Polygraph analyses: technical and practical background

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ABSTRACT

A lie is not the truth, a common definition found in each dictionary or encyclopaedia. Humans use it in different situations and for various reasons, but in the case of forensics, recruitment, and trust in the company or family, it can be curtailed in order to avoid it or to detect it. One of the possible detection tools is the polygraph, whereby lies may be registered and interpreted by means of physiological activities controlled by the autonomic nervous system, such as sweating, trembling, or changes in breathing or in the heart rate. The analyses of the aforementioned parameters are monitored in response to questions, thus, providing information about a possible lie. Questions should be asked according to one of the approved protocols and given procedures and algorithms, which are constantly developed and revised to provide the best possible results.

Introduction

The lie is one of the most common tools used by humans, and it is thought that it has been present since the beginning of mankind [1]. The conflict generated during lying in the human brain results in an increase in stress expressed on the behavioural level as a fight-or-fly reaction. The physiological manifestations, such as changes in blood pressure, heart rhythm and rate, breath deepness, and skin resistance changes, can be monitored in an attempt to detect a lie. The modern polygraph, an appliance used for recording changes in organ activity during true-false verification, is a small portable device (**Figure 1**). Together with the mobile PC, the polygraph registers the chang-
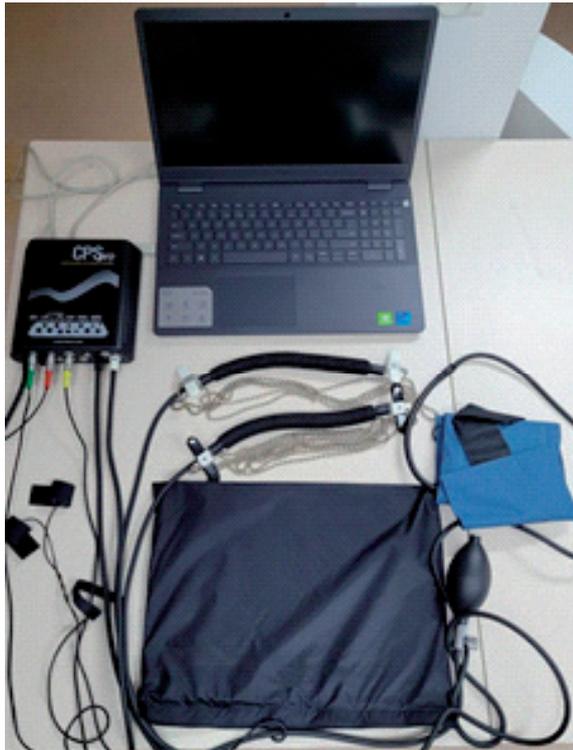
Figure 1. An example polygraph setup comprising a CPSpro – Stoeltinga and Dell mobile PC

es creating a record of the physiological fluctuations, since stress responses are regulated by the autonomic nervous system [2, 3].

It is necessary to emphasize the external conditions which can affect the examination, such as alcohol, or drugs, as well as the exclusion criteria. Bradley and Ainsworth (1984) [4] found that alcohol intoxication during a sham crime reduces crime detection accuracy, although Hammond (1980) [5] observed no difference in the detection of fraud using a sham crime scenario among healthy individuals, alcoholics, and psychopaths. Similarly, neither Raskin and Hare (1978) [6] nor Patrick and Iacono (1989) [7] found any differences in the detection of fraud between psychopathic and non-psychopathic prisoners. However, the studies of Waid et al. [8] indicate that the use of meprobamate reduces polygraph tests accuracy, although the studies conducted by [9,10] suggest that similar drugs, such as diazepam (Valium) and methylphenidate (Ritalin), show little effect on the polygraph results. Summarising, it is possible to state that drugs and alcohol may impact the result of the analyses, nevertheless, currently,

researchers are aware of that and, therefore, are able to extrapolate the effect on the results.

