https://doi.org/10.34836/pk.2020.310.1

Mateusz Ignaszak, M.Sc.
Adam Mickiewicz University in Poznań, Faculty of Law and Administration

Influence of selected personality traits on the course and results of fingerprint comparison

Summary

Forensic experts in the field of fingerprint examination are prone to cognitive errors that can affect the opinion issuing process. A study was conducted to determine if students exhibiting certain intensities of two personality traits: the need for cognitive closure and controllability, have a predisposition to be better fingerprint examination experts compared to others. The study consisted of three stages: completion of personality questionnaires, training in fingerprint examination, and finally a fingerprint examination – related task. The task was appropriately staged to introduce cognitive illusions, led by which, the subjects were more likely to give incorrect answers. No significant correlation was found between the studied characteristics and correctness, biases, caution, and decisiveness in the task performed. The subjects were significantly more likely to give incorrect answers. There was a positive correlation of time with the number of correct answers. A significant positive correlation was also observed between the preference of order and caution in task performance. The results obtained can be used in typing individuals who will perform better at comparing fingerprints.

Key words: fingerprint expertise, comparative testing, expert personality traits, cognitive closure, controllability, cognitive bias

Introduction

When performing any activity, we engage cognitive resources. To avoid consuming energy unnecessarily, our minds have evolutionarily developed optimization processes that allow us to survive despite our limitations in perceiving the world. We can distinguish between limitations related to too much or too little information, the speed of decision-making and action, as well as the efficiency and capacity of our memory. When an algorithm that optimizes cognition is launched, a phenomenon called cognitive bias can occur, understood as a heuristic shortcut that interferes with the ability to make rational decisions (Sternberg, 2009). This reduces cognitive load, but also increases the likelihood of reasoning bias.

A particularly interesting problem is the susceptibility of people with expert knowledge to cognitive biases. There are studies involving experts in various fields as subjects. For example, airplane pilots have better abilities to assess distance-space relations and better mental rotation skills (Danziger, Levav, Avnaim-Pesso, 2011). It is also known that better developed spatial abilities are a good predictor of anatomy learning among physicians (Fernandez, Dror, Smith, 2011).

In order to give a theoretical framework to the problem of the process of analyzing forensic traces, the following sections will mainly refer to literature references related to fingerprint examination experts. The subjects of the presented study, on the other hand, were students. There is an obvious difference in knowledge and expertise between the two groups. It should be noted, however, that students comparing traces are performing the same cognitive operations as experts. Undoubtedly, such a decision-making process will be less often correct. However, this is beyond the focus of this study.

Forensic experts are also prone to cognitive biases, the effects of which have been described in several reports. Unfortunately, the institutions listed in the following section only collectively present the cases, without classifying them according to the field of forensic science or the type of studies carried out: identification[1], classification[2] and individualization[3] (Inman, Rudin,

[1] The purpose of identification studies is to determine the physical and chemical nature of the trace.

[2] The purpose of classification studies is to identify a group of potential trace sources.

[3] The purpose of individualization studies is to determine the common source (origin) of the objects being compared. These studies require particular attention as carrying the highest evidentiary value.

2002). Therefore, the conclusions indicated below should be extrapolated with caution to assessing the work of fingerprint examination experts.

The Supreme Audit Office has commented on the current model of appointing expert witnesses, stating that there is currently no guarantee of ensuring a factual and reliable opinion by those appointed as expert witnesses (Supreme Audit Office, 2015). In addition, as part of the Forensic Watch programme, quality flaws in expert opinions have been pointed out (European Centre for Initiatives in Forensic Science Foundation, 2018). Forensic Watch indicates that the purpose of the project is, among other things, to implement a qualitative assessment of expert witness qualifications. Also the conclusions of the Supreme Audit Office refer to the verification of experts' qualifications. The process of recruiting and selecting expert candidates should also fall into these categories. The following study report contributes to the discussion on changing the expert typing procedure. In turn, the report of the Helsinki Foundation for Human Rights in cooperation with the Polish Chamber of Commerce cites, among other things, the problem of submitting all the evidence gathered in a case to an expert when only a fragment of it is needed to prepare an expert opinion. This situation can affect expert's attitude toward the event and, consequently, the conclusions included in the opinion (Grabowska et al., 2014).

In contrast, a few years earlier, a report of the National Academy of Sciences listed cognitive bias as a separate category, pointing out, for example, that bias in favor of the party for whom the expert opinion is being prepared is expected to affect the final outcome (National Research Council, 2009). It also highlighted the inadequacy of current protocols and procedures to minimize such effects. Despite the fact that this phenomenon has been described for the realities of the work of American forensic experts, expert cognitive processes based on the senses and human brain infrastructure are universal, so the results of this study can serve as a starting point for a discussion on the impact of cognitive limitations on experts' work in Poland.

The foundation for the problems described in the above reports is the fact that the forensic expert is a human being who is limited in the use of his or her senses and mind by both biological properties and psychological characteristics. A detailed classification was made by Dror (2020), who divided the sources of cognitive biases into eight categories in a pyramid structure; at the top of the pyramid he placed those directly related to the case under consideration, in the middle he ranked aspects related to the specific person and his or her characteristics, and, finally, at the bottom he included factors related to human nature.

Given the extensive literature on cognitive biases in forensic science and the profile of the study reported herein, the remainder of this article focuses exclusively on citing the results of fingerprinting experiments. It has been shown that when experts re-examine the same trace (after a break of several months), they come to different conclusions in about 10% of cases (Ulery et al., 2012). It has further been pointed out that experts should base their opinions only on the material necessary for the opinion, and thus in isolation from other data related to the case that may affect the decision (Dror, Rosenthal, 2008). This problem also applies to the contact between law enforcement agencies and experts, especially in the case of laboratories that are in the organizational structure of the police or special services (Zapf, Dror, 2017). Furthermore, experts are unaware of how susceptible they are to cognitive bias and often underestimate the likelihood of adverse external and internal factors influencing their opinions (Murrie et al., 2019). Conversely, when providing an opinion that verifies an expert opinion provided by another expert, knowledge of the original phrasing influences the final decision (Fraser-Mackenzie, Dror, Wertheim, 2013). Prejudice in favor of the party who commissioned the expert opinion has a similar effect (Dror, 2015).

In most studies measuring the effects of cognitive biases on the decision-making process of forensic experts, the research method follows the same model procedure of manipulating the context between the experimental and control groups. In one of the studies, to enhance the effect of cognitive bias, subliminal messages: "guilty" or "the same" were involved to make the subjects more likely to match the trace to the comparison material (Dror et al., 2005). The results of the study confirmed the impact of emotions and subliminal information. However, these effects do not occur for traces that are either distinct or inconsistent with the comparison material.

