

VISUAL ILLUSION OF THE CHANGE OF THE SIZE OF ARCHITECTURAL AND URBAN OBJECTS OBSERVED UPON A CHANGE OF THE OBSERVER'S DISTANCE: PARAMETERS THAT INFLUENCE IT PHENOMENOLOGICALLY

Đorđe Đorđević¹, University of Belgrade, Faculty of Architecture, Belgrade, Serbia
Gordana Vujić, University of Belgrade, Faculty of Architecture, Belgrade, Serbia

This paper explores the visual phenomena of a seeming change of the target-object's size (as a focus of concrete visual perception) in the function of an observer's motion so that it "seems" contrary to the law of linear perspective (in the sense of an expected increase of the target volume/monumentality – by getting closer or a decrease – by getting farther away).

This phenomenon is described in a geometrical and perceptual aspect; the result of this comprehensive approach led to identify parameters that determine it phenomenologically. It was established that the explored visual phenomenon is a specific "size illusion", i.e. an "angular size illusion" that occurs when influenced by factors of the perceptual kind – activated by a specific dynamic relationship (on a visual plan) between the target object and its surrounding competitive objects, as an observer moves. By understanding the character of this phenomenon (both in a geometrical and perceptual sense), it is possible to apply the acquired knowledge in practice – in programming the visual effects to be obtained (such as to visually optimize or minimize the monumentality of targeted objects) in all architectural and urban fields (planning, designing and reconstruction).

Key words: *perspective, visual-direction perception, size-distance illusion, angular size illusion, new Size-Distance Invariance Hypothesis (SDIH)*

INTRODUCTION

Objective

The complex structure of constructed setting (urban and contemporary rural), requires planning, designing, analysis and evaluation in term of numerous architectural and urban aspects (such as engineering, functional, socio-psychological, ecological, economic, aesthetic, etc). Each determines specific terms of its own phenomenology. In that sense, the need to simultaneously meet all possible

requirements points out the undeniable importance to appropriately model space on various levels, highlighting the role of geometrical and complementary visual perception parameters, especially those referring to morphological space characteristics, particularly in the function of visibility and recognizability (Đokić, 2003, 2007).

Recognizability also refers to the existence of dominants and accents in architectural and urban spaces/scenes. In this matter, it is important to note that they are not a sole product of relevant dimensioning, materialization and/or colorist processing of individual constituent elements (or compositions) that need to be visually highlighted, but also a product of an appropriate

geometrical organization of physical structure of immediate/farther setting – required to realize a complex visual interaction with the observer, based on visual illusions. Consequently, with an appropriate design of the morphological structure of the urban matrix and taking into account the motion parameter (motion/time), it is possible to program visual phenomena/illusions that some matrix constituents will make even more monumental (or purposefully degraded) – by meeting preconditions that enable the impression of their volume increase (i.e. of decrease), by increasing (i.e. decreasing) the distance of the observer (Zdravković-Jovanović et al., 1995) which, as regards phenomenology, is contrary to the laws on linear perspective (Zdravković-Jovanović, 1995).

¹ Bul. kralja Aleksandra 73/II, 11 000 Beograd, Serbia
konekt@EUnet.rs

Relevance

In view of the importance of the application of visual illusion in architectural and urban planning, design and reconstruction, this paper represents an attempt at scientifically identifying the determinants of the phenomenology, which, according to the author, are essential for its utility and simple applicability in contemporary architectural practice.

Because visual illusion has not been studied in architecture and urbanism in this manner, this paper represents a specific scientific contribution to the research of its vital determinants.

PREVIOUS RESEARCH

The aim of the phenomena of visual illusion is to divert the system of visual perception with respect to a correct reading of its actual characteristics (foremost size/volume, but also the shape, color and location/distance) of perceived entities (disposed in plane and space), which makes them particularly attractive for many studies in optics, neurophysiology and psychology.