Interestingly, polygraph analyses cannot be used in all cases. According to the American Polygraph Association (APA), the test can be performed only if several criteria are fulfilled:
› a person does not present with any mental disorders,
› the person tested is over 12 years of age and is able to think in an abstract manner,
› the IQ is higher than 55 and mean age equivalence indicates an age of not less than 12 years,
› the person has a Global Assessment of Functioning scale score of less than 50 [16]

Physical disabilities (e.g. amputation of a finger, arm, hand, as well as spine injures) are potentially problematic; however, the sensor can be omitted, or placed elsewhere, for instance, EDA can be placed not on the finger, but on a foot [16].

In practice, polygraph tests constitute valuable tools for detecting truthfulness, confabulation and fraudulent behaviour in various areas (criminal departments, national security agencies, business, industry, science):
› for detecting lies in forensics (criminal investigation) [11],
› as evidence and circumstantial evidence for government agencies and legal systems [12],
› to identify terrorism suspects and other individuals presenting anti-social behaviour who may be concealing their identity [13],
› as a tool supporting the administration of justice to individuals facing wrongful convictions [14],
› in industry and business, they can contribute to increasing the organisational efficiency, facilitating the selection of candidates with appropriate skills and experience, and promoting the employee integrity in the workplace [15].

The physiological parameters can be recorded using different body parts (**Figure 2**), for instance, the chest, arm, and fingers (**Table 1**). For proper analyses, the following procedures should be followed:
1. Pre-test interview.
2. Acquaintance test.
3. Main test.
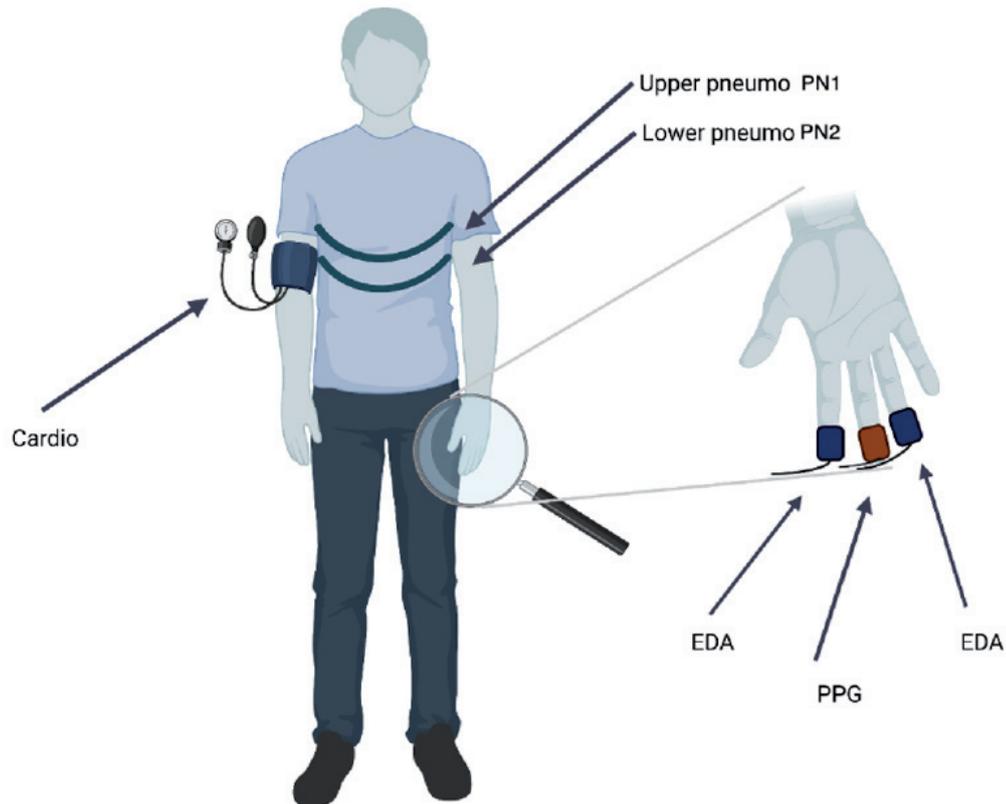4. Final talk.
5. Data analyses.

