Image Recognition in the Traffic Sign System - Semiotic and Linguistic Aspects

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Abstract- **The traffic sign system is a complex structure composed of images and verbal text. This research aims to focus on the nature of the road sign as an image, its recognition by road users, the relationship between verbal text and image in road sign design, how much they interact and how text contributes to the basic functions of the sign - to direct and regulate traffic and the behaviour of road users. The theory of sign, a subject of study in semiotic science, is examined. The sign as an image influences, informs, regulates the behaviour of road users - these are its main functions. The system of road signs is composed on the basis of a common code of symbols and images, which is modified in different linguistic and cultural environments. The text component complements and supports the functions of the image. Its structure and pattern in different languages are also investigated in order to check the necessity or redundancy of the verbal text in the composition of the road sign as a whole. By using an interdisciplinary approach between semiotics and linguistics, the research could be extended towards improving the design of road signs in order to improve communication on the road through the road sign system, an element of traffic.**

Keywords— semiotics, linguistics, road safety, road signs, code, image

I. INTRODUCTION

The object of the research is the system of road signs. Usually the problems are considered in the research field of road engineers, planners, builders, traffic control and transport authorities. Road signs as an element of infrastructure are part of our surroundings. But they are also a communication system that could be studied by specialists in the fields of cognitive psychology, linguistics, even cultural anthropology.

The subject of this research is the relationship between images and verbal text in road signs and how they interact as a whole.

The aim of the study is to broaden the field of analysis from highly specialized scholars who seem to have monopolized the topic of the perception of road signs as only regulating traffic rules. The research would be more thorough if it were complemented with methods from other scientific fields and an interdisciplinary approach to the study of this topic - how road signs affect road users - was created. Road signs are a complex of image (symbol) and referenced verbal text. In their unity, they perform the functions of directing, guiding and indicating the correct directions and courses of action for road users. Their correct perception contributes to the fulfilment of their functions.

I will try to analyse to what extent the text or the image prevails over the picture (symbol), how they interact, whether there is a need to increase the volume of the verbal text, comparing the type of construction in the text between English and other languages.

The research methodology compiles various methods from the scientific field of semiotics, linguistics (general linguistics, cognitive linguistics, sociolinguistics), engineering design of road signs. It is part of a larger scientific work on the subject. By conducting a content analysis of traffic regulations and enforcement manuals, regulations of different countries, it compares different approaches in their amendment and enforcement. Certain examples are selected to summarize the conclusions drawn due to the limited length of the text. The corpus of the present study covers such road signs which have correspondences in the Bulgarian language and which lack verbal text but are present in other languages. The studied material contains road signs from the systems of Bulgaria, Poland, USA, Russia, Japan in order to find the differences in trends. The common ground between all is the international conventions designed to unify the rules and create a common and universal code of communication. Given the cultural and social differences around the world, as well as a number of geographical, ethno-social, economic and other factors, there are also particularities,

which are illustrated by examples, with comparisons being made with Bulgarian regulations. The material under study is considered as an object of semiotic science, since by its nature it is a sign system.

The research procedures applied are comparative analysis of the content of road signs between different languages, content analysis of traffic regulations and manuals, empirical observations: analysis of real road signs and their effects on the behaviour of road users, photographic material, attitude survey of 56 respondents with an online questionnaire in Bulgarian.

Road signs have been known to mankind since ancient times. In the Roman Empire, stone tablets and other signs indicated distances and directions. In the Middle Ages, the materials used to make signs changed [1], and with the advent of industrialization, the increasing use of the automobile and the increase in traffic flow and international traffic in the early 20th century, there was a need to develop uniform rules and norms for all countries of the world in order to regulate traffic and guide drivers.

The first international discussions and forums held to discuss and establish common rules for road traffic in Paris in 1909 and 1926, and in Geneva, led to the adoption of the Geneva Convention of 1931 for the unification and standardisation of traffic signals and the Vienna Convention on Road Signs and Signals of 1968.

