

# DOES A MODIFIED GUILTY KNOWLEDGE TEST REVEAL ANOMALOUS INTERACTIONS WITHIN PAIRS OF PARTICIPANTS?

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**ABSTRACT:** This study aimed to investigate anomalously modulated physiological responses as an indicator of anomalous interactions between emotionally related partners. For this purpose, we used a modified version of the Guilty Knowledge Test. In this experiment, partners were spatially separated. One partner (Participant 1) was confronted with probe objects such that these objects gained particular significance for Participant 1. The other partner (Participant 2) was investigated for differences in their physiological responses to pictures of probe objects and pictures of objects that Participant 1 had not been confronted with (irrelevant objects). In the case of an anomalous interaction between participants, the particular significance of probe objects was expected to modulate the physiological responses of Participant 2. Physiological variables consisted of electrodermal activity, heart rate, respiratory activity, and pulse activity. Behavioral variables consisted of reaction times and hit rate in a guessing task. Paranormal beliefs and connectedness of participants were assessed, via questionnaires, as possible moderators for the performance of Participant 2. Correlations between questionnaire scores and physiological as well as behavioral variables were analyzed. Overall, the analyses revealed no anomalously modulated physiological responses or other indicators for anomalous interaction between participants. Methodological remarks and implications for future studies are discussed.

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*Keywords:* anomalous interaction, psychophysiology, Guilty Knowledge Test, participant pairs, connectedness of participants, paranormal belief

## **Psychophysiology in Parapsychological Research**

The investigation of correlations between bodily functions and mental processes is the research approach of psychophysiology. Physiological variables (e.g., electrodermal activity and heart rate) are measurable as spontaneous activity (nonspecific responses during resting phases), as tonic activity (long-term level), or as phasic responses to presented stimuli (Stern, Ray, & Quigley, 2001). Analyses refer to changes in participants' physiological activity depending on task or presented stimulus.

Psychophysiology was introduced into parapsychological research in the second decade of the 20th century (for reviews see Beloff, 1974; Palmer, 1978; Schouten, 1976). Thereby, anomalously modulated physiological activity, i.e., physiological activity related to spatially and/or temporally

separate events (e.g., stimulus presentation), was measured as an indicator for extrasensory perception (ESP).

Justification for the implementation of the physiological approach in parapsychology is based on analyses of spontaneous ESP cases, according to which, ESP is basically unconscious but able to produce bodily reactions and emotions (e.g., Broughton, 2006; Rhine, 1962; Tyrell, 1946). In particular, crisis situations causing emotional arousal seem to provoke spontaneous ESP experiences (e.g., Rhine, 1978; Stevenson, 1971). Hence, the use of emotive stimuli and the investigation of autonomic responses seem to be more appropriate for detecting anomalous phenomena than investigating behavior (Beloff, 1974; Broughton, 2002) or reactions of the central nervous system, which are linked to cognitive processes (Barry, 1996).

Aside from emotional arousal, possible moderator variables that are thought to influence the performance of participants in parapsychological experiments are the degree of participants' paranormal belief (Schmeidler, 1945; for a meta-analysis see Lawrence, 1993) and the connectedness of partners in participant pairs (e.g., Alexander & Broughton, 1999; Delanoy, Morris, Brady, & Roe, 1999; Schmidt, Tippenhauer, & Walach, 2001).

A vast amount of parapsychological research using physiological measurement has investigated anomalous phenomena such as ESP within pairs of participants. Most of these studies principally used the same procedure: One partner (Participant 1) participates in a periodic event. This event consists of either a stimulation of Participant 1 or the attempt of Participant 1 to influence a partner (Participant 2) by means of mental activity. Simultaneously, Participant 2 rests, spatially separated from Participant 1 and isolated from any stimulus. Participant 2 is tested for physiological differences in tonic activity or nonspecific physiological responses between periods with and without the stimulus event. Significant differences in Participant 2 between these two kinds of periods are interpreted as indicators of an anomalous effect.

Several parapsychological working models have been tested via this procedure. Significant effects were interpreted as ESP (e.g., Ramakers, 2008), *direct mental interaction with living systems* (DMILS; e.g., Delanoy, 2001), or unexplained correlations in brain activity between participants (e.g., Wackermann, Seiter, Keibel, & Walach, 2003). Overall, results are heterogeneous (reviews of early ESP studies with physiological measurement: Beloff, 1974; Palmer, 1978, 1982; Schouten, 1976; meta-analysis of DMILS studies: Schmidt, Schneider, Utts, & Walach, 2004; review of brain correlation studies: Charman, 2006).

An unusual approach consists of stimulating Participant 2 instead of measuring tonic activity or nonspecific responses of a resting and not stimulated participant. Phasic physiological responses of Participant 2 to presented stimuli are measured and analyzed for response differences related

to different stimulation conditions in the spatially separated Participant 1. If there are statistically significant response differences, the physiological responses of Participant 2 are regarded as anomalously modulated.

In this vein, Herbert, Boehm, and Plihal (2002) used the startle eye-blink modification paradigm to examine startle responses of Participant 2 depending on the different stimulation conditions of the spatially separated Participant 1. These conditions consisted of presenting pictures with varying emotional content (positive, negative, and neutral). Normally, startle-reflex components are stronger during confrontation with positive than with negative pictures. In the study mentioned above, the researchers measured startle reflex by electromyographic (EMG) startle eye-blink amplitudes and startle-related electroencephalographic (EEG) components. No evidence for an influence of Participant 1 on the startle reflex of Participant 2 was found in an analysis of EMG amplitudes. EEG analyses revealed significant differences in startle-related EEG amplitudes at single electrodes sites of Participant 2 when Participant 1 was confronted with positive pictures.