Figure 2. Location of sensors: Upper pneumo PN1 – Thoracic Pneumograph; Lower pneumo PN2 – Abdominal Pneumograph; Cardio – Blood pressure measurement; EDA – Electro Dermal Activity (Galvanometer); PPG – PhotoPlethysmograph (Created with BioRender.com)

Table 1. Physiological parameters and channels used in a polygraph examination [16]

Physiological parameter	Observed change	Type of sensor	Sensor location
Respiratory rhythm	– apnoea – breath suppression – breath rate retardation – breath rate acceleration – shallow breathing – respiratory depression	Pneumo	Upper and lower chest
Skin ectodermal activity	– skin dryness – hyperhidrosis	EDA	Fingers
Blood pressure and heart rate	– heart rate depression – heart rate acceleration – blood pressure fluctuations – extrasystoles	Cardio	Arm or thumb
Blood volume changes in veins	– decreases of the volume in small and distal vessels	PPG / PLE	Tip of the finger

Test procedure

Regardless of the reason for the test (forensic investigation, screening, legal evidence of offenders or private purposes), the examiners have to prepare a suitable place, the equipment as well as themselves. The test should be conducted in quiet and private conditions, in a location with no disturbance or disruption, whereas the examined person needs to understand the language and all the question asked, and crucially, the person cannot be forced, but must express a willingness to be tested [16]. The examiner should have all the available background information concerning the investigated issue so that they can ask pertinent questions as well as select the appropriate and most adapted protocol and set of questions [17].

Pre-test interview

The interview includes the verification of the subject's identity, obtaining written consent to participate in the procedure, explaining the main principles of the polygraph test, a comprehensive discussion of the main issues which will be verified during the test, familiarisation with the test questions and their discussion. The pre-test interview should reduce the participant's stress by asking questions regarding basic personal information, such as occupation, age, health status and memory [18], which also helps to determine if a person is physically and mentally fit to take part in the test. Additionally, the examiner should also explain the procedure and ensure that the participant understands that they will only be asked questions concerning the investigated issue [16]. In this part the examiner frequently asks, such questions as "Do you understand that you will be asked only the questions about the case?" or "Do you understand all the steps in the procedure?" [16].

Acquaintance test

This test is also referred to as a demonstration test (abbreviated as "demo"), and it is designed to relax or activate the participant. In addition, it also reveals the participant's typical level of emotional agitation when responding to answers, which allows to observe the variability of the registered physiological reactions, particularly when the person is deliberately misleading (so-called psychophysiological response to a known lie). Furthermore, the acquaintance test also enables the participant to grow accustomed to the testing situation and the installed sensors [19]. This part of the procedure is based on irrelevant questions (described in „Main test" section).

Main test

The main test is central to the investigation and involves questions pertaining to the issue under investigation asked in 20–25 second intervals to provide time for recovery [16]. The participant should be instructed to provide only "yes" or "no" answers, and the questions should be simple and close to the true/false mode [16]. The questions are the most crucial element of the procedure, since they constitute emotional triggers, eliciting physiological responses which can be detected and recorded for further analysis (**Table 2**). The questions can be categorised as shown in **Figure 3**.

The questions should:
› be simple, direct and easy to understand,
› be determined and adjusted in time,
› describe the relationship between the participant and the issue,
› not lead to incorrect answers,
› aim at complex references,
› avoid sophisticated law, medical, psychological, motivation, terminology, vernacular and jargon,
› be adjusted in terms of complexity [16].

