



A comparison of various psychophysiological parameters for detecting concealed information.



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Introduction

The **Guilty Actions Test (GAT)** is a method used in Forensic Psychophysiology (detection of deception); It is a modification of the Guilty Knowledge Test (GKT), and aims to classify individuals as either deceptive (guilty) or truthful (innocent) on the basis of differential physiological responses to specific items.

Structure of the GAT

- **Multiple choice questions** related to specific details of the crime being investigated are usually employed. In contrast to the GKT, such questions check for actual participation in addition to crime-related knowledge (Bradley et al., 1996).
- Each question consists of one **crime-related relevant item (RI)** and several **irrelevant items (IIs)**, which are similarly plausible to persons without any knowledge of the crime being investigated.

Assumptions

- **Guilty subjects** will react stronger on the RIs than on the IIs because they recognise crime-related information and have to lie to the RIs.
- **Innocent subjects without any knowledge about the crime** will show a random response pattern.

Parameters

- **Skin Conductance Responses (SCR):** Overall, SCR-magnitudes are larger to RIs than to IIs for guilty subjects; This difference has been replicated by many studies (cf. MacLaren, 2001).
- **Respiration:** Respiration Line Length (RLL) tends to be smaller to RIs than to IIs for guilty subjects.
- **Cardiovascular Parameters:** Currently, there is no clear evidence to confirm if standard cardiovascular parameters of polygraphy (relative blood pressure, finger pulse) differentiate between guilty and innocent subjects using the GAT.
- **Voice Stress Analysis (VSA):** Although the hit rates of numerous commercially available systems have not exceeded classification by chance, the vendor of the computerised system TrusterPro claims that it can identify deceptions with hit rates above 90%.

Method

Participants

The sample consisted of 60 male participants aged between 19 and 56 years ($M = 26.5$; $SD = 6.3$), randomly assigned to one of the following groups:

1. Guilty subjects (n = 30):

Committed a mock theft of money and credit card from an open-access departmental library.

2. Innocent subjects (n = 30):

Carried out a specific instruction in the same floor of the building, but were oblivious to the relevant details of the mock crime scene.

Procedure

Subsequently, each subject was required to undergo a **GAT examination**:

- The test itself consisted of 6 multiple choice questions with 1 buffer item (the first in each sequence), 1 RI and 4 IIs. Stimuli were presented as pre-recorded audio samples, and the inter-stimulus-interval was 22 s. The subject was told to deny any knowledge of each item.
- *Example of a GAT question:*

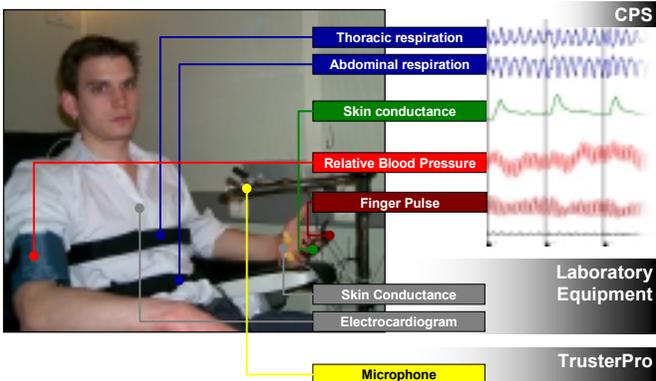
What amount of money did you steal from the wallet? Was it...					
a) 100,- €	b) 120,- €	c) 150,- €	d) 50,- €	e) 70,- €	f) 120,- €

- A financial reward was offered for an innocent test result to motivate the subjects to avoid detection.

Measurement

Three sources of data were collected (see illustration):

1. Laboratory equipment (LE): SCR, phasic heart rate (HR)
2. Computerized Polygraph System (Stoelting Company): SCR, thoracic and abdominal respiration, relative blood pressure, finger pulse
3. TrusterPro: Computerized Voice Stress Analysis Software (Version 6.30)



Scoring algorithms

1. Laboratory equipment:

- **SCR:** Amplitude of SCR (in μS) with a latency of 1-3 s following question onset.
- **Phasic heart rate:** Sec-by-sec difference scores (ΔHR) in relation to 1 second prestimulus baseline value.

2. Computerized Polygraph System:

- **SCR:** Amplitude of the largest skin conductance increase that began between 0.5 s and 10.5 s after question onset.
- **Respiration:** Respiration Line Length for each respiration channel within a time window of 0-10 s following question onset.
- **Relative blood pressure:** Amplitude of the largest baseline increase that began within 12 s after question onset.
- **Finger pulse:** Magnitude and duration of decreases in the amplitude of finger pulses that began a minimum of 2 s after the question onset.

