# BEFORE COGNITION: THE ACTIVE CONTRIBUTION OF THE HEART/ANS TO INTUITIVE DECISION MAKING AS MEASURED ON REPEAT ENTREPRENEURS IN THE CAMBRIDGE TECHNOPOL

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## ABSTRACT

This paper reports the preliminary results of a pilot study testing the efficacy of a new experimental protocol to measure the psychophysiological basis of entrepreneurial intuition—that part of entrepreneurial decision and action that is *not* based on reason or memory, but on an awareness of energetically-encoded information of the future. A multi-methods approach incorporating electrophysiological measures of the autonomic nervous system (ANS) was used to investigate intuition in a sample of 8 serial entrepreneurs with usable data from the Cambridge Technopol. The results are promising: the mean pattern of recordings for all subjects show that informational input was received by the ANS some *6 to 7 seconds before* the outcome of the investment choice was known. Also random permutation analysis of individual recordings identified five instances in which the physiological measures had significant or marginally significant predictive power in discriminating future win/loss outcomes. Overall, the physiological measures were able to detect intuitive perception of a future outcome in four of the eight entrepreneurs. However, some improvements to the protocol's design and data collection procedures (when used in non-laboratory field settings) will be necessary to optimize the protocol's targeting and measurement of entrepreneurial intuition.

## INTRODUCTION

Uncertainty has surrounded the question – "do successful Entrepreneurs respond to and assimilate information differently to managers, and does this contribute to how they make decisions"? Shane and Venkataraman (2000) proffer that two factors influence the probability that particular people and not others are able to discover and exploit opportunities: the possession of the information necessary to identify an opportunity and the cognitive style necessary to exploit it (Shane and Venkataraman 2000). We propose that a third option must be considered, that of nonlocal intuition (see next section) in seeking to understand particular styles of knowing which are more appropriate than others for the conduct of entrepreneurial activities (Allinson and Hayes 1996). Some entrepreneurs just seem to be at the right place at the right time with the correct decisions and unlike scientists, entrepreneurs do not enjoy the luxury of making decisions on the basis of orderly time consuming rational analysis (Simon 1987).

In rational decision making, goals and alternatives are made explicit, the consequences of pursuing different alternatives are calculated and these consequences are evaluated in terms of how close they are to the goals (Barnard 1938). To succeed in today's business world the repeat entrepreneur must

respond to the need for a rapid decision, usually too rapid to allow for an orderly sequential analysis of the situation. The amount of information available also provides a significant hindrance to a thorough analysis that in itself is very time consuming.

Whilst there has been a significant focus of attention on entrepreneurial behavior, understanding how entrepreneurs make decisions has been less researched and therefore understood. Most scholars agree that what differentiates an entrepreneur from the rest is their behavior. Nevertheless, attempting to differentiate the behavior of an entrepreneur from others has thus far proved difficult (Keh, Foo et al. 2002; Mitchell, Busenitz et al. 2002).

Even though their has been a failure to uncover some homogenous traits, practitioners, scholars, venture capitalists and financiers consider the entrepreneur to be critical to the success of the firm (Mitchell, Busenitz et al., 2002). Whilst there has been little substance to the entrepreneurial personality, it seems counterintuitive to ignore individual differences (Krueger, 2003). For this reason an alternative approach of how entrepreneurs make decisions was chosen so as to determine whether this avenue of investigation can provide some clarity in differentiating the behavior of serial entrepreneurs. Allinson et al. (2000) argue that the nature of entrepreneurship and the style of the successful entrepreneur will, by necessity be more intuitive. They argue that entrepreneurs tend to bypass rigorous analysis because they are decisive and appreciate the time value of money and the competitive nature of most markets and industries.

**Concept of Intuition**

So what is intuition and why is it important? One argument is that intuition is the ability of an individual to access their subconscious mind. Whilst the subconscious mind is able to synthesize up to 50 million bits of information per second the conscious mind is only able to process about 50 bits of information over the same time (Nørretranders, 1999), the conscious mind is only able to process 126 bits of information over the same time. A normal conversation requires the ability to process to process 40 bits of information per second (Csikszentimihalyi, 2002).

Intuition has been strongly associated with various models of pattern recognition, mostly devised by cognitive psychologists. For rationalists, opportunity recognition exists in the external world as complex patterns of observable stimuli (Baron, 2004). We recognize objects or patterns through a number of interrelated processes. One such process is the *feature-analysis model* (Larsen and Budsen 1996, in Baron). This model suggests that patterns are identified by their distinctive features. In opportunity recognition this may be economic value and newness of a product or service. The drawback with this model is that it is primarily applicable to simple patterns.

In contrast *prototype models* apply to more complex patterns. Through experience we construct prototype models that is, what a particular model should look like. Prototypes are the most commonly experienced object or patterns of a prototype. For opportunity recognition an entrepreneur may seek central characteristics such as the likelihood of competition, economic value, desirability and other characteristics critical to their prototype. The likelihood of a match would enable an entrepreneur to conclude whether the opportunity is worth pursuing (Craig & Lindsay, 2001, in Baron).

The final model of pattern recognition emphasizes the importance of specific knowledge. It is known as an *exemplar model* (Hahn & Chater, 1997, in Baron). Hahn & Chater (1997) would argue that an individual would compare existing opportunities with exemplar models of excellent and poor business opportunities. This fits well with the argument that entrepreneurs' "just know a good opportunity when they see one".

Simon's (1987) intuition is merely the application of one's professional judgment to the situation. It could use any of the aforementioned pattern recognition models. Simon's makes his point on a Grand Chess Master's ability to make strong moves quickly. He argues that his skill is in his knowledge, acquired by long experience of the kinds of patterns and clusters of pieces that occur on chessboards. For a Chess Master a chess board is not an arrangement of 25 pieces but an arrangement of a half a dozen familiar patterns that previous experience recognises. The skills of the manager depend on the same kind of intuitive skills of chess masters (Simon, 1987). Interestingly Barnard (1938) does not regard the non-logical processes of decision making as magical in any sense, he argues that they are grounded in knowledge and experience.