The interview procedure should be based on one of the commonly applicable techniques, such as CQT (Control Questions Test), GKT (Guilty Knowledge Test) or CIT (Concealed Infor-

Table 2. Question types and examples [17]

Question type	Abbreviation	Description	Example
Irrelevant Questions	IQ	The questions are not case-specific, aim to identify the most common reactions during the acquaintance test; serve to eliminate stress and orientate the responses	Is it currently the year 2020? Is Anna your name?
Relevant Questions	RQ	The questions pertain only to the investigated case and its circumstances	Did you steal the jewellery? Did you use a hammer to break the window?
Sacrifice Relevant Questions	ScR	Usually asked as a first relevant question to determine the intention of telling the truth	Are you going to answer the questions concerning the case precisely and accurately?
Control Questions	CQ	The questions address similar situations and cases as that under investigation	Had you stolen anything before turning 18?
Probable Lie Comparisons Questions	PLC	A question in response to which the participant is likely to lie	Did you ever lie in the first 20 years of your life?
Exclusive question	C(ex)	The question which does not overlap the time and/or case under investigation	Have you been to this place during your studies?
Inclusive question	C(in)	The question generally addresses the main case, but does not ask about it directly	Have you ever stolen anything from the shop?

mation Test) and can follow protocols such as the US Federal You-Phase, ZCT (Zone Comparison Test), Utah ZCT (Utah Zone Comparison Test), Utah ZTC DLC (Utah Zone Comparison Test Directed-Lie Test), USAF (United States Air Force) etc. (**Table 3**) [16]. The general principle of each protocol is to randomize the questions and to mix them in order to create the most unique combination, thereby allowing the detection of a lie [16].
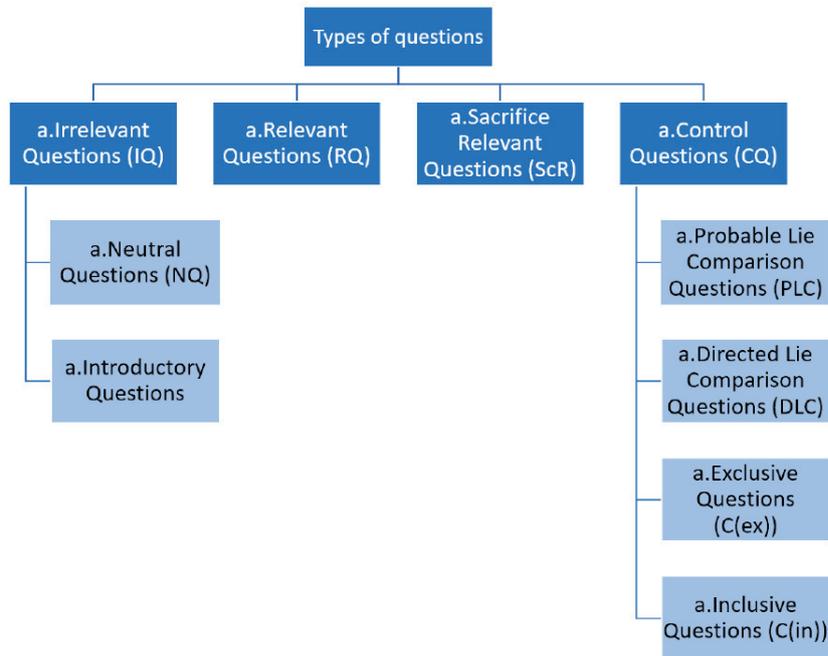

Figure 3. The categorisation of questions

Table 3. The types of questions used in the different protocols [16].