Two studies were also conducted, in which the main task was to mark and describe minutiae. The first considered whether training has an impact on fingerprint analysis. The results showed that the subjects who had undergone a training detected an average of 3.4 more minutiae, primarily in lower quality traces. It has also been noted that despite better performance, there were still individual differences between subjects (Schiffer, Champod, 2007). The second study examined *observational bias* (also known as *streetlight effect*) i.e., the tendency to look for answers in places where they are easiest to find. Context was manipulated (a trace from either a terrorist crime or a theft) and the presence or absence of comparative material consistent/ inconsistent with the described trace. The results showed that, in all the cases, there were no significant differences in the number of minutiae described, which should be understood as the absence of streetlight effect (Schiffer, Champod, 2007).

Wójcikiewicz (2013), on the other hand, points to the occurrence of problems related to "cognitive contamination", emphasizing that limiting the material made available to an expert to the extent necessary to issue an opinion is not an unequivocally good solution. He explains that an expert may find information in the case file that is relevant to his/her opinion. This observation should be considered accurate. After all, the investigator (or other body appointing the expert), in addition to the secured traces and comparative material, may not provide other information, considering it unnecessary (e.g. data on the place where the traces were secured or the prevailing weather conditions at the scene), although they could be used auxiliary in preparing the opinion. Wójcikiewicz also describes several ways to prevent the negative consequences of inadequate release of materials: the use of a "blind expert", two experts, one of whom is "blind", sequential unmasking, a "evidence line-up", and rivalrous redundancy. At the same time, he points out that the "blindness" of experts in the form of lack of information about the results of previous expertise seems to be the most realistic improvement in Polish conditions. He also mentions two completely different solutions. One of them is the accreditation of experts, also proposed by Tomaszewski and Rzeszotarski (2008), as a possibility of introducing the control institution in the procedure of entering an expert into the expert witness list. The other is forensic education of lawyers; for example, according to Nawrocka and Kiejnich (2018), it should also include classes in cognitive psychology, during which the impact of cognitive biases on forensic expertise would be presented.

With respect to the human factors that determine susceptibility to cognitive biases in forensic expertise, the question arises as to what kind of personality an expert candidate should have in order to reduce the influence of undesirable factors on fingerprint expertise as much as possible. Given the lack of literature in this area, this article attempts to formulate a partial answer, within a very narrow scope, limited to two selected personality traits: the need for cognitive closure (which describes the attitude of seeking and having certain and specific knowledge in order to make decisions) and controllability (which describes the susceptibility of a person to controlling external influences on decision making).

The stimulus for choosing the first of these features was the case study involving the erroneous comparison of traces secured after the 2004 terrorist attack in Madrid, which resulted in the wrongful prosecution of Brandon Mayfield. Charlton, Fraser-Mackenzie, and Dror (2010) indicate that fingerprint examination experts may be more likely to make expertise biases due to the high need for closure[4]. Such individuals may *seize* information that emerges at the initial stage of trace analysis and then *freeze* it, omitting or putting a lesser value to the successively revealed information. In contrast, individuals with a low need for cognitive closure may make mistakes when they *"unfreeze"* information too quickly due to other information stimuli that are not relevant to expertise. In high-profile cases, or those where an expert opinion is required as soon as possible, an expert with a high need for cognitive closure needs less information analyzed from the trace and comparative material to make a decision about their compatibility.

Controllability, on the other hand, was chosen because of the characteristics of this personality trait relating to the influence of "control signals" on decision making (Żyluk, 2016). When it comes to sources of cognitive bias, we can distinguish a group of external and internal factors that can impinge on expert opinion. This index enables placing a person on the controllability scale, and next, make an attempt to answer the question of whether this observation provides an indication of greater susceptibility to sources of external (e.g., pressure, contaminated traces, suggestions) or internal (e.g., emotions, training, experience) cognitive bias.

At the same time, there are many tools available to assess human personality traits. Hence, the purpose of this study is to examine whether selected characteristics related to the cognitive aspect of human functioning determine the correctness of fingerprinting task performance among students. The main hypotheses of the study assume the following:

- intensity level of the need for cognitive closure correlates negatively with correctness in solving comparative fingerprint tasks;
- intensity level of controllability correlates negatively with correctness in solving comparative fingerprint tasks;
- intensity level of the need for cognitive closure correlates positively with caution in task performance;
- intensity level of the need for cognitive closure correlates negatively with decisiveness in task performance.

The selection of study subjects as students with no experience in forensic fingerprint analysis was dictated by previous research in this area[5]. The aim of the study was to find out whether it is possible to select among individual students who, having a certain intensity of selected personality traits, will perform better at comparing fingerprint traces.

The study was carried out as part of the preparation of a master's thesis entitled: "Cognitive aspects of evidence examinations" at the Laboratory of Criminalistics, Faculty of Law and Administration, Adam Mickiewicz University in Poznań.

[4] The term "need for cognitive closure" is often abbreviated in the literature as "need for closure".

[5] Among others: Dror et al., 2005; Vokey, Tangen, Cole, 2009.

Materials and methods

Subjects

Forty-six subjects were surveyed, including 29 law students, 16 computer science students, and one faculty member – a total of 21 females and 25 males ranging in age from 19 to 41.

The need for cognitive closure

The first step of the study was to complete two psychometric tests: Abbreviated version of the Need for Cognitive Closure Scale and Controllability Questionnaire. The test sheets and answer keys were obtained via email from the test authors along with permission to use them in the master's thesis. This stage took approximately 10 minutes to complete.

The need for cognitive closure is a trait that describes the attitude of seeking and possessing certain and specific knowledge in order to reduce uncertainty in learning about the world. It influences the construction and use of cognitive schemas, which then determine how people act and think in the world around them (Kossowska, 2003). It does not correlate with intelligence.

A person with a high need for cognitive closure prefers predictability and order, and does not tolerate ambiguity (Webster, Kruglanski, 1994). He or she may also make hasty judgments and decisions based on information gathered without considering other alternative views (Webster, Kruglanski, 1997). Such a person is resistant to change, which has its source in the already formed structure of knowledge and, consequently, the conviction that the world is ordered.

A person with a low need for cognitive closure prefers uncertainty and rarely presents a strong and definitive opinion on a given topic. He or she values the freedom that comes from being open to new information and alternative views, and therefore makes longer and more thorough analysis. Such a person is able to adapt to changes (Kossowska, 2003).