Taking an information processing perspective, we view intuition as a process by which information normally outside the range of cognitive processes is sensed and perceived in the body and mind as certainty of knowledge or feeling (positive or negative) about the totality of a thing distant or yet to

happen (McCraty, Atkinson, & Bradley, 2004a; 2004b) and their experience will raise the physiological signal levels to possible measurement levels (Tiller, 2001). This "thing" can be a material object or event, or a mental 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 like 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. Also, the experience of intuition is not confined to cognitive perception, but involves the *entire* psychophysiological system, often manifesting through a wide range of emotional feelings and physiological changes experienced throughout the body. The involvement of the entire psychophysiological system in processing intuitive perception is the basis of its detection and measurement using electrophysiological instrumentation, as shown below (Bradley 2006, LaPira & Gillin 2006)

**Previous Research**

In earlier empirical research on repeat entrepreneurs in the Cambridge Technopole (UK) to asses the propensity of non-local intuition in decision making characteristics, the concept of "Triangulation" was used to seek insights into non-local intuition. The two assessments previously evaluated were Cognitive Style Index and In-depth Interviews (LaPira and Gillin 2006). The third leg of the triangle, namely - experimental evidence from electro-physiological measure of intuition (McCraty, Atkinson, & Bradley, 2004a & 2004b) - is the subject of this paper.

*Cognitive Style Index*

The Cognitive Style Index (CSI) is a self-report questionnaire, which consists of 38 questions whose aim is to ascertain whether a respondent's cognitive style is either analytical or intuitive. The instrument is designed so that a person who is analytical is most likely to achieve a high score - maximum of 76. A low score would indicate that the respondent is more intuitive - the lower the score the more intuitive the respondent. From the results of LaPira and Gillin (2006), it is shown (Fig. 1) the majority of Cambridge repeat entrepreneurs tested scored less than 32, the mean CSI score being 25 (dashed line) with a standard deviation of 7.3. The entrepreneurs scored significantly lower when compared with the 1200 Managers that were tested in previous studies (Allinson et al 1996). Their mean score was 41 with a standard deviation of 11.

*Interviews with Repeat Entrepreneurs*

As well as completing the CSI instrument each respondent was interviewed using a semi-structured in-depth interviewing process. Using an agreed interview protocol each interviewee identified and recollected their experience in identifying opportunities and building new firms whilst dealing with difficult business decisions. Spiritual and or religious beliefs as well as philanthropic activities were also important aspects of the interview protocol. The interviews were subsequently transcribed and the content was analyzed (LaPira and Gillin 2006) using a qualitative software program known as NVivo™. The content analysis protocol advocated by (Krippendorff 1980) was used to identify the primary meaning units (intuition, desire to serve, commitment, adaptability, honesty/integrity, holistic values, passion and vision) contributing to entrepreneur decision making.

**Electro-physiological measures of intuition**

Although there is now a voluminous body of rigorous experimental research documenting the phenomenon of intuitive perception (see Radin's review, 1997), mainstream science still regards the findings of these studies as anomalous (Walach & Schmidt, 2005). Even among those who study it, intuition is viewed largely as the result of past experience—a function of the unconscious mind accessing existing information within the brain from forgotten experience (Agor, 1984; Eisenhardt & Zbaracki, 1992; Hogarth, 2001; Laughlin, 1997; Lieberman, 2000; Myers, 2002). In presenting a very brief review of the evidence from studies that challenge this view, we draw heavily on McCraty et al. (2004a)

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 and electrophysiological instrumentation, these studies have shown that the body often responds to a future emotionally arousing stimulus four to seven seconds *prior* to experiencing the stimulus (Radin, 1997; Bierman, 2000; Radin, 2002; Spottiswoode and May, 2003).

The first studies we are aware of to examine changes in brain activity that preceded an unknown stimulus were conducted by Levin and Kennedy (1975). They observed a significantly larger contingent negative variation (CNV) which is a slow brain wave potential associated with anticipation, expectancy, or cortical priming just before subjects were presented a target stimulus. Warren et al. later found significant differences in event-related potentials (ERP) between target and non-target stimuli presented during forced-choice precognition tasks (Warren et al., 1992; Warren et al., 1992). Don et al. extended these ERP findings in a series of gambling studies in which they found enhanced negativity in the ERP's was widely distributed across the scalp in response to future targets (Don et al., 1998; McDonough et al., 2002). The authors concluded from these studies that the ERP effect was an indicator of "unconscious precognition," since the study participants' overt guessing accuracy did not differ from chance expectations.

More recently, a number of researchers have explored physiological predictors of future events by investigating whether the human autonomic nervous system could unconsciously respond to randomly selected future emotional stimuli. Radin (1997, 2004) 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. Comparison of SCL response between emotional and calm trials showed a significantly greater change in electrodermal activity around 5 seconds before a future emotional picture than before a future calm picture. These results have since been replicated (Bem, 2003; Bierman, 2000; Bierman & Radin, 1997; Bierman & Scholte, 2002; Radin, 2004), 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 (Bierman & Scholte, 2002). Finally, a recent study, conducted by McCraty, Atkinson, and Bradley (2004a & 2004b), augmented Radin's protocol by adding measures of brain response (EEG) and heart rhythm activity (ECG) and found that not only did both the brain and heart receive the pre-stimulus information some 4-5seconds before a future emotional picture was randomly selected by the computer, but that the heart appeared to receive this information even before the brain. The consistent finding across these studies is that the *body typically responds to a future emotionally arousing stimulus four to seven seconds prior to experiencing the stimulus.*

In short, the important conclusion from these studies, for our purpose here, is that intuitive perception of a future event is related to the degree of emotional significance of that event. Moreover, that 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 and brain and possibly other organs in the body are all involved together in responding to intuitive information.

