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Semiotic Interpretation of the Traffic Light System: A Way to Influence Road Accidents

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Abstract

This work is part of a larger research that involves the science of semiotics in order to study road infrastructure (road devices) in road crossings, using the theoretical contributions of Ferdinand de Saussure, Umberto Eco and Charles Sanders Peirce, with the purpose to support the safe mobility of citizens. Pedestrians use the roads for work, study, recreation, and other activities of daily living providing a harmonious and safe way for people to move either on foot, by car, bicycle, public or private transport services. One of these road devices is the traffic light system used to control road traffic at an intersection or road junction. This system's optimal and safe operation is related to the infrastructure of the urban space, which results in safe or unsafe mobility for pedestrians. In this sense, the semiotic interpretation of the state transition diagram for a traffic light system (green-amber-red / red-amber-green light change) is being proposed to recognize whether the road may be a dangerous place for users. The research aims to propose an improvement in pedestrians' conditions to reduce traffic accidents in the most conflictive and dangerous road intersections. These places were determined by the Secretaría de Salud (2012) and disclosed in its Second Report on the Situation of Road Safety in Mexico City.

Interpretación semiótica del sistema de semáforos: una forma de incidir en los accidentes de tráfico

Abstract

El presente trabajo es parte de una investigación mayor que utiliza la ciencia de la semiótica para estudiar la infraestructura vial (dispositivos de tránsito) en los cruceros viales, utilizando los aportes teóricos de Ferdinand de Saussure, Umberto Eco y Charles Sanders Peirce, con el propósito de apoyar la movilidad segura de los ciudadanos. Los peatones utilizan las carreteras para el trabajo, el estudio, la recreación y otras actividades de la vida diaria, proporcionando una forma armoniosa y segura para que las personas se muevan ya sea a pie, en automóvil, bicicleta, servicios de transporte público o privado. Uno de estos dispositivos viales es el sistema de semáforos que se utiliza para controlar el tráfico vial en una intersección o cruce de carreteras. El funcionamiento óptimo y seguro de este sistema está relacionado con la infraestructura del espacio urbano, lo que se traduce en una movilidad segura o insegura para los peatones. En este sentido, la interpretación semiótica a través de un diagrama de transición de estados lumínicos (cambio de luz verde-ámbar-rojo / rojo-ámbar-verde) para un sistema de semáforo es una propuesta que podría ayudar a reconocer si la vía puede ser un lugar de riesgo para los usuarios. El objetivo de la investigación es proponer una opción para mejorar las condiciones de los peatones reduciendo los accidentes de tráfico en los cruces viales más conflictivos y peligrosos, dichos lugares fueron determinados por la Secretaría de Salud (2012), y dados a conocer en su *Segundo informe sobre la situación de la seguridad vial* en la Ciudad de México.

Palabras clave | Accidentes de tránsito, Signos, Semiótica, Señalética vial.

Introduction

The social context which brought about more visibility for the problem of traffic accidents was the Global Plan for the Decade of Action for Road Safety 2011-2020 proposed by the World Health Organization (WHO, 2011), since it was through this plan that is aimed to reduce the number of victims in traffic accidents in countries with a higher number of accidents like Mexico, India, China, Brazil, the United States, among others. This fact allowed us to have more awareness and information about traffic accidents; for example, in figure 1, it is shown that the leading cause of death in young people between 15 and 29 years of age is traffic accidents.
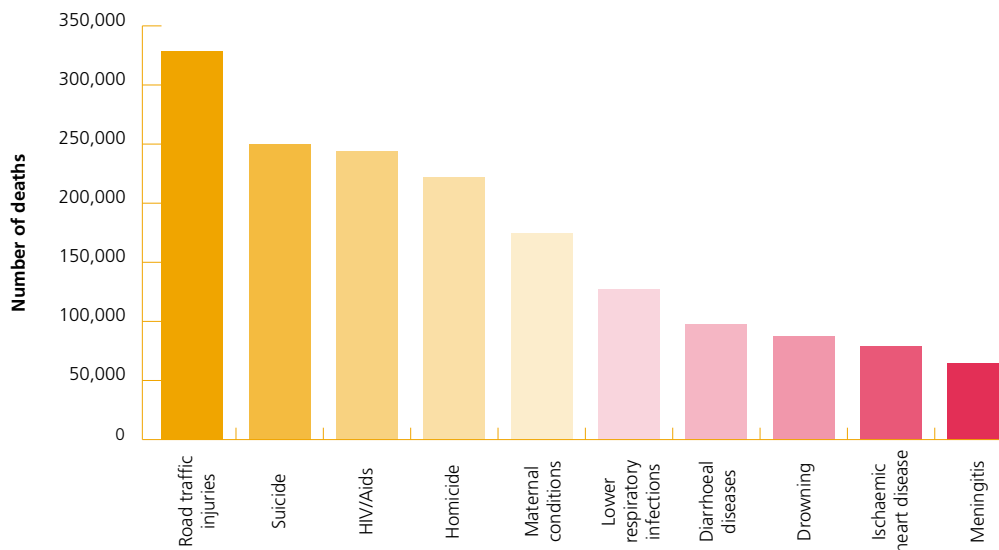
Figure 1.
Top ten main causes of death in people aged 15 to 29, 2012. Source: Retrieved from WHO (2015, p. x).

