DOES AUTONOMIC NERVOUS SYSTEM ACTIVITY CORRELATE WITH EVENTS CONVENTIONALLY CONSIDERED AS UNPERCEIVABLE? USING A GUESSING TASK WITH PHYSIOLOGICAL MEASUREMENT

By Tim Schönwetter, Wolfgang Ambach, and Dieter Vaitl

ABSTRACT: Prior studies seem to provide evidence for an anomalous increase in heart rate during the presentation of objects that were later randomly chosen and presented as target objects in a forced-choice guessing task. We investigated 48 participant pairs in a modified paradigm: We implemented a spatially separated partner who handled the particular target object during each of 14 blocks of the task while trying to influence the participant under physiological investigation, by mental means alone. Response differences between targets and nontargets were evaluated by measuring heart rate changes, electrodermal response amplitudes, respiratory changes, and pulse activity. Paranormal belief and partner connectedness were investigated as possible moderator variables for physiological response differences and hit rate. The analyses did not show evidence of anomalous physiological response differences between targets and nontargets (effect sizes < .2, *p* values > .1) or any influences of moderator variables. Methodological analyses provided evidence for a serial position effect in prior studies; this observation might point toward a particular significance of the last object presentation preceding the prompt to guess. In order to prevent this confound and to avoid biased estimation of the alpha level, future studies should balance stimulus positions.

Keywords: forced-choice guessing task, autonomic nervous system, physiological measurement, participant pairs, connectedness of participants, paranormal belief

There are several reports on the anomalous effects of events conventionally considered as not perceivable on affect, cognition, and behavior. This means that these events occur in an unforeseeable manner in the future and/or spatially separated from the person. The use of psychophysiological methods to examine correlations between the unforeseeable future or spatially separated events and the autonomic nervous system activity of the participants began in the 1950s (for reviews, see Beloff, 1974; Palmer, 1978, 1982). In this vein, Sartori, Massaccesi, Matinelly, and Tressoldi (2004) and Tressoldi, Martinelli, Massaccesi, and Sartori (2005) used a forced-choice guessing task (FCGT) with physiological measurement. In each block, four pictures of objects were presented sequentially on a screen, each for a period of 10 s. After that, participants conducted a precognition task: They were asked to guess which one of the four objects would be randomly chosen by the computer as a target. Then, one object was chosen randomly and presented. It was hypothesized that the future event of presenting one object as the target at the end of each block would affect the heart rate in response to this object during the previous sequential presentation despite the fact that the selection of the target object is conventionally considered to be unpredictable. The results of these studies revealed that a significantly increased heart rate was associated with the presentation of objects later shown as targets compared with the presentation of nontargets. Lobach and Bierman (2010) confirmed this result. In their study, a significantly higher heart rate was observed during the 3 s of object presentation due to a continuous decrease of the interbeat intervals throughout the 3 s. All these studies showed a hit rate of target objects at chance expectation.

In psychophysiological research, physiological responses to the stimuli presented are explained by the concept of the orienting response. This is a response of an organism to all perceivable changes in the environment, and was first characterized by Pavlov in 1927 (Sokolov, 1963). The most important determinants of the orienting response are the novelty, significance, and intensity of a stimulus (e.g., Lynn, 1966). Stimuli that differ with respect to one or more of these determinants can be distinguished by means of the physiological responses they evoke during their sequential presentation (e.g., Barry, 1990; Ben-Shakhar, 1994; Turpin, 1999). This psychophysiological mechanism is used in the Guilty Knowledge Test (Lykken, 1959) for the detection of concealed information. In a common variant of the test, participants are confronted with objects belonging to different categories in a mock crime, with the aim to have these objects gain particular significance for the participants. In the subsequent test phase, pictures of these objects are presented sequentially in combination with pictures of unknown objects from the same categories. It is assumed that similar objects of one category evoke comparable physiological responses and that differences in the responses to the objects are mainly attributable to the particular significance the objects gained during the previous confrontation. By using such a categorical design, the statistical power of the test is enhanced. Each object presentation is combined with the question whether the object has been part of the mock task. The significance of the particular object, together with the instruction to deny one's knowledge, are known to evoke different electrodermal response amplitudes, heart rate changes, respiratory activity (assessed via the respiration line length), and pulse activity (assessed via the finger-pulse waveform length) than to objects that do not have a specific significance (Gamer, 2011). With respect to electrodermal activity, an increase in response amplitudes is directly associated with the modulation of the orienting response as a result of the significance of stimuli (Barry, 2004). However, with respect to heart rate, it remains to be debated which changes are directly related to the significance of stimuli (e.g., Barry & Maltzman, 1985; Graham & Clifton, 1966). Respiration line length and finger pulse waveform length are specific to the Guilty Knowledge Test; therefore, the relation of these measures to the significance of stimuli or to processes of concealing information is unclear. The Guilty Knowledge Test procedure usually provides results of high validity, with effect sizes above 2 (reviewed in Ben-Shakhar & Elaad, 2003).

In a pilot study, we investigated whether the differences in the physiological response to target and nontarget objects are due to the particular significance of the target objects. We therefore combined the methodological aspects of the Guilty Knowledge Test and the FCGT (Schönwetter & Ambach, 2010). Similar to recent Guilty Knowledge Test studies (e.g., Ambach, Stark, Peper, & Vaitl, 2008), we implemented a categorical design: within each block, similar objects belonging to a particular object category (e.g., household articles) were presented. Moreover, we investigated phasic electrodermal activity, respiratory activity, and pulse activity in addition to heart rate. The result of the studies of Sartori et al. (2004) and Tressoldi et al. (2005), which showed an increase in heart rate during the 10 s of target presentation in comparison to the presentation of nontarget objects, was not confirmed. Moreover, measurement of additional physiological parameters did not reveal differences between the response to targets and nontargets, indicating that the target object had no particular significance for the participants. However, visual inspection of the second-per-second values of heart rate revealed a stronger increase during 5 s after the presentation onset of the stimulus for targets compared to nontargets. This explorative observation and the one reported by Lobach and Bierman (2010) indicate that possible heart rate response differences to targets and nontargets could be due to a stronger initial increase in heart rate immediately after the onset of target objects.

Psychophysiological literature indicates that physiological responses to stimuli are also determined by the position of a stimulus within a sequential presentation. For example, the effects of habituation result in a decrease of the orienting response with the continuous presentation of similar stimuli (e.g., Barry, Feldmann, Gordon, Cocker & Rennie, 1993). Furthermore, studies investigating the psychophysiology of gambling have shown evidence of an increase in heart rate several seconds before a decision is made in a gambling task (e.g., Coventry & Norman, 1997), especially if a monetary gain is expected (Ladouceur, Sévigny, Blaszczynski, O'Connor, & Lavoie, 2003). These results suggest that the physiological responses to different object positions in the FCGT may also be determined by serial position effects. Because serial position effects were not taken into account in the procedure of previous FCGT studies, physiological responses to objects might have been confounded with physiological response differences due to object positions.

