. J Physiol 1989;413:299–313.

Eisenhardt K, Zbaracki M. Strategic decision making. Strategic Management J 1992;13:17–37.

Frysinger RC, Harper RM. Cardiac and respiratory correlations with unit discharge in epileptic human temporal lobe. Epilepsia 1990;31:162–171.

Good P. Permutation Tests: A Practical Guide to Resampling Methods for Testing Hypotheses. New York: Springer-Verlag, 1994.

Hjorth JS. Computer Intensive Statistical Methods: Validation Model Selection and Bootstrap. New York: Chapman & Hall, 1994.

Hogarth RM. Educating Intuition. Chicago: The University of Chicago Press, 2001.

Jennings JR, van der Molen MW. Cardiac timing and the central regulation of action. Psychol Res 2002;66:337–349.

Lacey BC, Lacey JI. Studies of heart rate and other bodily processes in sensorimotor behavior. In: Obrist PA, Black AH, Brener J,DiCara LV, eds. Cardiovascular Psychophysiology: Current Issues in Response Mechanisms, Biofeedback, and Methodology. Chicago: Aldine, 1974:538–564.

Laughlin C. The nature of intuition: A neuropsychological approach. In: Davis-Floyd R, Arvidson PS, eds. Intuition: The Inside Story. London: Routledge, 1997:19–37.

Loye D. The Sphinx and the Rainbow: Brain, Mind and Future Vision. New York: Bantam Books, 1983.

McCraty R. Influence of cardiac afferent input on heart-brain synchronization and cognitive performance (abstract). Int J Psychophysiol 2002;45:72–73.

McCraty R, Atkinson M. Psychophysiological coherence. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication 03–016, 2003.

McCraty R, Childre D. The appreciative heart: The psychophysiology of positive emotions and optimal functioning. Boulder Creek, CA: HeartMath Research Center, Institute of HeartMath, Publication No. 02-026, 2002.

McCraty R, Childre D. The grateful heart: The psychophysiology of appreciation. In: Emmons RA, McCullough ME, eds. The Psychology of Gratitude. New York: Oxford University Press, 2004:240–265.

McDonough BE, Don NS, Warren CA. Differential event-related potentials to targets and decoys in a guessing task. J Scientific Exploration 2002;16:187–206.

McGraw-Hill Dictionary of Scientific and Technical Terms, 5th edition. New York: McGraw-Hill, 1994.

Myers DG. Intuition: Its Powers and Perils. New Haven: Yale University Press, 2002.

Nadeau R, Kafatos M. The Non-Local Universe: The New Physics and Matters of the Mind. New York: Oxford University Press, 1999.

Penrose R. The Emperor's New Mind: Concerning Computers, Minds, and the Laws of Physics. New York: Oxford University Press, 1989.

Radin DI. The Conscious Universe. San Franscisco: HarperEdge, 1997a.

Radin DI. Unconscious perception of future emotions: An experiment in presentiment. J Sci Exploration 1997b;11:163–180.

Radin DI. Electrodermal presentiments of future emotions. J Scientific Exploration (in press).

Randich A, Gebhart GF. Vagal afferent modulation of nociception. Brain Res Rev 1992;17:77–99.

Rau H, Pauli P, Brody S, Elbert T. Baroreceptor stimulation alters cortical activity. Psychophysiol 1993;30:322–325.

Rosenthal R. Combining results of independent studies. Psychol Bull 1978;85:185–193.

Sandman CA, Walker BB, Berka C. Influence of afferent cardiovascular feedback on behavior and the cortical evoked potential. In: Cacioppo JT, Petty RE, eds. Perspectives in Cardiovascular Psychophysiology. New York: The Guilford Press, 1982: 189–222.

Sarbin T, Taft R, Bailey D. Clinical Inference and Cognitive Theory. New York: Holt, Rinehart & Winston, 1960.

Spottiswoode SJP, May ECP. Skin conductance prestimulus response: Analyses, artifacts and a pilot study. J Scientific Exploration 17:617–642.

Tiller WA, McCraty R, Atkinson M. Cardiac coherence: A new, noninvasive measure of autonomic nervous system order. Altern Ther Health Med 1996;2:52–65.

Torff B, Sternberg RJ. Intuitive conceptions among learners and teachers. In: Torff B, Sternberg RJ, eds. Understanding and Teaching the Intuitive Mind: Student and Teacher Learning. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers, 2001: 3–26.

van der Molen MW, Somsen RJ, Jennings JR, Nieuwboer RT, Orlebeke JF. A psychophysiological investigation of cognitive-energetic relations in human information processing: A heart rate/additive factors approach. Acta Psychol 1987;66:251–289.

van der Molen MW, Somsen RJM, Orlebeke JF. The rhythm of the heart beat in information processing. In: Ackles PK, Jennings JR, Coles MGH, eds. Advances in Psychophysiology, Vol. 1. London: JAI Press, 1985:1–88.

van der Veen FM, van der Molen MW, Jennings JR. Selective attention and response inhibition alter phase-dependent cardiac slowing. Psychophysiology 2001;38:896–902.

Warren CA, McDonough BE, Don NS. Event-related brain potential changes in a psi task. J Parapsychol 1992a;56:1–30.

Warren CA, McDonough BE, Don NS. Partial replication of single subject event-related potential effects in a psi task. The Parapsychological Association 35th Annual Convention: Proceedings of Presented Papers, 1992b:169–181.

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