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Fuzzy logic behind forensic identity¹

Abstract

With the development of forensic sciences during the 20th century, macro-scaled empirical relations were supplemented with micro- and submicro-scaled probability relations. High sensitivity analysis methods imposed increasingly stringent criteria on the science of individualization. This process even labelled those traditional forensic sciences junks, which rely heavily on an indefinable set of characteristics in order to achieve individuality. However, this has not led to a systematic change in the judicial interpretation of expert evidence. In this paper I will therefore address the theoretical question: What logic lies behind forensic identity? In order to answer this question, I conducted explanatory research in the fields of forensics, criminal law, philosophy and logic. Following the collection and interpretation of qualitative data, such as the relevant literature, legislation and case law, I came to the conclusion that fuzzy logic lies behind forensic identity.

Keywords: forensic identification, individualization, identity, fuzzy logic, philosophy

Introduction

Forensic sciences support criminal law by providing general principled solutions for scientific questions that arise during the criminal procedure (Chisum et al., 2011, 4.). In practice, the forensic expert is the person who presents this knowledge on a scientific level before the authorities (Alapy, 1930, 264.). His/her task is often aimed at forensic identification, that is to individualize the link between two or more objects (Kertész, 1972, 326.). However, following formal logic, the fact that forensic experts preliminarily analyze, compare and evaluate objects arisen, collected and managed under various conditions, make source

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conclusions contradictory (Angyal, 2016, 11.). In this paper I will therefore address the theoretical question: What kind of logic lies behind forensic identity? The answer to this question is of methodological importance in the field of forensics (Viski, 1960, 75.). Namely, because the logic behind forensic identity highlights those axioms, that forensic disciplines are supposed to describe through the exploration of causal mechanisms. The task of forensic scientists, on the other hand, is considerably complicated by the fact that the axioms in question are theoretical cornerstones that cannot be proved or refuted by complete induction (Katona, 2002, 158.).

Materials and methods

In order to extend the theory of forensic identification, I conducted explanatory research in the fields of forensics, criminal law, philosophy and logic. In doing so, I was determined to explore the logic behind forensic identity. Following the collection and interpretation of qualitative data, such as relevant literature, legislation and case law, I established the causal link between forensic identification and fuzzy set theory.

Results

Forensic- or criminalistic identification? Identical or non-identical?

The term forensic sciences began to be used in states under Anglo-Saxon legal systems to denote and systematize the auxiliary sciences of criminal- and, later, civil justice (Chisum et al., 2011, 4.). On the contrary, in continental legal systems, this body of knowledge has been conceptualized as criminalistic technique (Viski, 1960, 70.). However, my question on scientific terminology and systematization has still not been answered. The situation is further complicated by the fact that the concept of criminalistics is used as a branch of forensic sciences by Anglo-Saxon authors, namely: trace evidence (Chisum et al., 2011, 5.), while continental European authors usually refer to it as a discipline that includes investigative acts as well as techniques (Fenyvesi, 2017, 23.). Different meaning in these linguistic areas can therefore be associated with forensic and criminalistic identification. The most glaring example of this is that, in continental European legal systems, criminalistic identification can not only be performed by an expert who has acquired the scientific knowledge of the given forensic field,

but even by lay persons (e.g. investigators and witnesses) (Kertész, 1972, 318.). The differential specificity of forensic identification is therefore best reflected in both legal systems by the concept of expert evidence. However, the practical task of forensic identification can only be performed on strong theoretical foundations (Alapy, 1930, 264.). The current differentiation and specialization of forensic sciences is threatening with atomization. In order to counteract this, criminalists need to explore continually the connection between forensic disciplines. The systematization of forensic sciences by internal contexts not only provides a clear overview, but also strengthens the collaboration between the practitioners of these various fields (Fogarasi, 1958, 414.). Whether it is forensic science in the Anglo-Saxon sense or criminalistics in the continental European sense, one thing is for certain: their first and most important disciplinary level issue is the identity-of identity and non-identity.

The identity of identity and non-identity

Ontology or epistemology?