3. TrusterPro:

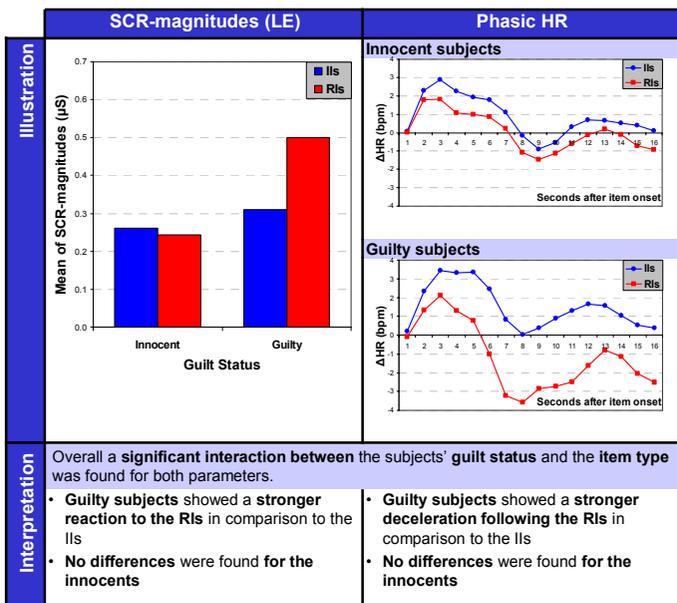
- **Several scoring algorithms** using concrete decisions of the software compared to deeper analyses based on raw-values for the examined speech samples.

Lykken-Scoring (MacLaren, 2001) to classify each subject as guilty vs. innocent:

2 Pts.	Response to the RI is the largest in the inspected multiple-choice block
1 Pt.	Response to the RI is the second largest in the inspected multiple-choice block
0 Pts.	At least two of the responses to the IIs are higher than the response to the RI

Classification as guilty, if the sum of all points is greater or equal to 6 points.

Results (Physiological Parameters)



CPS: Response magnitudes

Using the Lykken-scoring on the automatically computed response magnitudes of the CPS (for channels **thoracic respiration** and **skin conductance** only) yielded an overall hit rate of 85%.

This result demonstrates that the CPS scoring algorithm, which was originally validated with the control question test, can also be used effectively for the GAT.

CPS	
Sensitivity¹:	76.7%
Specificity²:	93.3%
Overall:	85.0%

¹ hit rate for guilty subjects
² hit rate for innocent subjects

Optimised scoring algorithm using physiological parameters

In order to take into account the absolute response differences further computations on the **standardised raw values of the physiological responses** to the test items were carried out. A difference score was computed between each RI and the IIs of the corresponding question block for every physiological parameter, followed by a discriminant analysis (stepwise procedure) to estimate the contribution of each parameter to the differentiation between the two groups.

Only **SCR, total Respiration Line Length** (mean of RLL for thoracic and abdominal respiration) and **phasic HR** were included in the discriminant function. For the GAT, standard cardiovascular parameters of polygraphy (relative blood pressure, finger pulse) did not differentiate between guilty and innocent subjects.

Physiological parameters	
Sensitivity:	93.3%
Specificity:	96.7%
Overall:	95.0%

Cross validation of the discriminant function (leave one out method) yielded an overall hit rate of 93.3% (sensitivity: 90%, specificity: 96.7%).



An Examination of Various Psychophysiological Parameters for Detecting Concealed Information

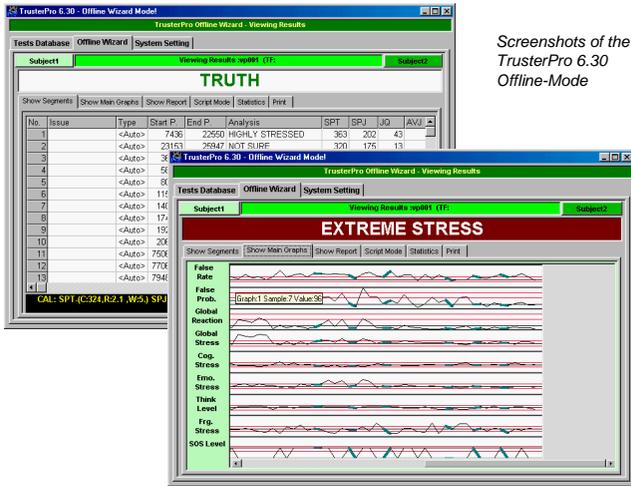
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Results (TrusterPro)



Overall Classifications

Classifications using the TrusterPro Offline-Mode in conjunction with the recommended scoring algorithm of the vendor yielded a **poor hit rate**, not significantly better than classification by chance.

TrusterPro	
Sensitivity:	30.0%
Specificity:	83.3%
Overall:	56.7%

Distribution of the results on the relevant segments

The following table shows the distribution of the TrusterPro decisions concerning the relevant segments. The GAT itself consisted of 6 RIs, resulting in 6 TrusterPro diagnoses for every subject.

TrusterPro Decision	Ground truth	N	Mean	SD
<NDI> No Deception Indicated	Innocent	30	3.77	1.17
	Guilty	30	3.33	1.06
<INC> Inconclusive	Innocent	30	1.73	1.08
	Guilty	30	2.10	1.24
<INC+> Inconclusive Plus	Innocent	30	0.30	0.47
	Guilty	30	0.23	0.50
<DI> Deception Indicated	Innocent	30	0.20	0.48
	Guilty	30	0.33	0.55

According to the logic of TrusterPro, the innocent subjects should have a higher frequency of NDI-results and a lower frequency of DI-results. For the guilty subjects this pattern should be reversed.