In the same vein, Moulton and Kosslyn (2008) used functional magnetic resonance imaging (fMRI) for measuring the brain activity of Participant 2 during the presentation of pictures. In each trial of a guessing task, Participant 2 was successively confronted with two pictures, taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). The spatially separated Participant 1 was simultaneously confronted with one of the two pictures (psi stimulus) and tried to mentally send it to Participant 2. After the presentation, Participant 2 was asked to guess the psi stimulus. Based on intensive research in cognitive neuroscience, suppressed brain activity was expected when Participant 2 knew about the psi stimulus. Further, enhanced brain activity was expected in the case of increased attention to the psi stimuli. If there was no anomalous effect, no difference in brain activity between presentation of psi pictures and nonpsi pictures was expected. Analyses of hit rate and brain activity revealed no evidence for an anomalous effect. The authors interpreted their negative results as “the strongest evidence yet obtained against the existence of paranormal mental phenomena” (Moulton & Kosslyn, 2008). This conclusion was criticized by Palmer (2009). Other fMRI studies, which investigated the influence of a participant’s mental activity on the brain functions of a spatially separated and nonstimulated partner, yielded positive results (Achterberg, Cooke, Richards, Standish, Kozak, & Lake, 2005; Richards, Kozak, Johnson, & Standish, 2005).

The attempt to investigate anomalously modulated physiological responses to presented stimuli may provide advantages compared to the usual method. It involves the possibility of using well-investigated psychophysiological paradigms and developing clear hypotheses about physiological response differences of Participant 2, which are expected in the presence of anomalous interaction between participants.

## The Guilty Knowledge Test

The Guilty Knowledge Test (GKT, also known as the Concealed Information Test) is a well-established experimental paradigm in psychophysiological research. It was developed by Lykken (1959) for detecting guilty knowledge by means of measuring physiological response differences between stimuli with and without particular significance for the participant.

In a variant of the GKT, participants become familiar with different objects by handling them during a mock crime. Thereby, these objects gain particular significance for the participant. Each object belongs to a particular category. Afterwards, pictures of the objects are presented in succession and by category on a computer screen, in combination with four other objects in that category. Thus, each presented category consists of one known object (probe object) and four previously unseen objects (irrelevant objects). Participants are asked whether each object was part of the mock crime or not. The significance of the probe object is enhanced by the instruction to conceal the knowledge of this object during the presentation but to answer all other questions truthfully. Response differences to probe and irrelevant objects are detectable by means of physiological measurement (for a review see Ben-Shakhar & Elaad, 2003; MacLaren, 2001). A memory test is often conducted after the GKT to test participants' memories of the probe objects (e.g., Ambach, Stark, Peper, & Vaitl, 2008).

The *orienting response* (OR) is a basic component of physiological responses in the GKT (e.g., Ben-Shakhar & Elaad, 2002; Gati & Ben-Shakhar, 1990; Lykken, 1974; Verschuere, Crombez, Clercq, & Koster, 2004). The OR is the response of an organism to all perceivable changes in the environment, and was first characterized by Pavlov in 1927 (Sokolov, 1963a). According to Sokolov (1963b), the OR is a unitary reaction consisting of motor and autonomic components (e.g., cardiovascular and skin conductance responses), as well as respiratory changes, and it ensures optimal perception of new stimuli. The OR is modulated by the novelty, significance, and intensity of the stimulus (Lynn, 1966). In the GKT, the particular significance of probe objects is regarded as mainly responsible for the differences in the OR between probe and irrelevant objects (e.g., Barry, 2004; Ben-Shakhar, 1994; Furedy, 2009). The instruction to answer deceptively (i.e., to deny the knowledge about the probe objects) induces a response conflict and a response inhibition for probe objects, and also modulates the physiological responses and the reaction times. Thereby, deceptive answering improves the accuracy of the GKT for detecting concealed information (e.g., Ambach et al., 2008; Ben-Shakhar & Elaad, 2002; Ben-Shakhar & Elaad, 2003; Bradley, MacLaren, & Carle, 1996; Elaad & Ben-Shakhar, 1991; Furedy & Ben-Shakhar, 1991; Vendemia, Buzan, & Simon-Dack, 2005; Verschuere, Crombez, Koster, Van Bockstaele, & De Clercq, 2007).

Typical physiological and behavioral response differences in the GKT between probe and irrelevant objects consist of higher electrodermal response amplitudes, suppressed respiration, decelerated heart rate, reduced pulse amplitudes, and longer reaction times to probe objects (e.g., Gamer, Rill, Vossel, & Gödert, 2006).

### **Aims of the Study**

In this study, we aimed to investigate anomalously modulated physiological responses as an indicator of anomalous interactions between participants. For this purpose, we modified the GKT to investigate participant pairs. At the beginning of the experiment, the partners in each pair were spatially separated. Because the question of the timing of anomalous interactions is still open, the usual timing protocol of GKT studies was retained. First, Participant 1 was confronted with objects (probe objects) in a Mock Task (MT); the MT was expected to create a crisis situation for Participant 1 and therefore induce negative emotional arousal. After Participant 1 completed the MT, Participant 2 was tested for physiological response differences between pictures of the probe and irrelevant objects in a modified GKT (MGKT). This procedure is contrary to most parapsychological studies, which use synchronistic timing.

For every object presentation in the MGKT, Participants 2 were asked whether they were certain that the object was part of the MT. These participants were instructed not to guess, but to answer “yes” only in case of absolute certainty. We expected a low number of “yes” responses, because Participants 2 would not normally be expected to be sure about the probe objects. Hence, in the case of anomalous interactions between participants, we expected response conflict and response inhibition to be apparent subsequent to the presentation of the probe objects.

The standard concluding memory test was designed as a Guessing Task (GT) in order to test participants’ conjectures about the probe objects.

