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An interfering Go/No-go task does not affect accuracy in a Concealed Information Test

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Abstract

Following the idea that response inhibition processes play a central role in concealing information, the present study investigated the influence of a Go/No-go task as an interfering mental activity, performed parallel to the Concealed Information Test (CIT), on the detectability of concealed information.

40 undergraduate students participated in a mock-crime experiment and simultaneously performed a CIT and a Go/No-go task. Electrodermal activity (EDA), respiration line length (RLL), heart rate (HR) and finger pulse waveform length (FPWL) were registered. Reaction times were recorded as behavioral measures in the Go/No-go task as well as in the CIT. As a within-subject control condition, the CIT was also applied without an additional task.

The parallel task did not influence the mean differences of the physiological measures of the mock-crime-related probe and the irrelevant items. This finding might possibly be due to the fact that the applied parallel task induced a tonic rather than a phasic mental activity, which did not influence differential responding to CIT items. No physiological evidence for an interaction between the parallel task and sub-processes of deception (e.g. inhibition) was found. Subjects' performance in the Go/No-go parallel task did not contribute to the detection of concealed information. Generalizability needs further investigations of different variations of the parallel task.

Key Words

Concealed Information Test; Go/No-go task; Interference task; Countermeasures

Introduction

'Lie detection' and the Concealed Information Test

The application of psychophysiological measures for the detection of concealed information varies strongly between countries, and its value in the area of forensic sciences strongly depends on the reliability of the test. Validity is the crucial point in the discussion about the detection of 'guilty' knowledge using psychophysiological measures. Here, the risk of false-positive outcomes as well as the intentional distortion of results are important issues. Throughout the history of polygraphy and lie detection, interview techniques as well as the simultaneous recordings of several physiological measures have been improved (Lykken, 1998).

The Concealed Knowledge Test (CIT), originally called Guilty Knowledge Test, by Lykken (1959), is a systematic and standardized type of interrogation, which is combined with a simultaneous measurement of several physiological data channels. In comparison to the still influential Control Question Test (CQT), originally by Reid (1947), the CIT is more frequently used in research because it includes 'control' conditions in a more scientific sense (Furedy, 1996; Myers and Arbuthnot, 1997; Fiedler et al., 2002; Ben-Shakhar, 2002; Ben-Shakhar and Elaad, 2003).

Theoretically, the CIT is predominantly based on the orienting reflex; this is empirically supported (Lykken, 1974; Gati and Ben-Shakhar, 1990; Ben-Shakhar and Elaad, 2002; Verschuere et al., 2004; Verschuere et al., 2005). The relevance, accuracy and validity of different physiological measures for the detection of concealed knowledge are still a matter of ongoing research (see Elaad et al., 1992; Elaad and Ben-Shakhar, 2006). A typical investigation procedure includes the continuous collection of physiological data such as electrodermal activity (EDA), electrocardiogram (ECG), breathing activity, and finger plethysmogram. In addition, bodily movements and a subject's voice may be registered.

The CIT compares a subject's physiological responses towards a number of crime-relevant yes-or-no questions (for a review, see Elaad, 1998; Ben-Shakhar and Elaad, 2002; Carmel et al., 2003). Each *'probe'* item of a crime-relevant question is combined with four or five *'irrelevant'* items of the same category (e.g. keys, tools), resulting in a block of five to six questions for each category. These questions are presented blockwise with the *probe* item never being presented first; additionally, the first item of each block is discarded from evaluation. It is assumed that only a person with specific knowledge will distinguish between *probe* and *irrelevant* items. This distinction will be reflected by physiological measures even when the subject is trying to conceal his or her crucial knowledge. Subjects possessing the critical knowledge will tend to show the largest response within a block to the *probe* item. In contrast, for a person without specific knowledge, a random pattern of response measures is expected to occur without a preference for either the *probe* or the *irrelevant* items. If a CIT comprises six or seven blocks of questions, the presence or absence of concealed knowledge can be assessed with considerable accuracy.

Psychophysiological measurement in the Concealed Information Test (CIT) has been shown to result in relatively high correct-classification rates for guilty and not-guilty subjects (for meta-analyses on the accuracy of the CIT, see MacLaren, 2001 and Ben-Shakhar and Elaad, 2003).

Interfering mental activity

The influence of additional mental efforts on the detection of concealed information has mainly been studied in the context of mental countermeasures. The majority of guilty subjects investigated in forensic settings for example are highly motivated to keep their knowledge concealed. They might therefore attempt to distort the test by physical or mental countermeasures. In general, attempts to suppress autonomic responses to critical (*probe*) items have only a slim chance of success, yet, the application of countermeasures during *irrelevant* trials has previously been shown to lead to a distortion of the test by increasing autonomic arousal in these trials (e.g. Lykken, 1998; Ben-Shakhar and Dolev, 1996).

Distracting mental strategies include thinking exciting thoughts, imagery, arithmetic calculations, relaxation, or focusing attention on an irrelevant issue. Considerable distorting effects of mental countermeasures on the detection of concealed knowledge in a CIT have been reported by Honts et al. (1996) and Ben-Shakhar and Dolev (1996). Besides the selective application of countermeasures during *irrelevant* trials, additional tasks continuously demanding attention throughout the entire test have been studied. The latter tended to decrease CIT accuracy but were less effective than the voluntary enhancement of phasic responses to *irrelevant* items (Elaad and Ben-Shakhar, 1991; Ben-Shakhar and Dolev, 1996).

However, additional tasks during a CIT have also been used for a different purpose. Here, the additional task was introduced in order to compare the individual mean *probe* response with the individual mean *target* response. These studies used '*target*' items to which the subjects had to give an answer, typically 'yes'; this answer had to be different from the answer given to the *probe* and *irrelevant* items, typically 'no' (Farwell and Donchin, 1991; Ben-Shakhar et al., 1999; Rosenfeld, 2002). In these studies, it was not a question of task interference but of individual standardization of physiological responses, which had motivated the application of the additional task.

Generally, the effects of an additional mental task on CIT accuracy depend on the affected sub-processes when concealing information. Therefore, the effects of additional mental processes on CIT accuracy can be used to explain the sub-processes involved in concealing information, and vice versa. A recent conceptualization of deception proposes the involvement of attention, memory, emotion, response selection, and motor responses (Vendemia et al., 2005a; Vendemia et al., 2005b). Concerning response selection, neuroimaging studies suggest that the truthful answer is prepotent and that inhibition of this answer is necessary for deception (Spence et al., 2001; Langleben et al., 2002; Spence et al., 2004; Nunez et al., 2005). Although a deceptive answer is neither a necessary nor a sufficient condition for physiological detection of concealed information, it has been shown that deceptive answering improves CIT accuracy (Bradley et al., 1996; Furedy and Ben-Shakhar, 1991; Elaad and Ben-Shakhar, 1991). Therefore it seems promising to study the effects of procedures influencing sub-processes of deception on CIT accuracy.

Aim of the present study

The present study was designed to investigate the influence of interfering mental activity on the accuracy of a CIT. A Go/No-go task had to be performed simultaneously with the CIT. Go/No-go or stop signal tasks are commonly used to investigate processes of selective attention or response inhibition (Oosterlaan et al., 1998; Aron et al., 2004). Therefore the mental processes (attention, stimulus discrimination, response conflict, and response inhibition) evoked by the parallel task were expected to interfere with the ongoing processes in a CIT. As Verschuere et al. (2007) concluded it seems promising to study the role of inhibitory processes in a CIT using an experimental manipulation of inhibitory processes. To our knowledge no previous CIT study has used an additional task with the intention to interfere with sub-processes of deception, especially with response inhibition.