According to the Secretaría de Salud (2012), in Mexico City, the most significant risk areas are intersections because there is more interaction between pedestrians and drivers, which causes greater insecurity for those who walk. One of the causes of this danger is traffic control devices. Hence the interest in understanding this problem from a semiotic approach to determine what role traffic lights play in traffic accidents.

Using sign theory to try and understand and explain the problem is based on the fact that signage transmits messages. Ferdinand de Saussure tells us that Semiology "is the science that studies the life of signs in the bosom of society" (2012, pp. 66). Signals (the traffic light system) are studied as signs that generate meaning in different actors' everyday lives that use the road network.

Materials and methods

The system of traffic lights is part of a traffic code. I will first discuss the meaning of this code to understand the function of these lighted signs, which are mainly used to control traffic at intersections. Secondly, using the theory of Charles Sanders Peirce (2012a; 2012b; 2012c; 2012d & 2012e) and Umberto Eco (1990; 1997 & 2006), I will explain the interpretation and function of these signs from a semiotic point of view and evaluate, using a sign diagram describing the traffic lights system may or not have a pedestrian crossing. It is essential to mention that examples for this paper were taken from specific cases in Mexico City (Avenida Tacuba y Avenida Reforma; Eje Lázaro Cárdenas y Avenida del Taller; Av. Guerrero y Eje 1 Norte).

The Traffic Code

The objects (traffic control devices) turn into signs and these signs into signals which become part of the code, in other words, a system of signage valid for a community, when the following situations occur:

1. The objects (traffic control devices) turn into signs and these signs into signals which become part of the code, in other words, a system of signage valid for a community, when the following situations occur:

2. When there is social acceptance (convention), in other words, the code is made up of norms, conventions, and signals of a social and cultural environment. Victorino Zecchetto (2010, pp. 118) writes that "the sign belongs to a cultural order because it is invested with meaning." From there, the signs

Alphabet	A B C D E F G H I J K L M N Ñ O P Q R **S** T U V W X Y Z
	a b c d **e f** g h i j k l m n ñ o p q r s **t** u v w x **y** z
Phonemes	**S** + **a** + **f** + **e** + **t** + **y**
Morphonemes	**S a f e** + **t y**
Word	**S a f e t y**

Figure 2.
Semiotic system of signs.
Source: Modified from Osnaya (2020).

are created to operate within a determined group of people. Nathan Houser (2012) points out that all thinking which presumes to be developed uses conventional signs. A convention, whether linguistic or semiotic, depends mainly on the life of people in the community to make a convention their own.

3. There is a possibility of combination with other signs. The code acts as a system because it works due to the relationship between and integrating its elements. Helena Beristáin (2010, pp. 480) tells us that a semiotic system of signs is controlled by a series of norms and general rules, according to which they are organized and combined to generate communication processes. A clear example of this is the alphabet. Because of the large number of possibilities, we have access to 24 phonemes, which generate morphemes. These morphemes make up what we know as the word, transmitting meaning (Figure 2).

4. The code should be clear and precise. Once a code is established, this code becomes "a firm and necessary base upon which any type of communicability can occur," as Zecchetto (2010, pp. 123) described. For example, if the traffic code did not use the agreed-upon colors in the traffic light systems, users would not understand their meaning.

Figure 3.
Informative traffic signs.
Source: Own elaboration with information from
Secretaría de Comunicaciones y Transportes (2001).

To conclude this concept of code, we will mention, straightforwardly, the Zecchetto classification, which divides the code into two groups: meaning and conduct (Zecchetto, 2010). As the name indicates, the first element has the function of meaning; in this case, the signs are related to each other syntagmatically within a system, and the message of these signs is interpreted through a social agreement or convention. The same is true of linguistic codes, logic, mathematics, and non-verbal communication such as mimes. The interpretation of this type of code tends to normalize human behavior within a specific culture. These codes act on two levels, the individual and the institutional; examples of the first are the uses and methods of eating, dressing, greeting, etc. Institutionally we would be talking about aspects like marriage, work, religion, among others. The traffic code belongs to two categories since on the one side; it is a norm that transmits a meaning derived from individuals who travel and those who oversee controlling traffic on public streets to guarantee safety and the flow of vehicles and pedestrians. For instance, figure 3 is part of a code of meaning because it points out that there is a zoo in the place, in the other hand, figure 3 evokes meaning and conduct, first of all, the sign (figure 4) means it is forbidden to pass the car in front (meaning), and this determines the behavior of the driver since he is instructed not to pass the car that is in front of him.

