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Recognition of emotions by analysing facial expressions with FaceReader (Noldus) vs detection of deception by polygraph examination. A pilot study

Jan Widacki*
Michał Widacki**
Bartosz Wójcik***
Anna Szuba-Boroń****

Abstract

FaceReader is a software package designed by the Dutch company Noldus (established and managed by Professor Lucas Noldus) for the automatic recognition and analysis of facial expression. The package was described in European Polygraph in 2022 with respect to its potential applicability for the detection of deception (see Widacki et al. 2022: 37–51). This article discusses the results of a pilot study aimed at testing whether the analysis of facial expression can be successfully used for the detection of deception, discovering what emotions are triggered by critical questions in tests during polygraph examinations, and what physiological reactions to these emotions can be observed and recorded in such an examination. The latter

* Andrzej Frycz Modrzewski Krakow University; https://orcid.org/0000-0001-9174-3501; jan.widacki@gmail.com
** Andrzej Frycz Modrzewski Krakow University; https://orcid.org/0000-0003-0461-5101
*** Independent researcher; https://orcid.org/0009-0009-3385-3978
**** Andrzej Frycz Modrzewski Krakow University; https://orcid.org/0000-0001-5417-5496

question is of particular importance for a better understanding of the psychophysiological essence of detection of deception and necessary for refining its methodology, especially with respect to improving the detection of attempts to manipulate or distort the recordings and counteracting them effectively.

This pilot study allowed a number of cautious conclusions to be drawn that nonetheless require further investigation, primarily by testing with a larger sample. It has also allowed us to gain experience that will help improve the protocol for organising such experiments.

Key words: FaceReader, detection of deception, facial expressions, microexpression, emotions

1. Introduction

Polygraph examination, like all instrumental methods for the detection of deception, records physiological changes considered to be correlated with the changes in bodily activity stimulated by the test questions (Widacki, 2018: 427). This observed change in the activity of the human body is not only the result of the emotions triggered by the questions, as believed by Münsterberg (Münsterberg, 1898; Widacki, 2021; Burtt, 1965), and as is often assumed today for the sake of simplification (see: Widacki, 2018: 427). It also results from the subject's cognitive effort of self-control caused by the eagerness to conceal the lie (Widacki, Dukała, 2015; Widacki, 2018, 2021). However, it cannot be ruled out that what we see here is yet another factor, operating in parallel or jointly with the emotion and the aforementioned cognitive effort, that could be the desire to supress some memories or relive them, as well as the cognitive effort of recalling, associating, etc. Thus, both the external (test questions, circumstances of examination) and aforementioned internal factors influence the observed and recorded physiological changes. Together they form the reaction to the test questions that provide the activating stimulus.

At least three fundamental motivation–emotion theories have been developed while attempting to understand the phenomenon of triggering psychophysiological reaction(s) eventually recorded by the polygraph during the examination, by the critical questions in the text (Mitrofan et al., 1992):

1) **Theory of conditioned response**. The theory argues that the physiological response is nothing but the consequence of an emotional activation caused by a conditioned stimulus. When a given stimulus is associated with a strong emotion, a broad response will be expected.

2) **Conflict theory**. According to this theory, both the motivation to lie and the desire to tell the truth are found in the physiological area. The more intensive the conflict, the broader the response.

3) **Theory of punishment**. According this theory, the physiological area during the stimulation is activated by the fear of consequences of potential detection. (Mitrofan et. al., 1992).

Three additional theories were formulated more recently (Lascu, 2021: 37–45):

1) **Theory of presumption of guilt**. The theory argues that the psychophysiological reaction will be highlighted in the relevant question, due to fact that the subject is aware of their guilt.

2) **Focus attention** theory. According this theory, the psycho-physiological response to a stimulus reflects the degree to which the stimulus was expected.

3) **Theory of dichotomisation**. This theory distinguishes two distinct categories of stimuli, namely the relevant and the irrelevant. Subjects who have information about the criminal act for which they are being investigated will focus on only one aspect of the presented stimulus, at the same time ignoring its other aspects that inform the investigator about the degree of the subject's stimulation (Lascu, 2021).