Any parallel task will most likely distract attention from the CIT and decrease its accuracy, as continuous countermeasures do (Elaad and Ben-Shakhar, 1991). Yet, if the parallel task interferes with sub-processes of deception, then more mental resources should be required when concealing the relevant information. This is expected to enhance the differential physiological responding to *probe* items in contrast to *irrelevant* items. The research question, as to which of these two opposing effects would prevail, motivated the study.

Another research question addresses the issue of whether the performance measures (reaction times and error rates) in the Go/No-go task, for *probe* and *irrelevant* CIT trials, provide additional information that could improve CIT accuracy. Concealing knowledge in *probe* trials might, more than truthful responding to *irrelevant* items, shift attention from the parallel task towards the CIT and, thereby, worsen performance in the additional task during these trials.

Materials and Methods

Subjects

Forty undergraduate students (28 m, 12 f; mean age 23.4 ± 3.4 years, 38 right-handed), voluntarily participated in the study for course credit and an additional incentive of 3 Euros. Informed consent was obtained from all subjects.

Mock crime scenario

In a shielded room, subjects had to handle seven objects according to the following task list: they had to lift a key with a pendant out of a small box which was hidden inside a soft-toy. With this key, they had to open a money case and take out an envelope which contained three Euros. They had to then put the money back into the envelope and hand it over to the second experimenter who kept it until the end of the experiment. They were told that they would receive the money at the end of the experiment given that their knowledge about the objects and their experiences in the shielded room would not be detected in a polygraph examination.

Concealed Information Test

We used a variant of the CIT consisting of seven *'scenario-related'* and four '*neutral*' categories, each comprising five questions with item presentations.

Questions and item pictures were presented on a 19'' monitor at a distance of 90 cm for 10.0 seconds, followed by a blank screen for equally distributed 5.0–7.5 second intervals. Picture size was 4.5° by 6° visual angle.

Seven *scenario-related* questions (e.g. 'Did you see this object in the deed room?') referred to the seven objects known from the mock crime: the soft-toy, its cap, the small box hidden within the soft-toy, the key with the pendant, the cloth that had covered the money case, the money case itself, and the envelope found inside. Each of the *scenario-related probe* items was combined with four *scenario-related irrelevant* items which belonged to the same item category (e.g. soft-toys, or caps); these had some categorical similarity, but were all unknown to the subjects. In addition to these seven *scenario-related* categories, four *neutral* item categories were presented in order to avoid that all questions in the entire experiment were answered with ‘no’. If answering all questions with 'no', subjects might come into an automated state, which might reduce answer preparation and emotional involvement. The *neutral* categories comprised everyday objects which had to be identified (e.g. 'Is this a pineapple?'). In each of these categories, one question had to be correctly answered with 'yes', the other four with 'no'. The neutral categories are not further evaluated here.

Each question was presented five times in sequence, together with a different picture of the corresponding category, which was simultaneously displayed below it. Seven *scenario-related* and four *neutral* questions, each comprising five item presentations, resulted in a total of 55 item presentations per run; the total experiment consisted of two runs with and without a parallel task (see below). Subjects were instructed to deny any knowledge of the items they had seen and touched in the scenario room, but to correctly answer the other presented questions and items. Thus, they had to say 'no' to all - *probe* and *irrelevant* - item presentations of the *scenario-related* type as well as to the *no* items of the *neutral* type; they also had to answer with 'yes' to the *yes* items of the *neutral* question type. Two indication fields containing question marks appeared simultaneously with the questions and prompted the subjects to answer. Answers had to be given as quickly as possible by pressing one of two response keys as well as by vocally responding with 'yes' or 'no'. Key assignment to 'yes' and 'no' was balanced across subjects. Following the answer, either 'yes' or 'no' replaced the question marks and remained on screen until the item question disappeared.

Interference task

In one of the two runs, subjects carried out an additional Go/No-go task which was presented in the upper part of the same monitor (see figure 1). The size of the Go/No-go task display was 2° visual angle in both dimensions. In the inner part of a black square figure, either a white square or a white circle appeared for 1.25 seconds every 2.5 seconds throughout the run. 22 per cent of the figures were white circles and 78 per cent were white squares. Subjects had to press a key, assigned to 'Go' signals, as quick as possible, if a square was presented; the circle did not require a response. As described above, the items and questions of the CIT had to be addressed at the same time. Immediate responses to both tasks were demanded in the instructions; no preference for either task was suggested. In the control condition 'without parallel task', the additional black-and-white figure was presented in the same way, but subjects were to ignore that part of the screen.

*** insert figure 1 about here ***

Procedure

After subjects had given their informed consent, they were lead to the experimental room; there, they were informed about the subsequent mock crime scenario by a second experimenter. After the mock crime procedure, subjects were lead back to the first experimenter who performed a 'polygraph investigation'. They were connected to the polygraph leads and asked to answer the CIT questions. Both runs were preceded by training trials consisting of two blocks with five irrelevant items each. In order to not confound parallel task effects with habituation effects, the sequence of the conditions was counterbalanced.

Physiological measurement

The physiological recordings took place in a dimly-lit, electromagnetically and acoustically shielded experimental chamber (*Industrial Acoustics GmbH*, Niederkrüchten, Germany). Subjects sat in an upright position so that they could comfortably watch the monitor and reach the keyboard. Temperature in the cabin was 21°C at the beginning of the first run, with an increase of max. 2°C throughout the course of the experiment.

Skin conductance (EDA), 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 µS. All data were sampled with 510 Hz. Triggers indicating question onsets and Go/No-go task onsets were registered with the same sampling frequency.

For skin conductance recordings, standard Ag/AgCl electrodes (*Hellige;* diameter 0.8 cm), isotonic signa electrode cream (*Parker Laboratories Inc.*) and a constant voltage of 0.5 volts were used. The electrodes were fixed at thenar and hypothenar sites of the non-dominant hand.

For registration of respiratory activity, a resistance-dependent transducer was used which was attached with a belt at the level of the lower thoracic aperture.

The 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 fourth finger of the non-dominant hand.

Behavioral measures

Subjects responded by both key presses and verbal expressions (the latter were not further analysed). Key presses indicating 'yes' or 'no' as answers to *scenario-related* or *neutral* questions were registered as well as the key presses, which subjects carried out in response to the Go/No-go task. The behavioral data were time-logged and stored on the stimulus-presenting computer for later evaluation of reaction times and error rates. Behavioral data were synchronized with physiological measures with an accuracy of ± 2 ms.

Data reduction and statistical analysis

Data from two subjects had to be discarded from skin conductance analysis because of technical problems; two further subjects were excluded because of electrodermal hypo-responding (more than 80% non-responses). Skin conductance response was defined as any increase in conductance that was initiated within a time window from 1.0 to 5.0 seconds after trial onset. The amplitude of the response was automatically evaluated as the difference between response onset and the subsequent maximum value in the set time window (Furedy et al., 1991).

