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Attempt at Detection of Deception Based on Records of Physiological Reactions Remotely Captured with FaceReader Software. Part 1

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Abstract

Strong emotions are among others manifested in the expressive movements (facial expression). Facial expressions are natural and universal by nature. They do not depend on ethnicity, culture, social status, age, etc. Nonetheless, humans are sometimes capable of controlling their facial expressions and hiding their emotions. Simulating emotions is a fundamental acting

skill. However, controlling facial impressions takes time. The onset of such a control is delayed by anything from 0.25 to even 0.1 second – the period when the authentic facial expression, adequate to the emotion is demonstrated – and therefore remains imperceptible to an external observer. This short-lived facial expression observed in that short meantime is known as microexpression.

FaceReader, designed by Dutch company Noldus (established and directed by Professor Lucas Noldus), is a software package for automatic recognition and analysis of facial expression. As its diagnostic value for validity as well as reliability, that is the level of correct indications, remains unknown, we decided to determine it experimentally and have chosen to run an experiment comparing its diagnostic value with that of a traditional polygraph examination.

Key words: FaceReader, FaceReader (Noldus), detection of deception, facial expressions, microexpression, Noldus

1. Introduction

Deception, lie, guilty knowledge, concealed information (terms that are identical from the methodological and logical points of view (Widacki, 2011), and therefore can be used interchangeably) are known to be accompanied by emotional changes and the subject's intellectual effort of self-control during a polygraph examination (Widacki, Dukała, 2015). Altogether, the reactions to the stimuli provided in the test questions trigger emotional changes (changes of body activity). Those changes of activity are accompanied by physiological changes (reactions) that are registered by a polygraph machine, and later interpreted in the context of the stimuli (test questions) that caused the reactions. The results of the interpretation can provide circumstantial evidence in criminal procedures, which, as any evidence, requires being confronted with the remaining body of evidence (Widacki, 2014).

Currently the effort of researchers of instrumental detection of deception runs basically along two main tracks. The first is the attempt to move from the psychophysiological level of the detection of deception to the neuropsychological one, using EEG and fMRI (Widacki, 2007).

The other, to which this study and research belong, is based on seeking such physiological correlates of body activity changes at the psychophysiological level that could be observed and recorded remotely (without contact), without the need to attach sensors to the body of the subject, which is the case in traditional polygraph examinations. It is a step towards the development of efficient methods of instrumental detection of deception without the knowledge, and ergo also consent, of the subject.

Such an examination, if undertaken without the knowledge and concession of the subject, obviously raises questions of ethical and legal nature, which require separate investigation and are not considered in this article. We generally believe that no such examinations should be carried out, and results obtained through them should not be permitted as evidence for investigative purposes, and even more so as evidence in criminal cases. However, such procedures seem useful in prevention of terrorist acts, and also in the operation of intelligence and counter-intelligence.

2. Attempts at lie detection based on remotely recorded physiological changes

Designing an efficient method of detection of deception based on observation, recording, and analysing data on physiological reactions obtained remotely first of all requires finding such reactions whose diagnostic value would be comparable to the diagnostic value of reactions recorded by a classical polygraph machine, that is reactions in the form of changes in the course of the breathing functions, the operation of the blood system, and the skin galvanic (electrodermal) responses. Secondly, which is furthermore far more difficult, it calls for designing such technique of examination in which the subject will not be aware that their physiological reactions are observed and recorded while they answer the questions. This makes it evident that the tests and types of questions used in this case must be different than in classical polygraph examinations.

State-of-the-art knowledge and technology make it possible to record remotely at least several physiological reactions that accompany deception. These include voice changes, eyeball movements, changes in facial temperature, and changes in facial expression. Each of these reactions, as well as attempts at their diagnostic use for detection of deception, has been subject of plentiful literature.

Voice changes were one of the first remotely observable parameters to be tested. Even without the use of any mechanical devices, the voice, not unlike facial expressions, provides grounds for recognising fundamental emotions, especially if powerfully experienced, as well as certain moods. Voice reflects fury, anger, fear, impatience, shyness, self-assuredness, and other emotions.

Attempts at lie detection based on voice changes have been undertaken in the United States since the 1970s. Several devices recording such changes have made it to the market under various brand names. Initially they were the PSE (Psychological

Stress Evaluator) and the VSA (Voice Stress Analizer), and later the CVSA (Computerised Voice Stress Analyzer) (Widacki, 2018). A similar device under the name of LVA 6.50 was constructed in Israel (Gramatyka, 2008).