The Need for Cognitive Closure Theory was proposed by an American psychologists (Kruglanski, Webster, Klem, 1993), who distinguished two processes that underlie it: *seizing* information from the environment and *"freezing"* it and securing it in cognitive structures (Kruglanski, Webster, 1996). They also prepared a test sheet in English consisting of 42 questions.

One of the Polish adaptations of this test is the Need for Cognitive Closure Scale (Kossowska, 2003) consisting of 32 items. Due to the length of the test, there have been instances where surveys have been conducted by eliminating individual items from the test sheet without providing adequate reasoning and criteria for question selection, which can lead to a reduction in the value of such a measurement. For this reason, a shortened version of the Need for Cognitive Closure Scale was prepared, retaining all the properties of the original, but consisting of only 15 items (Kossowska, Hanusz, Trejtowicz, 2012).

Additionally, during constructing the test, five subscales were specified as the areas of trait manifestation. These are: preference for order, preference for predictability, intolerance of ambiguity, mental closure, and decisiveness. With such a detailed and broad description of the range of human cognitive functioning, more detailed statistical analysis is possible.

It is worth noting that the tests presented herein describe very sophisticated and little known traits compared to the so-called "Big Five" mainly cited in the literature: neuroticism, extraversion, openness, agreeableness and conscientiousness. This provides an opportunity to look at problems from a new perspective and draw more precise conclusions.

On the Abbreviated Need for Cognitive Closure test, the number of possible points to be scored ranges from 15 to 90; the higher the score, the greater the need for cognitive closure.

Controllability

Controllability is a trait that determines a person's susceptibility to controlling influences that originate inside or outside the individual (Żyluk, 2016). There are two theoretical poles on the controllability scale: "intra-controllability" and "extra-controllability".

An intra-controllable person is independent of others and makes decisions on his or her own, which is based on his or her knowledge and experience. Moreover, such an individual, despite external pressure from various groups and persons, is able to resist pressure and continue his or her actions in accordance with the previously intended purpose. The person is also characterized by flexibility, thanks to which he or she can easily adapt to new conditions. He or she is able to approach problems creatively and outside the box, is socially active.

An extra-controllable person is characterized by dependence on the environment, has difficulty making decisions, and is even unable to take responsibility for his or her actions. For this reason, this individual prefers to be given instructions from others, which also involves respecting and obeying the person in charge. The person often relies on stereotypes and is therefore prone to prejudice against other ethnic or social groups. He or she does not tolerate ambiguity and consequently sees the world one-dimensionally. is socially passive.

Due to the fact that the presented concept is originally created in Polish language, similar foreign concepts should be pointed out. Similar to the described theory is the proposal of Walter Reckless (1961), who distinguishes between internal and external forces that inhibit a person from committing a crime. The former come from a moral system, religious beliefs, and a sense of what is right and wrong. External forces, in turn, are the influences of family, teachers, community groups, and others.

The study used the Controllability Questionnaire consisting of 17 questions, which was designed by female cognitive science students of the Faculty of Social Sciences, Adam Mickiewicz University in Poznań (Ciesielska, Migacz, Żyluk, 2014). The number of possible points to be scored ranges from 17 to 85, and the higher the score, the more extra-controllable the person is.

Fingerprinting

Comparative material and fingerprint traces were revealed and secured as part of a master's seminar in forensic science. For this purpose, tools from the Laboratory of Criminalistics, Adam Mickiewicz University and two glasses brought by the seminar participants were used. From the five comparison cards made by the participants, the most legible one was selected to be used in the main task. Subsequently, a total of 15 fingerprint traces from two glasses were revealed and secured, originating from two individuals (7 from one, 8 from the other), whereas the prints of the first individual were identical to the previously selected comparison card. Traces were applied to each glass in two rounds, each time by the grip of one hand. Between the grips, the glass was thoroughly cleaned. A silvery dust substance, argentorate, and a fingerprint brush were used to reveal the traces. The fingerprint impressions were then transferred to the black dactyloscopic foil. On the back, the origin of each trace (finger and person) was described.

The secured traces were scanned using an HP brand multifunctional printer at 600 dpi resolution. From the 15 traces secured earlier, 12 were selected that were the most legible, 6 of them originating from one person and the other half from another (each trace from a different finger). A sample task sheet was then prepared. GIMP software was used for color inversion and graphics processing. A pilotage testing was conducted on six seminar participants to obtain general comments on the content of the task, the quality of the traces and comparison material, and the timing of the task. Only the correctness of the answers was assessed due to the fact that the test subjects were familiar with the topic of the study. Finally, six traces from a single individual were selected (Figure 1), along with comparison material on a fingerprint card – also from a single (different) individual. The selected traces were the imprints of:

1. the middle finger of the left hand,
2. the thumb of the left hand,
3. the thumb of the right hand,
4. the index finger of the right hand,
5. the index finger of the left hand,
6. the ring finger of the left hand.

To maximize errors, traces consistent with the comparison material were not included in the final sheet. Limiting the number of traces was also a result of setting a reasonable time limit. In addition, as the time