What is the relationship between the material world and human consciousness? This is the principal issue of philosophy, firstly because it embraces the two extreme poles of the world – namely, material and spiritual phenomena – and secondly because it is challenging the person to master reality over and over again. In answering this question, philosophers split into two groups. Idealists are made up of those who think that the spirit is inherent, while materialists are made up of those who think that the nature is inherent (Szigeti, 1984, 111.). The problem of the relationship between matter and idea implicitly includes the issue of cognition in addition to the issue of primacy. Namely: How does the cognitive being become acquainted with, or can he/she become acquainted with the world at all? At first glance, it may seem that answering this question is necessary for deciding the issue of primacy. Because, in order to take a stand on the material or spiritual definiteness of the world, we must first ascertain whether the world can be known, and whether our cognition is really a cognition, not some sort of illusion. However, denying the possibility of cognition is in itself cognition, as well as asserting it, after all, they both count on being accepted as the general truth (Szigeti, 1984, 111.). Consequently, the more we deny the existence of truth, the more we consider true the proposition that there is no truth. By denying the truth abstractly, we are directly stating the truth. If our content-asserted theorem (no truth) becomes complete certainty, then the

form (proven truth) necessarily devalues the content: if the form does not prove it, then the content cannot become a universal truth either. The question of cognition cannot therefore be regarded as prior to the question of primacy. Otherwise, we end up in a paralogsism in which the form and the content mutually devalue each other (Szigeti, 1984, 112.). In this way, the main side of the essential philosophical question is not the epistemological side, but the ontological side. Especially because the cognitive being first had to become acquainted with the world to some extent in order to make the nature of cognition his/her research object based on his/her accumulated experience. The question of the possibility of cognition therefore necessarily presupposes research into the nature of the world (Szigeti, 1984, 113.). The same holds true for the process of forensic identification: understanding the unique relationship of the reference objects necessarily presupposes research into the nature of the source object.

Formal or dialectical logic?

Following formal logic, the fact that forensic experts preliminarily analyze, compare and evaluate objects arisen, collected and managed under various conditions, make source conclusions contradictory (Angyal, 2016, 11.). After all, the traditional formal logical principle of contradiction is defined by Aristotle as follows: *'It is not possible for the same thing at the same time both to belong and not to belong to the same thing in the same respect'* (Aristoteles, 1936, 101.). This principle, on the other hand, can be applied solely and exclusively to cases where the question is whether or not a concept, as a subject, really belongs to a predicate. In particular, in the case of the identity or non-identity of reference characteristics, two contradictory claims cannot be true together, because *'something is either A or not-A; there is no third'* (Hegel, 1979-B, 50.). The logical roots of the theory of forensic identification are therefore to be found in philosophical dialectics. The ancient type of philosophical dialectics is the Greek developmental dialectic and the accompanying emanational dialectic, which can be considered naïve only in the sense that they did not, and for the most part could not, rely on scientific data or theories, which also explains their spontaneity. As representatives of developmental dialectics in the 6th century BC, Anaximenes and Heraclitus were already drawing attention to phenomena such as the transformation of quantitative changes into qualitative difference and to contradiction as the driving force of movement and development (Szigeti, 1984, 506.). Although Plato did not completely break with this tradition, a new, rather problematic, historical type of dialectic, the emanational dialectic, began with him, which reverted the developmental process. What used to go from the simple to