The results were, however, discouraging, as the diagnostic value of detection of deception performed in this method remained far below the diagnostic value offered by polygraph examinations (Barland, 2002; Horvath, 2002). For that reason, they were disqualified by the US Department of Defence and American Equal Opportunity Commission that forbade their use in pre-employment tests, and also by the Wisconsin Court of Appeals (State of Wisconsin v. Paul D. Hoppe, 2001) (Widacki, 2018). Similarly, subsequent Polish experimental studies proved the relatively low diagnostic value of the tests conducted with such devices, remaining below the diagnostic value of polygraph examinations (Gramatyka, 2008; Pietruszka, 2006; 2008; 2009; Leśniak, Leśniak, Gramatyka, 2011).

Eyeball movement and pupillary reflex – attempts have long been made to use those as indicators of emotional changes, also ones accompanying lies. Avoiding eye contact and averting the eyes have been treated since times immemorial as symptoms of deception, most probably on the grounds of experience drawn from life. By the way, observation of eyeball movement is also used currently in non-instrumental lie detection (Gordon, Fleisher, 2011). It was only much later, towards the end of the 19th century that special devices, known as oculographs, began to be constructed for the observation of eyeball movement. Eye tracking, consisting of observation, recording, and analysis of eyeball movements, is used to determine what the eye focuses on. It is used in medicine, psychology (especially psychology of advertising) marketing, pedagogy, ergonomics, and studies of human–computer interactions among the others. Other than the eyeball movement, oculographs can also observe and record changes in the size of the subject's pupil (Duchowski, 2004; Jacob, Karn, 2003; Stolecka-Makowska, Wolny, 2014; Paśko, 2017; Orquin, Holmqvist, 2018). Initially, oculographs were installed on the head of the subject. Currently, apart from such devices, also ones that observe eyeball and pupillary movements remotely are used. Early in the 21st-century, attempts were made to use such devices for studying emotions, and especially for the detection of deception (Hacker et al. 2014; Kircher, Raskin, 2016). The results of those attempts also seem encouraging, even if the level of correct lie detection remains below that of classical polygraph examinations (Kircher, Raskin, 2016), and the techniques of such experimental examinations have as yet not required installing any sensors on the body of the subject even if they made the

subject stay close the oculograph, and their fully conscious participation in the examination, for which reason they do not make performing such test without the subject's knowledge possible.

Changes in facial temperature have long been considered a good indicator of emotional changes (Hilgard, 1967: 243; Woodworth, Schlosberg, 1966: 268), however it was only the use of an infrared camera for their observation and recording that made it possible to perform such tests remotely (Gołaszewski, Zając, Widacki, 2015). The results of experiments detecting deception based on the observation of facial temperature changes using an infrared camera might have been encouraging, yet inferior to the attempts at such a detection made in parallel with the use of the polygraph (Widacki, Widacki, Antos, 2016; Mikrut, Widacki, Widacki, 2018). Moreover, those attempts proved that method of lie detection to be highly complex technologically, which made it impractical (Mikrut, Widacki, Widacki, 2018). It required close proximity of the infrared camera lens to the face of the subject, and by that token did not practically allow performing such an examination the subject realising it was performed.

Changes in facial expression (including "microexpression") – strong emotions are among others manifested in the expressive movements (facial expressions) (Woodworth, Schlosberg, 1966: 168). Elementary life experience makes it possible to read at least the fundamental and strongest emotions, notably anger (fury), fear, joy, surprise and the like from facial expressions. Psychologists differentiate from seven to nine basic emotions that are expressed by the face (see below).

Facial expressions are natural and the universal by nature. They do not depend on ethnicity, culture, social status, age, etc.

Nonetheless, humans are at times capable of mastering their facial expressions and hiding their emotions, just like they know how to simulate them. Simulating emotions is a fundamental acting skill. However, controlling facial impressions takes time. The time required for it is very short, in the range of 0.25–0.1 second, comparable to winking an eye, and therefore imperceptible for an external observer. This is the time when the authentic facial expression, adequate to the emotion, is demonstrated. This short-living facial expression is known as microexpression. As has been mentioned, its time is generally too short to be noticed by an external observer. That is why its recognition and recording requires special devices that allow capturing it and then replaying at a much slower speed. American psychologists Silvan Tomkins (1911–91) and Paul Ekman (b. 1934) are considered the discoverers of microexpression. The

latter wrote many works on microexpression and detection of deception based on analysing microexpression. He has also written several books that have been translated among others into Polish (Ekman, 2011; 2001; 2003; Ekman, Davidson, 2012; Ekman, 2009; Ekman, Friesen, 1974; Ekman, Hager, 1979; Ekaman, Friesen, Ancoli, 1980). Ekman claims that studying microexpression is a good method of detecting deception (Ekman, 2001). Moreover, it seems that remote observation and recording of microexpression poses no major technical problems even if conducted without the subject's knowledge, unlike analysing facial temperature changes and eyeball movements.