Given that these visual illusions are based on a visual perception whose outcome is characterized by a paradoxical perceptible evaluation of these features (which is why they are called size illusions²), most attempts at defining them were, essentially, based on the implementation of the so-called "Apparent Distance Theory", i.e. of the "classic" SDIH hypothesis (Size-Distance Invariance Hypothesis - Kilpatrick and Ittelson, 1953). In terms of phenomenology, the hypothesis refers to issues of visual perception in the studied field. However, the results of the research that used these postulates were not scientifically satisfying, because for a specific percept's constant linear size "S" and its fixed distance "D" from an observer, the actual/physical visual angle "V(S)" of this size (which in fact identifies a functional relationship between sizes "S" and "D" in the form of: $\text{tg}V(S) = S/D$) is not an invariant (supported by the SDIH hypothesis!).

² Typical representatives of this type of visual illusions are: Moon illusion, Oculomotor micropsia/macropsia, Ebbinghaus illusion, Herring illusion, Ponzo illusion, Müller-Lyer illusion, Spiral after/effect, Orbison illusion, Jastrow illusion, Wundt illusion, Meyer wallpaper illusion and Curvature of the apparent fronto-parallel plane (AAPP) (remark by the author).

Since the perception of these "linear/distance sizes", except for monocular and binocular facts, is influenced by numerous contextual surrounding signals (such as distance/depth cues) that determine the perception of these visual angles (Rock and McDermott, 1964; Angular Size-Contrast Theory - Restle, 1970), a more comprehensive explanation of this interdependence was given by: Baird et al. (1990), McCready (1963, 1965, 1983, 1985, 1986, 1994) and Ross and Plug (2002) – with an altered ("perceptual") view that is the origin of the so-called "new" SDIH hypothesis ("New" Perceptual Size-Distance Invariance Hypothesis: McCready, 1963, 1965, 1983, 1985, 1986, 1994; Ross and Plug, 2002).

The new approach is that the target's visual angle is its perceived visual angle "V'"³ (Baird, 1970), i.e. that space perception implies a simultaneous perception of visual angles "V'" and perception of linear sizes "S" and "D" (perceived linear sizes) (Joynson, 1949; Komoda and Ono, 1974; Gogel and Eby, 1997; Higashiyama and Shimono, 1994; McCready, 1985, 1994), under the influence of distance/depth cues as imminent factors that (dictating changes in dimensions "L" of the percept's retinal image) cause changes in the size of the actual/physical visual angle "V" (in the sense of a certain correction ($V' = V \pm \Delta^\circ$)) and henceforth, in the size of the "read" size "S" (neurophysiologic explanation: Murray et al., 2006).

Given that the "size illusion" phenomenon is the result of a diversion of the visual perception system by contextual information of spatial and visual character, its presence (in terms of phenomenology) refers to issues pertaining to a certain dimension correction (increase/decrease) "L" of the retinal image of the percept's linear sizes "S" i.e. of the perceived visual angles "V'(S)", which confirms here too the importance of angle "V'" (and not the importance of the actual/physical visual angle "V").⁴

³The target's perception of visual angles "V'" implies perception of angles defined by pairs of eye-rays corresponding to ends of perceived linear sizes ("direction perception," "egocentric distance-signal perception" – Foley, 1980).

⁴According to the aforementioned, "Size illusions" are, in fact, "Visual angle illusions"/"Angular size illusions" (Baird, 1970; Komoda and Ono, 1974; Roscoe, 1984; Gogel and Eby, 1997; Higashiyama, 1992 Higashiyama and Shimono, 1994; McCready, 1985, 1986, 1994; Murray et al., 2006).

On the other hand, the study of "visual size illusions" in architecture and urbanism, in the form of a visual phenomenon related to the impression of an increase of the perceived architectural and urban object that occurs as the observer moves farther away, was conducted on the example of St. Mark's Church in Belgrade, Serbia (Zdravković-Jovanović et al., 1995).

That paper underlined that "one of the most striking phenomena related to the perception of architectural and urban compositions, is the illusion of an increase of the dominant's dimension with regard to the marker, with the increase of the observer's distance from which he perceives them". Here the term "dominant" implies "the perceived object" and the term "marker" all surrounding elements whose dimensions were "memorized" from "previous visual experiences".