**Hypothesis for Research on Entrepreneurial Intuition**

Drawing on this research and on the principles of quantum holography (Gabor, 1946; Pribram, 1991), Bradley (2006) has developed a theory of entrepreneurial intuition which offers an understanding of the psychophysiological basis of entrepreneurial intuition. He views the perception of things remote in space or ahead in time—nonlocal communication—as involving processes of energetic resonance connecting the body's psychophysiological systems to the quantum level. The theory explains how focused emotional attention directed to the nonlocal object of interest attunes the bio-emotional energy generated by the body's psychophysiological systems to a domain of quantum-holographical information, which contains implicit, energetically encoded information about the object. The body's perception of such implicit information about things distant in space/time is experienced as an intuition:

The entrepreneur's passionate attention—that is, the biological energy activated in his emotional connection to the object of interest (e.g., the quest for future opportunities in a certain field of business)—attunes him to the object's unfolding pattern of activity and to the implicit order of its future potential. Both the pattern of activity and the potential future order are spectrally encoded as a quantum hologram in a field of potential energy as implicit information in a domain apart from space and time. At a biological level, the body's psychophysiological systems generate numerous fields of energy, at various frequencies, that interpenetrate the field of potential energy. Of these, the heart

generates the most powerful rhythmic electromagnetic field, which radiates out from the body in all directions.

When the entrepreneur calms his mind and feelings, and adopts a heart-focused state of positive emotion directed to the object, a global shift to psychophysiological coherence is induced which optimizes attentional resonance with the incoming quantum level information from the object of interest. Such attunement brings the outgoing wave field of attentional energy from the entrepreneur's psychophysiological systems into harmonic resonance with the incoming wave field of energy from the object. The harmonic resonance between the two wave fields of energy creates an optimal channel for communication of nonlocal information (Bradley, 2006: 15).

This theory leads to the following hypothesis:

> The more the entrepreneur maintains coherent attentional interest directed to the object of interest, the greater the psychophysiological systems' access to an implicit field of quantum-holographic information and the greater the intuitive foreknowledge about the object of interest (Bradley, 2006: 15).

## RESEARCH DESIGN AND METHOD

We adopted Radin's (1997) basic experimental protocol. In addition to skin conductance level (SCL) the electrocardiogram (ECG) for heart rate variability (beat-to-beat decelerations/accelerations) measurement was included. 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).

The term *physiological coherence* is used 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., 2004). 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 oscillatory systems. The coherent mode is reflected by a smooth, sine wave-like pattern in the heart rhythms (figure 4) 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 1997). McCraty, (2002) and McCraty and Atkinson, (2003) have previously found that increased heart rhythm coherence correlates with significant improvements in performance on tasks requiring attentional focus and subtle discrimination which may be important elements of the intuitive effect studied here.

### Participants

Repeat entrepreneurs were chosen for this research because they are most likely to have demonstrated that their success is not due to luck alone, they have beaten the odds against success (Fiet, Van et al. 2004). Uncovering opportunities for a new venture is a pre-occupation for them. Shapero (1975) argues that we all have "antennae" and that repeat entrepreneurs have theirs tuned to certain frequencies – *opportunity recognition frequencies.*

In this research repeat entrepreneurs are classified as those entrepreneurs that have/had two or more successful ventures. For the purpose of maintaining some consistency in the selection of respondents for this research only owners of firms with less than 199 employees were chosen. We used the criteria set down by the Australian Bureau of Statistics (A.B.S. 1998) definition of a Small to Medium Enterprise, (SME).

In the last 20 years the Cambridge (UK) Technopole has become a beacon for regional development incorporating a strong University presence, high technology repeat entrepreneurs, cluster developments and associated access to capital (Segal, Quince and Wicksteed, 1985; Herriot, 2003; Myint, Vyakarnam and New, 2004; Library House, 2004)). According to Walter Herriot (2003) at St John's Innovation Centre, "twenty years ago Cambridge was a market town with a world class university, a population of 100,000 and a business infrastructure that was immature". Herriot claims there were only 25 knowledge-based (high tech) businesses in the City employing about 2000 people and no "independent" stock market listed companies. Of particular interest to this research is the role and

contribution of entrepreneurial leaders to the continuing growth of the Technopole and what drives their propensity for using spiritual intelligence and intuition in strategic innovation. Herriot (2003) reports the Greater Cambridge Partnership can identify some 3500 high tech. businesses in the Cambridge area, employing 50,000 staff and making a contribution of £7.6 billion to the UK economy.

"The majority of high technology companies that have shaped the success of the Cambridge cluster are connected to a handful of repeat entrepreneurs, business angels and venture capitalists as their involvement in developing new ventures have been repeatedly evidenced on the charts" (Myint, Vyakarnam & New 2004).

Based on the Myint et al (2004) data, seventeen successful serial entrepreneurs in the Cambridge Technopole (UK) were asked to participate in the study. Each participant had demonstrated a capacity for intuition with the self generation of a genuine response to opportunity recognition.); however, due to unanticipated technical difficulties with the electrophysiological instrumentation usable data were available for ten participants.

**Testing Procedure**

A number of Researchers have explored physiologic predictors of future events by investigating whether the human autonomic nervous systems can unconsciously respond to randomly selected future emotional stimuli. Using rigorous experimental protocols it was found that the body responds to a future emotionally arousing stimulus 4 – 7 seconds prior to experiencing the stimulus (Bierman, 2000; Radin, 1997b; 2003 Spottiswoode and May 2003) in (McCraty, Atkinson et al. 2004). McCraty, Atkinson, and Bradley (2004a & 2004b) have also found compelling evidence that the bodies psychophysiological systems receive and process information about a future event before the event actually happens.