### **Hypotheses**

Assuming anomalous interactions between participants, we expected the following results:

**Physiological analyses.** We hypothesized that the objects in the MT (probe objects) would have particular significance for Participant 2, and the physiological responses to the probe objects would be modulated by this significance. In this case, we expected a typical pattern of response differences: higher electrodermal response amplitudes, suppressed respiration, lower heart rate, and lower pulse activity for probes than for irrelevant objects.

**Behavioral Analyses.** Because of the expected response conflict and inhibition processes, we expected longer reaction times for probe than

for irrelevant objects in the MGKT. On the GT, the hit rate should be above chance.

**Correlation Analyses.** We assumed that participants with a stronger belief in paranormal phenomena, and participant pairs with stronger connectedness, would show stronger physiological response differences in the MGKT, and higher hit rates in the GT, than other participants.

## Method

### Participants

We recruited 52 participant pairs (20 pairs of friends, 29 couples, 3 pairs of siblings; 35 male, 65 female;  $M = 26.45$  years,  $SD = 7.05$ ) via an announcement in the local student job agency (25 pairs) and in a local newspaper (27 pairs). Participants were of reportedly good health, unmedicated, and participated voluntarily in the study for a payment of 24 Euros per pair. Informed consent was obtained from all participants. The data from two pairs had to be discarded because of noncompletion of the experiment.

### Procedure

The experiment consisted of four phases:

**Welcome Phase.** One of two experimenters welcomed the participant pairs to the laboratory. The experimenter informed the participants about the procedure and randomly assigned them to the two experimental tasks. Participant 1 was sent to an office, where a second experimenter, responsible for the MT, was waiting. Participant 2 remained with the first experimenter in the laboratory for the MGKT. Any contact between participants and between the experimenters was prevented until the end of the experiment.

**MT Phase.** After giving informed consent, Participant 1 was instructed about the MT. A training run preceded the main run. Afterwards, the experimenter left the room and Participant 1 started the main run with a key press. After Participant 1 had completed the task, the experimenter signaled the end of the MT to the other experimenter by slipping a blank sheet of paper under the door of the laboratory. Both directly before and after the MT, the emotional state of Participant 1 was assessed by a questionnaire. Additionally, Participant 1 filled in two personality questionnaires. Then, Participant 1 was kept busy with a brain teaser until Participant 2 completed the MGKT. Not until then did Participant 1 complete a questionnaire concerning the connectedness of the pair.

**MGKT Phase.** After giving informed consent, Participant 2 filled in two personality questionnaires and was led into the experimental room. There, the experimenter connected Participant 2 to the recording devices

and handed out written instructions. When the other experimenter signaled the end of the MT, the MGKT was initiated. A training run preceded the two main runs. After completing both main runs, Participant 2 performed the GT. At the end, a questionnaire concerning the connectedness of the pair was administered to Participant 2.

**Information and Closure Phase.** Both experimenters and both participants got together in the laboratory. The experimenters informed the participants of the cover story (see Mock Task) and answered questions about the theoretical background of the study. Finally, the participants received their payment.

Each of the two experimenters was responsible equally often for the MT and for the MGKT.

### **Mock Task**

In an office room, Participant 1 handled seven objects, each belonging to a different object category (e.g., household articles). Participant 1 handled the objects in sequence according to instructions displayed on a computer screen. After the participant had initiated the task by a key press, the sequence started with the instruction to collect a particular object that was located somewhere in the room (e.g., “Please collect the household article from the desk”). Then, the participant was instructed to estimate the weight of the object. The estimate had to be keyed in and feedback of its correctness was given (“correct” or “false”). This sequence was repeated for each object. Only the experimenter responsible for the MT, and Participant 1, knew the identity of the objects.

Each category consisted of five different objects; in each experimental session only one object from each category was presented. The selection of the objects to be presented was pseudo-randomized, so that each object in the category was selected equally often across participants.

The instruction sequence was computer controlled. The time allowed for collection of an object was 20 s. Participants then had 30 s to estimate the weight and a further 5 s to type in their estimate. Each sequence lasted 1.5 min; the duration of the whole task was nearly 10 min.

A cover story was implemented to induce negative emotional arousal and motivation for attentive inspection of the objects. Every “false” feedback was combined with a pretended reduction of the pair’s payment (loss of 1 Euro) and every “correct” feedback meant no such reduction. In fact, participants’ actual estimates did not determine their feedback—every participant received feedback that five responses were “false” and two were “correct.”

### **Modified Guilty Knowledge Test**

In the MGKT, Participant 2 was instructed to identify the objects that had been present in the partner’s task (probe objects).

We adopted the stimulus material, the program, and the experimental design of the MGKT reported by Ambach et al. (2008). Five pictures, including the probe object and four irrelevant objects from the same category that were not presented in the MT, were shown on the screen in sequence. To eliminate sequential effects, the order of the objects within each category and the position of the probe object within each category were pseudo-randomized for each run and balanced across participants. Participant 2 was told that some of the presented objects were part of the partner's task, but not how many.

Each picture was presented together with a question, which was simultaneously displayed above the picture and related to the MT (e.g., "Are you sure that this household article was present?"). Participants were instructed not to guess, but to answer "yes" only if they were absolutely certain about the presentation of the object in the MT.

Preceding each category, two neutral objects were presented as distractors. The neutral questions referred to everyday objects that had to be identified (e.g., "Is this a yellow flower?"). Participants had to answer one of the two neutral questions correctly with "yes" and the other correctly with "no" (using a pseudo-randomized sequence of "yes" and "no" answers). The correctness of the responses to these neutral questions was evaluated as a clue for the compliance of the participants. The presentation of five category-related objects and two neutral objects for each of the seven object categories resulted in a total of 49 object presentations per run; the total experiment consisted of two runs.