However, in line with the chosen approach, this paper interprets this visual phenomenon only from the aspect of descriptive geometry: laws on perspective space perception were used to explain this phenomenon. They are graphically interpreted by constructive procedures intended at presenting 3D space in the central projection (in that sense, the phenomenon itself was considered on an abstract model whose marker was one of the vertical edges of the object (the closest to the observed dominant), while a vertical plane placed parallel to the dominant's main front façade was used for the drawing plane. Consequently, this "engineering approach," on the one hand, did not make it possible to entirely perceive the analyzed phenomenon (from the psychological/perceptual point of view) that is otherwise necessary to adopt comprehensive conclusions. On the other hand, the phenomenon description based solely on the used model (without any reference to the actual situation in a non-abstract setting), left open the issue of a broad applicability of the adopted conclusions in professional practice (and in morphologically different contexts).

That is why the authors of this paper wished to conduct a more comprehensive research of the essential aspects of this visual illusion: especially of the facts that determine its origin and the parameters that describe the principal phenomenology (bearing in mind the influence of the ever-present contextual surrounding signals as the fundamental determinants of perceptual kind).



*Figure 1:
Focus of interest (St. Sava's Temple in Belgrade, Serbia)
with surrounding objects as main segments
of "its" marker volume*



*Figure 2:
Focus of interest (St. Mark's Church in Belgrade, Serbia)
with the surrounding vegetation and objects
as elements of "its" marker volume*



*Figure 3:
Focus of interest
with the surrounding vegetation as the only element
of "its" marker volume*

STARTING CONSIDERATIONS

Definition of terms

In line with the concept of this paper, the main categories and subjects of this research are formulated as follows:

(1) focus of interest "F" (hereinafter "focus") is an architectural and urban object (or its part) that represents the observer's primary subject of interest. It is located in the central zone of the visual field (field of sharp vision); it consists of: (i) focus volume: the composition of all visible focus mass, (ii) the focus contour line (marked with "k(F)" on graphic illustrations: the contour of the perceptible (visible) focus volume in the function of a specific observer's position and (iii) the composition-related focus elements (secondary mass and elements of the façade decoration), and

(2) visual marker "R" (hereafter "marker") is a variable category in the function of the observer's motion, called so because it is assumed here that in a competitive relation with respect to the focus of interest (in the visual sense), it makes the analyzed phenomenon possible; the marker consists of: (i) the marker volume: part of a closer or farther architectural/urban setting of the focus that is partially or completely an integral part of the acquired visual field and (ii) the marker line: the contour of the perceived marker volume (marked with "k(R)" on graphic illustrations) that, in a visual sense, partially or completely "frames" the focus of interest.

Typology of the marker volumes

With respect to this wording, the marker volume consists of one or more architectural and urban

elements or their parts: (i) objects that are visually competitive with respect to the focus of interest (figure 1), (ii) vegetation visually competitive with respect to the focus of interest (figure 2) and (iii) combined - "competitive" objects and vegetation (figure 3).

Geometry of the marker volume

Depending on the geometry of elements constituting the marker volume, the marker line consists of parts of straight lines and/or curves - 2D lines and/or 3D lines, that represent the contours of these elements (in the function of the actual observers' position) and it is visible as a seemingly continuous line - in the form of "outlines" of the marker volume (figures 4 and 5).

A realistic 3D setting is characterized by a large amount of spatial and visual information - located in different space depth planes (at different distances from the observer). The informative quality of such spaces imminently leads to changes of the subject of interest - from closer to information located farther away from the observer (with smaller or larger reorientation of the perception direction - with

or without head or eyelense motion), under the influence of visual, selective and controlled attention mechanisms. (Milošević, 2002). Since this information contains descriptors that generate constituent elements of this setting and its compositions (architectural objects, elements of urban equipment, including vegetation, etc.), as the observer moves through this setting, the imminent feature of the visual perception is an uninterrupted change of the visual field (i.e. perceived space facts), the result of which are structural changes in the perceived marker volume and consequently its marker line (some of its elements gradually disappear from the visual field leaving place for new ones) (figure 6 / (a), (b) and (c)).

Defining the starting hypothesis

Given that, as underlined at the beginning of this paper, this visual phenomenon - in this context and the way suggested here, was not studied, it was necessary for the following starting hypothesis to be defined.