II. MATERIALS AND METHODS

Use tables and figures to adjust column length. On the last page adjust the length of columns so that they are equal. Use hyphenation only if it is necessary. Use Spell check. The Roman numerals used to number the sections are optional. If you do use them, do not number Acknowledgment and References, and arrange subheadings with letters.

The general characteristic of the traffic sign system is given by the definition in the Bulgarian legislation. According to Ordinance No. RD-02-21-1 of 23.11.2023 on road signalization with road signs (the Ordinance) "a road sign is a planar representation of a certain shape, dimensions, colours and symbols" [2]. Road signs and other means of signalling shall comply with the requirements of BDS 1517:2006 "Road traffic signs. Dimensions and letters".

If we apply the semiotic approach and the theory of Charles Pearce [3] and Charles Morris about the sign (index, image, icon, symbol), then we could say that road signs fit into the general definition of what a sign is: a material structure that denotes a certain object of reality, "something that stands in for something else different" from our surroundings [4]. For example, the road sign, whose material expression is the A18 'Pedestrian crossing', conveys the idea that crossing is permitted at the precise location. There is a process of communication between road signs and road users in which it is important to analyse how road signs are interpreted by different social groups of people (drivers, pedestrians, cyclists). Road signs are a

means of communication between road users and the road infrastructure and are part of the road-human-car system.

Using Ch. Pearce [5] for a "triadic relation" [6] of the elements in the sign system, based on the "sign triangle" [7] of the German mathematician Gottlob Frege [8] and later extended by Ch. Morris [9], we obtain the following configuration for the traffic sign system:
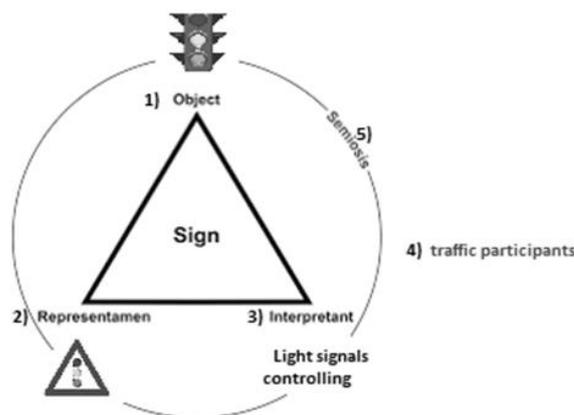

Fig. 1. Semiotic system of traffic signs: 1) Object of reality which the sign replaces; 2) Representamen – a form representing the sign; 3) Interpretant – mental image or thought arising in the mind of the individual interpreter; 4) Interpreter: the person/subject involved in the perception of the message [10] all road users; 5) Semiosis/sign situation: the process of sign functioning [11]

The relation between the signified object of reality and the sign itself by which it is signified is studied by the semiotic division semantics, the relation between the sign and the other signs in the system as combinations is of interest to syntactics, and the relation of signs to interpreters is studied by pragmatics as a division of semiotics. In this sense, it is important to analyse "the behaviour of signs in the actual processes of communication" [12], to what extent an image has a clear relationship with the object of reality, how a particular sign functions in consonance or disharmony with other signs, whether a sign with textual content and an image often contradict or complement each other, and how the sign influences and whether it is recognized by recipients.

In the study of the linguistic elements in the structure of the road sign, an analysis is applied at the lexical, morphological, syntactic and semantic levels. The source of the researched material are examples from Bulgarian reality in comparison with their analogues or lack of such from other languages. The present study is far from exhaustive due to the extensive corpus to be studied, but it is a guideline and a reason for further elaboration of the issues. A linguistic analysis could also contribute to a deeper investigation of the structures, word combinations, and sentence nature of the selected phrases. They function together in a complex system and therefore have features of intertextuality, as they are subordinated to a common form of existence - the regulation of traffic.

III. RESULTS AND DISCUSSION

A. *Semiotic analysis: classical theory of sign*

Road signs are a complex system that is inherently secondary, artificially created, consisting of verbal text (lexemes) and iconic text (containing information about the specific object. For example, the A18 'Pedestrian crossing' road sign contains a pictogram, but in combination with the triangular shape in red border signals and warns (one of the functions of road signs).