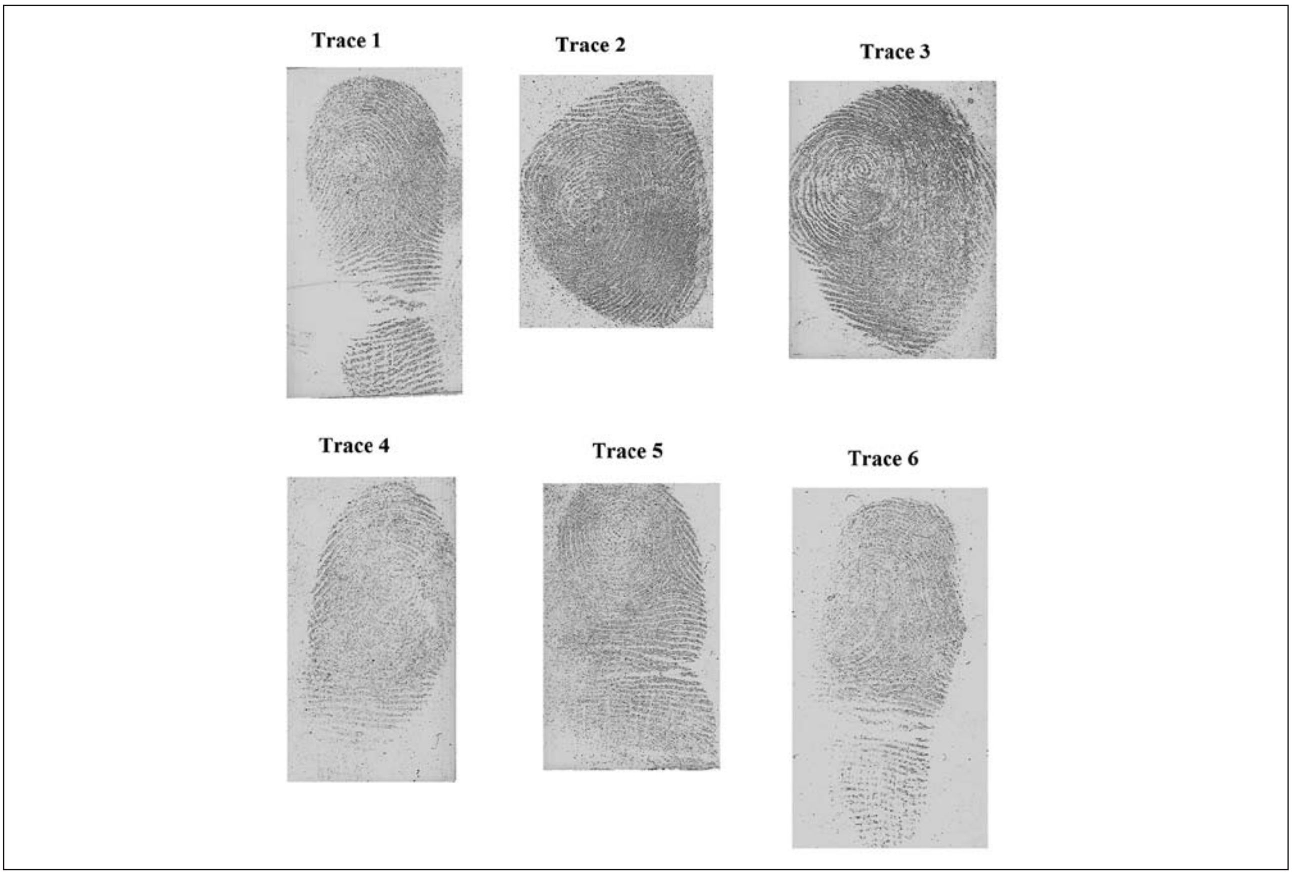

Fig. 1. Traces used in the study.

to solve the task decreases, so does the test subjects' involvement.

Training

The second phase was to provide training in fingerprint examination. The presentation was prepared on the basis of literature[6], additionally including figures and other photos from the internet, as well as comparative material and traces secured during the seminar. The scope of training included:

1. model examples of revealing and securing traces from glassware, including the materials used,
2. the scope of activities performed by the expert:
   a. assessing the legibility of traces and their origin,
   b. the ACE-V standard of trace analysis and evaluation,
3. numerical and holistic standard,
4. examples with general pattern layout,
5. examples with minutiae marking on trace and comparative material, and their evaluation.

The necessity of the training phase stems from the fact that the fingerprint examination expert is an experienced forensic scientist, and, as a consequence, it was necessary to approximate his work as closely as possible and provide basic information about this profession. A pilotage was conducted during the seminar, after which all comments were taken into account and the training took its final form. This stage took approximately 20 minutes to complete.

Task

The third and final stage of the study was the forensic trace examination task, for which two aspects require special attention: the content of the task as well as the traces and comparison material used. The task took on the following content:

> Imagine that you are an expert in the field of fingerprint examination. By virtue of the prosecutor's order, you have received evidence from a case of violent rape, i.e. falling under Article 197 § 1 of the Penal Code. Your task is to determine whether the traces you have secured originate from any of the fingers of Andrzej Bukał, who, based on other multiple pieces of evidence (primarily witness testimony and lack of an alibi), is the prime suspect in this case.
> Mark an X in the table if you believe the trace does not originate, probably does not originate from the suspect, or there is no basis for inference. If the trace is consistent with any of the comparative imprints on the fingerprint card, indicate its position, e.g. row 2. In the column, "the trace probably originates from the finger", write "the index finger of the right hand" (or abbreviation "P2" – in accordance with the numbering on the comparison material).
> **The traces and comparison material presented originate from a real case.**

6 Primarily: Czubak, 2002, p. 79–122; Widacki, 2002; Kasprzak et al., 2006.

The following cognitive illusions were introduced in the task content in order to elicit the appropriate manipulation:

1. the type of crime the person is suspected of: violent rape. This procedure is called the "context effect" in the literature; its purpose is to introduce an emotional bias that can negatively affect the analysis and evaluation of evidence,
2. "other multiple evidence (witness testimony and lack of alibi)". This fragment refers to information that is irrelevant from the expert's point of view. It is intended to have the additional effect of making inferences based on data outside the material for analysis,
3. "the trace and comparison material originate from the real case". This statement is not true. It was a manipulation to force greater commitment to the task.

The cognitive illusions introduced were intended to create a strong belief that the suspect was indeed the perpetrator of the crime. Investigators should have therefore evaluated the trace as originating from the comparison material more frequently. It should be emphasized that, without a doubt, a fingerprint examination expert would not have gotten a request with the same wording as quoted above. However, the task was formulated in such a way as to place students in conditions resembling as closely as possible those in which an expert would analyze traces (imitating, for example, pressure from superiors or suggestions from principals). At the same time, the introduction of cognitive illusions directly in the content of the task, rather than in the form of the prepared trial file, was also dictated by the rationality of the length of the study conducted.

The test subjects could choose one of five answers:

1. "the trace does not originate",
2. "the trace probably does not originate",
3. "no basis for inference"
4. "the trace probably originates from a finger…"
5. "the trace originates from a finger…"

The test sheet used six previously prepared fingerprint traces and comparison material. This stage took about 20 minutes to complete.

Data analysis methods

IBM SPSS Statistics program was used for statistical analysis. Calculations were performed to indicate descriptive statistics: smallest, largest, and average values of measured characteristics and other data (age, time to complete the task). The results for both tests were checked for normal distribution, for which purpose the Kolmogorov-Smirnov test was used.