Other theories have also been proposed, for example, the **"analytical theory"** (Scientific Analytic) Theory of Polygraph Testing (Nelson, 2016) which is intended to explain the phenomenon of the psychophysiological reaction to the test questions.

This theory rejects the hypothesis that reactions are caused by fear, anger, sadness, or any other single emotion or any other single psychological process, as well as the hypothesis that emotions with different content can trigger different physiological reactions that are observed and recorded during a polygraph examination.

The experiment we conducted demonstrates that the emotions elicited by the successive questions were individual for every subject. This is aligned with common life experience which shows us that some people may experience a sense of joy by cheating somebody else, but there are also those whose emotions triggered by cheating are different, for example, fear or shame. The reaction depends on many factors, such as personality type, accepted values, as well as a plethora of external circumstances.

Should only the emotional realm be studied in subjects, it has to be remembered that emotions never occur in isolation, in an elemental, static form, but are fragments of a continuous process of interacting with our environment, by receiving, identifying, and reacting to external stimuli (Cannon, 1932: 227; Łosiak, 2007: 25 and ff). Moreover, being elements of a continuous process, some emotions may transform into others, superimpose themselves, etc. The rate of these transitions depends both on the rate of change of the stimuli, or solely on their intensity, and also quite likely also on the type of personality (degree of emotional lability), and the current psychophysiological condition of the subject, among other factors. Moreover, individual emotions may also enter into various interactions, which is why the so-called "primary emotions" listed by multiple authors are more of a theoretical construct than actual entities (see: Scherer, 2005, 2012).

For practical purposes, i.e. the detection of deception, the reasons for the physiological reaction triggered by a test question and subsequently recorded by the polygraph during examination remain largely irrelevant (Nelson, 2016). It is enough that – with the risk of an error rate not exceeding that in the majority of identification methods used routinely for investigative purposes (and later accepted as evidence in court) – this method allows a lie to be detected (Widacki, 1977; Widacki & Horvath, 1978), i.e. to determine whether the subject answers the critical questions in the test truthfully or deceptively. Deception is considered to cover both deliberate lies and concealing the fact of having some information. The effectiveness of such a method for detecting deception has been supported by over a century of practical application and numerous experimental studies (Widacki, 1977).

However, it makes sense to understand more deeply the mechanism of the psychophysiological detection of deception, i.e. to identify what actual reactions are triggered by the question in the polygraph test, or, in other words, what is correlated with the physiological reaction recorded during a polygraph examination. Besides the purely cognitive, the reasons are also scientific and practical, for the study can help discover mechanisms of deliberate interference with the recordings, as well as contribute to the discovery and counteracting of such attempts. It can also be useful for conducting the pre-test interview and thus contribute both to enhancing the psychophysiological techniques of detecting deception and interpreting its recordings.

As mentioned above, all that a polygraph recording reflects is the intensity of stimulation caused by a test question. It provides no information about the other two components of emotional state (level of body/bodily activation): namely, the valence or the content of the arousal.

The content of stimulation (the quality of the emotion experienced) is what the subject is actually experiencing and what psychologists usually boil down to the primary emotions of happiness, anger, fear, surprise, sadness, disdain, disgust, interest, revulsion, and shame (Ekman, Friesen, 1978; Hjortsjö, 1970; Tomkins 1999, 2008; Izard, 1977, 1994; Izard, Rosen, 1998).

It is generally accepted (see above) that the content of responses stimulated by test questions during a polygraph examination are primarily (though not solely!) fear (or anxiety) of the negative consequences of detecting a lie, the "subject's cognitive effort of self-control during examination", and possibly also other factors (see above) (Widacki, Dukała, 2015; Widacki, 2021: 58).

Other physiological correlates of the general activation level of the body, of which only some are recorded by a classical polygraph, include expressive behaviours such as pantomimic and expressive facial movements. These have been excessively discussed in the literature (Woodworth, Schlosberg, 1966).

In the light of current scientific understanding, which validates many centuries of common-sense observations, it is beyond any doubt that the expressive movements of the face (facial expressions) are correlated with experiences (emotions). So by watching the facial expressions, it is possible to draw conclusions about the experiences of the person whose facial expressions are being observed, particularly the emotions they are currently experiencing.