Fig. 2. Road sign A18 Pedestrian crossing [13]

As stated in the Ordinance, Art. 1, "group A danger warning signs shall have the form of an equilateral triangle with a horizontal base and a vertically superimposed apex, a red border stripe, a white background and symbols in black". Pursuant to Article 23, para. 1 of the same Regulation, "danger warning signs shall be placed before the dangerous section at a distance of 50 to 100 m - in populated areas". All this information is contained in the road sign marked A18 'Pedestrian crossing ', which in turn is the name of the sign itself. Non-linguistic signs have no nominative function, they do not name an object, but they themselves bear a name, which in turn gives them a special status and distinguishes them from other signs in semiotic systems.

Initially, in defining road signs in international conventions, the principle of arbitrariness in determining their form and type is fundamental [14]. The visualisation and symbolism of signs could be found in colours as well as shapes and sizes. However, in the choice of colours of traffic lights, the three colours (red, yellow and green) are not directly related to the act of driving. But from a cultural point of view, we have given them special importance so that they take up positions as the main traffic lights.

The colour red symbolizes the situation that is associated with the occurrence of risk, danger, endangerment, symbolizes physical injury and blood, is associated with emergency or urgent care (the colours of ambulances and hospitals); yellow implies focusing attention, showing a reaction or taking some action (stopping or continuing traffic), preparing to perform an action; the colour green is presumably associated with nature, relaxation, tranquillity [15], it means a permissive mode of performing an action - crossing the roadway. The choice of the colours of light signals is motivated, conventional, not arbitrary. It depends on a number of factors that play a role in the reading of the code by the interpreter, which in our case are the road users. The perception and interpretation of the traffic sign, in particular the traffic light, by the interpreter himself depends on his age, education, inner conviction in following the conventionally accepted code (whether to follow the rules imposed in the regulations). Accordingly, in the event of non-compliance, i.e. in the event of non-

compliance with the message code, he will incur his own penalty (e.g. a penalty follows if the light turns red).

The semiotic system of road signs contains the following characteristic according to the closed-open paradigm: on the one hand, it is a closed system because it presupposes the functions of signs to signal and indicate specifically and only the traffic on the road. But it is also open in that it is subject to change, to the addition of new signs, to the deletion of others due to obsolescence, etc. This shows its flexibility, its relevance to meet contemporary challenges and its ability to be transformed and updated according to need and public attitudes.

Road signs are: artificial, secondary, linguistic (signs with text) or non-linguistic (images, symbols, indices), audio (some systems in cars, traffic light beep, car horn), tactile (pedestrian and blind signal sensors), visual - according to their mode of perception; conventional, motivated - according to their mode of occurrence. Road signs according to their object relation according to the classification of prof. Mosko Moskov [16] could be defined as: icon (image of the signposted object, but has similarity and resemblance to it); index (the object signposted by the sign has an impact on the sign itself), symbol (expresses in general terms the idea conceptually and motivated according to accepted customs and beliefs), signal (pre-agreed sign).

In order to be recognised and clearly understood, traffic signs should be subject to a certain code known in advance to the recipients. "A code is any system of symbols (signs) which, by prior agreement, is determined to convey information and to transmit it from the transmitter to the receiver" [17]. "A sign is a relation, a relationship between a transmitter and a receiver against the background of reality" [18]. It is necessary that the codes of the sender of the message match the codes of the receiver of the message in order for the message to be successfully read and received [19]. Since road signs exist as a means of communication between people and are a product of human society, they are highly social in nature, but they only fulfil their functions as signs with a certain meaning in a communication environment by a prearranged agreement [20]. Road signs are complex constructions consisting of different types of elements, each of which carries information and aims to convey that information in a clear and explicit manner.

B. *Linguistic analysis of the textual content*

Linguistic analysis is applied in examining the linguistic constructs, verbal expressions and phrases contained in the structure of road signs, to what extent they help or hinder the correct perception at the sensory level of the image.