To test the hypotheses, correlations between test scores and task performance were examined. To calculate the sum of correct and incorrect answers, the following classification was used:

– the following answers were considered bias: “the trace probably originates from…” and “the trace originates from…”
– the following answers were considered correct: “the trace does not originate” and “the trace probably does not originate”,
– the answer: “no basis for inference” was considered neural. Because the traces were of poor quality, the evaluation of some examples may have been problematic,
– caution is characterized by the fact that the subject has a belief in the non-origin or origin of a trace from any of the positions of the comparative material, yet he/she is not making a categorical decision. As a result, an option expressing the probability of the trace’s origin is selected. Caution is the sum of points in the columns “the trace probably originates from…” and “the trace probably does not originate”,
– decisiveness is characterized by the confident answer.It was equated by the following answers: “the trace does not originate” and the trace originates from…”

Correlations were calculated with Pearson’s *r* coefficient due to the fact that the data collected were quotient in nature. A significance threshold of $p = 0.05$ was adopted.

Results

Of the 46 measurements, 45 were statistically analyzed (one test subject did not solve all the examples in the task). Gender has been shown not to differentiate task performance. A positive correlation was found between the subjects’ age and correctness in task performance ($r = 0.325$, $p = 0.029$).

The mean scores achieved by the subjects equaled 56 on the Abbreviated Need for Cognitive Closure Scale (NCC) and 44 on the Controllability Questionnaire (CQ) (Table 1). The distribution of feature intensities in the sample ranged from 40 to 78 in NCC and from 32 to 59 in CQ (Figure 2).

Test results follow a normal distribution (for NCC $\lambda = 0.089$, $p > 0.2$; for CQ $\lambda = 0.115$, $p = 0.165$).

A total of 270 answers were given. Subjects most often selected the answer, “the trace probably originates from a finger…” (incorrect answer). A total of 56% incorrect and 27% correct answers were given. None of the subjects solved all the examples correctly. Traces number 3 and 2 were the easiest for the subjects to evaluate, while traces number 1, 5, and 6 were the most

Tab. 1. Descriptive statistics: minimum, maximum, and mean values for the subjects’ age, task completion time, need for cognitive closure, and controllability.

	Minimum	Maximum	Mean	Standard deviation
Age	19	41	22.4	3.9
Time	8	22	14.5	3.9
NCC	40	78	56.5	8.1
CQ	32	59	44.0	7.1

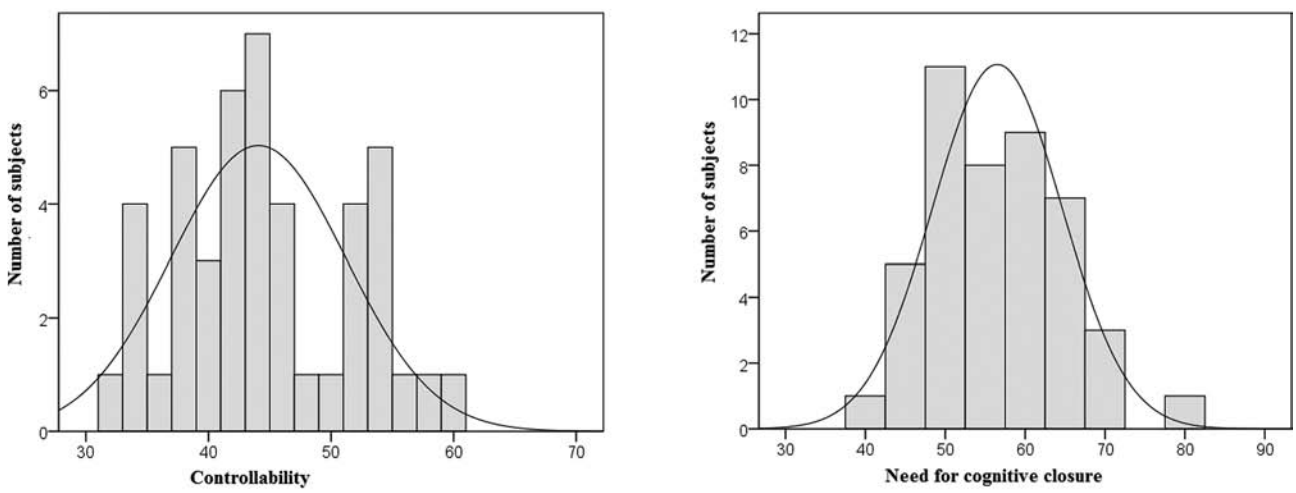

Fig. 2. Distributions of values for NCC and CQ obtained in the sample.

difficult (Table 2). Each possible answer was marked at least once. In addition, there was also a positive correlation between task completion time and task correctness ($r = 0.372$, $p = 0.013$) and between task completion time and the response , "the trace probably does not originate from" ($r = 0.402$, $p = 0.007$) (Figure 3).

Statistical significance for correctness, biases, caution, and decisiveness exceeds $p = 0.05$, meaning that they were not found to be statistically significantly correlated with the need for cognitive closure and controllability (Table 3). In general, no associations of any kind were seen other than a slight increase in caution with an increase in NCC.

A positive trend was observed between the need for cognitive closure and the number of biases ($r = 0.224$, $p = 0.140$).

To better understand the nature of the correlation, a subscale analysis of the Abbreviated Need for Cognitive Closure Scale was conducted. Due to the multiplicity of measurements, only statistically significant results are cited. There was a significant positive correlation of preference for order with caution in task performance ($r = 0.295$, $p = 0.049$) (Figure 4).

Summary

No significant correlations were found between the level of need for cognitive closure and controllability, and correctness, biases, caution, and decisiveness in the task performed. In view of this, it is not possible to conclude conclusively whether scores on the Abbreviated Need for Cognitive Closure Scale and the Controllability Questionnaire are good predictors of selecting individuals for fingerprint analysis-related work.

Given the sophistication of the Abbreviated NCC Scale, it was also possible to conduct a more detailed analysis in terms of the subscales used. By doing so, it was shown that the greater the preference for order, the more often the test subjects were cautious in performing the task. This observation makes sense, as it is indirectly consistent with the baseline assumption of more cautious task performance by those with a higher need for cognitive closure.

There was a positive correlation of time with the number of correct answers in the task. This means that the longer the subjects performed the task, the more correct answers they gave. This may be indicative

Tab. 2. Aggregated task results.