Protocol type	Question series	Question Set
Utah ZTC	Series I	I^1, ScR^2, $N1^3$, $C1^4$, $R1^5$, N2, C2, R2, N3, C3, R3
	Series II	I, ScR, N2, C3, R2, N3, C1, R3, N1, C2, R1
	Series III	I, ScR, N3, C2, R3, N1, C3, R1, N2, C1, R2
Federal ZCT	Series I	N1, ScR, $S^6$1, C1, R1, C2, R2, S2, C3, R3
You-Phase (Bi-Zone)	Series I	N1, ScR, S1, C1, R1, C2, R2, C3, S2
USAF MGQT	Series I (option I)	N1, ScR, C1, R1, C2, R2, C3, (R3, C16, R4)
	Series I (option II)	N1, ScR, C1, R1, R2, C2, (R3, C3, R4, R5, C4,)
Utah MGQT	Series I	I, ScR, N1, C1, R1, R2, C2, N2 (optional), R3, R4, C3, N3
DLST (TES)	Series I	N1, N2, ScR, C1, R1, R2, C2, R1, R2, C1, R1, R2, C2
LEPET	Series I	N1, ScR, C1, R1, C2, N2, R2, C3, R3, C4, R4, C5
	Series II	N1, ScR, C1, R1, C2, R2, N2, C3, R3, C4
	Series III (deepen)	N1, ScR, C1, R1, C2, R2, C3, R3, C4, R4, C5
IZCT	Series I	N1, 2I, ScR3, 4N, $C(ex)5^7$, R6, N7, $8C(in)^8$, R9, N10, C11, R12, $Cm^9$13

1. Introductory question e.g.: Do you understand that in the test I am going to ask only about the case we have talked about?
2. Sacrificed relevant question e.g.: Are you going to answer the questions concerning the case precisely and accurately?
3. Neutral question e.g., Is it currently the year 2020?
4. Comparison question e.g., Had you stolen anything before turning 18?
5. Relevant question e.g., Did you use a hammer to hit the man?
6. Symptomatic question e.g., Are you afraid that I will ask you about something else than the investigated case, even though I promised that I would only ask you about it?
7. Exclusive question e.g., Did you steal food while studying at the university?
8. Inclusive question e.g., Have you ever stolen anything?

The final talk

The test should be completed with the final talk, during which the participant is not informed about the results, rather reassured about the validity of all the steps.

Data analyses and opinion

The polygraph expert does not provide their evaluation directly after the test since the polygrams need to be assessed taking into consideration the pre-interview results, as well as the personal and case background information. It is crucial, due to the fact that a purposefully non-cooperative (PNC) person may try to restrict their physiological reactions [16]. There are numerous guidelines dedicated to polygraph data analyses. The ones currently used by licensed professionals are based on the scientific, physiological, psychological, neurophysiological and psychophysiological approaches, as well as the decision theory and signals reception theory [16]. On the basis of the physiological parameters, the data collected during the polygraph are taken into account when evaluating the polygrams and assessed based on numerical scales, that is, each relevant question is assigned a specific numerical value. Subsequently, the results obtained for the physiological responses recorded for the relevant questions are compared with the control questions. Each measured physiological parameter is evaluated separately.

The most objective visual analysis method of the test data in polygraphy research is the numerical analysis according to the Empirical Scoring System (ESS). It is used in the comparative questioning techniques (CQT) and the CIT test. The ESS analysis uses a 3-point rating scale in the range: +1, 0, -1 with the exception of the electrodermal activity (EDA) sensor, which is assigned values in the range of: +2, 0, -2 [21–27]. On the basis of the empirical research, the following diagnostic conditions are distinguished for individual recording channels: pneumo, EDA / GSR, cardio, PLE / PPG. The established decision thresholds are applied after numerical scores are assigned to the response records to the critical questions. In turn, test scores are calculated according to the abovementioned scores – in (-1)-0-1 scale for minor sensors and (-2)-0-2 for major, where (-2) means lie, 0 non-deciding and 2 truth answers. Then, after summing up, the percentage of the answers considered to be true can be obtained.