Questions and object pictures were presented to Participant 2 foveally on a 19-in. monitor at a distance of 90 cm for 10 s, followed by a blank screen for equally distributed 5.0–7.5-s intervals. Picture size was  $6.0^\circ \times 8.0^\circ$  of the visual angle.

Two indication fields containing question marks appeared with a delay of 4 s after a question was asked; this prompted participants to answer. They had to answer as quickly as possible, both by pressing one of the two response keys and by responding vocally with "yes" or "no." Key assignment was balanced across participants. Following the answer, the given "yes" or "no" replaced the question marks and remained visible on the screen for as long as the object question was presented.

### **Guessing Task**

In the concluding GT, all five pictures in each category were presented simultaneously on the screen. Participant 2 was now informed that one object in each category had been part of the partner's task. He or she was asked to guess which object among the five this was. The objects were numbered from "1" to "5" and participants responded by pressing a number on a numeric keypad.



## **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 so that they could see the monitor and reach the keyboard comfortably.

Skin conductance, 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, Washington). The A/D-converting resolution was 14 bit, allowing skin conductance to be measured with a resolution of 0.01  $\mu$ S. All data were sampled with 510 Hz. Triggers indicating stimulus onsets were registered with the same sampling frequency.

For skin conductance recordings, 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 volts was used. The electrodes were affixed at 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, California) with built-in length-dependent electrical resistance were used. They were fixated at the upper thorax and the abdomen.

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

Finger pulse signal was transmitted by an infrared system in a cuff around the middle finger of the nondominant hand.

## **Behavioral Measures**

During the MGKT, participants responded both with “yes” or “no” by key presses and with verbal expressions (the latter were not analyzed further). During the GT, participants responded with “1” to “5” by key press. The key presses were time-logged and stored on the stimulus-presenting computer for later evaluation of reaction times in the MGKT and hit rate in the GT.

## **Questionnaires**

Participants’ paranormal beliefs were recorded via the Paranormal Conviction Scale (PCS; Schriever, 1998/1999, 2000), which is in the German language and based on the Paranormal Belief Scale (Tobacyk, 1991; Tobacyk & Milford, 1983). Participants’ exceptional experiences were recorded by means of an unpublished scale from our laboratory (results of the scale are not reported). Only the questionnaires completed by Participants 2 were analyzed.

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 assessed by averaging the QER scores of both partners.

For analyzing the influence of the MT on participants' emotional state and emotional arousal, the Self-Assessment Manikin (SAM; Bradley & Lang, 1994) was filled in both before and after the MT. The SAM consists of the scales Emotional Valence ("Valence"), Emotional Arousal ("Arousal"), and Feeling of Dominance ("Dominance").

### **Data Reduction**

All neutral objects and the first irrelevant object of each category were buffer items and therefore discarded from analyses. In addition, trials with a missing key press within the time-window provided for answering (2.5 s) were discarded. For 50 participant pairs, this resulted in 2,654 valid trials for physiological analyses and analysis of reaction times.

Data from two participants had to be discarded from the heart rate (HR) analysis, one because of technical artifacts and the other because of extrasystoles. HR data were notch-filtered at 50 Hz; R-wave peaks were automatically detected and visually controlled. The R-R intervals were transformed into HR, and real-time scaled (Velden & Wölk, 1987). Phasic heart rate (pHR) was calculated by subtracting a baseline (average of three s before stimulus onset) from each of 10 second-per-second post-stimulus values.

Respiratory data were low-pass filtered and the respiration line length (RLL) was computed automatically over a time interval of 10 s after trial onset for breast (RLL\_breast) and abdominal respiration (RLL\_abd). The RLL measure integrates information about frequency and depth of respiration. The method has been derived from Timm (1982) and modified by Kircher and Raskin (2003). Data from two participants had to be discarded because of technical artifacts.

The finger pulse waveform length (FPWL) within the first 10 s after trial onset was calculated from the finger pulse waveform and then subjected to further analyses (Elaad, & Ben-Shakhar, 2006). The FPWL comprises information about HR and pulse amplitude.

Data from four participants had to be discarded from the skin conductance analysis because of electrodermal hyporesponding ( $\geq 90\%$  nonresponses). Skin conductance reactions were assessed by a computerized method (LEDALAB, Version 3.2.3) based on decomposition of overlapping reactions by means of nonnegative deconvolution (Benedek & Kaernbach, 2010). The sums of the EDA amplitudes within the time window after stimulus onset (0.5–4.5 s) were additively combined to form a first response (EDA\_1). The sum of the EDA responses between 4.5 and 8.5 s after stimulus onset (i.e., 0.5–4.5 s after the participants were prompted to answer) was calculated as the second response (EDA\_2).

Lykken and Venables (1971) proposed a within-subject standardization of measured values. Here, according to Ben-Shakhar (1985), EDA, RLL, pHR, FPWL, and RT were *z*-transformed for each participant. The responses of all trials with probe and irrelevant items of a 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, Illinois).

For each physiological measure as well as for reaction times, a *t* test for matched samples was conducted (one-tailed,  $\alpha = .05$ ). Cohen's *d* was calculated as an effect size estimate according to Cohen, 1988 (2nd edition, p. 48, formulas 2.3.5 and 2.3.6).

For analyzing the hit rate in the GT, a binomial test for proportions was performed (one-tailed,  $\alpha = .05$ ).

Pearson product-moment correlation analyses were conducted between scores on the questionnaires and *z*-score differences between probe and irrelevant objects (physiological measures and RTs) as well as the number of hits in the GT. Correlation coefficients were tested for statistical significance (two-tailed,  $\alpha = .05$ ).