	Does not originate	P does not originate	No basis for inference	P originates	Originates
Trace 1	4	1	2	31	7
Trace 2	16	6	7	15	1
Trace 3	20	6	3	12	4
Trace 4	4	2	24	11	4
Trace 5	3	3	2	30	7
Trace 6	4	4	8	26	3
Total	51	22	46	125	26
Share (%)	19	8	17	46	10

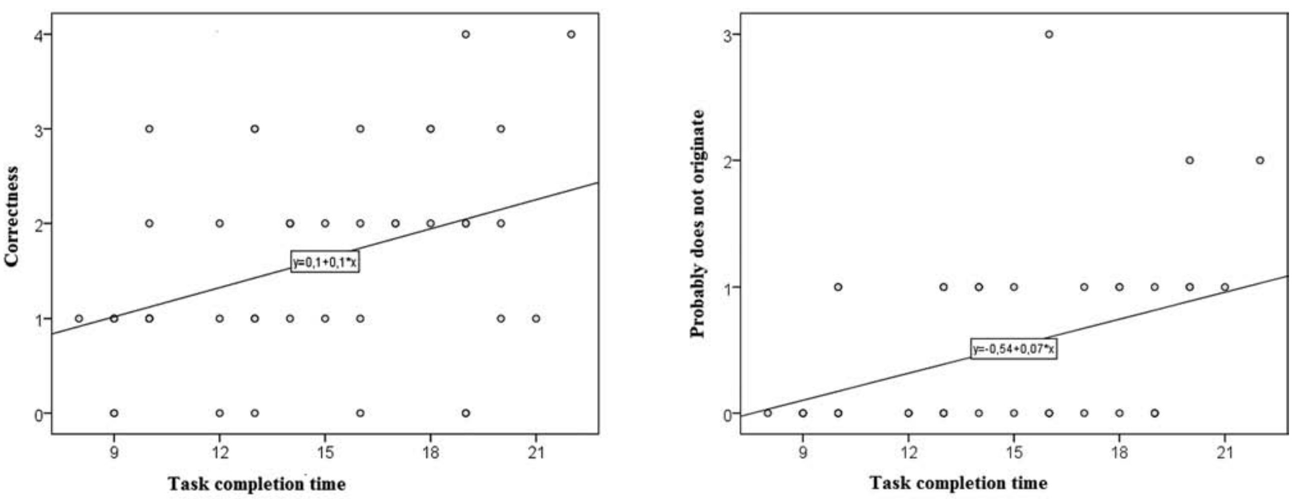

Fig. 3. Relationships between task completion time and correctness, and the answer, "the trace probably does not originate from".

Tab. 3. Correlations of the need for cognitive closure and controllability with correctness, biases, caution and decisiveness.

	Correctness		Biases		Caution		Decisiveness	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*
NCC	–0.042	0.785	0.224	0.140	0.148	0.330	–0.141	0.355
CQ	0.079	0.606	0.032	0.834	–0.057	0.711	–0.029	0.852

r – Pearson's correlation coefficient

p – significance

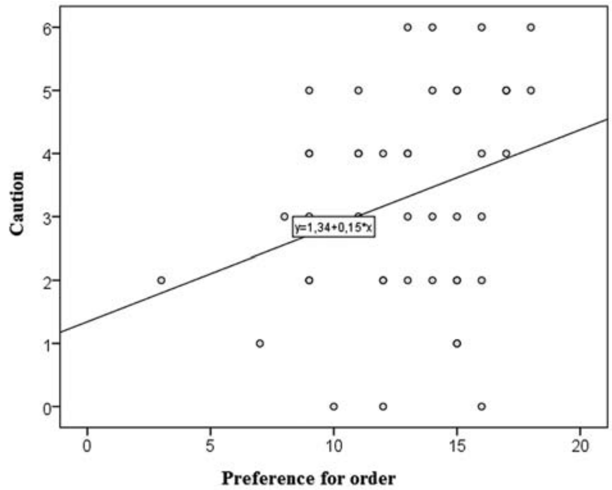

Fig. 4. The relationship between caution and preference for order.

of the meticulousness of such individuals, which is then reflected in the length of the task and greater correctness. Furthermore, one of the two components of correctness was the answer , "the trace probably does not originate from," which also correlated positively with task completion time. Thus, it can be seen that those who spent more time on the task not only performed better, but also chose a more cautious version of the answer. In addition, the longer the subjects thought about the answer, the more likely they were to choose the cautious rather than the firm option, in addition to the correct answer.

There was a correlation of the age of the subjects with the correctness, however, most of the subjects were between 19 and 22 years of age, so this correlation was not meaningful due to the low scatter of values.

It is not possible to explicitly assume that the hypotheses put forward are not consistent with reality. The test scores of most subjects oscillated around the middle of the scale and one standard deviation. Therefore, it would be worthwhile to undertake the same study again, but this time to administer the test part first, and then after summation of the results, to select individuals who would fall on the whole spectrum of the scale, and proceed only with these individuals to the training and task stage. Moreover, it would be more beneficial to prepare a web-based version of the study in order to reach a wider audience, while saving time on data analysis.

Although the results of both tests followed a normal distribution, there were no datapoints located at the extremes of the scale. The subjects scored most frequently in the range of 40 to 70 for NCC and 30 to 60 for CQ. If extreme datapoints would have been recorded, one would expect to see higher correlation coefficients and lower levels of significance. To obtain more extreme datapoints, the number of study subjects would need to be increased. However, it is uncertain how these results would be distributed across the scales. In this case, it seems best to locate individuals who have extreme intensities of both of the traits studied. For low need of cognitive closure, these could be people who are creative and open to multiple interpretations, such as art students. In relation to the high need for cognitive closure, science (mathematics and physics) students, seem to be appropriate, because of their desire for certain and unchanging knowledge. Intra-controllable individuals would likely be found in the freelance and decision-making positions where independence is valued. Extra-controllable individuals, on the other hand, would be found among employees who are most likely to follow orders from superiors, such as those in the uniformed services.

The subjects were significantly more likely to give incorrect answers in the fingerprint comparison task. Whether this was the result of introduced context and cognitive illusions is difficult to state conclusively. Since all the examples were inconsistent with the comparison material, the subjects may have been looking for the correct answers due to the habits of everyday life, when it is unlikely that all the answers are the same when taking the tests. It can also be the effect of contrast, that is, finding relationships where there are none (Jeanguenat, Buildings, Dror, 2017). To resolve this contention, the same study would need to be conducted in a control group without manipulation of the task content.