Ten participants took part in this pilot experiment. Each participant had demonstrated a capacity for intuition with the self generation of a genuine response to opportunity recognition. In the experimental sessions for the pilot study, each participant was seated in a comfortable chair. A video monitor was located approximately one meter in front of the participant at eye level, and a computer mouse was attached for the participant to click when ready to initiate each trial.

The following hardware was used in the experimental protocol. The inter-beat Heart Rate & DC skin conductance module (data logger) was designed and constructed by David Simpson from the Brain Sciences Institute. The Random Number Generator is an Araneus Alea 1, which provides high quality, unbiased and uncorrelated random numbers that pass a number of stringent statistical tests including the Diehard and NIST test.

All recordings were performed using 3M brand Red Dot® EKG Littman electrodes. DC Skin Conductance (SC) was detected using electrodes attached to the pads of the participant's index and second fingers of the non-dominant hand. SC measurements were performed using current limited 0.5Volts DC excitation.

The ECG was detected using a standard lead-one configuration. A band-limited differential amplifier detected the QRS waveform of the ECG. All between-beats-heart-rate (BBHR) measurements were timed using a micro-processor based system. The resultant SC and BBHR measurements were passed to a monitoring computer system via a 6kV isolated RS232 interface (to AS3551:2004).

Participants were told that they were participating in a trial to test their capacity for making reliable investment decisions with minimal data and analysis. The protocol involves a two step process; a roulette protocol—the Roulette experiment—followed by an investment decision in a potential growth company—the Business Case experiment.

*The Roulette Experiment.* Using the principle of a roulette wheel, this test is based on choosing an investment amount (bet) and then making a choice of red or black and comparing the result with that generated in the future by a random generated choice. The participants have the option of choosing from four investment amounts, ranging from 5-10 cents. Once they select the button of their choice the test begins. The sound of a roulette wheel is triggered after six seconds. The result of each run is tallied on the bottom left-hand side of the screen so that the participant knows whether he/she is winning or losing and by how much. After a cool down period a message appears to repress the button. This experiment was replayed 25 times before the participant moves to the next stage, the company investment experiment.

*The Business Case Experiment.* The second half of the protocol involves the participants making a choice on an investment decision in a potential growth company. Sixty actual firms were chosen for this part of the experiment and entered and saved on the computer as a database. Twenty-six of the firms had failed and thirty-four of the firms were successful at the time of selecting the cases. Firms were chosen from a range of industries, countries and levels of failures and successes. Where at all possible mixtures of both successful and failed firms for the same industry were included so that the participant could not presume that a firm in a particular industry is more likely than not to fail or succeed.

The participant is presented with a company profile of very limited information—enough to interest the serial entrepreneur but not enough information to identify the company cognitively. Under conditions of uncertainly, such as limited information, Allison et al. (2000) found intuitive decisions were more likely to occur.

The limited information presented was:

Type of industry

Private or public ownership

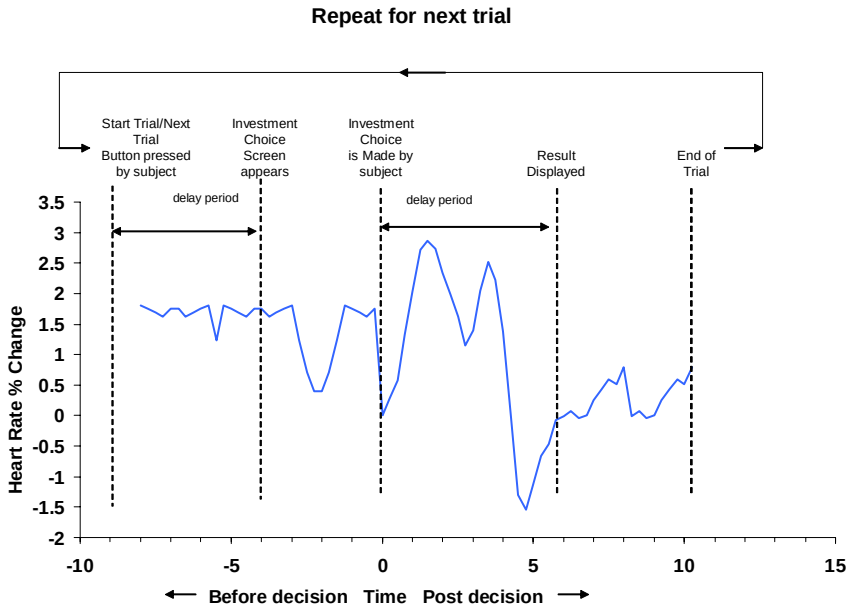
Management team (professional management team or entrepreneur)

Current Funding

The participant has an investment bank of $100,000, they may choose either to invest or not-invest a proportion of the total bank. After the participant has made his/her choice according to the investment options available, the randomly selected company appears after a 6-sec delay whereby the computer confirms the company as a success or failure and tallies the results of the investment.

The protocol (Figure 1) seeks an investment decision from the entrepreneur following the presentation of a randomly generated potential high growth company (Gillin, Lapira & Scicluna 2006, Gillin and Atkinson 2006). The subsequent 'Next' button is selected from the 'Result Displayed' point. There is then a delay before the 'Investment Choice Screen' appears.