Figure 4.
Restrictive traffic signs.
Source: Own elaboration with information from
Secretaría de Comunicaciones y Transportes (2001).

The Process of Semiosis and the Traffic Control Signals (Traffic Lights)

According to Peirce (2012a, pp. 35), the concept of semiosis is the sign relationship through which the processes of interpretation are developed to obtain knowledge of the world; in other words, semiosis describes the process of thinking. Semiosis includes three components: a sign, an object, and an interpreter (Peirce, 2012d, pp. 495), but inference (an elemental condition for semiosis) also allows for the comprehension of all reality. For example, if **A** is equal to **M**, and **C** is **M**, infer that **C** is equal to **A** (Figure 5). That is to say, that thinking is derived from the perception of exterior facts and previous knowledge.
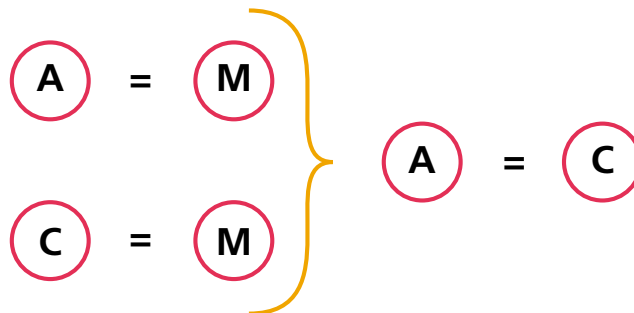
Figure 5.
Guiding Principle of Pierce's Inference.
Source: Own elaboration.

Umberto Eco writes that "The semiosis process is the relationship between sensitive information and the interpreter's conceptual model" (Eco, 1997, pp. 71).[1] We will use the following example to understand this idea: a person walks in a park and perceives, through their hearing, a signal (sign). At this first moment of perception, the subject recognizes this fact (the sound) as exterior and the quality of something (firstness). After this, the experience (previous knowledge) of this person makes them infer that something (object) can be hypothetically a canary (secondness). Eco (1997, pp. 74) tells us that giving a name to the experience is a hypothesis, and this serves to distinguish a sensation from the rest. Thirdly, the individual investigates to verify their hypothesis and disparage any doubt. They observe that the bird emitting the sound has yellow feathers, and by comparing the bird with their conceptual model, they can safely say it is a canary. It is then that their perception is framed within the laws of nature, and they arrive at what is called thirdness.[2]

As we can see in the above paragraph, semiosis refers to the interpretation of sensory information and seeks the pragmatic meaning of things. This implies the institution of habit in people. Peirce (2012c, pp. 175-177) maintains that the production of the belief is the only function of thinking and that the essence of this is the establishment of habit. To explain this, we will again look at the example of the canary. The sound produced from the bird provoked the person to doubt which object was omitting the sound. Nevertheless, as we already discussed, the process of semiosis allowed the individual to generate a belief in what type of sound is emitted by canaries. They associated their perception with their prior knowledge and recognized the sound of a canary because they habitually listened to canaries.

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[1] [T. del A.] Original text: El proceso de semiosis es la relación de datos sensibles con el modelo conceptual que tiene el intérprete (Eco, 1997, pp. 71).

[2] The concepts of firstness, secondness and thirdness are taken from Peirce (2012e, pp. 525). According to the author, the sign occurs as a growth phenomenon. That is: the existence of a secondness is because there is a firstness and the existence of a thirdness is because there is a firstness and a secondness.

In the following example (Figure 6), the process of semiosis comes about in the following way: 1) one person that walks in the street perceives light from their sense of sight (quality); this sense provides a willingness to encounter and interact with something. 2) Then, the subject's experience determines that the object is a traffic light (fact). In this second phase of the semiosis process, the individual decides by comparison or experience what type of light it is, such as green or yellow. 3) An instant later, the exact interpretation mechanism begins to work: the red light on the traffic light means that I stop not to hurt myself. Eco (1997, pp. 90) writes that memory and culture intervene in interpreting sensory information. Both factors act to achieve an understanding of the nature of the object. According to Manual of Traffic Control Devices in Urban and Suburban Areas - MDCTAUS, the red light of a traffic light is an imperative indicating: Stop! Go no further! (Secretaría de Comunicaciones y Transportes, 2001).