The verbal text is in its own way also a sign - a language. The ancient philosopher Augustine united the theory of sign and the theory of language, defining signs as a genus and the linguistic sign as their kind [21]. In the field of linguistics, the linguistic sign became the main object of study for the French scholar Ferdinand de Saussure, "the

founder of modern theoretical linguistics" [22]. He developed the idea of signifier and signified (the word and the object of reality it represents). "As the most complex and universal sign system, natural (verbal) language is a part of semiotics", due to the fact that "as a system of signs, it possesses all the qualities of signification sui generis. Language is the most important, fundamental means of communication in human society" [23] and is present at every level and dimension of human existence. The linguistic signs are the basic building unit in the structure of the language, these are: morpheme, word, phrase, sentence, text [24]. In road signs, word, phrase and sentence are present depending on the length of the phrase. In some countries additional signs or signs containing verbal text are used.

In the absence or presence of a text element to clarify the main image in the traffic sign, confusion or ambiguity of the sign information could occur. Empirical observations show that in the Bulgarian traffic sign system the content of text material is much more limited than images and symbols. From the point of view of designers and traffic engineers this is acceptable, since during traffic, especially when driving a vehicle, any additional activity (looking at a sign or long text) would lead to distraction and distraction, which would cause a risk of an accident. There are also cases of designing and making road signs where the message is not clear and explicit. Example:

Fig. 3.   Road sign A42 Reduced visibility ahead [25]

When a blitz survey was conducted on the meaning of a particular road sign with road users in an informal setting during a training session, the responses were "Traffic jam", "Obstruction on the road" and "Poor visibility". Allowing for different interpretations of the sign suggests that its depiction is not sufficiently clear and explicit, hence it does not fulfil its communicative and appealing (regulative) function. If there were a brief explanation of the content of the sign, then the possibility of its misinterpretation would certainly be ruled out.

At the morphological and syntactic level, English-speaking countries have word combinations and syntactic structures that could constitute independent sentences, even verbless ones. Example: "Not a through street", "Left lane ends", "Centre Lane Closed Ahead", "No Traffic Signs", etc., from the group of warning signs (W - warning, from English), unlike in Bulgarian-out of all 43 warning signs from group "A", none contains verbal text.

Fig. 4.   Road sign W8-14 Fallen Rocks (US)

Fig. 5.   Road sign A17 Risk of collapse or presence of fallen stones

Again in the USA, signs containing the additional verbal expression " No turn on red", in combination with a red dot symbol, and "Yield to pedestrian ahead" are common.

For comparison with the Bulgarian system, again there is a difference in the representation of the character with symbol and text. [26], [27].

Comparing the English and Russian traffic sign systems, V. H. Shashkova distinguishes two tendencies: in English "verb phrases, including predicate binomials, predominate, and in Russian - noun phrases" [28]. What peculiarities of the language is this due to? Predicate constructions contain much more action, the actor is concretized - each participant in the movement, the interpreters, which achieves greater involvement in the process of moving and driving and personal involvement by personalizing the actor.

In the use of syntactic structures, it is also necessary to refine the length of the phrase so as not to distract drivers.

At the semantic level, the meaning of the signified is conveyed through an iconic image, including a pictogram or a visually recreated image of the object from reality. In semasiological terms, this is reminiscent of ancient alphabets, some of the first known in history, which consisted of a series of symbols and representations of animals, plants, people, geographical objects, etc., for the purpose of communication and information delivery, a fundamental function of language as a sign system. In this sense, given the sequence of symbols and images in the road sign system, we could conclude that we are dealing with a language of communication whose code is the specific images in road signs. Unlike in English, where only images are present to convey information, in English the verbal phrase purposely carries an additional clarification to the main message and overlaps semantically with the image.