At the same time, it should be noted that people without experience in comparing fingerprints make significantly more mistakes than experts (Langenburg, Champod, Wertheim, 2009). It has also been shown that experts notice more minutiae than laypeople (Langenburg, 2004). In addition, Thompson and Tangen (2014) indicate that fingerprint examination experts do very well with illegible traces. Moreover, even despite the approximately 20-minute training that makes students more skillful at comparing fingerprint traces than laypeople, they are still less competent than experts (Stevenage, Pitfield, 2016). These observations provide a limitation to the direct extrapolation of the results obtained in the study conducted among students to fingerprint examination experts. The individuality of each expert, particularly in terms of aptitude for expertise, is also influenced by perception. Experts acquire the ability to properly perceive and compare traces through years of practice (Moszczyński, 2011). Therefore, fingerprint examination experts, not laypeople, should be the subject of future research in this field.

Some traces scored better than others, which can be interpreted in two ways. First, despite the high illegibility of the traces, some were of better quality than others. Second, there may be a cognitive predisposition to compare some fingers. This observation would be consistent with the study by Vokey et al. (2009), who showed that students vary in their effectiveness at identifying different fingers (the little finger is considered the most difficult). However, the authors did not explain what might be behind this effect. At the same time, it is known that the fingerprint ridges on the little finger have the smallest width and are relatively low compared to the fingerprint ridges of other fingers. Perhaps also the surface area of the finger determines the possibility of its analysis: the smaller it is, the less minutiae can be described. Ultimately, cognitive predisposition may also play a role in trace assessment.

A positive trend was observed between the level of need for cognitive closure and the number of biases made on the task. This observation is consistent with the initial hypothesis. Due to the quality of the traces, such individuals may feel discomfort caused by ambiguity in a difficult task.

The obtained test results can be used in typing people who compare fingerprints with greater accuracy. The trend indicating that extra-controllable subjects responded more cautiously may mean that there is some mechanism in place to compensate for this cognitive bias. Such individuals are aware that they may be more vulnerable to outside influences, so they approach tasks with distrust. Hence, controllability may be a predictor of correct execution of fingerprinting tasks. However, one has to consider whether the NCC subscale – preference for caution – is also a good determinant – depending on whether explicit or probabilistic judgments are more desirable. Further research should be done in this area, particularly using tests that measure the intensity of cognitive ability.

It is worth noting that the cognitive aspect of forensic trace examination is only part of a larger problem. Dror (2016) proposes a model that accounts not only for cognitive biases affecting the observation and decision-making process, but also for potential other factors that may affect job performance. As mentioned earlier, experts re-comparing fingerprints they have previously encountered perform this task correctly only 89% of the time (Dror, Rosenthal, 2008). It would therefore be reasonable to assume a lower than baseline 100% expert performance. If so, this would detract from the strength of the cognitive biases that occur. One would have to wonder if there is some common cause of the two phenomena. Perhaps the examination of fingerprints is an activity that, due to the human cognitive apparatus, will always be characterized by inconsistencies in the conclusions formulated based on the repeated measurements.

As noted at the outset, cognitive biases can originate at various levels related more to human nature or strictly to a particular issue (Zapf, Dror, 2017). In order to monitor the whole process, it would be necessary to propose a comprehensive model of the "life" of a cognitive bias: from securing the trace, through its analysis and expertise, followed by the judicial process (whereby the the law of precedent and state law should be distinguished), and ending with sentencing and the imposition of the punishment on the perpetrator. For example, there is a well-known study that shows that judges rule against the offender when they are pre-meal and in his favor when they are post-meal (Danziger, Levav, & Avnaim-Pesso, 2011).

Moreover, given the multiplicity and diversity of cognitive biases in the literature, while lacking a unified categorization, it would be advisable to create an appropriate division, hierarchy, and location of them at each stage of the "life" of a cognitive bias. This would make it possible to construct mechanisms of defence against each type of bias and determine which ones affect fingerprint examination experts more strongly and how often they occur.

The literature shows that fingerprint examination experts are also susceptible to all kinds of internal and external influences in their work – some individuals are influenced less, while others more. Neither the causes nor the source of these differences are known. However, mere awareness of the limitations of our cognition and the cognitive biases that follow is not enough to reduce their impact on the work of fingerprint examination experts.

Sources of Figures and Tables:
Fig. 1–4: Author
Tables 1–3: Author

Bibliography

1. Ciesielska, A., Migacz, A., Żyluk, N. (2014). *Kwestionariusz Sterowności (Raport niepublikowany z procesu projektowania narzędzia na zaliczenie przedmiotu psychometria).* Poznań: Adam Mickiewicz University, Institute of Psychology.
2. Charlton, D., Fraser-Mackenzie, P.A., Dror, I.E. (2010). Emotional experiences and motivating factors associated with fingerprint analysis. *Journal of Forensic Sciences*, *55*(2).