Respiratory data of three subjects had to be discarded from evaluation because of artifacts. After low-pass filtering, the total respiration line length (RLL) was automatically computed over a time interval of 10 seconds after trial onset. 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).

ECG data from three subjects had to be excluded from analysis because of frequent extrasystoles. After notch filtering at 50 Hz, R-wave peaks were automatically detected and visually controlled. The R-R intervals were transformed into heart rate (HR) and real-time scaled (Velden and Wölk, 1987). The HR during the last second before trial onset served as pre-stimulus baseline. The phasic heart rate (pHR) was calculated by subtracting this value from each second-per-second post-stimulus value. For extracting the trialwise information of the phasic HR, the mean change in HR within 15 seconds after trial onset, compared to the pre-stimulus baseline, was calculated (Bradley and Janisse, 1981).

From the finger pulse waveform, the finger pulse waveform length (FPWL) within the first 10 seconds after trial onset was calculated and subjected to further analyses (Elaad and Ben-Shakhar, 2006). The FPWL comprises information about both HR and pulse amplitude and is often interpreted as an indirect measure of arterial blood pressure.

The delay between trial onset and the pressing of the key was calculated as reaction time. In the Go/No-go parallel task, additional reaction times were measured after each 'Go' symbol appeared on the screen. Missing reactions to 'Go' symbols and key presses after 'No-go' symbols were detected as errors. The number of errors (false misses and false reactions) within the Go/No-Go task were calculated per trial.

<u>Standardization:</u> A within-subject standardization of measured values was proposed by Lykken and Venables (1971). Here, according to Ben-Shakhar (1985), Gronau et al. (2005) and Gamer et al. (2006), the physiological and behavioral measures are z-transformed for each subject and each data channel. All trials, including both runs of the experiment (*probe* and *irrelevant* trials of the *scenario-related* question type as well as *yes* and *no* trials of the *neutral* question type, not including the first trials of each stimulus category), were used for the calculation of individual means and

standard deviations. The z-transformed values from *scenario-related* trials were used in subsequent statistical analyses.

Statistics: Statistical analyses were performed with *SPSS*, Version 12.0 (*SPSS Inc.*, Chicago).

For each physiological and behavioral measure, a repeated measurements 2*2 ANOVA was calculated. The first factor, Probe, differentiated *probe* vs. *irrelevant* trials, and the second factor, Task, differentiated between the experimental conditions with and without parallel task. Significance level for the assessment of main and interaction effects was set to 0.05. Follow-up t-tests for matched samples (one-tailed, significance level 0.05) were carried out when interactions were found. Cohen's *d* was calculated as effect size estimate.

The validity of each data channel and the validity of an optimized combination of measures were evaluated with a binary logistic regression analysis. This procedure aimed at identifying the contribution of the various measures to differentiate between *probe* and *irrelevant* items. The probability, with which a trial has to be regarded as a *probe* trial is a function of the optimized linear combination of measures. Thus, trial type served as dependent variable, and the various measures as predictors. In a first calculation, a stepwise inclusion of parameters was performed following a Wald-statistic with probabilities for inclusion and exclusion set to 0.05 and 0.10, respectively. Secondly, in order to estimate the predictive value of each measure per se, they were included singularly in an analogous regression analysis. The logistic regression model was based on randomly selected 70% of trials, and the remaining 30% served as cross-validation in order to estimate the shrinkage of the regression model.

The ROC curve reflects the item-differentiation capability of the single data channels and their combinations for all possible cutoff-points; the area under the ROC curve, varying between 0 and 1 with a chance level of 0.5, serves as an overall index of detection accuracy (Bamber, 1975; Ben-Shakhar and Elaad, 2003; Gronau et al., 2005). Note that the ROC data in the present study refer to the classification of single items as *probe* or *irrelevant*, regardless of their grouping in categories. Thus, the present data are not comparable with ROC data from CIT studies, which refer to a different data aggregation level, mainly the differentiation between '*guilty*' and '*not guilty*' subjects.

Results

Table 1 summarizes means and standard errors of means of absolute values for each data channel.

*** insert table 1 about here ***

Figure 2 illustrates mean z-values and standard errors of means for each measure.

*** insert figure 2 about here ***

Skin conductance:

Figure 3 illustrates the averaged intra-trial course of skin conductance, depicting grand means for *probe* and *irrelevant* items under both experimental conditions. Mean absolute responses were larger in *probe* than in *irrelevant* trials. Interestingly, the absolute response difference between both situations remained unchanged by the parallel task.

*** insert figure 3 about here ***

ANOVA for skin conductance data showed greater responses to *probe* items than to *irrelevant* items; $F(1,35) = 75.00$, $p < 0.001$, $d = 2.49$, but did neither reveal a main effect for Task; $F(1,35) = 0.82$, nor an interaction Probe by Task; $F(1,35) = 0.23$.

Respiration:

ANOVA for RLL data showed lower respiratory activity in *probe* than in *irrelevant* trials; $F(1,36) = 38.42$, $p < 0.001$, $d = -1.82$, but did neither reveal a main effect for Task; $F(1,36) = 0.48$, nor an interaction Probe by Task; $F(1,36) = 0.00$.

<u>Heart rate:</u>

Second-per-second values of HR after trial onsets of *probe* and *irrelevant* items are depicted for both experimental conditions in figure 4.

*** insert figure 4 about here ***

The typical biphasic HR course consists of an increase within the first three seconds after trial onset, followed by a decrease lasting about ten seconds. Phasic HR, averaged over fifteen seconds after trial onset, differed strongly between trial types. The deceleration was more pronounced for *probe* than for *irrelevant* trials. The parallel task appears not to have an influence on this differentiation.
ANOVA for pHR data showed enhanced HR decelerations after *probe* items in comparison to *irrelevant* items; $F(1,36) = 40.95$, $p < 0.001$, $d = -2.26$, but did neither reveal a main effect for Task; $F(1,36) = 0.69$, nor an interaction Probe by Task; $F(1,36) = 0.33$, indicating that the differentiation between item types was not influenced by the parallel task.

<u>Finger pulse:</u>

ANOVA for FPWL indicated lower FPWL values for *probe* items in comparison to *irrelevant* items; $F(1,39) = 18.06$, $p < 0.001$, $d = -1.20$, but did neither reveal a main effect for Task; $F(1,39) = 0.06$, nor an interaction Probe by Task; $F(1,39) = 0.98$.

Reaction times:

The mean reaction times to the CIT questions were 1572 ms with a standard deviation of 614 ms. ANOVA for reaction times yielded effects for Probe; $F(1,39) = 25.11$, $p < 0.001$, $d = -1.41$, and Probe by Task; $F(1,39) = 17.20$, $p < 0.001$, but not for Task; $F(1,39) = 2.12$. Mean reaction times to the CIT questions were shorter in *probe* than in *irrelevant* trials under the condition without parallel task; $T(39) = 6.19$, $p < 0.001$, $d = -0.85$, but, in the parallel task condition, this effect was markedly reduced and did not yield significance; $T(39) = 1.68$, $p > 0.05$.

Go/No-go reaction times:

The reaction times of the Go/No-go task were distributed with a mean of 596 ms and a standard deviation of 243 ms. They did not significantly differ between *probe* and *irrelevant* trials; $T(39) = 0.40$, $p > 0.05$.