FaceReader from Noldus (see: Widacki, Wójcik, Szuba-Boroń, 2022) is a software package for the automatic recognition and analysis of facial expression, particularly of the six primary emotions: happiness, sadness, anger, surprise, fear, and disgust. In addition, the software includes "neutral emotions" (Widacki, Wójcik, Szuba-Boroń, 2022).

2. The goal of the experiment

The experiment was intended to provide information about the emotional content underlying the subjects' reactions during a polygraph examination aimed at lie detection. Is it obviously the fear (anxiety) of the negative consequences of the detection of the lie, as is usually assumed – next to the incontrovertible cognitive effort of the subject concerning self-control during the examination (see above) – or perhaps another emotion?

Another goal of the experiment was to test whether Noldus's FaceReader, a system for the analysis of facial expressions (including what is known as micro-expressions) (Ekman, Friesen, 1978) allows lies to be detected (hidden information) at a level not inferior to that of a classical polygraph examination. If this were to be the case, we would be dealing with another method of instrumental lie detection, all the more useful as it does not require sensors to be attached to the subject and therefore theoretically allows remote tests to be conducted, even without the subject's consent or awareness.

3. The Study Group

The study group consisted of six female postgraduate students in the fields of criminology, social rehabilitation, and public administration, all of whom volunteered to take part in the research. The participants' ages ranged from 20 to 40 (average: 26.6). None of the participants reported any health-related complaints on the day of the study. According to their own declarations, none had ever sought the assistance of a psychologist or psychiatrist.

They were initially informed that the experiment would involve an attempt to detect deception using two independent methods: one being a classic polygraph examination, the other – analysis of facial expression captured on video and evaluated by the FaceReader software developed by Noldus.

All participants declared that they had heard of polygraph examinations (lie detection), but had no knowledge of the procedure, even at the basic, textbook level.

All subjects reported experiencing stress related to their participation in the experiment, which they attributed to curiosity and excitement about the study itself, their participation in it, and anticipation of the result. Asked to rate this stress on a scale from 1 to 10, their responses ranged from 3 to 10 (average: 6.33). They were

also asked to assess their self-perceived ability to conceal their lies, in particular by controlling their facial expressions. This too was rated on a 1–10 scale, and the participants rated their ability between 5 and 9 (average: 7.5). Thus, they believed that they were, on the whole, successful in managing their facial cues and masking deception. The participants' self-assessment results are presented in Table 1.1.

Table 1.1

Subject ID	Stress self-assessment	Self-assessment of the ability to conceal lies by managing facial cues
KSW0617A1	5	6
KSW0617A2	3	5
KSW0618A3	6	9
KSW0618A4	10	9
KSW0624A5	5	8
KSW0624A6	8	8

Source: own materials.

4. Organisation of the Experiment

Each subject was interviewed individually. During this pre-test conversation, she was told whether she would play the role of a "guilty" or an "innocent" subject in the experiment. Two subjects were assigned the role of the "guilty" and four were assigned the role of "innocent" individuals.

The "guilty" subject was instructed to go to the library, locate a damaged book on a designated shelf, and retrieve three banknotes hidden between its pages: one PLN 50 note, one PLN 20 note, and one PLN 10 note, totalling PLN 80 (approx. USD 20). She was to look for and page through the book and extract the money discreetly, making sure no one else saw her doing this. The banknotes were to be taken and concealed on her person, while the book was to be returned to the shelf without drawing attention. She was to deny any involvement during the examination. She was instructed to claim she knew nothing about any money, was unaware of how much there was, or where exactly it had been hidden. She was also informed that if her deception was not detected during the polygraph examination, she would be allowed to keep the PLN 80. If it was detected, she would have to return the money.

The "innocent" subjects were informed that this was the role they had been assigned for the purposes of the experiment. During the examination, they were to answer all questions truthfully. They were given no information about the particulars of the experiment, in particular, they did not know who had been assigned the "guilty" role, where the "guilty" individual was supposed to take the book with the banknotes from, what the banknotes were, or their denominations.

This setup was designed to recreate a situation emotionally and motivationally analogous to that experienced by subjects in real-life investigative contexts.