I   light

II   **red** light

III   **red** light of the traffic light ⟷ full stop

Figure 6.
Peirce's theory and process of semiosis.
Source: Own elaboration.

Habit and Belief as a Way of Relating to the Traffic Code

In Mexico, as in many other countries like India, China, and Brazil, there is a lack of traffic education (Figure 7). The way many people learn to interact in the streets is from other people's experiences. Peirce (2012b) tells us that Roger Bacon saw that something could be transmitted through experience. An example of this is the first instructions given to children by older people. Some of these include the following: when you see the green light, that means you can cross the street, it is best to cross at the corner, walk on the sidewalk, etc. This is the way a belief is formed. According to Peirce, it is the state of human behavior that tells us how
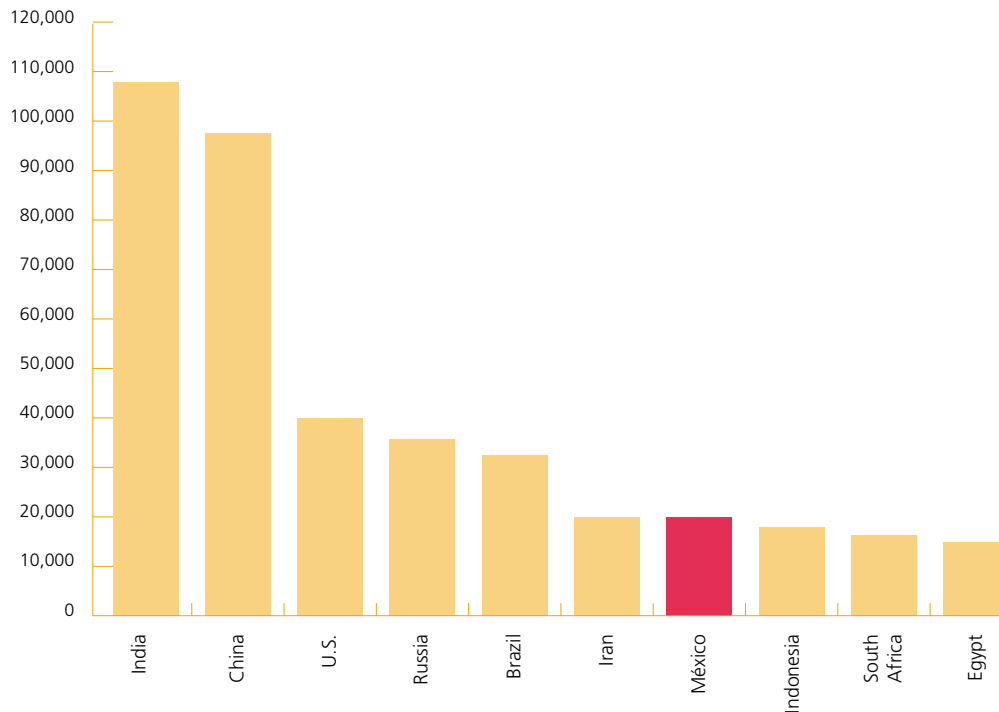
Figure 7.
Countries in the world with the highest absolute number of fatalities due to traffic accidents (Information as of 2007). Source: Own elaboration with informatio from OMS (2009).

to act in certain circumstances, and at the same time, it implies that a habit has been established in the person. About this, Peirce (2012b, pp. 177) tells us that "the habit implies the establishment of our nature as a rule of action."

How a habit can form in each of the traffic actors is, first, from a doubt. Doubts make us proceed to eliminate this state of uncertainty and achieve a state of belief. For example, an individual with no experience in mobility stops at a vital intersection and doubts whether to cross the street. Because of this doubt, the pedestrian asks himself several questions. Where and at what moment should I cross the street? Maybe they notice that people cross the street when cars stop in front of the red light and that when the light turns green, the cars move, and that is an unsafe time to cross the road. Then, after seeing norms and rules acquired day after day, a belief is generated in the person about how to cross the street. Instead of just belief, this turns into a habit.

This research aims to recognize how this code functions in terms of mobility, which means knowing the true meaning of traffic signage. This includes the color code of the traffic lights, or the figure and colors painted on the pavement,

etc. These factual inferences of traffic signs are what Peirce (2012b) calls the primary directive of inference. This means that all red traffic lights mean stop and all green mean go.