Participants' scores on the SAM before and after the MT were analyzed by means of paired *t* tests (two-tailed,  $\alpha = .05$ ).

## **Results**

### **Physiological Analysis**

In case of anomalous interaction between participants, probe objects should have obtained significance for Participant 2. If so, we expected particular physiological response differences between probe and irrelevant objects. These differences should have consisted of higher averages on EDA\_1 and EDA\_2, and lower averages on RLL, pHR, and FPWL for probe than for irrelevant objects. This hypothesized systematic pattern of physiological response differences was not found: For probe objects, the averages for EDA\_1, EDA\_2, and RLL\_breast tended to be lower than for irrelevant objects. The averages of RLL\_abd, pHR, and FPWL tended to be higher for probe than for irrelevant objects (Table 1).

For each physiological channel, a *t* test for paired measures (one-tailed) was conducted (assessed via *z* values). None of the tests revealed a significant difference in physiological reactions to probe versus irrelevant objects (Table 2).

Table 1  
*Descriptive Statistics of Raw Scores for Each Physiological Data Channel  
 for Probe and Irrelevant Objects*

	Probe objects		Irrelevant objects	
	<i>M</i>	<i>SEM</i>	<i>M</i>	<i>SEM</i>
EDA_1 [nS]	157	19	173	23
EDA_2 [nS]	256	33	264	31
RLL_breast [arb. units]	1668	119	1678	115
RLL_abd [arb. units]	2618	250	2613	251
pHR [1/min]	1.28	0.27	1.09	0.19
FPWL [arb. units]	178	150	176	142

*Note.* *M* = Means; *SEM* = Standard error of means; EDA\_1 = First electrodermal response; EDA\_2 = Second electrodermal response; RLL\_breast = Breast respiration line length; RLL\_abd = Abdominal respiration line length; pHR = Phasic heart rate; FPWL = Finger pulse waveform length.

Table 2  
*Calculated *t* Values, *p* Values, and Effect Sizes for the Differential Responses  
 to Probe versus Irrelevant Objects*

	<i>t</i> ( <i>df</i> )	<i>p</i>	Effect size ( <i>d</i> )
EDA_1	-0.36 (45)	.641	-0.054
EDA_2	-0.71 (45)	.759	-0.105
RLL_breast	-0.67 (47)	.252	-0.097
RLL_abd	0.55 (47)	.706	0.079
pHR	0.90 (47)	.813	0.130
FPWL	0.97 (49)	.831	0.137

*Note.* *df* = Degrees of freedom; *d* = Cohen's *d*; EDA\_1 = First electrodermal response; EDA\_2 = Second electrodermal response; RLL\_breast = Breast respiration line length; RLL\_abd = Abdominal respiration line length; pHR = Phasic heart rate; FPWL = Finger pulse waveform length.

### **Behavioral Analysis**

We hypothesized that reaction times in the MGKT would be longer for probe than for irrelevant objects in the case of anomalous interactions

between participants. Hit rates in the subsequent GT were expected to be above chance.

Analysis of reaction times revealed no differences between probe ( $M = 803.73$ ,  $SEM = 238.9$  ms), and irrelevant objects ( $M = 805.66$ ,  $SEM = 198.47$  ms),  $t(49) = -0.82$ ,  $p = .415$ ,  $d = -0.116$ .

The number of hits in the GT, averaged across participants, was  $M = 1.42$ ,  $SD = 1.11$ . In 350 trials, 71 hits occurred. This proportion is at chance level (expected proportion = .20, sample proportion = .203,  $z = 0.13$ ,  $p = .894$ ).

**Correlation Analyses**

We tested whether the degree of paranormal belief and the connectedness of the participants were correlated with physiological and behavioral response differences between probe and irrelevant objects. Table 3 shows the results of the correlation analyses. The response difference of pHR between probe and irrelevant objects correlated significantly with the scores on the PCS,  $r(46) = .32$ ,  $p = .028$ . No other correlation occurred (Table 3).

Table 3  
Correlations Between Scores on Questionnaires and Response Differences to Probe versus Irrelevant Objects as Well as Hit Rates in the GT

	PCS		QER	
	<i>r</i> ( <i>df</i> )	<i>p</i>	<i>r</i> ( <i>df</i> )	<i>p</i>
dEDA_1	.16 (44)	.366	.01 (44)	.945
dEDA_2	-.27 (44)	.075	.15 (44)	.323
dRLL_breast	-.05 (46)	.746	.05 (46)	.717
dRLL_abd	-.04 (46)	.794	.06 (46)	.667
dpHR	.32 (46)	.028	-.16 (46)	.288
dFPWL	.07 (48)	.628	.05 (48)	.745
dRT	.17 (48)	.235	.09 (48)	.547
GT	.03 (48)	.817	.10 (48)	.503

*Note.* PCS = Paranormal Conviction Scale; QER = Questionnaire on the Evaluation of Relationships; *r* = Pearson product-moment correlation; *df* = Degrees of freedom; EDA\_1 = First electrodermal response; EDA\_2 = Second electrodermal response; RLL\_breast = Breast respiration line length; RLL\_abd = Abdominal respiration line length; pHR = Phasic heart rate; FPWL = Finger pulse waveform length; GT = Guessing Task.

### Analysis of the Influence of the MT

We expected the MT to influence the emotional state and the emotional arousal of Participants 1. Table 4 shows the averaged scores of the SAM before and after the MT. For each scale the mean score was lower after the MT. The difference was significant for the scales Valence,  $t(49) = 5.83$ ,  $p < .001$ , and Dominance,  $t(49) = 2.76$ ,  $p = .004$ , but not for Arousal,  $t(49) = 0.60$ ,  $p = .299$ .