The examinations were conducted in a professional polygraph laboratory using a Lafayette LX-5000 computerised polygraph and a Logitech HD 1080 camera.

They were conducted by two experts: a professional polygraph examiner (a certified member of the American Polygraph Association) and a licensed psychologist and psychotherapist. Neither examiner knew which role had been assigned to which subject, so they did not know which subject was playing the role of "guilty" or "innocent".

Peak of Tension (POT) tests were selected for the examination, based on the assumption that Control Question Techniques (CQT) are of limited utility in experimental conditions. In such settings, it is extremely difficult to construct a control question whose gravity (emotional significance) would not exceed that of the relevant question.

Each subject had administered stimulation tests of the "concealed number" and "mother's name" (Widacki, 1981: 67–68) type administered, followed by diagnostic POT tests concerning the book and the money. Some diagnostic tests were repeated in some cases. A total of 54 tests were conducted, each containing one relevant question.

Each of the six subjects underwent the same four stimulation tests ("number" and "mother's name") and POT (Peak of Tension) type diagnostic tests concerning the recorded number (7 questions), the subject's mother's name (8 questions) (e.g. Karolina; Natalia; Patrycja; Iza; Kamila; Barbara), the location of the hidden money (6 questions), and the value of money hidden (6 questions). The latter were repeated in some cases. Each of the tests included a single "relevant question". In total, the subjects were asked 347 questions, including 54 relevant

questions. In the stimulation tests, the relevant item was the subject's mother's name, which she attempted to conceal from the examiner. In the number test, the subject selected a number in secret, without the examiner's knowledge. In the tests concerning the location and amount of the hidden money, the relevant question was question number 4 or 5. The "guilty" subjects had previously been instructed to lie when answering that question.

5. Results

The results obtained by each subject are presented in the tables below, which include the intensity of responses to the relevant question in each subtest and the final conclusion of the polygraph examination based on the overall test result.

The examinations are incomplete in some tables (with only two tests present instead of three). This was caused by technical issues related to the high processing power required by the FaceReader software, which in some cases failed to save recordings due to errors.

Table 2.1 Results of the polygraph and FaceReader analysis for subject KSW0617A1

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
1	1			0.15		0.02	0.01		0.13	
	2			0.09		0.24	0.06		0.15	
	3			0.15		0.2	0.06		0.05	
	4			0.42		0.18	0.08		0.05	
	5			0.09		0.11	0.08		0.1	
	6			0.4		0.12	0.05		0.13	
	7			0.14		0.14	0.05		0.05	
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
2	1					0.15				
	2					0.18				
	3					0.15				
	4					0.11				
	5				0.02	0.18	0.01			
	6					0.11				
	7					0.11				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
3	1				0.01	0.16				
	2			0.03		0.2				
	3				0.01	0.15				
	4				0.01	0.2				
	5				0.01	0.2				
	6			0.5	0.01	0.2	0.01	0.02	0.01	
	7				0.01	0.2	0.01		0.02	
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
1	1			0.09	0.05					
	2			0.4						
	3			0.26						
	4			0.4						
	5			0.47						
	6			0.2	0.05					
	7			0.05	0.04	0.11	0.04			
	8			0.04	0.04	0.1	0.03			

Question 4 (number 4)

Question 5 (Karolina)

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
2	1				0.03	0.1	0.01			
	2			0.01	0.01	0.06	0.01			
	3			0.15	0.05	0.04				
	4			0.02	0.05	0.05				
	5			0.03	0.05	0.1				
	6				0.03	0.03				
	7				0.08	0.03				
	8				0.02	0.05				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
1	1				0.09	0.11				
	2				0.05	0.01	0.01			
	3				0.05	0.06				
	4				0.03	0.08	0.01			
	5				0.07	0.06				
	6				0.05	0.11				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
2	1				0.01	0.17	0.01			
	2			0.25		0.28	0.01			
	3			0.2		0.06			0.02	
	4				0.02	0.15				Question 4 (book)
	5					0.23				
	6					0.2				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
3	1				0.01	0.1	0.01			
	2				0.01	0.03				
	3					0.18	0.03			
	4					0.18	0.01			
	5					0.11				
	6					0.1				

Source: own materials.