Graphic/Semiotic Interpretation of the Traffic Light

Not only is it enough to have signs that act as signals in the thirdness stage on streets, but it is also necessary that these signals form a system of meaning, a syntactic unit with other signals so that semiosis can begin and allow the interpreter to move safely. In order to complete an analysis of this, we will turn to Peirce's (2012d, pp. 649, note22) definition of the signal, which states: "A sign is something that is in place of something else for someone who is in a specific situation or circumstance." Sticking to this definition of sign, we will use the model from Table 1 to complete a study of traffic signs *in situ* (Osnaya, 2015).

Table 1.
Study of traffic signs *in situ*.

A signal is something that is in place of something else for someone who is in a specific situation or circumstance (Peirce, 2012d).		
1	Something	The signal
2	That is in place of something else	The object in the urban space
3	For someone	Pedestrians, drivers, cyclists
4	Who is in a specific situation	Normativity for the application and use of the devices. MDCTAUS regulates this
5	Or circumstance	Context: determined by the conditions in the urban space

**Source:** Own elaboration with information from Osnaya (2015).

The fourth row points out the relationship between the sign and the object in terms of thirdness or law, according to the previous table. In Mexico, most of the signs that we observe on the street are regulated by the government of the State of Mexico through MDCTAUS. This instrument was first published in the Gaceta Oficial del Distrito Federal –the Official Government Journal for publishing new law or policy (Gobierno del Distrito Federal, 2001), and legally makes this public policy. All the sixteen mayorships must adopt this signage and regulations. This study does not focus on the direct correlation between signs and objects. In general terms, that has more to do with designing the signs about its object, which is already normed and established globally.

The third point implies to the receiver of traffic signs that we can identify pedestrians, drivers, cyclists, etc. The manual also clearly defines the use of signs for each one. The points that have the most important relationship with our research are number four and five because they have to do with the application and use of traffic control devices, where streets intersect, and where it is crucial to have an established information code to travel safely. At this point in the present study, it is pertinent to emphasize that the code used in a road junction is not only determined by the traffic light system since other devices work together syntagmatically to create meaning. Victorino Zecchetto (2010, pp. 119) tells us that "signals do not have meaning unless related to others." We will now look at how the light traffic system works when two streets meet, and they are two-way streets.

First, it is necessary to understand that El Reglamento de dispositivos viales para el control de tránsito en zonas urbanas y suburbanas del Distrito Federal (the regulations for devices controlling traffic in urban and suburban areas) is a code (made up of signals, images, lights, etc.). We call it a code because it exists within a convention, a social agreement, and a mechanism for obeying rules (Eco, 1990). This idea is related to the concept Saussure (2012) has of language. He understands language as a social construct generated through convention and adopted by a community. It is possible to understand the code as an organized and hierarchical

system with norms and rules which guarantee the arbitrary union of two planes: expression and content. According to Umberto Eco (2006), a code acts as a binary choice, in other words, the choice between yes and no. A crossing system that works as a go or stop. The reason for this is to make sure the information is transmitted in the simplest of ways and avoid errors. Let us look at the *Sistema de Operación de los Semáforos* or SOS –by its acronym in Spanish– (Traffic Light Operating System) at a crossing with two intersections.

Figure 8 is the graphic representation of a road crossing; the right side represents one of the roads and the left side the other, in this specific case, when on the right side, the red light is linked to the traffic light of the car (sa1), pedestrians (sp1) can cross the street, the opposite happens with the other road it is possible to identify that the operation of traffic lights relies mainly on the possibility of red and green, which stop or allow for the flow of pedestrian or automobile traffic.

	Automobile signal	Pedestrian signal	Green light	Yellow light	Red light
Symbology	sa	sp	v	a	r
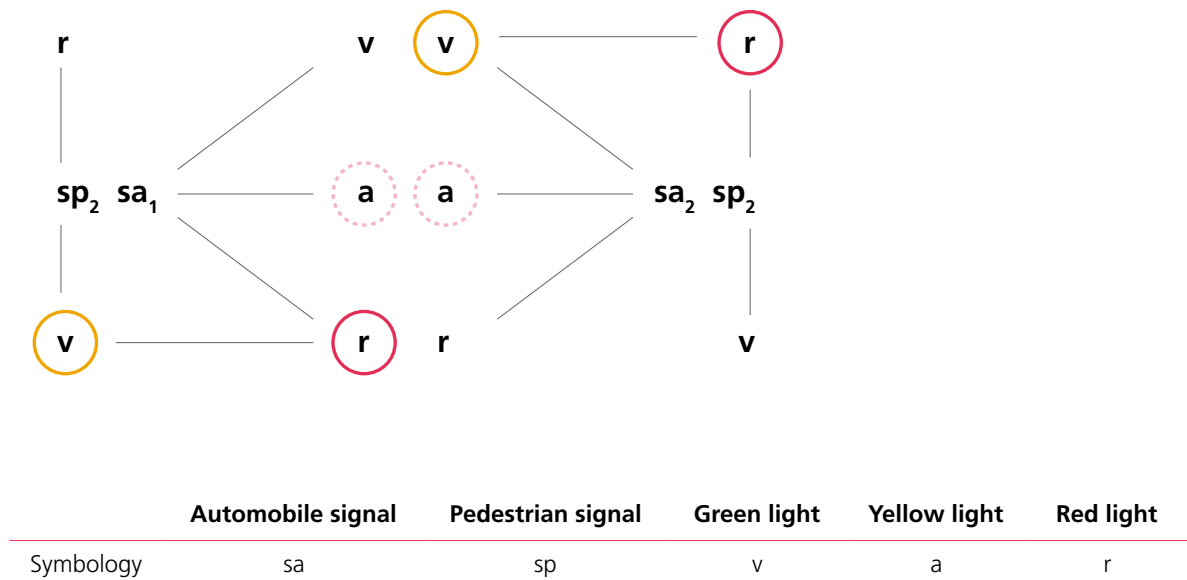
Figure 8.
Traffic Light Operating System in a two intersection road junction.
Source: Own elaboration.