3. Czubak, A. (2002). Ekspertyza daktyloskopijna. In: J. Wójcikiewicz (ed.), *Ekspertyza sądowa*. Kraków: Zakamycze Publishing House.
4. Danziger, S., Levav, J., Avnaim-Pesso, L. (2011). Extraneous factors in judicial decisions. *Proceedings of the National Academy of Sciences*, *108*(17), https://doi.org/10.1073/pnas.1018033108.
5. Dror, I. (2015). Cognitive neuroscience in forensic science: Understanding and utilizing the human element. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *370*(1674), https://doi.org/10.1098/rstb.2014.0255.
6. Dror, I. (2016). A hierarchy of expert performance. *Journal of Applied Research in Memory and Cognition*, *5*(2), https://doi.org/10.1016/j.jarmac.2016.03.001.
7. Dror, I.E. (2020). Cognitive and human factors in expert decision making: Six fallacies and the eight sources of bias. *Analytical Chemistry*, *92*(12).
8. Dror, I.E., Péron, A., Hind, S.-L., Charlton, D. (2005). When emotions get the better of us: The effect of contextual top-down processing on matching fingerprints. *Applied Cognitive Psychology*, *19*.
9. Dror, I., Rosenthal, R. (2008). Meta-analytically quantifying the reliability and biasability of forensic experts. *Journal of Forensic Sciences*, *53*(4), https://doi.org/10.1111/j.1556-4029.2008.00762.x.
10. Fernandez, R., Dror, I.E., Smith, C. (2011). Spatial abilities of expert clinical anatomists: Comparison of abilities between novices, intermediates, and experts in anatomy. *Anatomical Sciences Education*, *4*(1).
11. Fraser-Mackenzie, P., Dror, I., Wertheim, K. (2013). Cognitive and contextual influences in determination of latent fingerprint suitability for identification judgments. *Science and Justice*, *53*(2), https://doi.org/10.1016/j.scijus.2012.12.002.
12. European Centre for Initiatives in Forensic Science Foundation (2018). *Ocena kompetencji biegłych sądowych. Oczekiwania i rekomendacje*. Warsaw: European Centre for Initiatives in Forensic Science Foundation, http://forensicwatch.pl/web/pliki/baza-wiedzy/Opracowania/Ocena-Kompetencji-Bieglych-Sadowych.pdf (access: 20.09.2019).
13. Grabowska, B., Pietryka, A., Wolny, M., Bodnar, A. (2014). *Biegli sądowi w Polsce*. Warsaw: Helsinki Foundation for Human Rights, http://beta.hfhr.pl/wp-content/uploads/2015/10/HFPC_PRB_biegli-sądowi_w_polsce.pdf (access 20.09.2019).
14. Inman, K., Rudin, N. (2002). *Principles and Practice of Criminalistics: The Profession of Forensic Science*. Boca Raton–London–New York–Washington D.C.: CRC Press.
15. Jeanguenat, A., Budowle, B., Dror, I. (2017). Strengthening forensic DNA decision making through a better understanding of the influence of cognitive bias. *Science and Justice*, *57*(6), https://doi.org/10.1016/j.scijus.2017.07.005.
16. Kasprzak, J., Młodziejowski, B., Brzęk, W., Moszczyński, J. (2006). *Kryminalistyka*. Warsaw: Difin Advisory and Information Center.
17. Kossowska, M. (2003). Różnice indywidualne w potrzebie poznawczego domknięcia. *Przegląd Psychologiczny, 46*(4).
18. Kossowska, M., Hanusz, K., Trejtowicz, M. (2012). Skrócona wersja Skali Potrzeby Poznawczego Domknięcia. Dobór pozycji i walidacja skali. *Psychologia Społeczna*, *7*(1).
19. Kruglanski, A.W., Webster, D.M. (1996). Motivated closing of the mind: “Seizing” and “freezing”. *Psychological Review*, *103*(2).
20. Kruglanski, A.W., Webster, D.M., Klem, A. (1993). Motivated resistance and openness to persuasion in the presence or absence of prior information. *Journal of Personality and Social Psychology*, *65*(5).
21. Langenburg, G. (2004). Pilot study: A statistical analysis of the ACE-V methodology – analysis stage. *Journal of Forensic Identification*, *54*(1).
22. Langenburg, G., Champod, C., Wertheim, P. (2009). Testing for potential contextual bias effects during the verification stage of the ACE-V methodology when conducting fingerprint comparisons. *Journal of Forensic Sciences*, *54*(3), https://doi.org/10.1111/j.1556-4029.2009.01025.x.
23. Moszczyński, J. (2011). *Subiektywizm w badaniach kryminalistycznych*. Olsztyn: University of Warmia and Mazury Publishing House in Olsztyn.
24. Murrie, D., Gardner, B., Kelley, S., Dror, I. (2019). Perceptions and estimates of error rates in forensic science: A survey of forensic analysts. *Forensic Science International*, *302*, https://doi.org/10.1016/j.forsciint.2019.109887.
25. Supreme Audit Office (2015). *Funkcjonowanie biegłych w wymiarze sprawiedliwości*. Warsaw: Supreme Audit Office, https://www.nik.gov.pl/plik/id,9608,vp,11856.pdf (access: 20.09.2019).
26. National Research Council (2009). *Strengthening Forensic Science in the United States: A Path Forward*. Washington, D.C.: National Academies Press, https://doi.org/10.17226/1258.
27. Nawrocka, M., Kiejnich, K. (2018). Cognitive biases in fingerprint expert opinions. *Problems of Forensic Sciences*, *111*.
28. Reckless, W.C. (1961). A new theory of deliquency and crime. *Federal Probation Journal*, *25*.
29. Schiffer, B., Champod, C. (2007). The potential (negative) influence of observational biases at the analysis stage of fingermark individualisation. *Forensic Science International*, *167*.
30. Sternberg, R.J. (2009). *Cognitive Psychology*. Wadsworth: Cengage Learning.
31. Stevenage, S., Pitfield, C. (2016). Fact or friction: Examination of the transparency, reliability and sufficiency of the ACE-V method of fingerprint analysis. *Forensic Science International*, *267*.

32. Thompson, M.B., Tangen, J.M. (2014). The nature of expertise in fingerprint matching: Experts can do a lot with a little. *PLOS ONE*, *9*(12), e114759, https://doi.org/10.1371/journal.pone.0114759.
33. Tomaszewski, T., Rzeszotarski, K. (2008). Weryfikacja kwalifikacji biegłych wydających opinie kryminalistyczne (na przykładzie opinii fonoskopijnych). In H. Kołecki (ed.), *Kryminalistyka i nauki penalne wobec przestępczości*. *Księga pamiątkowa dedykowana Profesorowi Mirosławowi Owocowi*. Poznań: Publishing House of Poznań.
34. Ulery, B.T., Hicklin, R.A., Buscaglia, J., Roberts, M.A. (2012). Repeatability and reproducibility of decisions by latent fingerprint examiners. *PLOS ONE*, *7*(3), https://doi.org/10.1371/journal.pone.0032800.
35. Vokey, J.R., Tangen, J.M., Cole, S.A. (2009). On the preliminary psychophysics of fingerprint identification. *Quarterly Journal of Experimental Psychology*, *62*(5).
36. Webster, D.M., Kruglanski, A.W. (1994). Individual differences in need for cognitive closure. *Journal of Personality and Social Psychology*, *67*(6).
37. Webster, D.M., Kruglanski, A.W. (1997). Cognitive and social consequences of the need for cognitive closure. *European Review of Social Psychology*, *8*(1).
38. Widacki, J. (2002). *Kryminalistyka*. Warsaw: CH Beck.
39. Wójcikiewicz, J. (2013). „Ślepy" biegły – lepszy biegły?: pięć sposobów na udaną opinię. In: E. Gruza (ed.), *Oblicza współczesnej kryminalistyki: księga jubileuszowa profesora Huberta Kołeckiego*. Warsaw: Graduates Association of the Faculty of Law and Administration of the University of Warsaw.
40. Zapf, P., Dror, I. (2017). Understanding and mitigating bias in forensic evaluation: Lessons from forensic science. *International Journal of Forensic Mental Health*, *16*(3), https://doi.org/10.1080/14999013.2017.1317302.
41. Żyluk, N. (2016). *Sterowność a wyuczona zaradność i jej korelaty*. In: J. Urbańska, K. Karpe, N. Żyluk (ed.), *Zaradność absolwentów szkół wyższych*. Poznań: Faculty Research Publishing House of WNS AMU.

Translation Hanna Wierzchosławska