In the first case (Table 2.1), the polygrapher correctly identified the number selected by the subject but incorrectly identified the subject's mother's name and wrongly assessed her knowledge regarding the location of the hidden sum of money, concluding that she possessed such knowledge, when in fact she was an "innocent" person. The subsequent test concerning the amount of hidden money could not be recorded in the FaceReader software due to technical issues and was therefore not conducted.

Table 2.2. Results of the polygraph and FaceReader analysis for subject KSW0617A2

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
1	1					0.1	0.01			
	2		0.02			0.04	0.02		0.07	
	3					0.18	0.02		0.06	
	4					0.13	0.01			
	5					0.3	0.01			
	6					0.11				
	7					0.28	0.01			
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
2	1					0.23				
	2					0.23			0.01	
	3					0.24				
	4					0.25				Question 5 (number 5)
	5					0.25				
	6					0.24				
	7					0.23				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
3	1					0.21				
	2					0.23	0.01			
	3					0.23	0.01			
	4					0.23				
	5					0.2				
	6					0.24	0.01			
	7					0.2	0.01			

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
4	1					0.17			0.08	
	2					0.14			0.04	
	3					0.15			0.12	
	4					0.15				
	5					0.2				
	6					0.15				
	7					0.14				
	8					0.14				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
5	1					0.25				
	2					0.18				
	3					0.13				
	4					0.2				
	5					0.19				
	6		0.8					0.59		
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
6	1					0.25				
	2					0.2				
	3					0.2				
	4					0.2				
	5					0.26				
	6			0.18		0.23				
	7					0.2				
	8					0.23				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
7	1					0.15				
	2					0.22				
	3					0.21				
	4					0.22				
	5					0.22				
	6					0.18				

Question 4 (Natalia)

Question 4 book

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
8	1					0.19				
	2					0.2				
	3			0.18		0.2				
	4					0.22				
	5					0.2				
	6					0.19				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
9	1					0.2				
	2					0.18				
	3					0.11				
	4					0.2				
	5					0.19				
	6					0.15				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
10	1					0.18				no indication
	2					0.21				
	3					0.19				
	4					0.2				
	5					0.16				
	6					0.23				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
11	1					0.15	0.02			
	2					0.21	0.01			
	3					0.2	0.01			
	4					0.16	0.01			
	5					0.14	0.01			
	6					0.16	0.01			
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
12	1			0.07		0.2				
	2					0.15				
	3			0.19		0.16				
	4			0.42		0.16				
	5					0.16				
	6					0.2				

Source: own materials.

In the second case (Table 2.2), the polygrapher correctly identified the number in the concealed number test, correctly identified the subject's mother's name, and, in the tests concerning taking money from the book and the amount of money taken, did not detect any knowledge of the critical event so he classified the subject as "innocent".

Table 2.3 Results of the polygraph and FaceReader analysis for subject KSW0618A3

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
1	1				0.01	0.4	0.09			
	2					0.31	0.09			
	3					0.51	0.09			
	4					0.6	0.13			
	5					0.45	0.09			
	6					0.7	0.22			
	7					0.7	0.24			
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
2	1					0.12			0.32	Question 5
	2					0.13			0.33	
	3					0.15			0.05	
	4					0.19			0.5	
	5					0.15			0.15	
	6					0.18			0.35	
	7					0.19			0.25	
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
3	1					0.24			0.5	
	2					0.22			0.39	
	3					0.23			0.73	
	4					0.21			0.98	
	5					0.39			0.03	
	6					0.24			0.28	
	7					0.3			0.26	

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
4	1		0.05			0.04			0.34	
	2		0.01			0.1			0.2	
	3					0.13			0.2	
	4					0.21			0.12	
	5					0.1			0.15	
	6					0.16			0.1	
	7					0.2			0.08	
	8					0.27			0.1	
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	Question 6 (PATRYCJA)
5	1		0.01			0.16			0.15	
	2					0.23			0.1	
	3			0.1		0.3			0.7	
	4					0.25			0.72	
	5					0.2			0.32	
	6					0.26			0.28	
	7					0.25			0.71	
						0.24			0.7	
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
6	1		0.02			0.03			0.27	
	2		0.01			0.12			0.21	
	3					0.21			0.19	
	4		0.01			0.22	0.01		0.2	
	5					0.24			0.2	
	6					0.24			0.17	
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	Question 4 (book)
7	1					0.24			0.13	
	2					0.28			0.1	
	3					0.26			0.13	
	4					0.27			0.08	
	5			0.12		0.25			0.78	
	6					0.2			0.82	