Yellow
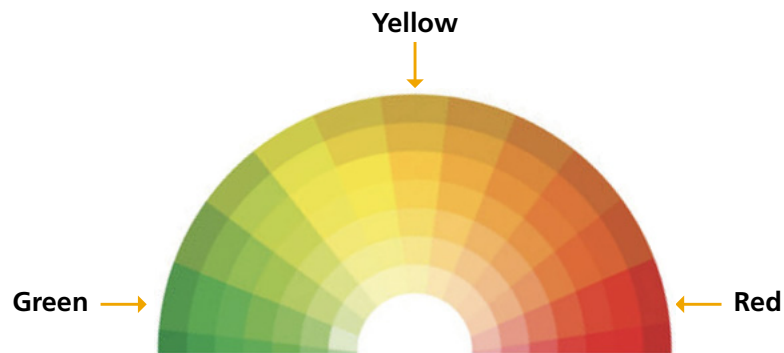
Green →   ← **Red**

Figure 9.
Color wheel theory.
Source: Own elaboration.

Nevertheless, even if the operability of the traffic light is mainly expressed by green and red, the color change cannot happen immediately. There is a period for conversion, indicated by the amber light. This light is a middle-way point in the color wheel, between green and red (Figure 9). The signal shows a lighter tone of color so that the perception will be that the change is gradual. This signal warns the change interpreter, aiming to keep the receiver alert and in a state of caution.

Continuing with our interpretation of code, it is also possible to observe that the syntagmatic possibility is binomial; in other words, it is only possible to understand two types of syntax. The following example is of a crossing with two trajectories (Figure 10).
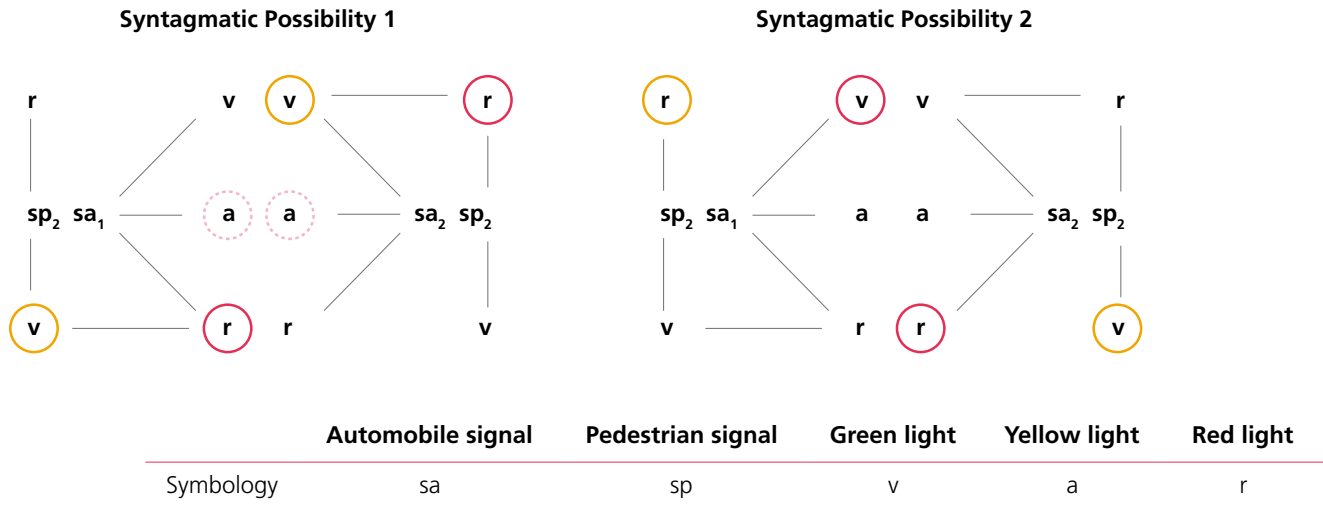
Syntagmatic Possibility 1   **Syntagmatic Possibility 2**

	Automobile signal	Pedestrian signal	Green light	Yellow light	Red light
Symbology	sa	sp	v	a	r

Figure 10.
Example of a cross with two trajectories.
Source: Own elaboration.