In addition to the correlations between future events and physiological activity addressed in the FCGT, another line of investigation examined correlations between the physiological activity of participants and spatially separated events involving an emotionally related partner (e.g., Schmidt, Schneider, Utts, & Walach, 2004). In a previous study, we used a modified Guilty Knowledge Test to investigate anomalous interactions between spatially separated partners (Schönwetter, Ambach, & Vaitl, 2011). At first, one partner of an emotionally related pair handled objects during a task. These objects thus gained particular significance for him/her. Assessment of the physiological responses of the spatially separated participant to objects with and without significance for the partner revealed no differences in the responses to these objects. We suggested that in future studies the partner event should be synchronized with the physiological assessment of the participant. Further, we stated that physiological responses to stimuli may be confounded with physiological responses occurring as a consequence of the answering behavior during the presentation of each object. The FCGT paradigm seems to be well suited for the implementation of a synchronous partner event. As in the Guilty Knowledge Test, objects are presented sequentially, but because answers are given only during the simultaneous presentation of all pictures at the end of each block, the single-object presentations are not followed by behavioral responses. Thus, the confounding effect on physiological responses with answering behavior is avoided. Additionally, the combination of two events might be advantageous for the detection of anomalous effects. If a partner event and a future event assign particular significance to target objects in the FCGT, physiological response differences between targets and nontargets should occur in correlation with at least one event with physiological activity. Moreover, studies using the Guilty Knowledge Test have shown that the increased significance of an object for a participant is associated with greater differences in the physiological responses to objects with and without significance (Ambach, Dummel, Lüer, & Vaitl, 2011; Jokinen, Santtila, Ravaja, & Puttonen, 2006). If both events correlate with physiological responses in the FCGT, effect sizes are possibly increased due to the enhanced significance of the target objects.

This approach was implemented in a study by Moulton and Kosslyn (2008). In addition to the presentation of a target object at the end of each block of the FCGT, the particular target object was presented to a spatially separated partner of the investigated participant during the sequential presentation of the objects. The emotionally related partner was instructed to influence the participant's guess by mental means alone. The authors used functional magnetic resonance imaging (fMRI) to assess central nervous system response differences between targets and nontargets; the analyses did not yield significant results. The authors concluded that they had provided "the strongest evidence yet" against the existence of paranormal phenomena, which was criticized by Palmer (2009). Further criticism may refer to the lack of investigation of the effect of moderator variables. Several studies seem to provide evidence for an enhanced performance of participant pairs with a strong emotional connection between partners in parapsychological studies; however, the influence of this moderator variable remains controversial (e.g., Alexander & Broughton, 1999; Delanoy, Morris, Brady, & Roe, 1999; Schmidt, Tippenhauer, & Walach, 2001). Another possible moderator variable that may influence the performance of participants in parapsychological experiments is the degree of participants' paranormal belief (Schmeidler, 1945; for a meta-analysis see Lawrence, 1993).

Aims of the Study

In the present study, we modified the FCGT and included methodological aspects of the Guilty Knowledge Test. We implemented a categorical design and included physiological measures commonly investigated in the Guilty Knowledge Test. Furthermore, we balanced target positions across participants to prevent confounding the effect on physiological responses with a possible serial position effect. Moreover, we included a synchronous partner event in the FCGT, thus using a modification of the partner event of our previous partner study (Schönwetter et al., 2011). By including these methodological aspects, we aimed at investigating whether possible response differences to target and nontarget objects in the FCGT may be due to the particular significance of targets. The following hypotheses were tested:

Physiological responses. Based on our pilot study (Ambach & Schönwetter, 2010) we hypothesized a stronger increase of heart rate in response to targets compared with nontargets during the first 5 s after stimulus onset in cases of an anomalous effect. In addition, electrodermal response amplitudes were expected to be enhanced with the presentation of target objects if these objects have particular significance for participants. Differences in respiration and pulse activity between targets and nontargets were examined in an explorative manner during 10 s after stimulus onset, as is usually done in the Guilty Knowledge Test (Ambach et al., 2008).

Hit rate. In cases of anomalous intuition or knowledge of participants about the target objects, the hit rate is expected to be above chance values.

Moderator variables. If an anomalous effect is moderated by the degree of paranormal belief, participants with a stronger belief were expected to show increased electrodermal response amplitudes, a stronger increase in heart rate, and a higher hit rate for targets compared with nontargets. These correlations were also expected to be present in cases of participant pairs with stronger connectedness. Greater response differences in respiration and pulse activity were also hypothesized between targets and nontargets for participants with a stronger paranormal belief and pairs with stronger connectedness.

Effects of serial position. Independent of the physiological response differences between targets and nontargets, we hypothesized serial position effects in the FCGT paradigm. In order to investigate whether such effects could have been responsible for confounding physiological responses by position in prior studies, we tested tonic heart rate and phasic heart rate for differences between object positions.

Method

Participants

We recruited 48 participant pairs (19 pairs of friends, 19 couples, 9 pairs of siblings, 1 pair of mother and daughter; 29 male, 67 female; mean age = 24.8 ± 5.6 years) via an announcement in the local student job agency (18 pairs) and in a local newspaper (27 pairs) as well as via a notice in the university (3 pairs). Participants were of reportedly good health, were not taking medications, and participated voluntarily in the study, receiving a payment of 16 Euros per pair. Informed consent was obtained from all participants.

Procedure

Each run of the experiment was conducted by two experimenters, one responsible for the FCGT with physiological measurement (Experimenter 1) and the other responsible for the partner event (Experimenter 2). One of the experimenters was always the first author of this article; the other experimenter was one of two placement students. The assignment of the experimenters to the experimental tasks was unsystematically varied so that each experimenter was repeatedly responsible for each task.

Welcome Phase. Experimenter 1 welcomed the participant pairs to the laboratory, informed them about the procedure, and randomly assigned them to the two experimental tasks. Participant 2 was sent to an office, where Experimenter 2, responsible for the synchronous partner event, was waiting. Participant 1 remained in the laboratory with the first experimenter, who administered the FCGT. Any contact between participants and between the experimenters was prevented until the end of the experiment.