Table 4  
*Descriptive Statistics for the Valence, Arousal, and Dominance Scales of the SAM Before and After the MT*

	Before MT		After MT	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Valence	7.08	1.28	5.72	1.96
Arousal	4.66	1.86	4.50	2.02
Dominance	5.54	1.30	5.04	1.55

*Note.* MT = Mock task; *M* = Means; *SD* = Standard deviation.

### Exploratory Analyses of the MGKT

Contrary to our expectations, a high number of “yes” answers occurred in the MGKT. This enabled an exploratory analysis of decision behavior. Of the 50 participants, 34 answered “yes” in at least one trial,  $M = 14.3$ ,  $SD = 13.77$ , and 16 answered all trials with “no.” Overall, a “yes” answer was given in 20.6% (715) of all answered trials (3,474). “Yes” answers were associated with 140 hits (19.6%). This hit rate is near the chance level of guessing for one object among five (20%).

Exploratory correlation analyses were conducted between the scores on the questionnaires (QER, PCS) and the numbers of “yes” answers. The number of “yes” answers was positively and significantly correlated with scores on the PCS,  $r(48) = .43$ ,  $p = .002$ . No significant correlation was found between the numbers of “yes” answers and scores on the QER,  $r(48) = -.25$ ,  $p = .083$ .

### Discussion

The present study was aimed at investigating anomalously modulated physiological responses as an indicator of anomalous interactions between participants. To that end, we conducted a modification of the GKT.

In the experiment, one partner (Participant 1) was confronted with objects of different object categories in the MT. Therefore, these objects gained particular significance for the participant. Afterwards, the spatially separated partner (Participant 2) was confronted with pictures of these objects (probe) and of other objects of the same object categories (irrelevant). Physiological and behavioral response differences of Participant 2 between probe and irrelevant objects were analyzed.

### **Anomalous Modulated Physiological Responses**

We hypothesized that if there were anomalous interactions between participants, probe objects would have particular significance for Participant 2. Therefore, physiological responses to probe objects should be modulated by this significance, in contrast to responses to irrelevant objects. We expected the response differences to be qualitatively similar to the typical response differences in the GKT, consisting of higher electrodermal response amplitudes, suppressed respiration, decelerated heart rate, and lower pulse amplitudes to probe than to irrelevant items (Gamer et al., 2006). This hypothesized pattern of response differences was not found in the present study. In fact, no evidence for any systematic deviation of the physiological response differences among the physiological measures from a random pattern was found.

The typical GKT is a sensitive instrument for detecting particular physiological response differences between objects with and without particular significance, usually resulting in high effect sizes (Cohen's *d*)—around 2 for EDA or phasic HR (e.g., Ambach et al., 2008; Ben-Shakhar & Elaad, 2003). In contrast, in the present study, effect sizes were small (Cohen, 1988) and all response differences were nonsignificant. Accordingly, physiological analyses found no evidence for anomalously modulated physiological responses.

### **Behavioral Indicators for Anomalous Interaction**

Reaction times in the MGKT did not differ between probe and irrelevant objects. Apparently, probe objects did not evoke response conflict or inhibition, as we expected in case of enhanced significance of these objects for Participant 2.

In the GT, the number of correct choices was at chance level. Hence, we found no evidence for conscious knowledge of Participant 2 about the probe objects.

### **Influence of Moderator Variables on Participants' Performance**

For investigating the influence of participants' paranormal beliefs on their performance in the MGKT, we performed a correlation analysis

between scores on the paranormal belief scale and physiological response differences between the probe and irrelevant objects. Only the difference in pHR correlated significantly with the degree of paranormal belief. However, this result has to be interpreted cautiously because no alpha-correction for multiple testing was performed. No correlation occurred between the degree of paranormal belief and participants' hit rates in the GT.

The connectedness between participants was not correlated with physiological response differences or with hit rate in the GT.

Based on these results, we could not confirm our expectation of better performance in participants with stronger belief in paranormal phenomena or of participant pairs with closer emotional relationships.

### **Decision Behavior in the MGKT**

An unexpected finding concerned the high number of "yes" answers during the MGKT. Despite the instruction to answer with "yes" only in case of absolute sureness, two-thirds of the participants answered at least once with "yes"; the number ranged from 1 to 47 times. However, the hit rate for the "yes" answers was at chance level.

Earlier studies investigated cognitive biases as possible explanations for the behavior of participants with high scores on paranormal belief scales in parapsychological experiments. For example, Blackmore and Troscianko (1985) found that people with strong paranormal belief tend to underestimate the likelihood of coincidence, which is then interpreted as a paranormal event. Schienle, Vaitl, and Stark (1996) investigated the covariation bias in people with paranormal belief during a telepathy experiment. The covariation bias describes the tendency of people to estimate the co-occurrence of events in line with their belief about the covariation of these events. The authors found an overestimation of the number of successful telepathic transmissions for believers, whereas skeptics gave accurate estimates. In the present study, exploratory analyses revealed a positive and significant correlation between the number of "yes" answers and scores on the Paranormal Conviction Scale. Possibly, this result revealed the tendency of participants to confirm their conviction about the existence of paranormal phenomena. This confirmation bias may be due to cognitive dissonance produced by a contradiction between the instruction and participants' paranormal belief. Therefore, participants behaved in line with their subjective hypotheses rather than in line with the instructions.

### **Methodological Remarks**

Four methodical aspects could have negatively influenced the results of the present study.

The first aspect refers to possible weak points in the instructions for Participant 2. These participants did not respond consistently with "no"



as expected. Therefore, it is debatable whether the instruction to answer only with “yes” in case of absolute certitude was adequate to evoke response conflicts and processes of inhibition.