**Figure 1. Format of Test Protocol (Business Case Experiment)**




## Data and Statistical Analysis

*Skin conductance measures*

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 X 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*

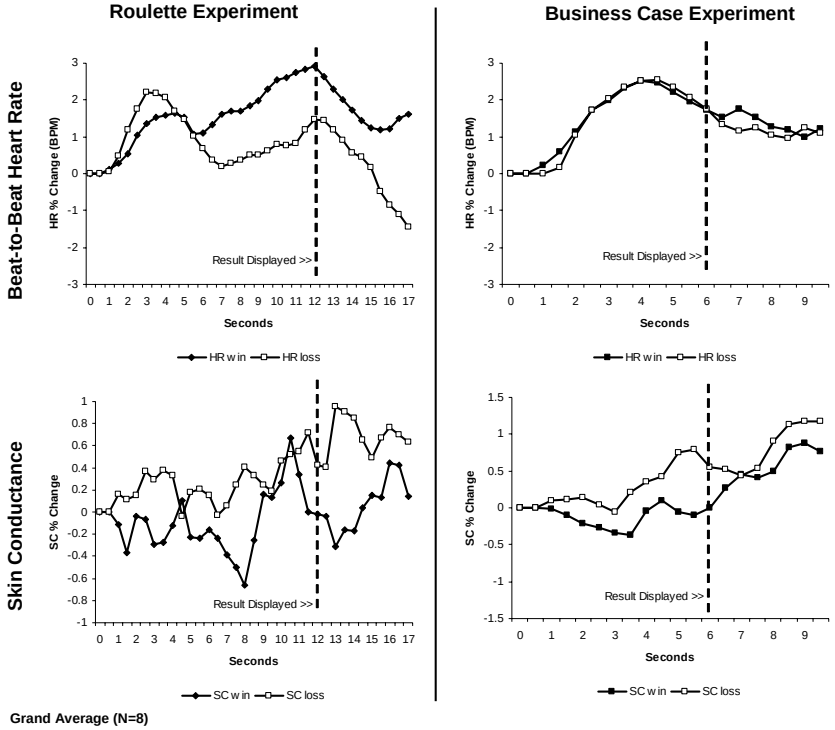
ECG data used for heart rate variability (HRV) analysis were all normal sinus intervals. All aberrant beats and artifacts were removed from the records: a computer algorithm eliminated intervals that varied by more than 30% of the mean of the previous four intervals, and any remaining artifacts were 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, following McCraty et al. (2004a & 2004b). Therefore, because it controls for autocorrelations inherent to physiological signals and their underlying non-normal distributions (Blair and Karniski, 1993), randomized permutation analysis (RPA) was used to determine statistical significance of the differences between win and loss curves during the prestimulus period. Applied separately to each individual's SCL and HRV data, RPA generates one standard deviate, or *z* score, per person, which is the post-choice pre-result differential value—i.e., the win/loss difference (Good, 1994; Hjorth, 1994; Radin, 1997b). For the RPA, we calculated a random distribution that was built up over 2,000 permutations.

## RESULTS

Figure 2 presents the grand average of the physiological recordings for all 8 participants during the post-investment period. The two graphs in the top half of the figure show the mean pattern of the recordings for beat-to-beat heart rate for the Roulette Experiment and the Business Case Experiment. There is evidence of separation between wins and losses in the mean heart rate pattern for the Roulette Experiment that begins at about *6 seconds prior* to the outcome result being displayed. But the mean heart rate curves for wins and losses in the Business Case Experiment show little evidence of separation and are virtually the same.

**Figure 2. Grand Average (All Subjects) of Physiological Recordings During Post-Intervention Choice Period**



The two graphs in the bottom half of Figure 2 show the mean pattern of skin conductance recordings for each experiment. Across all subjects the mean skin conductance pattern in the Roulette Experiment is somewhat greater for losses than that for wins, prior to the event occurring—especially around *6 to 7 seconds before* the outcome result is displayed. For the Business Experiment, a small separation between wins and losses is apparent in the pattern of skin conductance change during the post-investment period.

The results of the performance analysis across all 25 trials for the 8 useable cases are shown in Table 1. We used the Chi-squared significance test to identity a win/loss ratio beyond the threshold of chance. The data in the table show the degree to which each subject's intuitive Roulette bet and Business Case investment decision was successful once the decision outcome was known. The maximum observed win/loss ratio was 60% in the Roulette Experiment (Subjects 5, 18, 21), and minimum win/loss ratio was 36% (Subject 17). For the Business Investment Experiment the maximum win/loss ration was 68% (Subjects 17 and 19) and the minimum was 40% (Subject 20). While no participant's win/loss ratio exceeded the odds against chance in Roulette Experiment, in the business experiment 2 subjects (S17 and S19) had a win to loss ratio that approached significance ($p = 0.072$ for both subjects).

Table 1. Performance Analysis (Chi-Square) of Wins and Losses by Subject

| | Roulette Experiment | | | | | Businesses Experiment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sub# | Win | Lose | Win ratio | $\chi^2$ | $p$ = | Win | Lose | Win ratio | $\chi^2$ | $p$ = |
| S3 | 13 | 12 | 52% | 0.04 | 0.841 | 13 | 12 | 52% | 0.04 | 0.841 |
| S5 | 15 | 10 | 60% | 1 | 0.317 | NA | NA | NA | NA | NA |
| S16 | 12 | 13 | 48% | 0.04 | 0.841 | 14 | 11 | 56% | 0.36 | 0.549 |
| S17 | 9 | 16 | 36% | 1.96 | 0.162 | 17 | 8 | 68% | 3.24 | 0.072* |
| S18 | 15 | 10 | 60% | 1 | 0.317 | 15 | 10 | 60% | 1 | 0.317 |
| S19 | 12 | 13 | 48% | 0.04 | 0.841 | 17 | 8 | 68% | 3.24 | 0.072* |
| S20 | 14 | 11 | 56% | 0.36 | 0.549 | 10 | 15 | 40% | 1 | 0.317 |
| S21 | 15 | 10 | 60% | 1 | 0.317 | 12 | 13 | 48% | 0.04 | 0.841 |

Chi-Square

**Random Permutation Analysis**

The results of a random permutation analysis (RPA) across all 8 subjects (not shown) produced no significant findings for this sample of entrepreneurs as a group. This is not surprising given the high degree of individual variation in the physiological measures and the small sample size.