the complex (bottom-up determination) has now moved from the richest ideational being to the material element considered as the most basic and treated as a by-product of the ideational existence (top-down determination) (Szigeti, 1984, 507.). The emanation character that prevailed in medieval development greatly contributed to the degradation of dialectic among the representatives of the new age. However, not all emanations are dialectic just as not all dialectics are emanational. This is why, at the beginning of the new age, philosophers with significant materialistic orientation reintroduced the elements of emanational dialectic into the materialist developmental dialectic. This was, for example, the case of Bruno and Leibniz, who have criticised the theorems of their idealistic forerunner, Cusa (Szigeti, 1984, 510.). According to Cusa, the last significant thinker of the Middle Ages and the first of the New Age: *'the universe is trine, that of all things there is none which is not one from possibility, actuality, and uniting motion, and that none of these three can at all exist without the other two, so that of necessity these three are present in all things according to very different degrees. They are present so differently that no two things in the universe can be altogether equal with respect to any one of them'* (Cusanus, 1999, 122-123.). Therefore, if ascending or descending the scale of numbers, we actually arrive at a maximum or minimum: still we do not come to an actual maximum or minimum number to which there can be no greater or smaller number. However, actuality cannot be defined as a number: it is the beginning of all numbers because it is the minimum; and it is the end of all numbers, because it is the maximum. We cannot reach the actual minimum or maximum number, because the opposites coincide through their uniting motion (Cusanus, 1999, 16.). Although the first thesis that follows from the principle of Cusa's coincidence of opposites is the right conclusion that the universe is infinite but also the false conclusion that the universe is unstructured. The emanational aspect is thus a limitation of dialectic, since the starting point of the upper ideational determination does not allow it to unfold (Szigeti, 1984, 509.). The real change was brought about by the principle of *'the identity of identity and non-identity'* (Hegel, 1979-A, 50.), with which developmental dialectic has reached the point at which it can be reached on idealistic ground. Hegel's logic is also ontology, in which the emphasis is no longer on the coincidence of opposites, but on the unity of opposites. The mutually exclusive poles do not coincide in abstract identity without difference because the unity maintains them in their relative autonomy. Concrete identity not only bears the moment of negation externally, but also internally, by denying the independence of its own elements, into a new, synthetic unity. The phenomena (unity) of the material world are not only identical (specificity) but also non-identical (generality) with themselves ($A=\bar{A}$) (Szigeti, 1998, 468.). In this

dialectic unity of contradictory and contrary oppositions, however, there is always a degree of uncertainty in the solution of which the basic idea of fuzzy sets seems to be unfolding (Mészáros et al., 1986, 487.).

A solvable or unsolvable residual problem?

The categories of unity, specificity and generality are the material definitions of reality (the degrees of determination) which the sciences are meant to describe in an object-specific way (Szigeti, 1984, 198.). Thus, forensic sciences cannot be indifferent to answering the question: What is the quantitative (specificity) limit of the qualitative (generality) changes in the characteristics of the source object (unity)? Concerning this question, material ontology designates that the generality () of the source object () is the logical basis which succinctly and necessarily defines the inherent content of the trace: which source object could have left the specific trace. However, not just any kind of source object, but the ones within the ‘fuzzy set’ justified by the competent forensic discipline. According to Zadeh, the founding father of fuzzy logic: *‘A fuzzy set is a class of objects with a continuum of grades of membership. [...] the notion of a fuzzy set provides a convenient point of departure for the construction of a conceptual framework which [...] provides a natural way of dealing with problems in which the source of imprecision is the absence of sharply defined criteria of class membership rather than the presence of random variables’* (Zadeh, 1965, 338-339.). Given that forensic sciences do not operate by coincidences but by the rule of axioms, fuzzy set theory can be particularly suitable for solving the residual problem of individualization. In the development of forensic sciences, it can be shown that the use of more advanced tools reduces uncertainty but does not completely eliminate it. Forensic sciences have always operated with a degree of uncertainty. With the expansion of the scientific horizon, they are now able to say even more what the scope of uncertainty is. The latter, however, should not be seen as an unsolvable residual problem. On the contrary, we must acknowledge positional irrationality in the process of individualization: *‘phenomena that are difficult to access in terms of cognition but can still be grasped and managed conceptually and practically in terms of the overall process’* (Szigeti, 1991, 13-14.). The residual in this way is not unknowable but is not yet known at the given stage of development. At this point, it is worth recalling and applying Hartmann’s theory to my research topic, according to which human thinking tends to extend goal-means associations to circles of reality where we cannot talk about purposeful activity. Behind this naïve anthropomorphism is human inertia towards nature, which can only be traced through

scientific thinking: *'most of the time, one understands very well that coincidence could not have happened otherwise, but the realization of causal necessity is only a step away from this. But it is precisely this blind necessity that happens unexpectedly'* (Hartmann, 1970, 64.). However, the concept of coincidence can only be defined in terms of its opposite, of necessity, which cannot manifest itself in isolation, but in a multitude of events.