It is also imaginable that some participants were confused about this instruction because it suggests the possibility of being absolutely sure about probe objects. In particular, this could be the case for participants with rather weak beliefs in paranormal phenomena. Therefore, it is debatable whether all participants took the experiment seriously and were as motivated as possible, although we have no hints of a lack of compliance. Evidence for good compliance during the MGKT can be taken from the percentage of correct answers for the neutral questions. In the MGKT, two neutral questions preceded each category, whereof one had to be answered correctly with “no” and the other correctly with “yes” (see Modified Guilty Knowledge Test). The percentage of correctly answered neutral questions was 98%. The percentage of answered questions among all trials (neutral, irrelevant, and probe trials), which was 99%, provides further evidence for good compliance.

A further weak point refers to the exploratory analyses of the physiological data, which revealed significantly higher electrodermal activity for “yes” than for “no” answers. Therefore, physiological response differences between “yes” and “no” answers and between probe and irrelevant objects were confounded. However, “yes” and “no” answers were equally distributed for probe and irrelevant items in the present study (20% to 80%). Hence, it can be concluded that this issue did not affect the physiological analyses. Future studies should overcome these weak points in the instructions. One possible solution could be to attempt to conduct the MGKT without a question during the object presentation. In GKT studies without behavioral measures of the participants, differences in physiological responses between probe and irrelevant items were nonetheless statistically significant (Ben-Shakhar & Elaad, 2003).

The second methodical aspect refers to the timing of the experimental procedure. According to the usual GKT procedure and to the fact that the question of the timing of anomalous interactions is still open, a nonsynchronistic variant was used: One partner was confronted with objects and thereafter the other partner was investigated by means of physiological measures. This procedure is rather unusual in parapsychological research. Most studies investigating participant pairs focus on physiological responses of the nonstimulated participant that occurred at the same time as the stimulation of the partner. Thus, the timing characteristic of the present study could have been inadequate for measuring an anomalous effect. Therefore, we suggest synchronistic timing of the experimental procedure for future studies. The computer-controlled instructions of the MT could be synchronized category-wise with the presentation of the objects in the MGKT, so that Participant 1 handles one particular object at the same time as Participant 2 is presented all objects in the particular object category. For example, while

Participant 1 handles one particular household article, all household articles of the category are presented in succession to Participant 2.

The third methodical aspect refers to the influence of the event on the emotional state and emotional arousal of participants. The importance of events causing negative emotional arousal was confirmed in a few studies that analyzed reports of spontaneous cases (e.g., Rhine, 1978; Stevenson, 1971). Experimental parapsychology attempted to heighten the ecological validity of experiments by using emotional stimuli such as IAPS pictures (e.g., Moulton & Kosslyn, 2008; Ramakers, 2008). Because the aim of the GKT is to measure the modulation of orienting responses by their significance to the participant, all objects have to be neutral in emotionality and similar in initial significance. Probe objects should not have particular significance for Participant 1 until the MT. Therefore, we tried to evoke emotional arousal by implementing the MT with a difficult task and a pretended monetary loss for both participants. The influence of the MT on participants' emotional state and arousal was measured via the SAM. Results showed a significant reduction of participants' emotional valence in the direction of reduced happiness and a reduction of feeling of dominance during the MT. These results seem plausible; the reduction of participants' emotional valence could be explained by the pretended loss of payment. Participants' feelings of dominance were presumably reduced due to the predetermined feedback. However, reductions on both scales were small and the mean scores did not fall below the medians of the scales. Moreover, participants' arousal was not increased during the task and the mean scores fell slightly below the median of the scale before and after the MT. If a high level of emotional arousal is a necessary condition for the occurrence of anomalous interactions between participants, it is debatable whether the MT is an adequate method to achieve this condition. For future research, we suggest enhancing the emotional load of the task, for example, by implementing a real (not cover) story and by increasing the impact of the performance of Participant 1 on the monetary gain or loss of both participants. Further, the feedback during the MT could be dropped to evoke a greater feeling of uncertainty in Participant 1 during the entire task. So, if Participant 1 feels more responsible for the gain or loss of his or her partner, if this participant's performance is more important than in the present study, and if Participant 1 is more uncertain about his or her performance, all this could evoke enhanced emotional arousal in Participant 1 during the MT.

The fourth methodical aspect refers to the *experimenter effect*, that is, an experimenter influences a participant's behavior and score according to his or her expectancies through his or her own behavior (Rosenthal & Rubin, 1978). The present study was conducted double-blind to avoid this bias. The experimenter responsible for the MGKT did not know the particular probe objects, and the experimenter responsible for the MT did not have any contact with Participant 2 and with the other experimenter

until the end of each experimental session. Parapsychological research raised the question of a *parapsychological experimenter effect*, that is, the data of an experiment partially dependent on the influence of paranormal abilities of the experimenter. The unintentional use of these abilities depends on the experimenters' needs, wishes, expectancies, and moods (e.g., Kennedy & Taddonio, 1976). In the present study, nothing was known about the paranormal abilities of the experimenters and they were not tested for their paranormal belief, needs, and wishes to get a positive or negative result. Therefore, the influence of a possible parapsychological experimenter effect is unknown in this study.

### Conclusions

The present study failed to find anomalously modulated physiological responses or other indicators of anomalous interactions between participants. Nevertheless, the present method seems promising for future research. Behavioral (e.g., reaction times and decision behavior) as well as physiological variables were analyzed and interpreted on the basis of clear hypotheses about the effects that should occur if there are anomalous interactions between participants. Some methodological adaptations are suggested for future studies. First, the weak points of the instruction for Participant 2 have to be overcome. In particular, the prevention of an unequal distribution of "yes" and "no" answers for probe and irrelevant objects would be desirable to overcome the confounding of physiological response differences between answers. Second, the timing of the experimental procedure could be changed to a synchronistic variant, which is more in line with parapsychological research on anomalous interactions between participants. Third, the influence of the experimental procedure on participants' emotional arousal should be increased. Fourth, the influence of the parapsychological experimenter effect on the data could be tested. Taking into account these suggestions, the attempt of investigating anomalously modulated physiological responses (to presented stimuli) as indicators of anomalous interactions between participants should be continued.