Experimental Phase. After splitting the pairs, Participant 1 gave informed consent and completed a questionnaire on paranormal belief. The participant was then connected to the recording devices and was supplied with written task instructions. Experimenter 1 then gave a "ready" signal online to Experimenter 2. In the meantime, Participant 2 gave informed consent, filled in questionnaires on paranormal belief and on the relationship with participant 1, and received instructions on his/her task. Experimenter 2 gave the "ready" signal to Experimenter 1, who started the test run of the FCGT. In this manner, the test run of the synchronous partner event started automatically. After the test run and when participants had no further questions, both experimenters signaled "ready" to each other again, at which time Experimenter 1 started the main run of the FCGT, which also triggered the start of the main run of the synchronous partner. After the main run, Participant 1 was disconnected from the recording devices and completed a questionnaire on the evaluation of the relationship. Participant 2 filled in a questionnaire on the hit rate of the partner.

Disclosure Phase. Both experimenters and both participants met in the laboratory and the participants were informed about the hit rate of Participant 1. The experimenters answered questions about the theoretical background of the study. Finally, the participants received their payment.

Stimulus Material and Experimental Tasks

Stimulus material. The stimulus material used was adopted from Guilty Knowledge Test studies conducted by our group (e.g., Ambach et al., 2008). It consisted of 14 object categories (e.g., household articles). Each category consisted of four category-related objects (e.g., dustpan), and a photograph of each object was available in a standardized size (640 x 480 pixels).

Forced-Choice Guessing Task. In each block of the FCGT, Participant 1 was instructed to guess which one of four objects had been selected by the computer as target object. Each block started with a presentation of the block number for 2 s, followed by the sequential display of four pictures of objects of a particular object category on a screen, each for 6 s. The interstimulus interval between pictures consisted of a random period that lasted 6–8 s. After the sequential presentation of objects, all pictures within one category were presented simultaneously for 5 s and Participant 1 guessed the target object. One second after the selection, the correct target object was presented for 5 s, and after 12 s the next block started automatically (Figure 1, upper half). The FCGT consisted of 14 blocks, and each block consisted of a different object category. The total duration of the FCGT was approximately 20 min. Object pictures were presented foveally on a 19-inch monitor at a distance of 90 cm. Picture size was $6.0° \times 8.0°$ of the visual angle. The physiological activity of Participant 1 was measured continuously during the task.

Participant 1 was informed that the target object was being handled by his/her partner simultaneously to the presentation of its picture in each category, trying to influence the guess by mental means alone. For every correct guess, both partners earned a monetary bonus of 50 euro cents.

The category and object sequences were pseudorandomized and balanced across participants. To avoid unequal distribution of target positions, targets were selected pseudorandomly and balanced across participants by a computer prior to the start of the study. Each object within each category was chosen as a target with the same frequency at each block position. For each participant pair, a data file with the selected target objects was stored on a computer and unknown to all experimenters. A pseudorandom generator implemented in *Matlab, Version R2007b* (The MathWorks Inc., Natick, MA), which produces numbers seeded by the system clock, was used for the selection. The algorithm is based on Mersenne Twister and has a periodicity of (2^19937-1)/2 random numbers before the cycle repeats. The study was conducted in a double-blind manner; neither the experimenter responsible for the FCGT nor the investigated participant knew the particular target objects.

Synchronous Partner Event. In synchrony with each block of the FCGT, Participant 2 handled the particular target object in another room on the same floor. The target objects were placed in the office room by the experimenter responsible for the partner event and only known to him and Participant 2. After Experimenter 2 had placed the target objects in the office room, any contact with Experimenter 1 or Participant 1 was avoided. The start of the synchronous partner event was synchronized to the start of the FCGT via an online signal transmitted over the computer network.

The procedure used for the FCGT and synchronous partner event is depicted in Figure 1. Participant 2 handled each of the 14 target objects in sequence according to the instructions displayed on a computer screen. The sequence started with the display of instructions to collect a particular object that was located somewhere in the room (Instruction 1, depicted for ca. 20 s). Then, Participant 2 was instructed to handle the object, to focus on its characteristics, and to influence the partner's guess by mental means alone for ca. 60 s (Instruction 2). In each block, this instruction was displayed for 2 s before Participant 1 was presented the first object of the category and ended after Participant 1 had guessed the target object. Synchronous handling of the target object during the critical period of Participant 1's task was thus ensured in each block. Instruction 3 consisted of the command to lay the object aside in 4 s. The next block started automatically. The transition between each instruction was signaled acoustically. Participants were asked to comply carefully with the instruction sequence and to handle the objects throughout the given time.

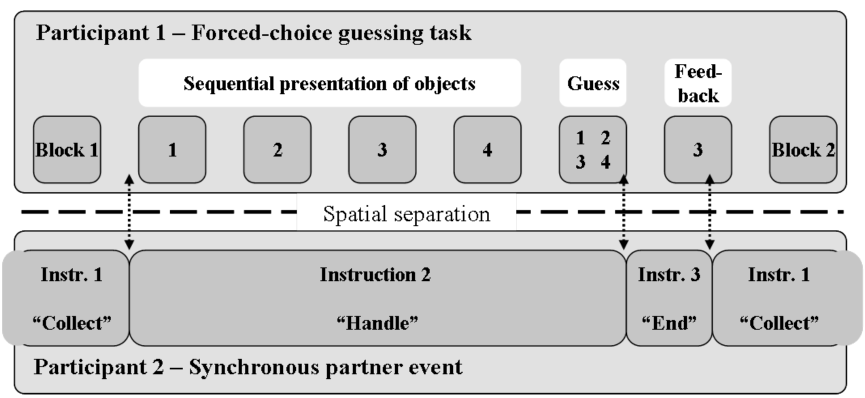

Figure 1. Schematic depiction of the synchronization of the forced-choice guessing task (upper half) and the synchronous partner event (lower half).

Physiological Measurement

The physiological recordings took place in a dimly lit, electrically and acoustically shielded experimental chamber (Industrial Acoustics GmbH, Niederkrüchten, Germany). Participants sat in an upright position that enabled visualization of the monitor and within comfortable reach of the keyboard.

Electrodermal activity, respiratory activity, electrocardiogram (ECG), and finger plethysmogram were registered. Physiological measures were A/D-converted and logged by the *Physiological Data System I 410-BCS* manufactured by J&J Engineering (Poulsbo, WA). The A/D-converting resolution was 14 bit, allowing skin conductance to be measured with a resolution of 0.01 µS. Data sampling was carried out at 510 Hz. Triggers indicating stimulus onsets were registered with the same sampling frequency.

For recording of the electrodermal activity, standard Ag/AgCl electrodes (Hellige; diameter 0.8 cm), an electrode paste of 0.5% saline in a neutral base (*TD 246 Skin Resistance*, Mansfield R&D, St. Albans, Vermont), and a constant voltage of 0.5 V were used. The electrodes were affixed to the thenar and hypothenar sites of the nondominant hand.

For registration of thoracic and abdominal respiratory activity, two PS-2 biofeedback respiration sensor belts (KarmaMatters, Berkeley, CA) with a built-in length-dependent electrical resistance were used. The belts were positioned on the upper thorax and abdomen.