None of the observed differences were statistically significant ($p > .1$).

Lykken-Scoring of the TrusterPro raw-values

TrusterPro reports 21 raw-values for every analysed segment. To examine differences in the distribution of the raw-values to RIs and IIs for guilty and innocent subjects, a Lykken-Scoring of the whole GAT was performed for each parameter. According to the low sensitivity of the TrusterPro (see above) an a-priori cut-off might be less optimal. Therefore the optimal cut-off for every parameter was computed using discriminant analyses.

Only **two parameters** showed a **significant differentiation between guilty subjects and innocents** and yielded a statistically significant hit rate:

Parameter	Sensitivity	Specificity	Overall	p
JQ	76.7%	66.7%	71.7%	< .01
Global Stress	76.7%	66.7%	71.7%	< .01

Optimised scoring algorithm

To take into account the absolute response differences between RIs and IIs, an optimised scoring algorithm, similar to the evaluation of the physiological parameters, was implemented (see above). A **standardised mean difference score for every TrusterPro parameter** was calculated and used as predictor variable in a discriminant analysis (stepwise procedure).

None of the TrusterPro raw-values yielded a significant differentiation between guilty and innocent subjects ($p > .05$).

Use of the TrusterPro in conjunction with the psychophysiological data

A **discriminant analysis** (stepwise procedure) with relevant psychophysiological measures (SCR, total RLL, phasic HR and relative blood pressure) and each raw-value of TrusterPro was performed, to examine the diagnostic value of the TrusterPro in addition to the psychophysiological parameters.

Only **SCR, total Respiration Line Length and phasic HR** were included in the discriminant function. The resulting model was identical to the physiological one (see above).

None of the TrusterPro values significantly enhanced the detection rates based solely on physiological responses.

Correlations between the TrusterPro and the psychophysiological data

Every relevant psychophysiological measure (SCR, total RLL, phasic HR and relative blood pressure) was correlated with the 21 raw parameters of TrusterPro.

Only **4 out of 84 correlations** yielded a significant result ($p < .05$).

Physiological measure	TrusterPro parameter	r	p
SCR	Emotional Stress	.297	< .05
SCR	Anticipation Level	-.263	< .05
SCR	Sub Cognitive	.286	< .05
Relative blood pressure	Sub Emotional	.420	< .01

No significant correlation could be found for the TrusterPro parameters with the highest expected diagnostic utility, namely **Lie Stress, Lie Probability and Global Stress**.

Discussion

- ✓ A combination of the **physiological parameters** skin conductance, respiration and phasic HR yielded **superior hit-rates in excess of 90%**. This discriminant function misclassified only one innocent subject, resulting in a specificity of 96.7%.
- ✓ The mean hit rate of the TrusterPro diagnosis (approximately 57%) was slightly above chance levels, but not statistically significant. A **tremendous discrepancy between decisions based on physiological responses in contrast to TrusterPro** was observed.
- ✓ Nevertheless the **Lykken-Scoring of two TrusterPro parameters** (JQ and Global Stress), for which the intrinsic nature could not be ascertained, showed a significant differentiation between guilty subjects and innocents. However, due to the high number of statistical analyses performed on the TrusterPro values, these results might be accidental.
- ✓ **None of the standardised raw-values of TrusterPro differentiated between guilty and innocent subjects.** A replication of the promising results based on the Lykken-Scoring failed.
- ✓ **TrusterPro could not enhance the hit-rates based solely on psychophysiological parameters.**
- ✓ An **interpretation of the few significant correlations between the TrusterPro values and the physiological measures was not impossible**, due to the lack of satisfactory documentation of the TrusterPro raw-values by the vendors.

Tasks for further research

- **Cross-validation of the discriminant function for the psychophysiological parameters** (SCR, total RLL and phasic HR) in an independent study.
- **Field studies** with concealed information techniques to examine the utility of the parameters outside the laboratory.
- Application of **TrusterPro in real life conditions**, where there is significant jeopardy, extreme levels of stress, and greater social interplay between the examiner and examinee.

Legend: Some Relevant TrusterPro Parameters (According to TrusterPro Quick / Training Guides)

- **JQ ("Jumps standard error")**: "A pure value indicating the uniform distribution of the low freq. range."; "TrusterPro associates this value with the global stress level."
- **Global Stress**: "Overall stress level indicator (not necessarily deception related)."
- **Emotional Stress**: "Indicates excitement, emotional condition and even traumatic situations."
- **Anticipation Level**: "Indicator that assesses the level of anticipation the subject is in. When conducting an interrogation, the anticipation rate should typically rise for the relevant question and then drop for DECEPTIVE subjects."
- **Sub Cognitive, Sub Emotional**: No additional information available.

References

Bradley, M.T., MacLaren, V.V. & Carle, S.B. (1996). Deception and Nondeception in Guilty Knowledge and Guilty Actions Polygraph Tests. *Journal of Applied Psychology, 81*, 153-160.

MacLaren, V.V. (2001). A Quantitative Review of the Guilty Knowledge Test. *Journal of Applied Psychology, 86*, 674-683.