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### **Abstracts in Other Languages**

#### *Spanish*

#### **¿REVELA UNA PRUEBA MODIFICADA DE CONOCIMIENTO CULPABLE INTERACCIONES ANÓMALA EN PARES DE PARTICIPANTES?**

**RESUMEN:** Este estudio tuvo como objetivo investigar respuestas fisiológicas anormalmente modulada como un indicador de las interacciones anómalas entre parejas vinculadas emocionalmente. Con este fin, usé una versión modificada de la Prueba de Conocimiento Culpable. En este experimento, las parejas fueron separadas espacialmente. Le presenté a uno de los miembros de la pareja (Participante 1) objetos específicos para que adquirieran una importancia especial para el participante. Evalué las diferencias en las respuestas fisiológicas del otro miembro (Participante 2) a imágenes de objetos presentados al Participante 1 y a objetos no presentados (objetos irrelevantes). En el caso de una interacción anómala entre los participantes, esperaba que la importancia especial de los objetos presentados al Participante 1 modularía las respuestas fisiológicas del participante 2. Las variables fisiológicas consistieron en la actividad electrodérmica, tasa cardíaca, actividad respiratoria, y pulso. Las variables de conducta consistieron en los tiempos de reacción y la tasa de aciertos al adivinar el objetivo. Evalué las creencias paranormales y la conexión entre los participantes a través de cuestionarios, como posibles moderadores para el desempeño de los participantes 2. Analicé las correlaciones entre las puntuaciones al cuestionario y fisiológicas, así como las variables de conducta. En general, los análisis no revelaron respuestas fisiológicas moduladas anormalmente u otros indicadores de interacción anómala entre los participantes. Discuto observaciones metodológicas e implicaciones para futuros estudios.

#### *French*

#### **EST-CE QU'UN TEST MODIFIE DE CONNAISSANCE DE CULPABILITE PEUT REVELER DES INTERACTIONS ANOMALES ENTRE DES PAIRES DE PARTICIPANTS ?**

**RESUME :** Cette étude tente d'étudier des réactions anormales modulées physiologiquement en tant qu'indicateur d'interactions anormales entre des partenaires émotionnellement liés. Pour ce faire, nous utilisons une version modifiée du Test de connaissance de culpabilité. Dans cette expérience, les



partenaires étaient séparés spatialement. L'un des partenaires (Participant 1) était confronté avec des objets-sondes tels que ces objets acquéraient une signification particulière pour le Participant 1. L'autre partenaire (Participant 2) était étudié pour ses différences dans ses réactions physiologiques à des images des objets-sondes et à des images d'objets auxquelles le Participant 1 n'avait pas été confronté (objets sans importance). Dans le cas d'une interaction anormale entre les participants, on s'attend à ce que la signification particulière des objets-sondes module les réactions physiologiques du Participant 2. Les variables physiologiques étaient l'activité électrodermale, la fréquence cardiaque, l'activité respiratoire et le pouls. Les variables comportementales étaient les temps de réaction et le taux de succès dans la tâche de divination. Les croyances paranormales et la connectivité des participants furent évaluées via des questionnaires, en tant que possibles modérateurs pour la performance du Participant 2. Les corrélations entre les scores au questionnaire et les variables physiologiques ainsi que comportementales furent analysées. Globalement, les analyses révélaient aucune réaction anormale modulée physiologiquement ou d'autres indicateurs d'interactions anormales entre les participants. Les remarques et implications méthodologiques pour d'autres études sont discutées.

*German*

#### EIGNET SICH EIN MODIFIZIERTER TATWISSENTEST ZUR AUFDECKUNG ANOMALER INTERAKTIONEN ZWISCHEN PARTNERN VON PROBANDENPAAREN?

**ZUSAMMENFASSUNG:** Ziel dieser Studie war die Untersuchung anomal modulierter physiologischer Reaktionen als Indikator für anomale Interaktionen zwischen emotional verbundenen Partnern. Dazu verwendeten wir eine modifizierte Form des Tatwissentests. Einer von zwei räumlich getrennten Partnern (Proband 1) wurde mit Objekten (relevante Objekte) konfrontiert, so dass diese Objekte eine besondere Bedeutung für Proband 1 bekamen. Danach wurde der andere Partner (Proband 2) auf physiologische Reaktionsunterschiede zwischen Bildern von relevanten Objekten und Bildern von Objekten, mit denen Proband 1 nicht konfrontiert wurde (irrelevante Objekte), untersucht. Im Falle einer anomalen Interaktion zwischen den Partnern erwarteten wir, dass die besondere Bedeutung der relevanten Objekte für Proband 1 die physiologischen Reaktionen von Proband 2 verändert. Elektrodermale Aktivität, Herzrate, Atemaktivität und Pulsaktivität wurden untersucht. Als Verhaltensdaten dienten Reaktionszeiten sowie Trefferquoten in einer Rateaufgabe. Der Glaube an paranormale Phänomene und die Verbundenheit der Probanden wurden als mögliche Moderatorvariablen für das Abschneiden von Proband 2 mittels Fragebögen gemessen. Zusammenhänge von Fragebogenwerten mit physiologischen Daten sowie mit Verhaltensdaten wurden untersucht. Es zeigten sich keine anomal modulierten physiologischen Reaktionen oder andere

Indikatoren für anomale Interaktionen zwischen den Probanden. Methodische Anmerkungen und Implikationen für zukünftige Studien werden diskutiert.