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
8	1					0.15	0.01		0.24	
	2		0.01			0.02			0.25	
	3					0.15	0.01		0.2	
	4					0.21	0.01		0.1	
	5					0.22			0.1	
	6					0.16			0.16	
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
9	1		0.02			0.16			0.25	Question 3 (PLN80)
	2					0.22			0.8	
	3					0.25			0.45	
	4					0.27			0.3	
	5					0.3			0.56	
	6					0.25			0.5	
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
10	1		0.05			0.22			0.2	
	2					0.25			0.08	
	3					0.26			0.04	
	4					0.27			0.08	
	5					0.28			0.09	
	6					0.3			0.09	

Source: own materials.

In the third case (Table 2.3), the polygrapher correctly identified the number selected by the subject in the concealed number test, correctly identified the mother's name, and, in the tests concerning taking money from the book and the amount taken, correctly determined the subject's knowledge of the act and therefore classified her as "guilty".

Table 2.4. Results of the polygraph and FaceReader analysis for subject KSW0618A4

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
1	1					0.11	0.02			
	2					0.22	0.08			
	3					0.1	0.01			
	4					0.11	0.03			
	5					0.04	0.01			
	6			0.15		0.1	0.03			
	7			0.2		0.09	0.083			
	8					0.2	0.03			Question 5 (IZA)
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
2	1					0.23	0.05			
	2			0.02		0.15	0.05			
	3			0.15		0.15	0.07			
	4			0.23		0.08	0.1			
	5			0.1		0.19	0.06			
	6			0.25		0.15	0.02			
	7			0.09		0.15	0.05			
	8			0.06		0.11	0.04			
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
3	1			0.01		0.18	0.05			
	2			0.09		0.11	0.03			
	3			0.11		0.22	0.04			
	4			0.01		0.11	0.04			
	5			0.07		0.08	0.03			
	6			0.09		0.08	0.01			
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	no indication
4	1					0.09				
	2					0.18	0.02			
	3			0.08		0.07	0.01			
	4			0.13		0.04	0.01			
	5			0.09		0.04	0.02			
	6			0.23		0.01	0.01			

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
5	1			0.02		0.13	0.01			
	2					0.1	0.05			
	3			0.1		0.1	0.01			
	4			0.2		0.05				
	5			0.2		0.1	0.03			
	6			0.05		0.05	0.01			
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	no indication
6	1			0.01		0.1	0.01			
	2			0.02		0.08	0.01			
	3			0.2		0.11				
	4			0.2		0.05				
	5			0.08		0.02				
	6			0.09		0.01				

Source: own materials.

In the fourth case (Table 2.4), the polygrapher correctly identified the mother's name and in the tests concerning taking money from the book and the amount taken, correctly found no indication of the subject's knowledge of the act and therefore classified her as "innocent".

Table 2.5. Results of the polygraph and FaceReader analysis for subject KSW0618A5

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
1	1					0.02			0.05	
	2					0.01			0.15	
	3					0.01			0.09	
	4		0.67			0.2	0.17			Question 4 (KAMILA)
	5					0.01			0.11	
	6					0.08			0.6	
	7					0.02			0.35	