Fig. 6.   (a) and (b) Road sign A13 Artificial bumps on the traffic lane [29], [30]

Fig. 7.   (a) and (b) Road sign R4-7b Keep Right Diagonal Arrow Sign (US) [31]

Fig. 8. (a) and (b) Road sign Distance over which road humps extend (UK) [32]

In English-speaking countries, the tendency is to supplement the image with a textual explanation to facilitate and guide road users. The sign is actualized, it is in the process of use, its material aspect is sensually perceived by the addressee. It can be seen that both cases of sign use in Bulgarian reality apply only the graphic representation. At the same time, the semantic sign is limited because its content lacks the information about the section to which the sign applies, which is additionally necessary to assimilate as a code and accessible knowledge (in Art. 23, para. 1 of the Ordinance - for settlements outside the boundaries of settlements, motorways, expressways and urban expressways). The sign thus remains simplified to its graphic representation and is likely to mislead or confuse road users, especially foreign visitors.

The vocabulary used as content in the overall image of the sign is logically related to the sphere of transport: road, traffic, directions - left right, forward, street, exit, zone, pedestrian, attention, danger, limit, speed. The lexemes used could be categorised according to their function - to indicate an object of reality (a type of obstacle or impediment), direction of traffic or restrictions, elements of the road infrastructure and environment, weather phenomena, etc.

Fig. 9. Road sign R2-1 Speed Limit (US) [33]

The speed limit is clearly and unambiguously imposed by the specific phrase, whereas symbols could not give the same information definitively without prior knowledge. Such texts clearly state the rules, helping primarily to comply with local regulations. For comparison with Bulgarian:

Fig. 10. Road sign Ж19 Recommended speed (Bulgaria) [34]

Only the blue colour indicates the recommended but not mandatory character of the sign, which should be known in advance in relation to the Bulgarian legislation.

It is interesting to consider another application of the same sign 'Ж19'. A mathematical model is used to design the traffic light regime [35] so that the so-called "green

wave" is respected, but in addition to the green signal, the 'Ж19' recommended speed sign should also be respected, which in this case is 50 km/h. Under these two conditions the interpreter (driver) could use the green wave' for faster and optimised movement. The two signs (light signal and speed advisory sign) are independent signs, but in the specific communication environment they form a heterogeneous - "super-sign", "formed by pre-existing simpler signs" [36] and their compliance as a whole result in a "green wave". In this sense, the "green" light signal is mandatory and conventional with respect to its appearance, but also function (always on green is allowed to pass). And the 'Ж19' sign is conventional in its introduction but arbitrary (arbitrary) in its function (it is up to the driver to decide whether to obey it as it is advisory).

Fig. 11. Road sign 1012-34 Grüne Welle bei km/h (Germany)

At the same time, the German legislation [37] explicitly states in a verbal expression under which conditions the "green wave" is observed. The verbal combination of the noun "Welle" and the adjective "grüne" is a noun phrase, a verbless clause followed by a circumstantial explanation of modality. As a syntactic construction it fulfils nominative, appellative, cognitive and representative functions - it names the idea of a green wave, indicates and regulates the behaviour of drivers, provides information about the correct functioning and application of the signified and as an expression presents the idea, the concept of observing certain conditions in order to "green wave" the road.

Differences in the interpretation of road signs could be observed in different countries around the world, which could lead to difficulties in sign recognition:

• according to the level of knowledge and/or proficiency in the language:

Fig. 12. Designation that indicates that vehicles and streetcars must slow down

Fig. 13. Closed to pedestrians and small and remote-controllable mobiles (Japan) [38]

Fig. 14. Road sign D-52 strefa ruchu – „Traffic zone"

Fig. 15. Road sign T-13 plate indicating a road stretch that has ruts as deformations of road surface (Poland) [39]

• according to cultural and linguistic specificities and differences

Fig. 16. (a) and (b) Road sign STOP in Japan and standard international sign [40], [41]

Fig. 17. (a) and (b) Road sign Snow chains sign in Bulgaria and Russian Federation [42]

In the Ordinance on Traffic Signals and Traffic Equipment on the Roads in Slovenia [43], Article 4 regulates the use of language in traffic signals - the inscriptions on traffic signals are in Slovenian throughout the country. In bilingual areas, in addition to signs in Slovenian, there are also signs in another language, so that the sign is first in Slovenian and then in the foreign language. Inscriptions on vertical road signs on motorways, expressways and main roads may be in languages other than Slovenian. Inscriptions on tourist signs may also be in foreign languages.