ECG was measured with Hellige electrodes (diameter 1.3 cm) according to Einthoven II.

Finger pulse signal was transmitted by an infrared system (photoplethymograph) using a cuff placed around the middle finger of the nondominant hand.

Behavioral Measures

Objects were numbered from "1" to "4" during the simultaneous presentation. Participants responded by keypress, and the signals were stored on the stimulus-presenting computer for later evaluation of correct choices. Reaction times were stored but not evaluated.

Questionnaires

Participants' paranormal beliefs were assessed via the Australian Sheep-Goat Scale (ASGS; Thalbourne & Delin, 1993; Thalbourne & Houtkooper, 2002).

The connectedness of each pair was evaluated by the Questionnaire on the Evaluation of Relationships (QER; Schmidt et al., 2001). A connectedness index for each participant pair was calculated by averaging the QER scores of both partners (QER index).

Additionally, Participants 2 made an estimation of the hit rate of their partner in the FCGT (results not shown).

Data Reduction

Analysis of the participants' choices was performed by adding the correct choices of all participants. Fifteen blocks were discarded based on the failure of participants to press a key.

Heart rate data were notch-filtered at 50 Hz; R-wave peaks were automatically detected and visually controlled. The R-R intervals were transformed into tonic heart rate, and real-time scaled (Velden & Wölk, 1987). The tonic heart rate during the last second before stimulus onset served as prestimulus baseline. The phasic heart rate was calculated by subtracting this baseline value from each second-per-second poststimulus value.

The respiration line length represents the sum of all inspiratory and expiratory respiratory movements; the measure integrates information about frequency and depth of respiration. The computation of the respiration line length is based on a method derived from Timm (1982) and modified by Kircher and Raskin (2003). Here, respiratory data were filtered with a low-pass filter (10 db at 2.8 Hz) and the total respiration line length (average of abdominal and thoracic respiration line length) was computed over a time interval of 10 s after stimulus onset and subjected to further analyses (Ambach et al., 2008).

The finger pulse waveform length represents the sum of all absolute plethysmographic changes during a determined time window; it integrates information of heart rate and pulse amplitude (Elaad & Ben-Shakhar, 2006). Here, the sum of the first 10 s of the finger pulse waveform after stimulus onset was computed as finger pulse waveform length and then subjected to further analyses (Ambach et al., 2008).

The phasic component of the electrodermal activity was defined as any increase in skin conductance that was initiated within a time window from 1 to 5 s after stimulus onset. The amplitude of the response was evaluated automatically as the difference between response onset and the subsequent maximum value in the set time window (Furedy & Ben-Shakhar, 1991). Data from two participants was discarded from the analysis because of electrodermal hypo-responding (≥80% nonresponses).

Lykken and Venables (1971) proposed a within-subject standardization of measured values. Here, according to Ben-Shakhar (1985), all physiological measures were z transformed for each participant. All the responses obtained from each participant were used for the calculation of individual means and standard deviations (Ambach et al., 2008). The z-transformed values were used in the subsequent statistical analyses.

Statistics

Statistical analyses were performed with *SYSTAT, Version 13 (Systat Software Inc.,* Chicago, IL).

For each physiological measure, a *t* test for matched samples (target vs. nontarget objects) was conducted. ($\alpha = .05$, one-tailed for phasic electrodermal activity and phasic heart rate; two-tailed for respiration line length and finger pulse waveform length). Cohen's *d* was calculated as an effect size estimate according to Cohen, 1988 (2nd edition, page 48, formulas 2.3.5 and 2.3.6).

To analyze the hit rate, a binomial test for proportions was performed (one-tailed, $\alpha = .05$). In addition, a Kolmogorov–Smirnov one-sample test was used to assess the observed distribution of hit rates for deviations from a binomial distribution (two-tailed, $\alpha = .05$).

Pearson product-moment correlation analyses were performed between scores on the questionnaires and differences in *z* scores between target and nontarget objects as well as the number of hits. Correlation coefficients were tested for statistical significance ($\alpha = .05$, one-tailed for phasic electrodermal activity and phasic heart rate; two-tailed for respiration line length and finger pulse waveform length).

In order to analyze differences in tonic and phasic heart rate between object positions, one-way ANOVAs for repeated measures (factor position with four levels) were conducted ($\alpha = .05$). Post hoc analyses for repeated measures were performed using the Bonferroni correction for multiple comparisons.

Results

Physiological Responses

The *z* scores for each physiological data channel for target and nontarget objects, averaged across all blocks and participants, are depicted in Table 1. For each physiological channel, a *t* test for paired measures (one-tailed) was conducted. None of the tests revealed a significant difference in physiological responses to target versus nontarget objects (Table 1).

Hit Rate

The average number of hits across all participants was $M = 3.15$, $SD = 1.37$ (expected average of hits: 3.5). The observed distribution of hit rates did not differ from the expected binomial distribution ($D = .10$, $p = .69$). In 657 valid blocks, 151 hits occurred. This proportion is at chance expectation (expected proportion = .25, sample proportion = .23, $z = -1.21$, $p = .89$).

Table 1
Z Values for Each Physiological Data Channel and Calculated t Values, p Values, and Effect Sizes for Differences in Responses to Target versus Nontarget Objects

	Target objects		Nontarget objects				
	M	*SD*	*M*	*SD*	*t (df)*	*p*	*ES* (*d*)
pHR	0.007	0.267	-0.002	0.089	0.163 (47)	.435	0.027
pEDA	-0.023	0.237	0.008	0.079	-0.644 (45)	.739	-0.090
RLL	0.006	0.230	-0.002	0.077	0.184 (47)	.855	0.027
FWPL	-0.008	0.185	0.003	0.062	-0.284 (47)	.778	-0.041

Note. M = Mean; *SEM* = Standard error of mean; *df* = Degrees of freedom; *ES* = Effect size (Cohen's *d*); pHR = Phasic heart rate; pEDA = Phasic electrodermal activity; RLL = Respiration line length; FPWL = Finger pulse waveform length.

Moderator Variables

As shown in Table 2, only the response differences of finger pulse waveform length between targets and nontargets correlated with the ASGS score of Participants 1. This correlation was nonsignificant after a Bonferroni correction for multiple testing (p = .71). No other significant correlations between scores on questionnaires and differences in physiological responses to targets and nontargets were detected. Further, scores on questionnaires did not correlate with the hit rate of participants.