According to Eco (2006), we can also find a semantic function in the syntax to recognize syntactic rules. The organization and meaning of the elements in the system are related to their value. The value of each component is due to the differences and opposites of each of the traffic devices. In the case of intersection lights, the value of each of the lights comes from the color difference. This allows for a system of relationships that provides the harmonious flow of each street. The value is understood in terms used by Saussure (2012, pp. 214), the property that a signal has to represent another idea when finding syntactic relationships with other signs. Also, this value will always be made up of mismatches and similarities; for example, in the case of the traffic light system, the opposite of reading (stop) is green (go). A color difference determines the value, and because each tone (this similar quality makes them part of the same code) gives it a particular meaning, and because of the relationship between both signals, it is possible to discuss the semantics and the syntax of the traffic code. To illustrate this, Figure 11 represents one of the two syntactic possibilities of a traffic crossing (Figure 11).
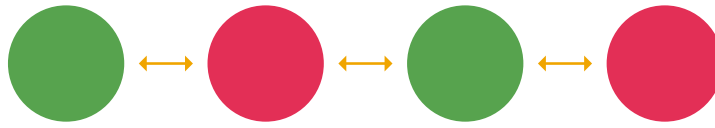
Syntax: GREEN + RED + GREEN + RED

Semantics: Pass with green light, stop with red light, advance with green light, do not advance with red light

Figure 11.
One of the two syntatic possibilities
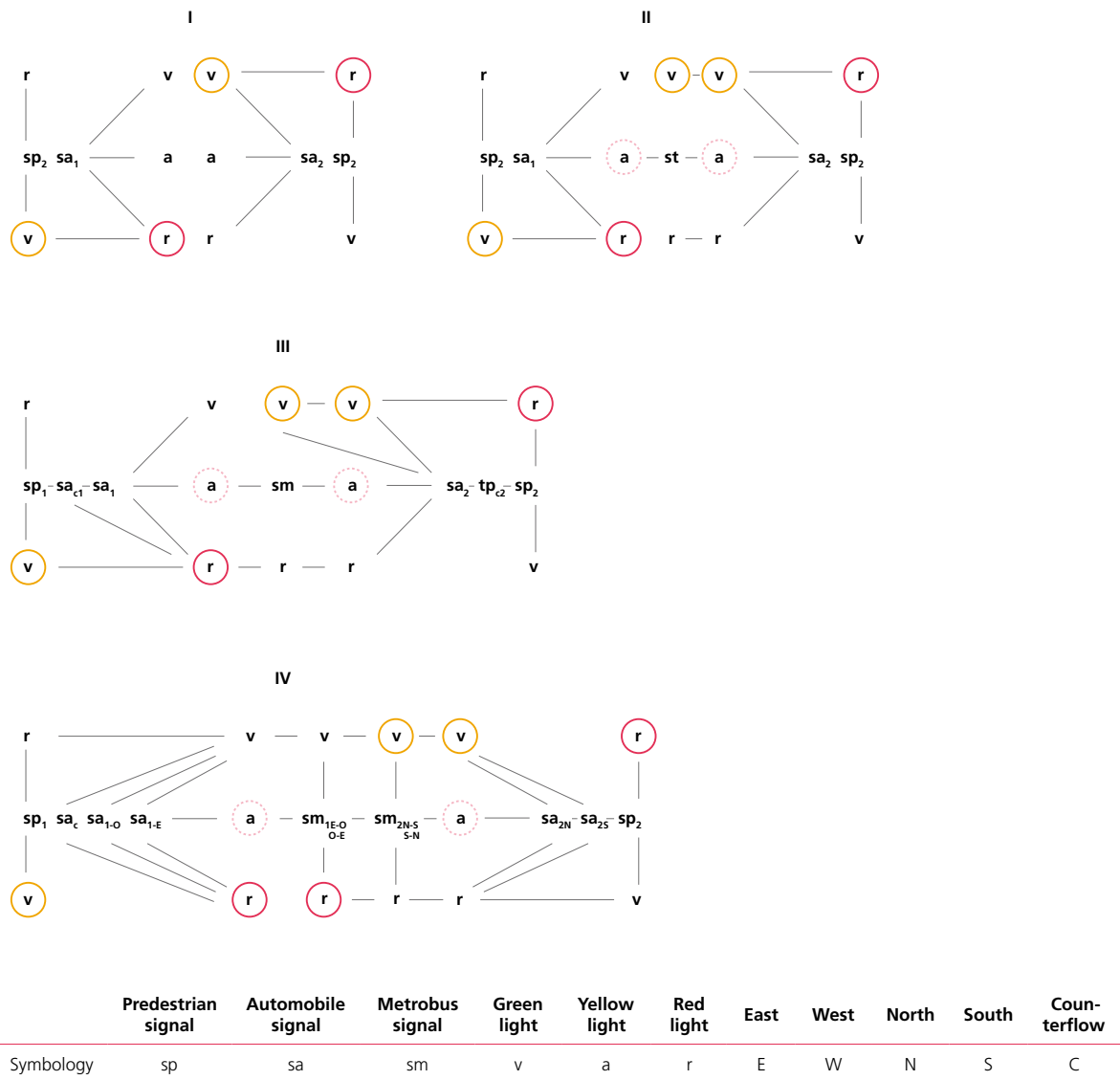of a traffic crossing.
Source: Own elaboration.