However, the results of the RPA by individual (Table 2) are more promising, and indicate that the experimental procedure using the physiological instrumentation has identified five instances involving four entrepreneurs (Subjects 17, 18, 19 and 20) in which the physiological measures of individual entrepreneur had significant or marginally significant predictive power in discriminating future outcomes. In short, there is clear evidence that the physiological measures were able to detect intuitive perception of a future outcome in four of the eight entrepreneurs.

For example, Subject 18 on both Roulette and Business Case experiments had 60% win/loss ratio. As can be seen in the recordings of the physiological measures for this individual (Figure 3 ), there was clear separation of the wave forms for the skin conductance data during the post-choice pre-result period in both the Roulette experiment and the Business Case experiment. It is worth noting that for the Business Case experiment the separation of the skin conductance waveforms was marginally significant ($z = -1.46$, $p = 0.073$). Given the extremely rigorous statistical requirements of the RPA method, these results are very promising. For this subject, the HRV results ($z = -0.27$, $p = 0.395$) did not show discriminatory ability to predict future win/loss outcome.

An even more intriguing situation is evident for Subject 17 (Figure 4). The results of RPA indicate that the HRV waveforms significantly predicted the future win/loss outcome during the Roulette Experiment ($z = 2.06$, $p = 0.02$), but the skin conductance measure did not ($z = 1.08$, $p = 0.141$). However, this entrepreneur's *cognitive* win/loss ratio was 36%, nearly significant, but in the wrong direction. For the Business Case Experiment the results were reversed: the win/loss ratio 60% and in the right direction, and this entrepreneur's skin conductance significantly predicted the future outcome ($z = -2.08$, $p = 0.019$), while the HRV did not ($z = -0.34$, $p = 0.367$). This was the only instance in which an entrepreneur's cognitive awareness of the future outcome matched his/her autonomic system's prediction of the future outcome.

The results for Subjects 19 and 20 (physiological recordings not shown) are interesting from another perspective. The performance analysis results (Table 1) show that while Subject 19's cognitive win/loss ratio was at chance level (48%) in the Roulette experiment, it was 68%—marginally significant ($Chi^2 = 3.24$, $p = 0.072$)—in the Business Case experiment.

Interestingly, the physiological processes of this entrepreneur's ANS was predicting the opposite outcome to that reflected in this subject's cognitive choice, in that his/her skin conductance was marginally significant ($z = -1.39$, $p = 0.082$) in the Roulette experiment, but not on the Business Case experiment ($z = 0.77$, $p = 0.221$). On neither experiment did the HRV results for this subject show any discriminatory ability to predict future win/loss outcome ($z = 0.35$, $p = 0.362$, and $z = -0.52$, $p = 0.302$, respectively).

Table 2. Results of Random Permutation Analysis of Physiological Measures by Subject for Roulette and Business Case Experiments

**Roulette experiment**

| | Beat-to-Beat Heart Rate | | | | Skin Conductance | | | |
|---|---|---|---|---|---|---|---|---|
| | Observed | z | $p =$ | | Observed | z | $p \sim^{\alpha}$ | |
| S3 | -30.49 | -0.68 | 0.247 | | -5.56 | -0.14 | 0.446 | |
| S5 | 16.75 | 0.96 | 0.170 | | NA | NA | NA | |
| S16 | 0.38 | -0.09 | 0.466 | | 5.73 | 0.40 | 0.346 | |
| S17 | 73.35 | 2.06 | 0.020 | * | 15.59 | 1.08 | 0.141 | |
| S18 | 8.30 | 0.30 | 0.381 | | -9.81 | -0.25 | 0.400 | |
| S19 | 8.41 | 0.35 | 0.362 | | -71.52 | -1.39 | 0.082 | † |
| S20 | NA | NA | NA | | 16.17 | 0.66 | 0.256 | |
| S21 | 19.73 | 1.08 | 0.141 | | NA | NA | NA | |

$\alpha$ Based on 2000 random permutations.

**Business case experiment**

| | Beat-to-Beat Heart Rate | | | Skin Conductance | | | |
|---|---|---|---|---|---|---|---|
| | Observed | z | $p =$ | Observed | z | $p \sim^{\alpha}$ | |
| S3 | -16.84 | -1.15 | 0.125 | -2.42 | -0.40 | 0.345 | |
| S5 | NA | NA | NA | NA | NA | NA | |
| S16 | 16.19 | 0.96 | 0.169 | 0.33 | 0.14 | 0.445 | |
| S17 | -1.77 | -0.34 | 0.367 | -12.69 | -2.08 | 0.019 | * |
| S18 | -4.85 | -0.27 | 0.395 | -13.53 | -1.46 | 0.073 | † |
| S19 | -6.22 | -0.52 | 0.302 | 17.48 | 0.77 | 0.221 | |
| S20 | NA | NA | NA | -17.51 | -2.06 | 0.020 | * |
| S21 | 7.56 | 1.16 | 0.123 | NA | NA | NA | |

$\alpha$ Based on 2000 random permutations.

* $p < 0.05$

† $p < 0.1$

In contrast, Subject 20's cognitive win/loss ratio was 56%, and in the right direction in the Roulette experiment, and at 40%, but in the wrong direction in the Business Case experiment; neither was significant. While the skin conductance result for the Roulette experiment ($z = 0.66$, $p = 0.256$, n.s.) did not show discriminatory ability to predict future win/loss outcome, there was a significant result for the Business Case experiment ($z = -2.06$, $p = 0.020$). What is interesting about the latter is that this suggests this subject's physiology was correctly predicting the future outcome, even though his/her cognitive choice was in the wrong direction. Unfortunately, the HRV data for this subject were not available as this was one of a number of cases for whom technical difficulties occurred in the electrophysiological recordings in a non-laboratory field setting which prevented the collection of usable HRV recordings.