Table 2
Correlations Between Scores on Questionnaires and Response Differences to Target versus Nontarget Objects as Well as the Hit Rate

	QER index		ASGS Participant 1		ASGS Participant 2	
	r (*df*)	*p*	*r* (*df*)	*p*	*r* (*df*)	*p*
dpHR	-.033 (46)	.588	-.225 (46)	.938	-.315 (46)	.985
dpEDA	-.223 (44)	.932	.025 (44)	.435	-.150 (44)	.840
dRLL	-.182 (46)	.217	.124 (46)	.400	.132 (46)	.370
dFPWL	.014 (46)	.924	.285 (46)	.050	.241 (46)	.098
Hit rate	.012 (46)	.468	.057 (46)	.350	.064 (46)	.333

Note. ASGS = Australian Sheep-Goat Scale; QER = Questionnaire on the Evaluation of Relationships; *r* = Pearson product-moment correlation; *df* = Degrees of freedom; pEDA= Phasic electrodermal activity; RLL = Respiration line length; pHR = Phasic heart rate; FPWL = Finger pulse waveform length.

Effects of Serial Position

Heart rate values recorded every second for each object position are depicted in Figure 2. At each position, an initial increase of heart rate for ca. 4 s after stimulus onset (0 s) is followed by a decrease until stimulus offset (6 s). Thereafter, heart rate increases and decreases again.

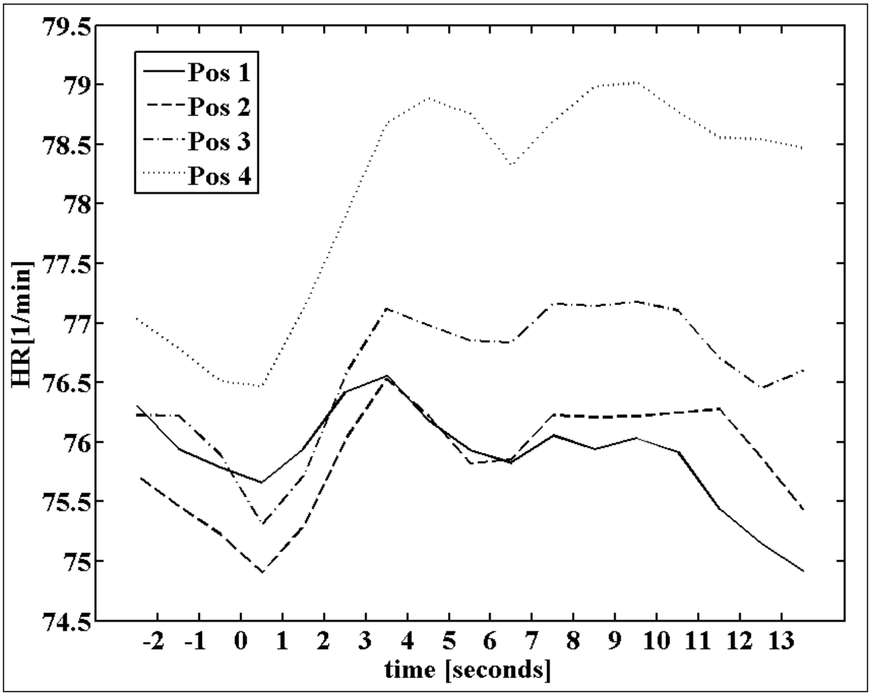

Figure 2. Heart rate values measured every second in each object position and averaged across all object presentations and participants; depicted are 3 s before and 13 s after stimulus onset (0 s).

Analyses of tonic heart rate revealed significant differences between positions, $F(3,141) = 48.24$, $p < .001$. Post hoc analyses revealed significant differences between positions 2 and 3 as well as between position 4 and all other positions (Figure 3, right graph). Analyses of phasic heart rate also showed significant differences between positions, $F(3,141) = 6.34$, $p < .001$, with a significantly higher phasic heart rate at position 4 in comparison to all other positions (Figure 3, left graph).

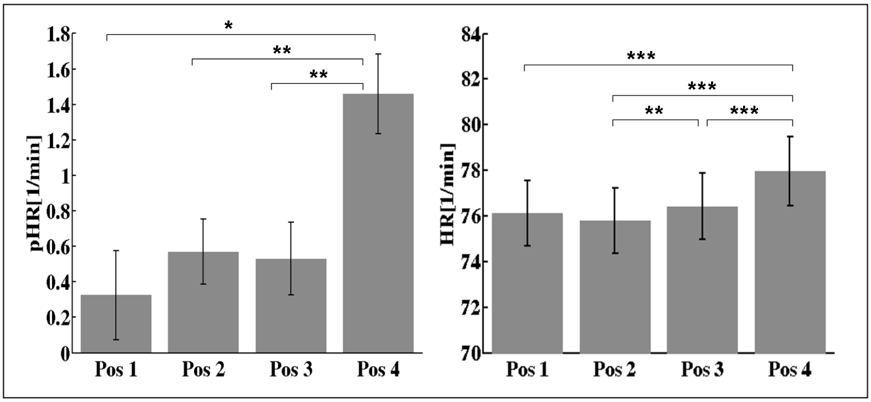

Figure 3. Tonic heart rate (right) and phasic heart rate (left) with standard errors of means for each object position. Post hoc analyses for matched samples were conducted; p values were assessed via z standardized values; ***$p \leq .001$, **$p \leq .01$, *$p \leq .05$.

Discussion

The present study was designed to investigate correlations between events that are conventionally considered as not perceivable and the physiological responses of the autonomic nervous system. We questioned, in particular, whether physiological response differences to target and nontarget objects in the FCGT are due to the particular significance of target objects. To that end, methodological aspects of the well-investigated Guilty Knowledge Test were included in the FCGT. We implemented a categorical design in the FCGT and balanced target positions across participants. Furthermore, we included a partner event in the FCGT. In addition to the assessment of heart rate changes during 5 s after stimulus onset (Schönwetter & Ambach, 2010), we investigated phasic electrodermal activity, respiratory activity, and pulse activity. Paranormal belief and degree of connectedness between participants were investigated as possible moderator variables for physiological response differences between targets and nontargets as well as for the hit rate in the FCGT. Moreover, the effects of object positions within blocks were examined by analyzing differences in tonic and phasic heart rate.

In the present study, the effect sizes of all physiological data channels were small ($d < 0.1$; Cohen, 1988). This is in line with the results of our FCGT pilot study (Schönwetter & Ambach, 2010) and our partner study (Schönwetter et al., 2011), indicating that the combination of two events in the FCGT and the synchronization of the partner event with the physiological measurement did not increase effect sizes.

Analyses revealed no significant difference in the heart rate increases in response to targets and nontargets. Hence, the explorative result of our pilot study (Schönwetter & Ambach, 2010) could not be confirmed. No significant difference in electrodermal response amplitudes between targets and nontargets was found. Further, no response differences in respiration and pulse activity were detected. Target objects did not appear to have a particular significance for participants. Accordingly, the physiological analyses carried out in the present study did not show evidence of anomalous correlations between future or spatially separated events and activity of the autonomic nervous system in the FCGT.