Go/No-go errors:

Each trial of the CIT with parallel task contained seven go/no-go signals; the absolute number of errors (false misses and false alarms) within one trial varied around a mean of 0.27 (mean error rate: 4.1 % of all Go/No-go signals) with a standard deviation of 0.26. T-tests did not reveal a difference between *probe* and *irrelevant* trials; $T(39) = 0.11$, $p > 0.05$.

Logistic regression model

The binary logistic regression and the following results refer to a trial type discrimination on a single-trial basis. In the stepwise inclusion following the Wald statistic, EDA, RLL and pHR were included successively. Optimal weights, standard errors, Wald statistic and significance level are summarized for both experimental conditions and across conditions in table 2.

*** insert table 2 about here ***

Rate of correct trial type classification (criterion: $p > 0.25$ for classification as *probe*) was 70.1% without parallel task (cross-validation: 69.3%), 69.3% with parallel task (cross-validation: 68.7%), and 69.8% (cross-validation: 69.0%) over conditions. Under variation of the cut-off point for decision, different rates of false-positive (classification of an *irrelevant* trial as *probe*) and false-negative outcomes (classification of a *probe* trial as *irrelevant*) are obtained. This is illustrated by ROC curves.

In addition to the stepwise inclusion, analogous analyses were performed with singular inclusion of each of the measures: ‘electrodermal activity’ (EDA), ‘phasic heart rate’ (pHR), ‘respiration line length’ (RLL), ‘finger pulse waveform length’ (FPWL), and 'reaction time' (RT). ROC areas were calculated separately for both experimental conditions with and without parallel task and across both conditions. For the condition with parallel task, ROC area values for the behavioral measures from the parallel task, namely 'Go/No-go task reaction time' (tRT) and 'Go/No-go task errors' (tERR), were added. Table 3 shows the areas under the ROC curves and their confidence intervals for each of the single measures and for their optimal-weight combination.

*** insert table 3 about here ***

In the evaluation which included each of the single measures singularly, EDA appeared to be the best predictor, followed by RLL and pHR. However, differences between these three measures were not significant. FPWL also differentiated between item types, yet significantly weaker than the above measures. In the parallel task condition, as compared to the control condition, the differentiation between *probe* and *irrelevant* items was not impaired, neither for the stepwise inclusion method, nor for the single measures, except for the CIT reaction times which contributed to differentiation in the condition without parallel task only. The parallel task behavioral measures (tRT and tERR) did not contribute to further differentiation. Figure 5 shows the ROC curves after stepwise inclusion of EDA, RLL and pHR for both experimental conditions. Area values obtained with this combination were 0.740 with and 0.755 without parallel task, with largely overlapping 95% confidence intervals.

*** insert figure 5 about here ***

Discussion

The goal of the present study was to examine the influence of an additional mental task on the detection of concealed knowledge in a CIT. In a laboratory mock-crime experiment, two runs of a CIT were performed. In one of the two runs, a straining Go/No-go task was given in parallel; the other run served as control condition without a parallel task.

Effects of information concealment on psychophysiological and behavioral measures

The present results showed large effects of concealing information on electrodermal activity, respiration line length and phasic heart rate. These effects are well-known from experiments using the CIT paradigm and could be confirmed in this study under both experimental conditions. In accordance with previous studies on detection of concealed knowledge (e.g. Bradley and Janisse, 1981; Ben-Shakhar and Elaad, 2003; Gamer, 2006), electrodermal activity, respiration line length and phasic heart rate differentiated between falsely denied recognition of known objects (*probe* items) and correct denying of knowledge about new objects (*irrelevant* items)[1]. Here, skin conductance showed the largest effect, followed by respiratory activity and phasic heart rate. In contrast to electrodermal, respiratory and ECG measures, only few authors (Podlesny and Raskin, 1978; Podlesny and Kircher, 1999; Hirota et al., 2003) have so far referred to pulse wave in the context of deception and its detection. Although finger pulse waveform length differed significantly between *probe* and *irrelevant* trials, its contribution to the differentiation between item types was minimal. This finding, however, contradicts recent findings by Elaad and Ben-Shakhar (2006), who emphasized the importance of this measure for the detection of concealed information.

The CIT reaction times contributed to the item type differentiation only in the condition without parallel task. Detection of concealed information using reaction times has recently been studied by Gronau et al. (2005), Walczyk et al. (2003), Seymour et al. (2000), and Vendemia et al. (2005b). They consistently found reaction times to be significantly longer in *probe* than in *irrelevant* trials and attribute this to a higher cognitive load associated with deception. Surprisingly, the present study showed shorter reaction times in *probe* trials. However, it has to be stated that RTs in this study have to be interpreted cautiously since overall mean RTs exceeded the range of other studies. With mean RTs clearly longer than one second, the longer RTs in *irrelevant* trials can be due to strategic manipulations (Ratcliff and McKoon, 1981; Seymour et al., 2000). Such manipulations might include selectively faster reactions in *probe* trials in order to keep a low profile.

Besides intentional delays, the longer overall RTs might be explained by the distracting effect of the frequently changing Go/No-go figure, which was displayed in both runs of the experiment. If so, *probe* items might have forced to attend to the CIT more than *irrelevant* items, which might explain shorter RTs in *probe* than in *irrelevant* trials. Also, the longer overall RTs might be due to the fact that subjects were presented both a question text and an item picture at each trial onset, with the question text varying with each new category, and both had to be evaluated before responding. A further explanation might be that subjects did not react with their maximum possible speed, although they had been prompted to answer 'immediately after item and question presentation'. The according part of the instruction might not have been forceful enough, or, subjects could have regarded the 'correctness' of their answer as more important than its promptness.

Effects of the interfering task

Referring to the main question of the study, whether and how the interfering task influenced the detection of concealed information, physiological differentiation between *probe* items (known from the mock-crime) and *irrelevant* items (not known so far) remained unchanged in the parallel task condition.

Furthermore, the behavioral measures (reaction times, error rates) of the parallel task did not provide additional information for the differentiation between item types.

Besides these main findings, psychophysiological indicators of higher arousal in the parallel task condition were not found. This holds for the average phasic increases in skin conductance and for the tonic measures of skin conductance level and heart rate. Higher arousal as a possible indicator for tonic activity in the parallel task condition was not proven statistically. This is surprising because subjects' reports, and the need for repeated training runs, suggest that the parallel task was highly demanding. (A reviewer's comment on the influence of task difficulty led to an additional analysis, which separated subjects by high versus low performance in the parallel task. Undiminished CIT accuracy was seen in both groups, so that different subjective task difficulty does not seem to affect CIT accuracy. Hence, it is unlikely that a general lack of task difficulty can hold for an explanation.)

Recent studies suggest that cognitive processes (e.g. attention, memory, and executive functions) are involved in deception and information concealment (Vendemia et al., 2005a; Vendemia, 2005b; Verschuere et al., 2005; Verschuere et al., 2007). Although the CIT is predominantly based on orienting (Lykken, 1974; Ben-Shakhar and Elaad, 2002; Verschuere, 2005), its accuracy is known to be influenced by deceptive answering (Bradley et al., 1996; Furedy and Ben-Shakhar, 1991; Elaad and Ben-Shakhar, 1991). Consequently, the role of mental processes in the CIT in addition to orienting has to be studied. Following the idea that response inhibition processes play a central role in concealing information, most recently supported by

Verschuere et al. (2007), a demanding Go/No-go task was chosen to interfere with the deceptive processes executed in a CIT.