The last example we want to discuss illustrates a participant (Subject 16, see Figure 5) whose cognitive win/loss ratio on the Roulette Experiment was close to chance (48%), and their physiological responses showed little predictive power. In the Business Case Experiment their win/loss ratio was slightly improved at 56%, and their HRV waveforms, which show clear separation, did not exceed the threshold of chance ($z = 0.96$, $p = 0.169$).

## DISCUSSION

This pilot study's purpose was to test efficacy of new experimental protocol for measuring physiological responses that are predictive of future outcomes in both a gambling and business case paradigm. Once the scientific integrity of the protocol and data collection procedures have been validated, we also hope to independently replicate previous experiments which demonstrated that

physiological measures accurately predict future events prior to the occurrence of the events. We also hope to broaden the application of such measures to research on decision making within the business and entrepreneurial community

**Figure 3. Physiological Measures Subject 18**

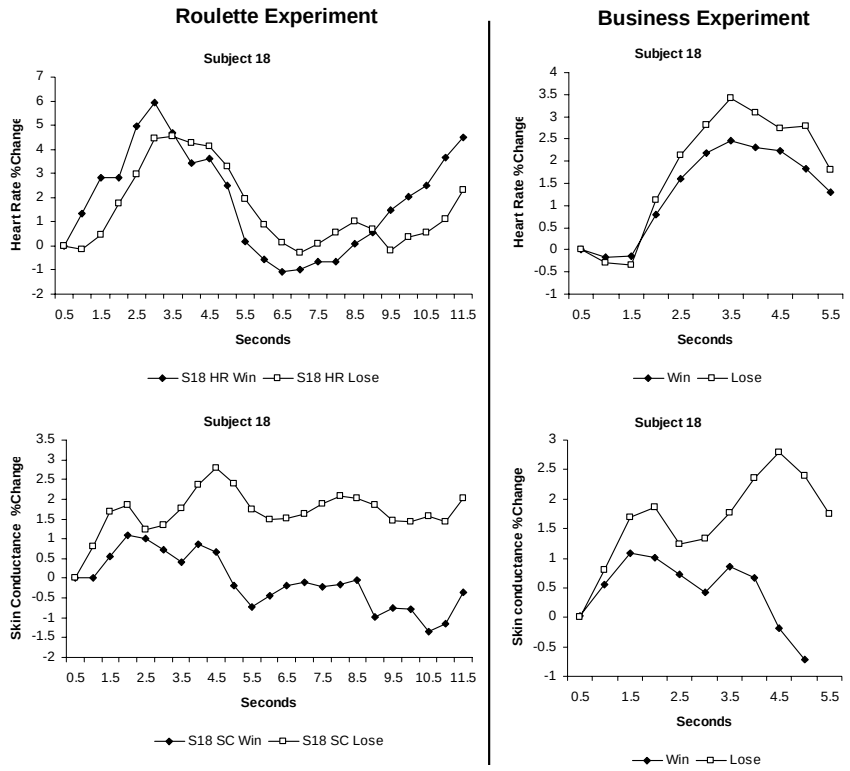



**Figure 4. Physiological Measures Subject 17**

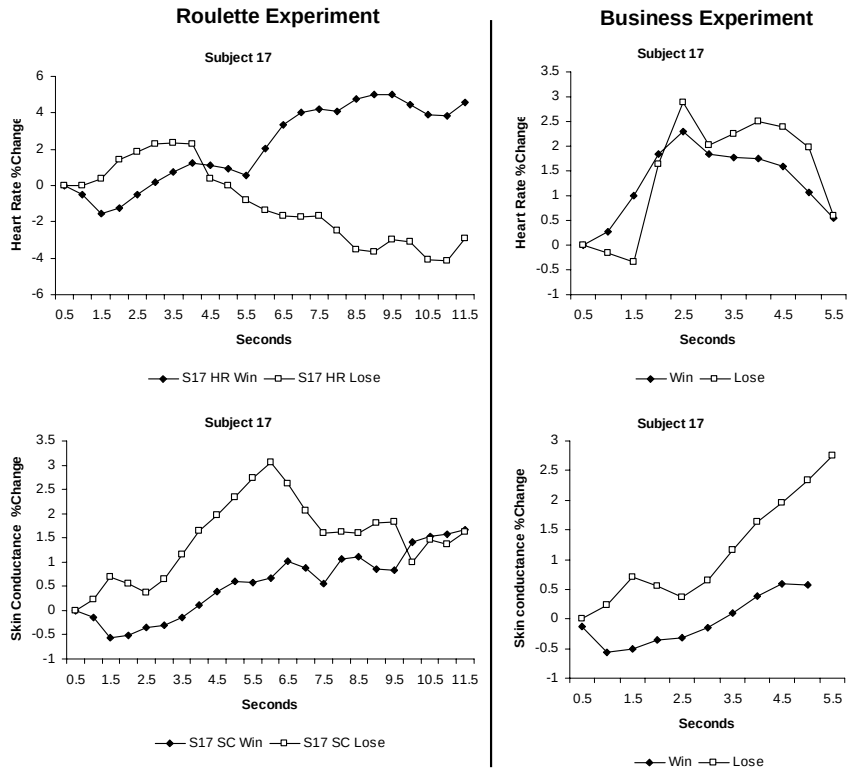
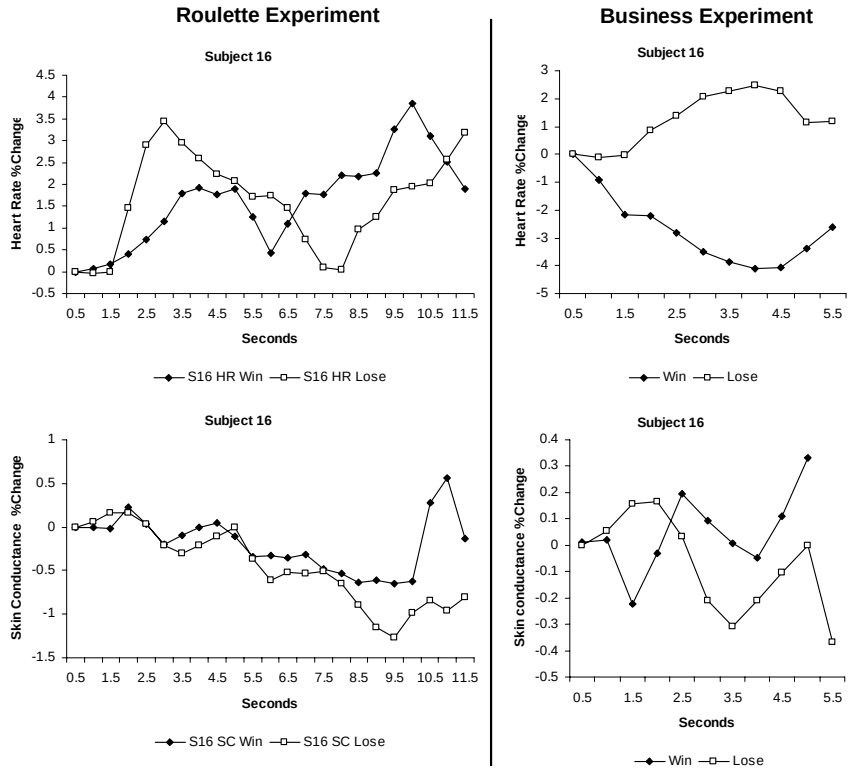