The fuzzy set of forensic identity

As the mathematical formalism of probability calculation offers a numerical measure for the nomothetic interpretation of mass-scale events, the question is increasingly being asked in the field of criminal procedure based on idiographic approach: How unique is unique? For traditional forensic sciences (researching morphological characteristics), the theory of dactyloscopic identification served as a methodological model: regarding the quality of the source object, the link between the characteristics of the reference objects is unique as long as the quantitative difference of the latter does not show a change to an extent that would lead to a qualitative transformation of the source object (Faulds, 1905, 53.). However, there are also qualitative transformations in scientific cognition, as a result of which it reveals increasingly more differences where it has previously seen identity before (Fogarasi, 1958, 57.). With the development of forensic sciences during the 20th century, macro-scaled empirical relations were supplemented with micro- and submicro-scaled probability relations (Katona, 2002, 168.). High sensitivity analysis methods imposed increasingly stringent criteria on the science of individualization: the general acceptance of the given method was replaced by the criterion of methodological reliability placing the Bayesian approach in the forefront of forensics (Broeders, 2014, 3513.). This process even labelled those traditional forensic sciences junks, which rely heavily on an indefinable set of characteristics in order to achieve individuality: *'No basis exists in theory or data for the core contention that every distinct object leaves its own unique set of markers that can be identified by a skilled forensic scientist. Their claims exaggerate the state of their science. This sort of exaggeration, combined with public credulity, is the classic reason that common law evidence doctrine required a heightened threshold for admission of expert testimony. [...] Forensic identification scientists can help themselves immediately by forswearing exaggerated, definitive conclusions in favor of humbler, scientifically justifiable, and probabilistic conclusions'* (Saks et al., 2008, 218-219.). Saks and Koehler, as well as criminalists who promote the fallacy

of individualization, ignore the fact that practice always verifies the scientific result. The ontological nature of the theory of dactyloscopic identification is proved by the fact that its axioms have retained their validity even in the midst of scientific and technical changes. Nothing proves this better than the case law of the United States: *'Because of its focus on methodological rigor, many tort reformers trumpet the Daubert standards as a way to get rid of junk science in the courtroom. [...] In this more comprehensive analysis, we too find very little evidence that adoption of the Daubert trilogy has any systematic effect on whom is offered as an expert in state court disputes. [...] we cannot determine exactly why Daubert seems to have no systematic effect'* (Helland et al., 2012, 32-33.). The answer lies in the fuzzy logic behind forensic identity. In the field of forensics, mathematical logic did not make logic out of mathematics, but made mathematics out of logic: some of the objects and methods of forensic identification provide an opportunity to quantify the frequency distribution of characteristics, while others *'do not constitute classes or sets in the usual mathematical sense [...] Yet, the fact remains that such imprecisely defined 'classes' play an important role in human thinking, particularly in the domains of pattern recognition'* (Zadeh, 1965, 339.). Therefore, it is now a common criticism of the Bayesian approach that it requires such numerical prior probability values that are quite difficult, time-consuming, expensive, or merely impossible to determine experimentally (Halliwell et al., 2003, 42.).

In practice, it is often unavoidable to use subjective probability estimates published by experts. According to the United States National Research Council: *'there is an equally important responsibility not to use numbers, which convey the impression of precision, when the understanding of relationships is indeed less secure. Thus, whilst quantitative risk assessment facilitates comparison, such comparison may be illusory or misleading if the use of precise numbers is unjustified'* (National Research Council, 1981, 15.). Various studies have pointed out that while point estimates of probability expressions are highly variable among subjects, probabilistic uncertainty, expressed in verbal form, can provide more accurate estimates of the frequency of multiple characteristics (Halliwell et al., 2003, 43.). All this suggests is that: it would be useful to include probabilistic expressions in forensic probabilistic models. Foucault shed light on the above problem, saying that there are many areas in society, especially criminal justice, *'where truth is formed, where a certain number of ground rules are defined – certain ground rules of subjectivity, subject areas, knowledge types – and consequently, if we take them into account, we can create the external story of truth'* (Foucault, 1998, 8.). However, we must not forget that practice is the final test of the applied scientific results (Hartmann, 1970, 134.). After all, in addition to the certainty of