As has been mentioned, when applied separately, all the methods described above (voice analysis, facial temperature change analysis, and microexpression analysis) have proven lower diagnostic values in experimental studies than polygraph examinations recording in parallel at least the following three functions of the organism: breathing, blood system, and the skin galvanic response (electrodermal reaction). As yet, there have been no results of studies combining the three other remotely recordable physiological reactions for detecting deception.

Of the remote methods for detection of deception listed above, it is perhaps the analysis of facial expressions, micro expressions included, that has recently received most attention. Many works devoted to the subject have lately been published all around the world (see: Samuel at al., 2019; Shen *et al.* 2021; Curtis, 2021; Ioannou *et al.* 2005; Dimberg, Thunberg, Grunedal, 2002; Monaro *et al.* 2022). In Poland this issue is practically unknown, and has only been discussed in a handful of general works that, furthermore, as a rule ignore most foreign literature (see: Laszczak, 2021).

Studying microexpression for capturing emotions serves many purposes, and is used primarily in psychology and psychiatry, and especially in the psychology of advertising and marketing. Its use for the detection of deception is only one of the potential options.

3. The mechanism of microexpression

The mechanism of microexpression is complex. At the level of execution, it is performed by 24 muscles of the head, mostly by the muscles of the face (*musculi capitis*). Around 70% of these muscles have been discovered to have no practical use save for the actuating facial expressions, which are known to express emotions.

Various facial expressions correspond to various emotional states. Ekman and Friesen (Ekman, Friesen, 1978), following Hjortsjö (1970) differentiate seven fundamental emotions:

- happiness
- anger
- fear
- surprise
- sadness
- disdain, and
- disgust.

Other authors include other fundamental emotions such as shame or revulsion (Tomkins 1999; 2008), and interest and surprise (Izard, 1977; 1994; Izard, Rosen, 1998).

A different muscular complex corresponds to each of these emotions. For example, drawing the brows towards each other and downwards, increasing the distance between the eyelids, pressing the lips, tilting the head slightly forward, and optionally also pushing the jaw forward are characteristic of the emotion of anger. The emotion of anger was intended to get the body ready to fight. In turn, the emotion of fear was to prepare the body for flight (Cannon, 1932: 227; Kępiński, 1972). In these cases, facial expressions played several functions, both independent (e.g. to scare the opponent) and derived from other changes in the body, and adjusting the body to operation in new conditions.

4. Observation of microexpression

By the very nature of facial expression changes, their observation calls for paying attention to several changes that take place in the subject's face simultaneously. In case of microexpressions, their aforementioned extremely short duration, lasting from 0.25 to 0.1 second, provides an additional hurdle.

There have been numerous attempts at solving the problem, much like there have been many attempts at investigation of microexpression for the detection of deception. As far as the first goes, attempts have been undertaken to develop special computer software to automatically investigate in parallel multiple elements of facial expressions and transform them into a legible chart, making it possible to recognise precisely the emotion causing facial changes.

Therefore, it is little wonder that such works are primarily conducted in teams with participation of computer scientists and in such departments of, usually, universities of technology as computer engineering, electronics and mechatronics, and computer sciences (Ioannou, Caridacis, Karpousis, Kollias, 2006; Starostenko, Contreras *et al.* 2011).

5. FaceReader system from Noldus

One of such software packages is FaceReader designed by Dutch company Noldus (established and directed by Professor Lucas Noldus of Radboud University in the Netherlands) that allows remote observation of the subject's facial expressions, processing information obtained from that observation, and returning their averaged recording as it recognises emotions by analysing the facial expressions (expressing emotions).

Thus, FaceReader™ is a software package for automatic recognition and analysis of facial expressions, notably the expressions of the six fundamental (universal) emotions: happiness, sadness, anger, surprise, fear, and disgust.

The software makes use of FACS (Facial Action Coding System) created by a Swiss anatomist Carl Herman Hjortsjö (1970), developed by Paul Ekman and Wallace V. Friesen, and published in 1978 (Ekman, Friesen, 1978) to be updated further later (Ekman, Friesen, Hager, 2002). The system "orders" the movements of facial muscles and allows categorising the movements of facial muscles for more precise determination of the emotional state.