**Figure 5. Physiological Measures Subject 16**




Our working premise is that no matter how intuitive information is initially introduced into the psychophysiological 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 amongst entrepreneurs, 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).

The results of the pilot test are promising, in that the physiological measures averaged across all subjects show that informational input was received by the autonomic system some *6 to 7 seconds before* the outcome of the investment choice was known. This is consistent with previous findings from a rigorous experiment, involving a much larger sample in a controlled laboratory setting, where it was found that the heart receives pre-stimulus information approximately 6 seconds prior to a future event (McCraty et al., 2004a & 2004b). Results from the random permutation analysis of individual recordings found five instances in which the physiological measures of individual entrepreneur had significant or marginally significant predictive power in discriminating future win/loss outcomes. Overall, there is clear evidence that the physiological measures were able to detect intuitive perception of a future outcome in four of the eight entrepreneurs.

An important observation from the data collected in this pilot study was that there does not appear to be any correlation between an entrepreneur's cognitive decision (win/loss ratio) and the physiological predictors of the future event, namely, the post-choice pre-result outcome. This is that is consistent with previous studies. From our perspective this is likely due to a combination of factors, such as an individual's cognitive bias to distrust feelings in decision making as well as the lack of attention paid to sensory input from emotions when making decisions. Relative to this last point, it is well established that we only perceive what we attend to, an effect called inattentional blindness. Thus, if we do not attend to the signals from the body they will not be perceived and have little change of being integrated into cognitive level decisions. This issue will be one of the topics studied in future research in which we plan to investigate whether the win/loss ratio can be improved by training participants to

become more aware of the sensory input from their feelings and emotions.

A study, currently underway at the Institute of HeartMath, is examining the session to session variability in both the cognitive and physiological measures of intuitive perception and the degree of relationship between the two. It is important to establish the session to session variability in order to rigorously determine if interventions or other factors can such as baseline affective state, environmental factors, socio-emotional fields, etc, affect intuitive ability. One of the factors we hypothesize will to have a significant impact on one's ability to access intuitive information is the overall social and emotional coherence of the relations in the individual's social group. Regular interaction within a coherent group, should amplify the harmonic resonance of the group's energetic field with the energetic field of an object of attentional interest, which, in turn, will increase the individual's access to the field of intuitive information. This should produce stronger intuitive ability than when the individual is operating in isolation.

**Limitations**

There were several limitations in this pilot study. First, problems were encountered in the data acquisition of the physiological measures. The equipment used to collect the data did not allow for the raw data to be monitored in real time as it was being recorded. This led to excessive amounts of missing data due to either improper electrode connections or artifacts. Secondly, this is the first time the business case protocol was tested. We will need to collect data from a larger sample individuals in order to assess the robustness of the protocol and determine if will need to be modified to insure we are assessing the physiological aspect of intuition. An important issue that may affect the results is the observation that many of the participants relied heavily on a cognitive assessment of the business cases and often had a preexisting opinion on the given case presented that seemed to influence their decision to invest or not. In some cases, the participants appeared to over analyze the case which may also have masked the physiological processes we were endeavoring to measure in order to predict the outcome of the future event.

## CONCLUSION

The results of the pilot test are promising, in that there is clear evidence that informational input was received by the ANS some *6 to 7 seconds before* the outcome of the investment choice was known, and also that the physiological measures were able to detect intuitive perception of a future outcome in four of the eight entrepreneurs. These findings are, in broad terms, consistent with a previous study which found that heart rate decelerations/accelerations and changes in skin conductance were able to significantly predict emotionally arousing future events (McCraty et al. 2004a & 2004b). This pilot study is the first effort that we know of to apply physiological measures to assess intuition in entrepreneurs. The results from this study constitute the first evidence that physiological measures are predictive of future outcomes in both business decision making processes and also a forced-choice decision experiment.

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