uncertainties, it is for the trier of fact to determine the probative value of expert evidence by comparing it with other data and evidence available in the case in question. This is how subjective elements take place in jurisprudence. Although positive law seeks to eliminate this subjectivity, criminal justice is also looking for certainty somewhere in the midst of uncertainty: the best possible solution available at a given degree; because the only one correct decision does not exist, only the one which is the most authoritative in the given conditions of the given age, both factually and legally. The concepts of morphological and substantive trace should therefore not be mechanically separated. Their separation is based on their information content relevant to the given case: if it is a reflected formal feature, we are talking about a morphological trace, and if it is a material feature, then we are talking about a substantial trace (residue material) (Kertész, 1973, 12.). The emphasis here is not on the fact that substantial traces represent the source object beside themselves because, even if we know the material properties of the source object, there are no reference materials that could be used to draw a conclusion about the individuality of the link between characteristics based on their quantitative and qualitative assessment. This is the objective dialectic relationship, the importance of which Locard has drawn to the attention of the forensic community during the discussion of the principle of mutual exchange (Locard, 1923, 80.). While it is true that, in the case of mutual exchange, it is possible to examine the individuality of the link between characteristics in the opposite direction, it must necessarily be preceded by the traditional approach of forensic identification. We can obviously go there and come back on the same route, but first we have to go there; in order to come back. The unique characteristics of the source object are constantly changing as a result of various circumstances, the process of which is interrupted by the stages of relative constancy that enable identification (Katona, 2002, 147.). Consequently, in order to be able to draw a source conclusion regarding a specific trace, we must first become familiar with the genus proximum of the source object nomothetically: that is the fuzzy set of its possibilities of change. Consequently, only in this way are we able to decide whether *'x does or does not belong to A'* (Zadeh, 1965, 339.).

Conclusions and discussion

In the present study, I sought to answer the question of the logic by which the theory of forensic identification can solve the contradiction that arises from the individualization of the link between two or more individual phenomena. After conducting explanatory research in the fields of forensics, criminal law,

philosophy and logic, I have come to the conclusion that fuzzy logic lies behind forensic identity.

The results of my research have methodological importance, which enriches the theory of forensic identification with the following knowledge:

- Given the differentiation of the Anglo-Saxon and European continental legal systems, expert evidence is the *differentia specifica* of forensic sciences, to which the theory of identification is given an independent disciplinary character.
- The question of cognition cannot be regarded as prior to the question of primacy regarding the theory of forensic identification: because understanding the unique relationship of the reference objects necessarily presupposes research into the nature of the source object.
- The ontology of forensic identification is rooted in the ancient Greek developmental dialectic, which medieval emanational limit Hegel, following the footsteps of Cusa, was able to overcome by the thesis of the identity of identity and non-identity, from which the basic idea of fuzzy sets has unfolded.
- In the development of forensic sciences, it can be shown that the use of more advanced tools reduces uncertainty but does not completely eliminate it. The resulting residual problem can be solved if we acknowledge positional irrationality in the process of individualization, namely that the residual in this way is not unknowable but is not yet known at the given stage of development.
- The theory of dactyloscopic identification has an ontological instead of a pseudo-scientific nature because its axioms have retained their validity even in the midst of scientific and technical changes. This is due to the fact that the unique characteristics of the source object form a fuzzy set.
- The concepts of morphological and substantive trace should not be mechanically separated in the field of forensics. Although both contain subjective elements, they can provide relevant information for the case in question.
- Criminal justice is an area in society, where practice checks the results of the applied forensic sciences by comparing it with other data and evidence available in the case in question.

The theses listed above form a theoretical bridge between the field of forensic identification and fuzzy set theory, and at the same time justify the influence of fuzzy approaches in forensic data analysis. The vision of forensic identification points in the direction of fuzzy expert systems.

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