The main task of FaceReader is to classify the facial expressions of participants in the test. The results obtained are analysed and visualised in real-time on several charts. These include line and/or bar charts, or alternatively pie charts showing the percentage share of a specific emotion in the process of expression.

Determining the facial expression with FaceReader:

1. **Face finding** – the position of the face in an image is found using a deep-learning-based face-finding algorithm, which searches for areas in the image having the appearance of a face at different scales.

2. **Face modelling** – FaceReader uses a facial modelling technique based on deep neural networks. It synthesises an artificial face model, which describes the location

of 468 key points in the face. It is a single pass quick method to directly estimate the full collection of landmarks in the face. After the initial estimation, the key points are compressed using Principal Component Analysis. This leads to a highly compressed vector representation describing the state of the face.

3. **Face classification** – with the above provided, classification on the facial expressions takes place by a trained deep artificial neural network recognising patterns in the face. FaceReader directly classifies the facial expressions from image pixels. Over 20,000 manually annotated images were used to train the artificial neural network.

The model allows FaceReader to classify facial expressions, and record Action Units (AU) and levels of activation, while the valency of facial expressions can be visualised.

Additionally, FaceReader is capable of discerning the "neutral" state of emotions and "contempt". It also records:

- blinking frequency (separately for the left and right eye)
- Head positions: "head turn left" (AU 51), "head turn right" (AU 52), "head up" (AU 53), "head down" (AU 54), "head tilt left" (AU 55), and "head tilt right" (AU 56)
- direction of gaze
- other features including gender, age, and facial hair (beard and/or moustache)
- heart rate/heart rate variations, in individually defined complex expression standard.

Other independent variables can be additionally introduced manually.

It must be noted that FaceReader analyses the left and right Action Units (AUs) separately. This unique feature makes it possible to define the intensity of muscle activity separately for the left and right sides of the face.

FaceReader captures and analyses 20 Action Units as well as several frequent and complex combinations thereof:

AU 1. – inner brow raiser

AU 2. – outer brow raiser

AU 4. – brow lowerer

AU 5. – upper lid raiser

AU 6. – cheek raiser

AU 7. – lid tightener
AU 9. – nose wrinkler
AU 10. – upper lip raiser
AU 12. – lip corner puller
AU 14. – dimpler
AU 15. – lip corner depressor
AU 17. – chin raiser
AU 18. – lip pucker
AU 20. – lip stretcher
AU 23. – lip tightener
AU 24. – lip pressor
AU 25. – lips part
AU 26. – jaw drop
AU 27. – mouth stretch, and
AU 43. – eyes closed.

The preliminary studies in the possibility of using computer applications for analysing emotions in studying deception in psychotherapy have already been conducted (Curtis, 2021). The capacity technology offers in investigating and understanding behaviour is emphasised in the context of multiple scientific disciplines. FaceReader software has been tested preliminary in consumer research (efficiency of advertising) and also in studying emotions in children based on video recordings to compare lie detecting efficiency of FaceReader and adults talking to the child (Gadea *et al.* 2015).

As the software producer (Noldus) informed, save for the case quoted above, FaceReader has never been used for the "detection of deception".

The diagnostic value of FaceReader, that is the level of its correct indications, remains unknown and we want to find it experimentally. Our experiment will be conducted in multiple stages. The first will be to compare the efficiency (diagnostic value, including validity and reliability) of detecting deception with the use of a traditional polygraph (using traditional polygraph examination techniques, that is CQT and CIT (GKT)) and the FaceReader system. The two methods will be applied in parallel. Thus, in the first stage of the experiment, the subject of a polygraph examination will have their facial expressions additionally captured and examined

by FaceReader. The reactions captured by the polygraph will subsequently be compared to those captured by the FaceReader system.

In the following stage of the experiment, we envisage the application of CQT, CIT/GKT polygraph examination techniques, while the diagnosis will only be based on observation of facial expressions with the FaceReader system from Noldus. The subject will be aware of being examined and of detection of the potential deception being the purpose of the examination.

These experiments should jointly provide an answer to the question whether Noldus's FaceReader can be successfully used in the place of a traditional polygraph machine.

If this is the case, that is the diagnostic value of such examination will be proven similar to that of a polygraph examination, we will proceed to the following, last stage of the experiment, which will have the examination remodelled so that the subject will not know that they are being examined and will not be informed about the examination. There will be no traditional CQ, CIT/GKT techniques used, but instead, a custom-built test with particular questions melded into a conversation, hidden between the non-diagnostic fragments of the conversation, will be tried out.

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