Final Comments

As time passes by, urban areas are subject to changes and modifications. This is due to the economic, cultural, political, and social transformations within the city. The demographic concentration and its natural growth produce reforms to the structure of the urban area through the creation of housing, public plazas, shopping centers, educational structures, and areas for recreation and work, etc. At the same time, streets also must be modified because of new needs in transport and mobility. Saussure (2012) writes that language is diachronic as time goes on. In an analog way, it is possible to observe how vehicle trajectories transform historically. It is necessary to think about two possible complications that then must be solved. The first has to do with the complexity of the traffic code because one street can include new methods of travel (Metrobus and bicycles).

In the last few years, Mexico City has opted for new mobility methods to reduce the use of the automobile. This includes the Metrobus and bicycles. Bicycle lanes have been installed within the main streets of the city. We must think of applying new devices to help street comprehension and use by drivers, pedestrians, cyclists, etc.

This situation is how much we can incorporate special lanes or roads for modes of transportation that are not cars. The number of signals will increase. This generates a situation where the user must decode more signals to cross a street, causing anxiety and confusion. In the following image, we can see the analysis of the chosen intersections and the rising scale of complexity in the traffic code. We can

see how the different mobility options raise the complexity of the code, and a crossing is more difficult because of the number of signals one must interpret (Figure 12). Diagrams (I, II, III, IV) show a growth in the syntagmatic relationships between these dynamic signals (traffic lights) at each pedestrian crossing.

	Predestrian signal	Automobile signal	Metrobus signal	Green light	Yellow light	Red light	East	West	North	South	Counterflow
Symbology	sp	sa	sm	v	a	r	E	W	N	S	C

Figure 12.
Operation of the vehicular and pedestrian flows of four pedestrian crossings in Mexico City. I) Dr. Río de la Loza and Eje Lázaro Cárdenas. II) Eje Lázaro Cárdenas and Dr. Río de la Loza. III) North Axis 1 and North Axis 2. IV) Av. Hidalgo and Av. Paseo de la Reforma.
Source: Own elaboration.

In figure 12 (diagram I), we observe a crossing that can only permit the flow of motor vehicles and people. The graphic interpretation is simple compared to the other examples. In the case of II, we can see how the code gets more complex because, unlike situation I, this one has a lane designated for the trolleybus system. The existence of three types of mobility implies an increase in traffic control devices. We can verify this if we compare each of the diagrams in figure 12. Of the four examples, the one that becomes most complex is IV because it involves the highest number of options for travel. The intersection can handle motor vehicles, pedestrians, Metrobus (the North-South-North direction), and buses opposite. This multiplicity of mobile actors implies the use of many traffic devices. The users must interpret more signals than if the reading is to carry out the same action, cross the street. As already mentioned, these trajectories' modifications obey the road infrastructure's diachronic changes as new needs and city demands arise. This also brings about an irrational use of space, causing mobility conflicts, safety issues, and risks for the users.

Finally, the contribution of this article is to offer a different approach to the study of road signs that benefit road users. Analogously, it is like when a house or building is planned; the first architectural plans are made symbolically; this is how the mobility of cars and people on a cruise ship could be planned in a first sense through diagrams that allow projecting safe mobilities. The road infrastructure is the responsibility of urban planners, architects, and engineers; however, in this work, there would be space for a specialist in visual communication who can look at and contribute to the installation of road safety devices from the field of semiotics and studies visuals.

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