As a main finding, it seems remarkable that the detection of concealed information by means of psychophysiology was not compromised by the additional and distracting mental demand, although there is evidence for a sufficient task difficulty. Neither an impairment nor an improvement of test accuracy, both imaginable for different reasons, was found to prevail; CIT and Go/No-go task appeared not to interact with each other physiologically.

This can be discussed in the light of 'phasic' versus 'tonic' activity. CIT questions are assumed to evoke a phasic mental effort as well as phasic autonomic responses; in contrast, the Go/No-go parallel task in this study is assumed to evoke tonic activity, thereby demanding additional mental effort when reacting to *probe* as well as *irrelevant* trials. If the 'tonic' mental effort demanded by the Go/No-go task did not interact physiologically with the 'phasic' responding to the CIT items, a pure additivity of the physiological responses evoked by both CIT and the interfering task could be implied. This could possibly explain why the parallel task did not influence the differential responses to CIT items.

The results could further be interpreted in comparison to the effects of different mental countermeasures on the CIT. Mental countermeasures, which were applied phasicly in order to evoke autonomous responses to *irrelevant* items, have been shown to distort the CIT considerably (Honts et al., 1996), whereas other mental countermeasures even enhanced CIT accuracy when applied selectively in *probe* trials, and tended to weaken it when applied continuously (Elaad and Ben-Shakhar, 1991). The Go/No-go task in this study can be compared with a continuous mental countermeasure, but here no distorting effect on the CIT was found.

One difference between common countermeasures and the parallel task in this study is the fixed temporal design of the parallel task, and this might contribute to explaining the different findings. The single sub-steps of a mental countermeasure (e.g. counting backwards by sevens) are mentally triggered by the investigated subject, while he or she is facing a *probe* or an *irrelevant* item. If more mental resources are allocated to the countermeasure during *probe* trials compared to *irrelevant* trials, a diminished test accuracy could consequently be the result. (Of course, not all countermeasures comprise distinguishable steps, but still, applying a countermeasure allows for controlling the timing of mental resource allocation.) In contrast, every single stimulus presentation within the Go/No-go task is timed by the experimental system, and attention is therefore distracted more evenly over trials than in the case of mental countermeasures; thus, the parallel task might influence the CIT response pattern less than a mental countermeasure.

Also, the opposite and rather speculative hypothesis, that the parallel task would enhance CIT accuracy via a specific interference with sub-processes of deception, was not found as a prevailing effect. Deceptive answering is known to influence differential responding to *probe* vs. *irrelevant* items (Bradley et al., 1996; Furedy and Ben-Shakhar, 1991; Elaad and Ben-Shakhar, 1991), but this influence was obviously not affected by the parallel task. Either no interaction of the parallel task with deception processes (e.g. by engaging response inhibition) has been achieved, or, if a competition of both tasks for specific mental resources actually has been provoked, it was not reflected in autonomous measures. In the latter case, central nervous measures might provide more exhaustive information.

When both hypotheses are taken together, the outcome that neither of both hypothesized mechanisms was found predominant over the other, is surprising. Despite the fact that the two opposite hypotheses - neither a decrease nor an increase in CIT accuracy due to the parallel task - could not be sustained by the results, the possibility has to be taken into account that the hypothesized effects might both have been activated but may have nullified each other. In this case, the parallel task could be said to have both effects. By continuously distracting attention from the CIT it might weaken differential physiological responding on the one hand. On the other hand, it might compete with deception for mental resources and cause information concealment in *probe* trials to be accompanied by more mental effort. The extent to which each mechanism has been activated can be speculated upon. To what extent specific parallel tasks interfere with the CIT procedure will be the subject of further studies. Also, generalizability of the findings to other interfering tasks remains to be seen. Further CIT studies using parallel tasks might provide insights into the sub-processes of deception, especially if a task was found to interact with some sub-process involved in the CIT. The inclusion of central nervous measures, or indirect measures such as the startle eye blink utilized by Verschuere et al. (2007), might help to specifically identify cognitive sub-processes, which are less reflected in autonomous measures.

From an applied perspective, other interfering tasks might provide incremental information in order to differentiate *probe* vs. *irrelevant* trials and, consequently, guilty vs. innocent subjects.

Another issue of interest considering the applied context, is whether a demanding parallel task would help to prevent investigated subjects from applying mental countermeasures. If the parallel task occupied a considerable amount of mental resources, which are available during performance of a CIT, then the application of mental countermeasures needing additional resources should become more difficult. Further studies using a countermeasure manipulation could help to clarify this tentative consideration.

Conclusions

Following the idea that response inhibition plays a central role in concealing information, a demanding Go/No-go task was chosen to interfere with the deceptive processes executed in a CIT. As a main finding, CIT accuracy was neither improved nor impaired by this parallel task, despite the fact that there was evidence for sufficient task difficulty.

The study can be regarded as a first step to study information concealment and deception using an interfering task. Subsequent studies, e.g. using a working memory parallel task, and the inclusion of central nervous measures, might provide valuable insights into the sub-processes of deception.

Figure Captions

Figure 1. Presentation of Concealed Information Test and parallel task. In the upper part of the screen, the visual Go/No-go task (square or circle) is presented in the center of a square black field. Below it, the Concealed Information Test is performed and a question and item picture is shown. Two question marks besides the depicted item prompted the subject's answer, and after the answer has been given, a 'yes' or 'no' text (reflecting the subject's answer) replaces the question marks. (Translation of the German question text: 'Did you utilize this object in your deed?')

Figure 2. Physiological and behavioral responses (within-subject z-values) to *probe* and *irrelevant* trials of the *scenario-related* type for conditions without and with parallel task. Means and standard errors of means are depicted for electrodermal activity (EDA), phasic heart rate (pHR), respiration line length (RLL), finger pulse waveform length (FPWL), and CIT reaction times (RT). (** $p < 0.01$; * $p < 0.05$)

Figure 3. Grand means of skin conductance reactions in *scenario-related* trials. Conductance courses are shown for *probe* and *irrelevant* trials. Solid lines: with parallel task, dashed lines: without parallel task.

Figure 4. Second-per-second values of heart rate following trial onsets showing a typical biphasic course. Solid lines: with parallel task, dashed lines: without parallel task.

Figure 5. Receiver operating characteristic (ROC) curves for conditions with and without parallel task. Included predictors were 'electrodermal activity' (EDA), 'phasic

heart rate' (pHR) and 'respiration line length' (RLL). Solid line: with parallel task, dashed line: without parallel task.

Footnotes

[1] Note that the within-subject z-standardization of the measures was based on all trials of a subject, in contrast to previous studies, which mostly used within-category standardization and thereby tended to overestimate effects (Meijer et al., 2007). Consequently, the binary logistic regression did not utilize the grouping of trials in categories, and ROC values are not comparable with the above mentioned studies.