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
2	1		0.22			0.2	0.02		0.1	
	2					0.25			0.7	
	3					0.27			0.4	
	4					0.25	0.02		0.09	
	5					0.3	0.01		0.09	
	6					0.2			0.55	
	7					0.22			0.35	Question 4 (KAMILA)
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
3	1					0.2			0.25	
	2			0.05		0.05	0.01		0.05	
	3					0.17			0.07	
	4					0.26	0.02			
	5					0.18	0.01		0.01	
	6					0.2			0.02	
	7					0.21			0.18	
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
4	1					0.19	0.03			no indication
	2					0.16	0.02			
	3			0.02		0.15	0.01			
	4			0.01		0.22	0.01			
	5					0.23			0.03	
	6					0.22			0.1	
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
5	1					0.25			0.2	
	2					0.2			0.05	
	3					0.17			0.15	
	4					0.11			0.12	
	5					0.29			0.01	
	6					0.22			0.11	
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
6	1					0.55			0.02	
	2					0.25			0.01	
	3					0.2			0.01	
	4					0.28			0.01	
	5					0.25			0.01	
	6					0.23			0.01	

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
7	1					0.23			0.6	no indication
	2					0.27			0.03	
	3					0.28			0.02	
	4					0.21			0.04	
	5					0.25			0.12	
	6					0.22			0.03	
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
8	1					0.25			0.02	
	2					0.2			0.01	
	3					0.18				
	4					0.23				
	5					0.28				
	6					0.09				

Source: own materials.

In the fifth case (Table 2.5), the polygrapher correctly identified the mother's name and, in the tests concerning taking money from the book and the amount taken, did not detect any such knowledge on the part of the subject so correctly classified her as "innocent".

Table 2.6. Results of the polygraph and FaceReader analysis for subject KSW0618A6

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
1	1					0.01			0.08	Question 4
	2					0.02				
	3					0.01				
	4			0.01		0.01				
	5					0.12				
	6					0.09				
	7					0.05				

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
2	1					0.2				
	2			0.01		0.15				
	3					0.2				
	4					0.22				
	5					0.27				
	6			0.01		0.15				
	7					0.21				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	Question 4
3	1					0.27				
	2					0.29	0.01			
	3					0.28				
	4					0.3				
	5					0.28				
	6					0.33				
	7					0.4				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
4	1					0.22				
	2			0.08		0.24	0.01		0.21	
	3					0.25				
	4					0.25				
	5					0.37				
	6					0.25				
	7					0.28				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	Question 5 (BARBARA)
5	1					0.25				
	2					0.22				
	3					0.3				
	4					0.23				
	5					0.28				
	6					0.25	0.01			
	7					0.29				

Test No.	Identified Emotions and Corresponding Numerical Values									Conclusion of the polygraph examination
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
6	1					0.16				Question 4 (book)
	2			0.01		0.25				
	3			0.05		0.23				
	4					0.19				
	5					0.25				
	6					0.55				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
7	1					0.22				
	2					0.16	0.01			
	3					0.24				
	4					0.23				
	5					0.25				
	6			0.05		0.27				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
8	1					0.3				Question 3 (PLN80)
	2					0.3				
	3					0.35	0.01			
	4			0.01		0.34	0.01			
	5					0.2				
	6					0.28				
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
9	1			0.1		0.2				
	2					0.1				
	3			0.01		0.23				
	4			0.01		0.18				
	5			0.15		0.25	0.03			
	6			0.01		0.1	0.01			
	QUESTION	NEUTRAL	HAPPY	SAD	ANGRY	SURPRISED	SCARED	DISGUSTED	CONTEMPT	
10	1			0.01		0.25				
	2			0.05		0.18				
	3			0.02		0.2				
	4			0.05		0.2				
	5			0.01		0.2				
	6					0.25				

Source: own materials.

In the sixth case (Table 2.6), the polygrapher correctly identified the number in the concealed number test, correctly identified the mother's name, and, in the tests concerning taking money from the book and the amount taken, correctly determined the subject's knowledge of the act, and consequently classified her as "guilty".

In five cases, the polygraph examination correctly classified the subjects as either "guilty" or "innocent"; in one case it incorrectly identified an "innocent" subject as "guilty". So, the accuracy of the polygraph results obtained in this experiment – 83.3% – corresponds to the typical accuracy rates observed in experimental polygraph studies and was therefore consistent with expectations.

6. Discussion of Results

It should be noted that the polygraph examination in this study only served as support for Noldus FaceReader. The starting assumption was that polygraph examination has an established diagnostic value and follows a rigorous methodology. The goal of the experiment was to compare the results of the polygraph examination with those obtained via the FaceReader software. The FaceReader examinations were conducted in an identical manner to that used in polygraph examinations, the sole difference being that Noldus FaceReader evaluated only facial expressions.