The particular cases in different countries contribute to the more extensive application of verbal structures in road sign construction. From the point of view of pragmatics, there is a wide application of verbal elements according to the peculiarities of the linguistic, social and cultural anthropological environment of communicators.

Verbal signs could facilitate communication and further enrich the structure of road images, taking into account the peculiarities of the particular linguistic environment as well as specifics in the cultural-social differentiation of societies. The tendency to use more verbal text in some countries, as opposed to the absence of it in others, could suggest the level of perception and correct application of the rules regulated by road signs.

By combining different types of elements - graphic, iconic, verbal - it enriches the information field and creates clarity and greater explicitness in conveying the message and complements the recognition of the images in them. However, it should also be limited so as not to cause distraction for drivers, who should receive and process data and information in the shortest possible time without disturbing their concentration and creating conditions for risk. There should be precise guidelines on how much

verbal text a sign can contain or the better and more appropriate option is a main sign with an image and an additional one with explanatory text. It is also important in what language the text is written. In a multi-language environment, one could select the most recognizable one so that the given code can be read by a larger number of interpreters. In countries where there is a single spoken language, it will only be familiar to locals. In this case, for the different language communities, the graphic material is more appropriate, the image carries information. But it needs to be designed and presented in a clear form, colour and composition.

"The question of the sign and its nature is common to many sciences. Any attempt to solve it from the point of view of only one science is at least one-sided, if not risky" [44]. In any case, the issue deserves attention and deeper analysis, especially in the Bulgarian reality, where the statistics on traffic accidents and road casualties and traumatism are alarming. We as a society are obliged to analyse thoroughly and apply ever wider ranges in the approach of researching the problem of road safety in order to make the elements of it work better.

IV. CONCLUSIONS

After a review of the content of traffic rules and enforcement manuals in languages such as Bulgarian, Romanian, German, it is noticeable that there is a tendency for a much smaller number of road signs to contain verbal text. At the same time, in the English-speaking world and countries such as the USA, Australia, UK, signs containing verbal text or elements with text account for more than half. This could be due to cultural anthropological, social, economic, ethno-linguistic or psychological factors. We are in an era of a rapidly evolving society, both technologically and evolutionarily. All of this calls for global uniform international legal norms to standardize and unify perceptions as far as this is applicable.

Given the different levels of awareness and experience, it is necessary to pay attention to the elements that make up the road sign in its material entirety - in addition to shape and colours, consideration should also be given to whether the image is sufficiently clear and gives clear and unambiguous information. There is a need to reinforce the concept of conformity to frame the applicability of signs and their uniformity. There is a need to study more thoroughly and carefully the differences in the perceptions of different social groups according to their competences, education, age, experience through surveys and questionnaires. Evaluating the effectiveness of signs in different social and cultural contexts could lead to new opportunities for improving the system and improving the design of the signs themselves.

A wider range of methods and approaches could be used, not only in road construction, design, but also in psychology and other seemingly distant scientific fields, such as cognitive linguistics, semiotics. Opportunities are also opening up for conducting technological research with sensors on how drivers react on a physical level when perceiving elements of road infrastructure. In this way, their reaction in the presence of more text than images, only

text or only images could be detected. This would contribute to a better design of road signs to increase their quality and improve their functions.

Nowadays, when traffic is becoming more and more intense, our quest to ensure better road safety calls for different perspectives, syncretic methods that involve an interdisciplinary approach, in order to get out of the field of narrow specialists and provide a broader range of scientific knowledge that can enrich and improve the current achievements.

In conclusion, a recommendation should be made regarding our country's efforts to build consensus in enforcing legal norms with a view to implementing the Road Traffic Act and implementing the signs and their auxiliary symbols.

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