Tables

Table 1

Means and standard errors of means (SEM, in brackets) of absolute values for each data channel. *Probe* vs. *irrelevant* items are contrasted under the conditions without and with parallel task. Electrodermal activity (EDA), respiration line length (RLL), phasic heart rate (pHR), finger pulse waveform length (FPWL), CIT reaction time (RT). reaction times from the Go/No-go task (tRT), and Go/No-go errors per trial (tERR) are listed.

	without parallel task				with parallel task			
	probe items		*irrelevant items*		*probe* items		*irrelevant items*	
	Mean	(SEM)	Mean	(SEM)	Mean	(SEM)	Mean	(SEM)
EDA [nS]	461	(82)	282	(60)	495	(104)	320	(66)
RLL [arb. units]	4640	(360)	5124	(372)	4626	(328)	5195	(364)
pHR [1/min]	-1.87	(0.45)	1.03	(0.19)	-1.95	(0.48)	0.61	(0.25)
FPWL [arb. units]	1271	(131)	1346	(141)	1264	(121)	1321	(131)
RT [ms]	1421	(68)	1570	(61)	1376	(58)	1415	(60)
tRT [ms]					605.62	(20)	601.55	(16)
tERR [count]					0.33	(0.04)	0.32	(0.03)

Table 2

Physiological measures included in the binary logistic regression: electrodermal activity (EDA), respiration line length (RLL), and phasic heart rate (pHR). Optimal weights (β), standard errors (SE) of β, Wald statistic and significance level (*p*) are listed for the conditions without and with parallel task and over both conditions ('overall').

measure	**β**	**SE**	**Wald**	***p***
without parallel task:				
EDA	0.687	0.103	44.22	< 0.001
RLL	-0.497	0.110	20.27	< 0.001
pHR	-0.533	0.098	29.32	< 0.001
constant	-1.264	0.103	149.78	< 0.001
with parallel task:				
EDA	0.557	0.092	36.48	< 0.001
RLL	-0.573	0.109	27.61	< 0.001
pHR	-0.447	0.102	19.30	< 0.001
constant	-1.309	0.103	162.95	< 0.001
overall:				
EDA	0.707	0.069	104.00	< 0.001
RLL	-0.632	0.077	67.09	< 0.001
pHR	-0.414	0.068	37.29	< 0.001
constant	-1.311	0.073	325.97	< 0.001

Table 3

Area under the receiver operating characteristic (ROC) curves and 95% confidence intervals for item type differentiation on a single-trial basis. Values are listed for inclusion of each single measure and for stepwise inclusion (Wald statistic). Conditions without and with parallel task and results over both conditions are presented in separate columns.

included parameters	**area under the ROC curve and 95% confidence intervals**					
	without parallel task		**with parallel task**		**overall**	
	area	confidence interval	area	confidence interval	area	confidence interval
single measures:						
EDA	0.677	0.636 - 0.719	0.667	0.627 - 0.707	0.672	0.643 - 0.701
RLL	0.651	0.609 - 0.693	0.654	0.613 - 0.696	0.652	0.622 - 0.681
pHR	0.650	0.609 - 0.691	0.619	0.577 - 0.662	0.636	0.606 - 0.665
FPWL	0.550	0.508 - 0.591	0.551	0.509 - 0.594	0.550	0.520 - 0.580
RT	0.629	0.588 - 0.671	0.533	0.490 - 0.576	0.579	0.549 - 0.609
tRT			0.487	0.443 - 0.531		
tERR			0.504	0.461 - 0.547		
after stepwise inclusion:						
EDA + RLL + pHR	0.755	0.718 - 0.791	0.740	0.703 - 0.777	0.748	0.722 - 0.774

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figure 1

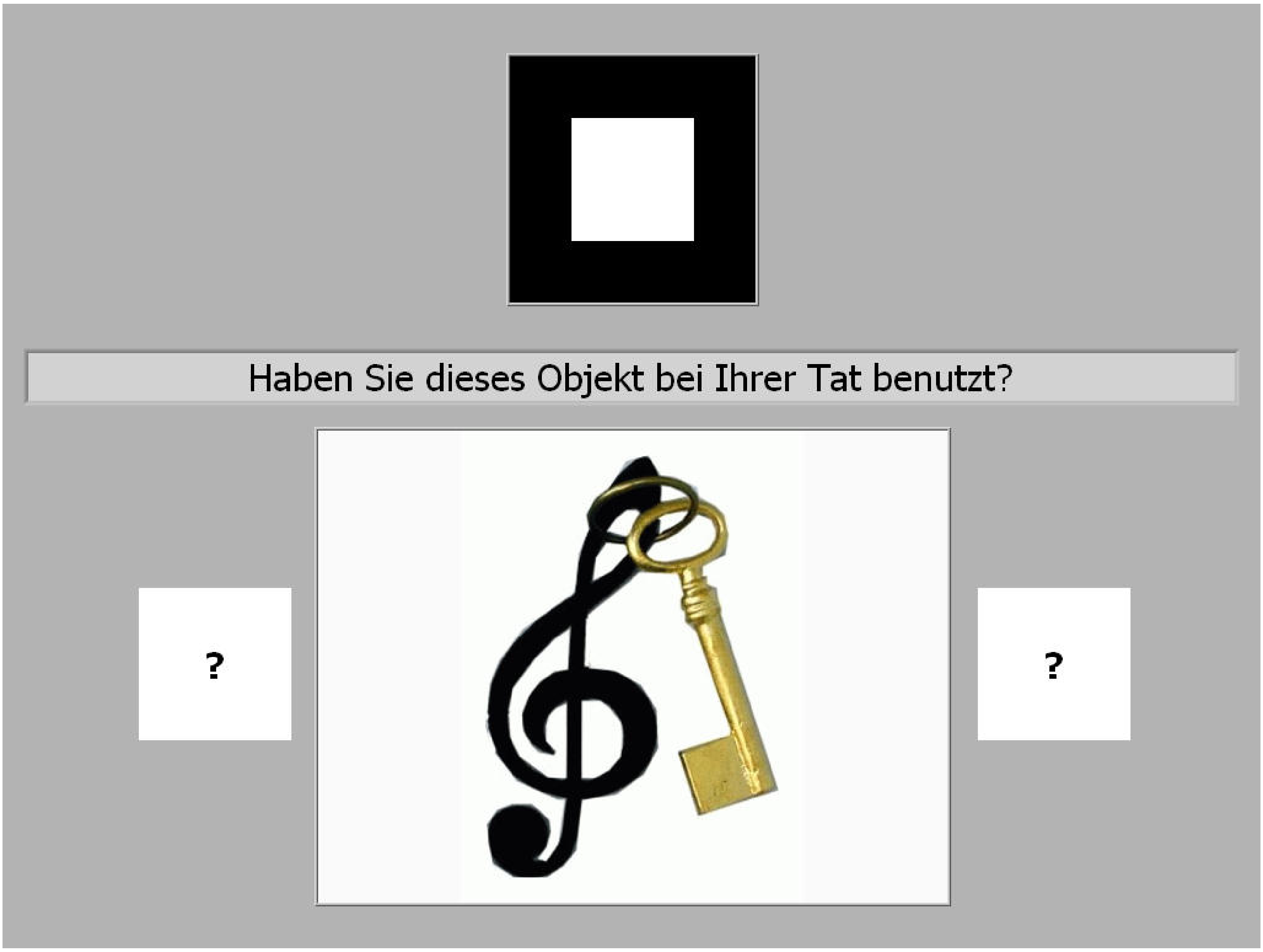
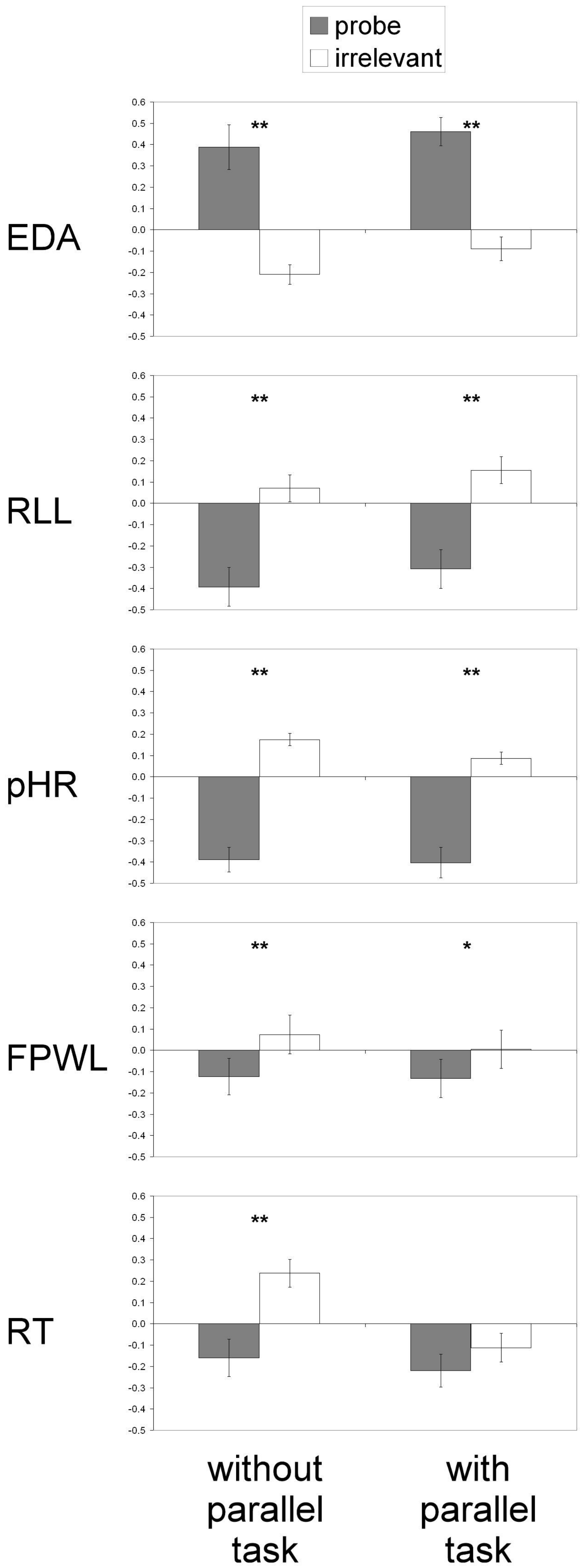