As in previous FCGT studies (Lobach & Bierman, 2010; Sartori et al., 2004; Schönwetter & Ambach, 2010; Tressoldi et al., 2005), the overall hit rate was at chance level. Furthermore, the hit-rate distribution of the participants did not deviate from the expected binomial distribution. These results indicated that all hit rates were a result of chance.

In agreement with the results of our pilot FCGT study (Schönwetter & Ambach, 2010) and of our previous partner study (Schönwetter et al., 2011), the degree of paranormal belief showed no correlation with physiological response differences between targets and nontargets or with the hit rate of participants. The significance of the correlation of finger pulse response differences between targets and nontargets with the degree of paranormal belief of Participants 1 disappeared after a correction of the alpha value due to multiple testing. It has to be mentioned that the Bonferroni correction conducted is considered conservative in rejecting the null hypothesis (e.g., Rosenthal & Rubin, 1984), especially if correlations were assumingly not independent from each other. Also in common with our previous study (Schönwetter et al., 2011), the degree of connectedness between partners showed no correlation with physiological response differences between targets and nontargets or with the hit rate. Hence, the hypothesis that these moderator variables possibly influence the performance of participants in studies investigating paranormal phenomena could not be confirmed.

Studies investigating case reports of the effect of events conventionally considered as unperceivable on cognition, affect, and behavior of people emphasized the importance of emotional arousal in the occurrence of anomalous experiences (e.g., Rhine, 1978; Stevenson, 1971). In some experimental paradigms, this finding was implemented by using arousing stimuli, such as pictures with emotional content (Beloff, 1974; Broughton, 2002). For example, in the presentiment paradigm, participants are sequentially confronted with emotional and neutral pictures. Studies (e.g., Bierman & Radin, 1997) have shown evidence of an increase in electrodermal response amplitudes several seconds before an emotional picture is presented. Moulton and Kosslyn (2008) used emotional and neutral pictures in the FCGT but found no differences between central nervous responses to targets and nontargets. In all other FCGT studies, only neutral stimuli were used, and emotional arousal was elicited by the guessing task. It is debatable whether this degree of emotional arousal is sufficient to establish anomalous correlations between events conventionally considered as unperceivable and activity of the autonomic nervous system. Therefore, the current results are limited to the FCGT paradigm with neutral stimuli.

In order to avoid any information exchange between the experimenters and to ensure a double-blind procedure of the experiment, the only form of communication consisted of the "ready" signal via the computer network. Nevertheless, Experimenter 2 could theoretically have provided information regarding the identity of a target object by using a particular delay when signaling the "ready" status. This possibility should be ruled out in future studies (e.g., by using covert "ready" signals and an automated start of the experiment after both experimenters have given their "ready" signals).

Because of the balancing of target positions and target objects across all participants, Experimenter 1 could have guessed the target objects in advance with a certain probability due to target presentations in prior runs of the experiment. This possibility was ruled out by changing the experimenters' roles repeatedly. Thus, no experimenter had utilizable knowledge of the target objects of prior runs. This methodological aspect should also be taken into account in future studies.

Methodological analyses revealed significant differences in heart rate between object positions. Except for position 1, the heart rate during the 6 s of object presentation was more enhanced the later an object was presented within a block. Studies on the psychophysiology of gambling have shown that an increased heart rate occurs several seconds before a decision is made in a gambling task (e.g., Coventry & Norman, 1997; Ladouceur et al., 2003). Therefore, guessing the target object at the end of each block possibly evoked higher states of arousal during the previous sequential presentation of objects the closer an object was presented to the task. Aside from the enhanced tonic heart rate levels, the strongest increase of phasic heart rate in correlation with stimulus onset occurred at position 4. This result suggests that the presentation of an object at the fourth position may have an unknown special significance for participants[1]. In a study by Coles and Duncan-Johnson (1975), participants showed the strongest increase of phasic heart rate in response to a stimulus within a series if the stimulus indicated the requirement of a motoric response. The authors concluded that the increase in heart rate was dependent on information processing, decision-making, and response preparation. In the FCGT, it is possible that the decision-making and response preparation processes mainly take place during the presentation of the fourth object, namely after all objects have been presented and just before the response of the participant was required.

---

1 An explorative analysis of electrodermal response amplitudes confirmed this result. Significantly enhanced amplitudes occurred at position 4 in comparison to position 2 and position 3.

In previous FCGT studies (Lobach & Bierman, 2010; Sartori et al., 2004; Schönwetter & Ambach, 2010; Tressoldi et al., 2005), the positions of target objects were not balanced due to random target choices, and the physiological responses to objects may have been codetermined by stimulus positions within the blocks. The differences in the responses to target and nontarget objects could therefore have been influenced by this bias. In the present study, this was avoided by balancing the positions of target objects across all participants. Even small deviations from fully balanced stimulus positions can cause a biased estimation of the alpha level in statistical testing. Therefore, it is strongly suggested that all experimental paradigms investigating physiological responses to sequentially presented stimuli take into account the effects of serial positioning if a treatment is assigned randomly to stimuli.

Conclusion

The present study failed to find evidence for correlations between events conventionally considered as not perceivable and activity of the autonomic nervous system in the FCGT paradigm. With respect to previous studies, we revealed a possible confounding of physiological response differences between targets and nontargets in the FCGT, if target objects were chosen randomly without balancing target positions within the blocks. In order to prevent this confound and to avoid biased estimation of the alpha level in future studies, we strongly suggest balancing the positions of experimentally treated stimuli whenever an experimental paradigm includes analyses of physiological responses to sequentially presented stimuli.

References

Alexander, C. H., & Broughton, R. S. (1999). CL1-ganzfeld study: A look at brain hemisphere differences and scoring in the autoganzfeld. *Journal of Parapsychology, 63*, 3–18.

Ambach, W., Dummel, S., Lüer, T., & Vaitl, D. (2011). *Physiological responses in a Concealed Information Test are determined interactively by encoding procedure and questioning format.* Manuscript submitted for publication.

Ambach, W., Stark, R., Peper, M., & Vaitl, D. (2008). Separating deceptive and orienting components in a Concealed Information Test. *International Journal of Psychophysiology, 70*, 95–104.

Barry, R. J. (1990). The orienting response: Stimulus factors and response measures. *Pavlovian Journal of Biological Science, 25*, 93–103.

Barry, R. J. (2004). Stimulus significance effects in habituation of the phasic and tonic orienting reflex. *Integrative Physiological & Behavioral Science, 39*, 166–179.

Barry, R. J., Feldmann, S., Gordon, E., Cocker, K. I., & Rennie, C. (1993). Elicitation and habituation of the electrodermal orienting response in a short interstimulus interval paradigm. *International Journal of Psychophysiology, 15*, 247–253.