Archiving of results, notes, any created papers and complete documentation of the procedure should be conducted according to the national and international law, e.g. Polish national law and the European Directive (EU) 2016/680 of the European Parliament and the Council of 27th April 2016 [28] protects natural persons concerning the processing of personal data by competent authorities for the prevention, investigation, detection or prosecution of criminal offences or the execution of criminal penalties, and the free movement of
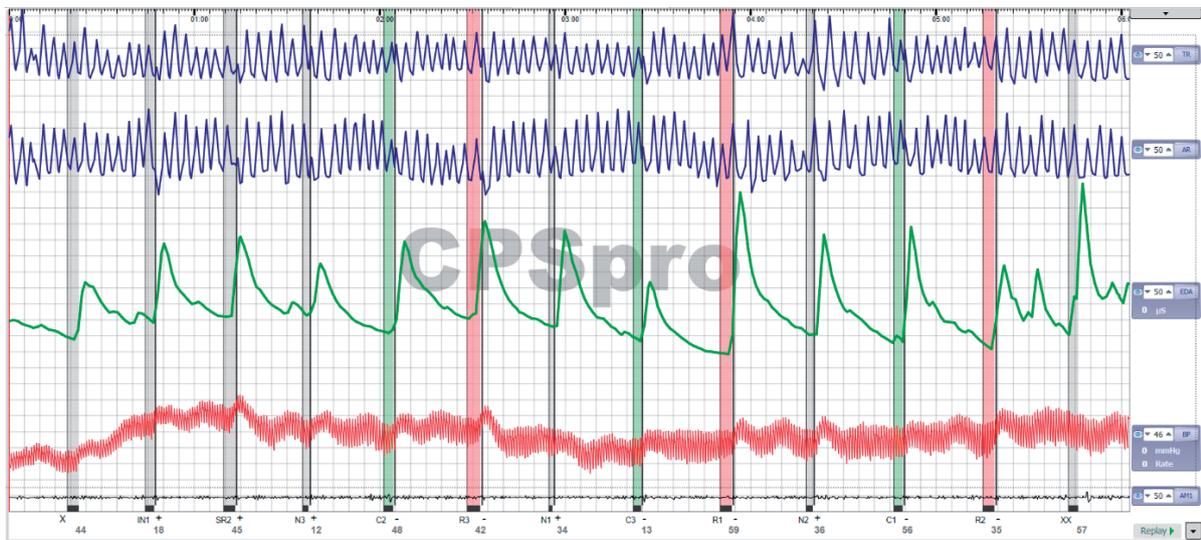

Figure 4. An example of a 5-channel polygram obtained by CPSpro - Stoelting

such data, and the repealing Council Framework Decision 2008/977/JHA.

Conclusions

The polygraph test procedure is based on the preparation of relatively simple questions in a moderately complicated protocol, which are asked in a strictly defined order, with a simultaneous measurement of the physiological reactions and responses in order to detect lies, or establish the objective truth. Polygraph procedures can be used for various purposes in different scientific areas, such as forensics, law, medicine or biotechnology, from finding an error to assessing honesty and truthfulness in the recruitment process, employee validation or a private loyalty manner. Since different polygraph procedures are required depending on the intended application, it is essential to consider the merits according to the polygraph techniques, protocols, validation tests, approaches and the situation. There are different ways to conduct the procedure and it will mainly depend on the issue and the person under investigation, as well as on the expert's preferences. Polygraphic analysis can be used not only to reveal the truth and lies, but they also provide significant insights with regard to stress and memory, due to a thorough analysis of bot the physiological parameters and the action of the autonomic nervous system. In addition, in terms of the diagnostics and personalization of therapy, particularly pharmacotherapy, polygraph tests allow to precisely determine the dosage on the basis of reliable effects of the therapy. It should be emphasized that the application of the polygraph in medicine and science will facilitate the introduction of a completely new quality also in the field of medical questionnaire research. According to our knowledge, the verification of the patient's declared data by means of physiological signals, regulated by the autonomic nervous system, would be a neurophysiological "authorization" of the patient's declaration of reliability. In this context, the polygraph may become a handy tool supporting the credibility of medical data [29–32].

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