figure 2



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pHR
FPWL
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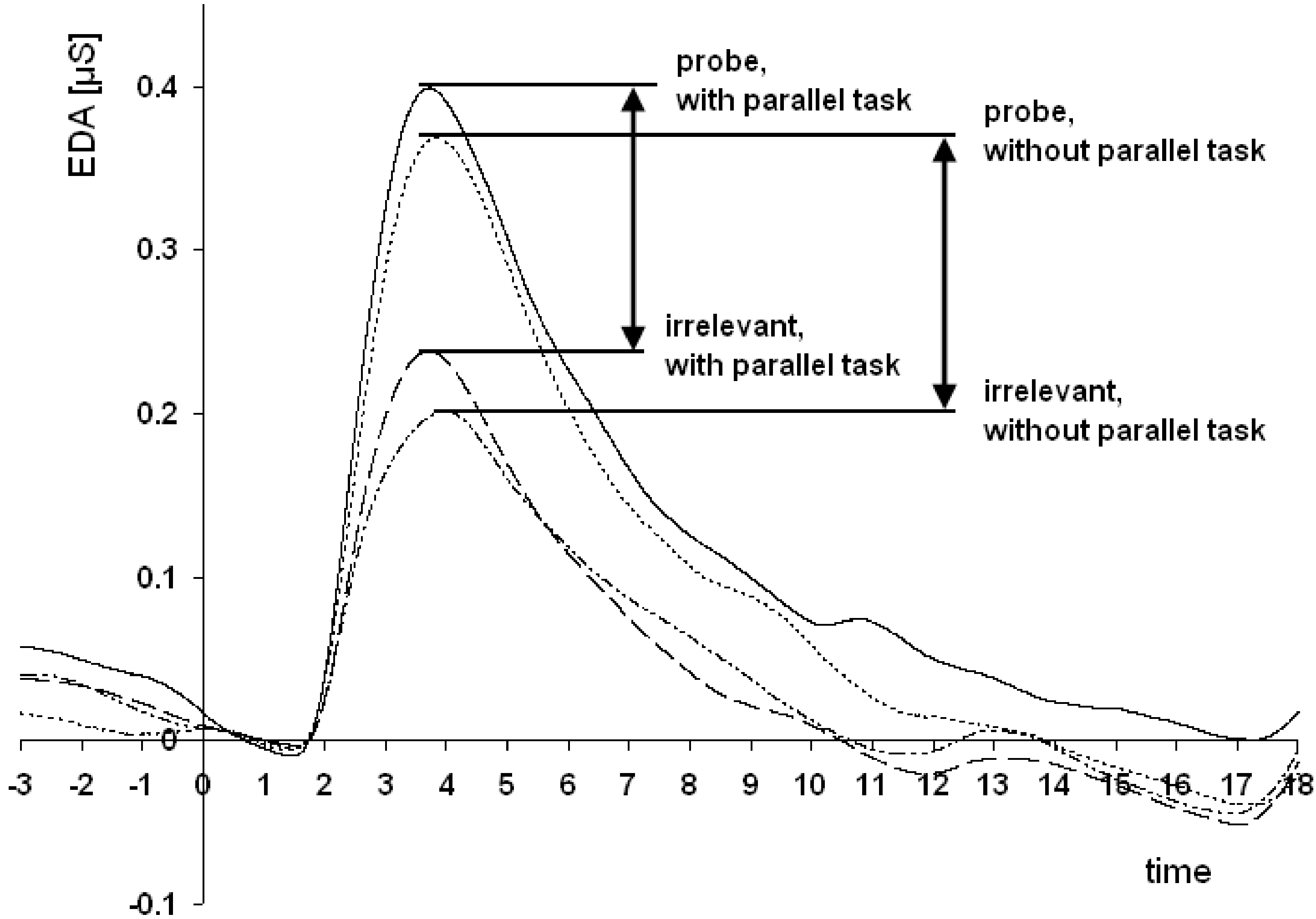
without parallel task
with parallel task

figure 3



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with parallel task
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irrelevant,
without parallel task