Barry, R. J., Maltzman, I. (1985). Heart rate deceleration is not an orienting reflex; heart rate acceleration is not a defensive reflex. *Pavlovian Journal of Biological Science, 20*, 15–28.

Beloff, J. (1974). ESP: The search for a physiological index. *Journal of the Society for Psychical Research, 74*, 403–420.

Ben-Shakhar, G. (1985). Standardization within individuals: A simple method to neutralize individual differences in skin conductance. *Psychophysiology, 22*, 292–299.

Ben-Shakhar, G. (1994). The roles of stimulus novelty and significance in determining the electrodermal orienting response: Interactive versus additive approaches. *Psychophysiology, 31*, 402–411.

Ben-Shakhar, G., & Elaad, E. (2003). The validity of psychophysiological detection of information with the guilty knowledge test: A meta-analytic review. *Journal of Applied Psychology, 88*, 131–151.

Bierman, D. J., & Radin, D. I. (1997). Anomalous anticipatory response on randomized future conditions. *Perceptual and Motor Skills, 84*, 689–690.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* San Diego, CA: McGraw-Hill.

Coles, M. G. H., & Duncan-Johnson, C. C. (1975). Cardiac activity and information processing: the effects of stimulus significance, and detection and response requirements. *Journal of Experimental Psychology, 1*, 418–428.

Coventry, K. R., & Norman, A. C. (1997). Arousal, sensation seeking and frequency of gambling in off-course horse racing bettors. *British Journal of Psychology, 88*, 671–681.

Delanoy, D. L., Morris, R. L., Brady, C., & Roe, A. (1999). An EDA DMILS study exploring agent-receiver pairing. *Proceedings of Presented Papers: The Parapsychological Association 42nd Annual Convention*, 68–82.

Elaad, E., & Ben-Shakhar, G. (2006). Finger pulse waveform length in the detection of concealed information. *International Journal of Psychophysiology, 61*, 226–234.

Furedy, J. J., & Ben-Shakhar, G. (1991). The roles of deception, intention to deceive, and motivation to avoid detection in the psychophysiological detection of guilty knowledge. *Psychophysiology, 28*, 163–171.

Gamer, M. (2011). Detecting concealed information using autonomic measures. In B. Verschuere, G. Ben-Shakhar, E. Meijer (Eds.): *Memory detection. Theory and application of the Concealed Information Test* (pp. 27–45). New York: Cambridge University Press.

Graham, F. K., & Clifton, R. K. (1966). Heart rate change as a component of the orienting reaction. *Psychophysiological Bulletin, 65*, 305–320.

Jokinen, A., Santtila, P., Ravaja, N., & Puttonen, S. (2006). Salience of Guilty Knowledge Test items affects accuracy in realistic mock crimes. *International Journal of Psychophysiology, 62*, 175–184.

Kircher, J. C., & Raskin, D. C. (2003). The computerized polygraph system II (Software version 4.01). Salt Lake City: Scientific Assessment Technologies.

Ladouceur, R., Sévigny, S., Blaszczynski, A., O'Connor, K., & Lavoie, M. E. (2003). Video lottery: winning expectancies and arousal. *Addiction, 98*, 733–738.

Lawrence, T. R. (1993). Gathering in the sheep and goats: A meta-analysis of forced-choice sheep-goat ESP studies, 1947–1993. *Proceedings of Presented Papers: The Parapsychological Association 36th Annual Convention*, 75–86.

Lobach, E., & Bierman, D. J. (2010). Somatic psi: Heart rate changes reflect future events, but do these changes improve our choices? *Abstracts of Presented Papers: The Parapsychological Association 53rd Annual Convention,* 17 – 18. Full article retrieved from http://www.uniamsterdam.nl/D.J.Bierman/publications//2010/Lobach&Bierman2010_PA_PsiPsychology_2.doc

Lykken, D. T. (1959). The GSR in the detection of guilt. *Journal of Applied Psychology, 43,* 385–388.

Lykken, D. T., & Venables, P. H. (1971). Direct measurement of skin conductance: A proposal for standardization. *Psychophysiology, 8,* 656–672.

Lynn, R. (1966). *Attention, arousal and the orientation reaction.* Oxford, England: Pergamon Press.

Moulton, S. T., & Kosslyn, S. M. (2008). Using neuroimaging to resolve the psi debate. *Journal of Cognitive Neuroscience, 20*, 182–192.

Palmer, J. (1978). Extrasensory perception: Research findings. In S. Krippner (Ed.). *Advances in parapsychological research 2* (pp. 122–197). New York: Plenum Press.

Palmer, J. (1982). ESP research findings: 1976–1978. In S. Krippner (Ed.). *Advances in parapsychological research 3* (pp. 56–73). New York: Plenum Press.

Palmer, J. (2009). Winning over the scientific mainstream. *Journal of Parapsychology, 73,* 3–8.

Rhine, L. E. (1978). The psi-process in spontaneous cases. *Journal of Parapsychology, 42,* 20–32.

Rosenthal, R., & Rubin, D. B. (1984). Multiple contrasts and ordered Bonferroni procedures. *Journal of Educational Psychology, 76*, 1028–1034.

Sartori, L., Massaccesi, S., Martinelli, M., & Tressoldi, P. E. (2004). Physiological correlates of ESP: Heart rate differences between targets and nontargets. *Journal of Parapsychology, 68*, 351–360.

Schmeidler, G. R. (1945). Separating the sheep from the goats. *Journal of the American Society for Psychical Research, 39*, 47–49.

Schmidt, S., Schneider, R., Utts, J., & Walach, H. (2004). Distant intentionality and the feeling of being stared at: Two meta-analyses. *British Journal of Psychology, 95*, 235–247.

Schmidt, S., Tippenhauer, G., & Walach, H. (2001). Connectedness between participants in an experiment on distant intention. *Proceedings of Presented Papers: The Parapsychological Association 44thAnnual Convention*, 285–300.

Schönwetter, T., & Ambach, W. (2010). Investigation of anomalous stimulus discrimination. *Abstracts of Presented Papers: The Parapsychological Association 53rd Annual Convention*, 58–59.

Schönwetter, T., Ambach, W., & Vaitl, D. (2011). Does a Guilty Knowledge Test reveal anomalous interactions within pairs of participants? *Journal of Parapsychology*, in press.

Sokolov, E. N. (1963). Higher nervous functions. The orienting reflex. *Annual Review of Physiology, 25*, 545–580.

Stevenson, I. (1971). The substantiality of spontaneous cases. *Proceedings of Presented Papers: The Parapsychological Association 11th Annual Convention*, 91–128.

Thalbourne, M. A., & Delin, P. S. (1993). A next instrument for measuring the sheep-goat variable: Its psychometric properties and factor structure. *Journal of the Society for Psychical Research, 59*, 172–187.