Following the software instructions, we measured the intensity of basic emotions predefined by the system: neutral, happy, sad, angry, surprised, scared, disgusted, and contemptuous. The intensity of a given emotion was defined by the amplitude of the curve generated by the software from the moment the question (stimulus) was asked to the moment the subject responded. The values representing the amplitude have been rounded to 0.01 in the tables presented above.

Regardless of the question type (number, mother's name, location of the hidden money or its value) all subjects – both "guilty" and "innocent" – demonstrated a consistent increase in the channel that FaceReader defines as "surprised" throughout the test. This was the only emotional response demonstrated by all subjects. The second most frequent emotion was fear ("scared"), which appeared when responding to certain stimuli. The third was "sadness", which was present in a handful of cases. There were no confirmed cases of the subjects exhibiting "disgusted" or "happy" emotions in response to any of the relevant questions.

Other emotional reactions appeared sporadically, in response to irrelevant questions.

An interesting case arose while examining the first subject, who was the only one to display emotional responses categorised as "anger" in response to questions. This was also the only case in which the polygrapher delivered incorrect results in nearly all the tests. Despite all the efforts taken, including an additional introspective interview with the subject, the reasons for these atypical reactions could not be determined.

Nor could any significant differences be observed, whether in type or intensity, between the emotional reactions of the subjects who concealed their guilt ("guilty") and those who were uninvolved ("innocent").

7. Conclusions

Based on this experiment, it can be concluded that the emotional response to the critical questions asked during the polygraph examination most frequently detected and recorded by the FaceReader software, was that of surprise. This emotion was elicited in every subject, in every test, and in nearly every question with the exception of the first "name" test performed by subject KSW0617A1. The second emotion that FaceReader most frequently recorded was fear ("scared"), which was observed in 28 of the 54 tests. The third emotion, still significant in terms of occurrence, was "sadness", which was recorded in 27 of the 54 tests conducted.

However, in most cases, the peak intensity of emotional response was recorded for questions situated midway through the test. In the name test, for example, three of the names placed in the middle of the test sequence – one correct, and two incorrect – were those entered by the subject.

The basic emotions identified by the FaceReader software in response to critical questions are summarised in the table below:

Indicated primary emotion	Total number of questions	Percentage (%)
Surprise	53	98%
Sadness	27	50%
Fear	28	52%
Happiness	2	3,7 %

(Where 100% = 54 questions)

It follows that in a laboratory setting, the strongest and most frequent basic emotion triggered by a critical question is surprise. However, this emotion does not typically appear in isolation, but rather in conjunction with other basic emotions, most notably fear (scared) and sadness (sad). In principle no other basic emotions occur in this context. Happiness was recorded in response to only two critical questions (3.7%) and occasionally appeared in reactions to irrelevant questions.

It cannot be ruled out that the cognitive process and the examination itself, which were a truth/lie-verification procedure, trigger only these "negative emotions".

Based on the results from FaceReader, which analyses facial expressions and identifies the corresponding emotional states, our study did not manage to distinguish between truthful and deceptive subjects. Their responses demonstrated no differences in the quality (type) or intensity (intensity) of emotion. The polygraph examination operating under the same experimental conditions succeeded in differentiating between liars and truth-tellers, yielding a diagnostic accuracy rate of 83.5%.

Assuming that FaceReader reliably identifies emotions based on its analysis of facial expressions, a number of preliminary and cautious conclusions may be drawn.

Above all, it appears that the emotional response experienced by a subject of a polygraph test triggered by the perception of and response to a critical question cannot be reduced to any single basic emotion (such as sadness, happiness, anger, surprise, fear, disgust, or contempt) or to a simple combination of two such emotions. Theoretically, a more far-reaching conclusion is also possible, namely that the emotion experienced is not, in fact, the crucial component of the subject's physiological reaction to test questions in a polygraph examination, and that other –less commonly appreciated – elements play a decisive role, such as the subject's cognitive effort related to self-control, mental associations, and memories.

This hypothesis, however, requires further research, certainly involving a significantly larger sample size.

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