figure 4

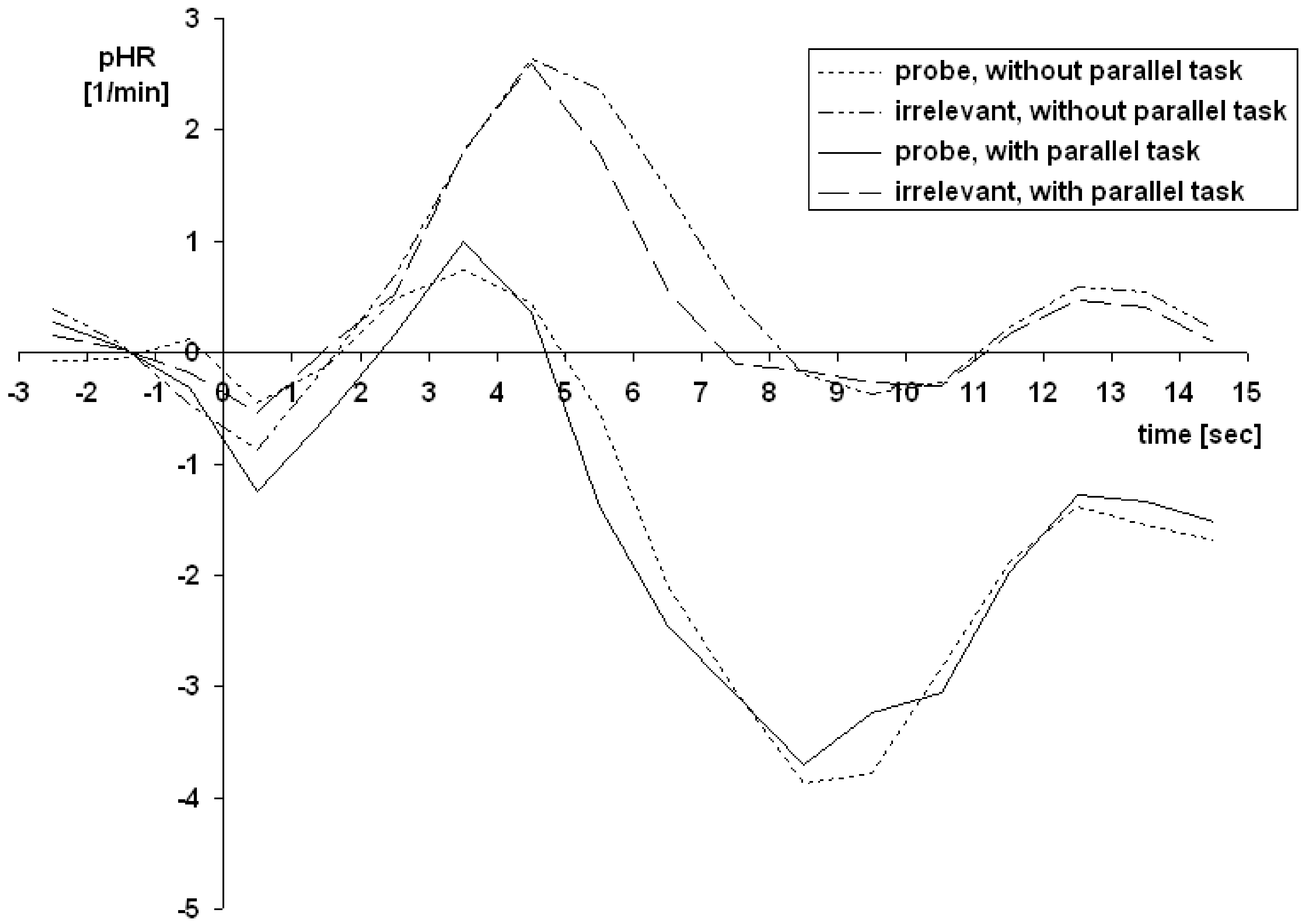
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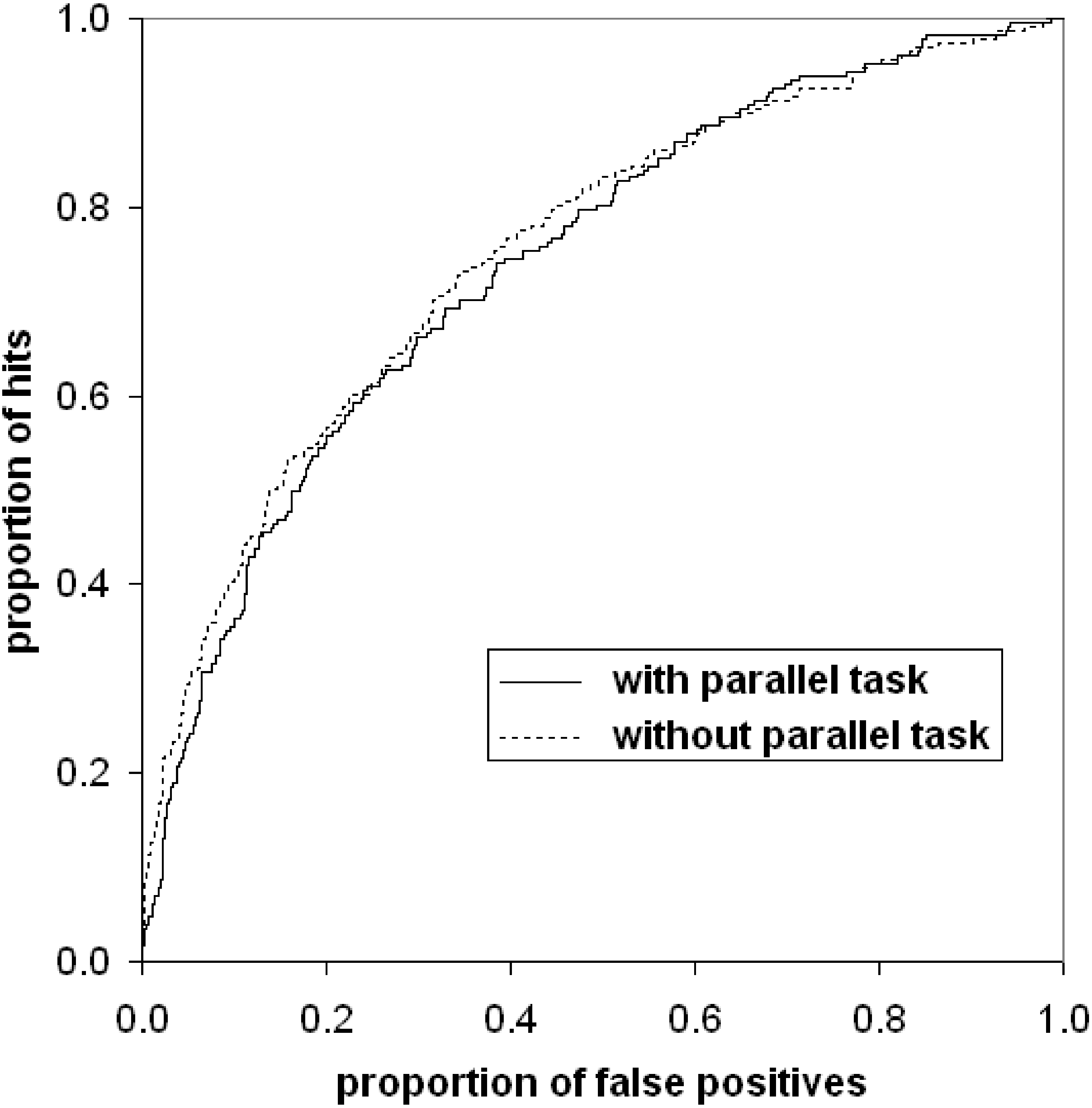
figure 5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with parallel task
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