Thalbourne, M. A., & Houtkooper, J. M. (2002). Religiosity/spirituality and belief in the paranormal: A German replication. *Journal of the Society for Psychical Research, 66*, 113–115.

Timm, H. W. (1982). Analyzing deception from respiration patterns. *Journal of Police Science & Administration, 10*, 47–51.

Tressoldi, P. E., Martinelli, M., Massaccesi, S., & Sartori, L. (2005). Heart rate differences between targets and nontargets in intuition tasks. *Human Physiology, 31*, 646–650.

Turpin, G. (1999). Effects of stimulus intensity, risetime, and duration on autonomic and behavioral responding: Implications for the differentiation of orienting, startle, and defense responses. *Psychophysiology, 36*, 453–463.

Velden, M., & Wölk, C. (1987). Depicting cardiac activity over real time: A proposal for standardization. *Journal of Psychophysiology, 1*, 173–175.

Acknowledgements

We thank the Bial Foundation for supporting this project with their research fund. We also thank Mirko Simon and Ulrich Hinderer for help with data collection.

Institute for Frontier Areas of Psychology and Mental Health (IGPP)
Wilhelmstraße 3a,
D - 79098, Freiburg, Germany
schoenwetter@igpp.de

Abstracts in Other Languages

French

EST-CE QUE L'ACTIVITE DU SYSTEME NERVEUX AUTONOME EST CORRELEE AVEC DES EVENEMENTS CONVENTIONNELLEMENT CONSIDERES COMME IMPERCEVABLES ? USAGE D'UNE TACHE DE DIVINATION AVEC DES MESURES PHYSIOLOGIQUES

RESUME: De précédentes études semblent avoir fourni des preuves d'une augmentation anomale de la fréquence cardiaque durant la présentation d'objets qui étaient ensuite choisis aléatoirement et présentés en tant que cibles dans une tâche de divination à choix forcé. Nous avons étudié 48 paires de participants dans un paradigme modifié : nous implémentons un partenaire spatiallement séparé qui prend en charge l'objet cible particulier durant chacun des 14 blocs de la tâche en tentant d'influencer le participant dont la physiologie est investiguée, par des moyens uniquement mentaux. Les différences de réactions entre cibles et non-cibles étaient évaluées par des mesures de la fréquence cardiaque, les amplitudes de réponses électro-dermales, les variations de la respiration et le pouls. La croyance au paranormal et la connectivité avec le partenaire étaient mesurées en tant que possibles variables modérant les différences de réactions physiologiques et le taux de réussite. Les analyses ne montrent pas de preuves de différences anomales de réaction physiologique entre les cibles et les non-cibles (tailles d'effet $< .2$, valeurs $p > .1$) ou de quelconques influences des variables modératrices. Les analyses méthodologiques fournissent des preuves pour un effet de position des séries dans les études antérieures ; cette observation pourrait indiquer une signification particulière de la dernière présentation d'objet précédant le moment de deviner. Pour éviter ce problème et l'estimation biaisée du niveau alpha, les études futures devraient équilibrer les positions de leurs stimuli.

Spanish

¿CORRELACIONA LA ACTIVIDAD DEL SISTEMA NERVIOSO AUTÓNOMO CON EVENTOS CONVENCIONALMENTE CONSIDERADOS IMPERCEPTIBLES? USO DE UNA TAREA DE ADIVINANZAS CON UNA MEDIDA FISIOLÓGICA

RESUMEN: Estudios previos parecen proporcionar evidencia de un aumento anormal en la frecuencia cardíaca durante la presentación de objetivos que posteriormente fueron escogidos al azar y presentados como objetivos en una tarea de adivinanza de elección forzada. Investigamos 48 pares de participantes en un paradigma modificado: Implementamos a un participante geográficamente separado que agarró el objeto durante cada uno de los 14 bloques de la tarea mientras trataba de influir mentalmente al participante en la investigación fisiológica. Evaluamos las diferencias de respuesta entre los objetivos y los distractores en cambios del ritmo cardíaco, amplitudes de respuesta electrodérmica, alteraciones respiratorias, y pulso. Medimos las creencias paranormales y vínculo entre las parejas como posibles variables moderadoras en las diferencias en la respuesta fisiológica y tasa de aciertos. Los análisis no mostraron evidencia de anomalías en las diferencias de respuesta fisiológica entre los objetivos y los distractores (valores de tamaño de efecto <.2, *p*> .1) ni influencia de variables moderadoras. Los análisis metodológicos proporcionaron evidencia de un efecto de posición serial en estudios previos; esta observación podría apuntar hacia el significado particular de la presentación del último objetivo precedente a la adivinanza. Con el fin de evitar este problema y evitar estimación sesgada del nivel alfa, los estudios futuros deben equilibrar las posiciones de los estímulos.

German

GIBT ES ZUSAMMENHÄNGE ZWISCHEN DER AKTIVITÄT DES AUTONOMEN NERVENSYSTEMS UND AUS KONVENTIONELLER SICHT NICHT WAHRNEHMBAREN EREIGNISSEN? EINE UNTERSUCHUNG MIT RATEAUFGABE UND PHYSIOLOGISCHER MESSUNG

ZUAMMENFASSUNG: Frühere Studien scheinen Hinweise auf einen anomalen Anstieg der Herzrate während der Präsentation von Objekten zu geben, die in einer Rateaufgabe später zufällig als Zielobjekte ausgewählt und präsentiert wurden. Wir untersuchten 48 Versuchspersonen-Paare in einer modifizierten Form des Paradigmas: In jedem von 14 Blöcken der Aufgabe hantierte ein räumlich getrennter Partner mit dem jeweiligen Zielobjekt und versuchte, die physiologisch untersuchte Versuchsperson rein mental zu beeinflussen. Physiologische Reaktionsunterschiede zwischen Zielobjekten und irrelevanten Objekten wurden in Bezug auf Herzrate, elektrodermale Aktivität, Atemaktivität und Pulsaktivität untersucht. Paranormale Überzeugungen und Verbundenheit der Partner wurden als mögliche Moderatorvariablen für physiologische Reaktionsunterschiede und Trefferrate erhoben. Die Analysen zeigten keine Hinweise auf physiologische Reaktionsunterschiede zwischen Zielobjekten und irrelevanten Objekten (Effektstärken < .2, p-Werte > .1) oder Einflüsse der Moderatorvariablen. Methodologische Analysen ergaben Hinweise auf Effekte der seriellen Position in früheren Studien. Diese Beobachtung deutet auf eine spezifische Bedeutsamkeit der letzten Objektpräsentation vor der Aufforderung zum Raten hin. Um eine Konfundierung der physiologischen Variablen und ein verfälschtes Signifikanzniveau zu vermeiden, sollten die Positionen der Zielobjekte in zukünftigen Studien ausbalanciert werden.