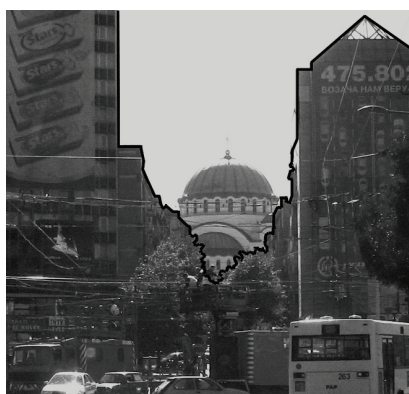


Figure 4: Focus of interest and a seemingly continuous marker line of "its" marker volume perceived from a given eye point as a series of straight lines and curves



Figure 5: Focus of interest and the seemingly continuous marker line of "its" marker volume perceived from a given eye point as a series of curves



Figure 6: Gradual change of the marker volume (and the marker line in the form of its contour) as a result of continuous motion: (a) the observer is the closest to the focus of interest; (b) and (c) the following positions of the observer, defined as he moves farther away from the focus of interest

The visual phenomenon referring to a seeming change of the focus volume in the function of the observer's motion in a manner that "appears" to be contrary to the law of linear perspective (in the sense of an expected volume/monumentality increase – by getting closer i.e. its decrease – by getting farther away), is the result of a dynamic relation (in the visual sense) existing between that focus and surrounding objects visually competitive with respect to it. For this dynamic relation to exist, the focus and the marker cannot belong to the same depth-plane.

Defining the conditions required to analyze this visual phenomenon

Since the studied visual occurrence is a phenomenon that belongs to the field of visual perception, it will occur provided the observer consistently completes the process of visual illusion of a specific context. This implies the perception of the focus and its setting (henceforth, the marker), in a manner that will meet the following requirements:

(1) as the subject of the analyzed visual occurrence (henceforth, the perception) is the focus of a specific interest, the route along which the observer moves has to maintain: (i) a "good" visibility, by preserving entirely the visibility of the focus (or at least a major part of its volume) from all potential positions on the route, (ii) a "clear" visibility, able to hold the percept without interruption in the central zone of the visual field (field of sharp vision), from all potential positions on the route and (iii) a continuous visibility, exclusively, in order to secure continuity of the flow of visual experience. Consequently, geometrically speaking, the route has to be continuous and as approximate as possible to a straight line (of any space direction); the visual experience will "last" provided the route is as long

as possible (to the limit to which the perception is possible in accordance with the criteria described); and

(2) bearing in mind the hypothesis that the analyzed phenomenon is the result of a dynamic relation existing between the focus and its competitive setting (in a visual sense), as well as the fact that the marker/marker volume is a part of such setting, it is necessary for the marker also to be present in the visual field i.e. visible from all potential positions on the route – so as to meet the afore mentioned requirements⁵.

Defining the geometry of the used model of the setting

To explain the essence of this phenomenon in a concise but comprehensive way and for the purpose of this study a simplified model of the 3D setting with the following geometrical features was defined:

(1) the marker "R" is represented with two mutually spaced out identical vertical rectangles located on the same plane, with the upper edges horizontal and at the same height; the marker is constant (it does not change with the change of the observer's position),

(2) the route from which the observer perceives the marker and the focus is a straight line and belongs to the vertical plane of symmetry of the related marker composition; the route is horizontal and located on the plane where the lower (horizontal) edges of the rectangle are situated, and

(3) the focus "F" is the hexadron that is visible along the entire route – through the space

⁵ Since the marker is not an immediate subject of the observer's interest (but the focus), the "peripheral vision" can be responsible for it (Author's note).

existing between the marker rectangles (positioned in the "back" depth-plane); it is positioned so as to lie on a horizontal route plane, so that one of the pairs of its opposite vertical sides is parallel to the plane of the marker rectangles and the plane of their symmetry is identical to the said marker structure symmetry plane.

Therefore, it is necessary to note that: (i) the adoption of a "constant" marker (invariable in the function of the observer's motion) and presented in a simplified manner as described, and (ii) the choice of a straight line route of horizontal direction, are the consequence of the fact that this paper represents an initial study, aimed at identifying the core of this phenomenon (in terms of phenomenology), which can be done by using a model of elementary composition-related structures (geometrically speaking) – with a minimum number of variable parameters. In addition, the positioning of the marker between the observer and the focus (in a depth-plane "closer" to the observer), is the result of a desire to define a model of the setting that is conceptually/structurally in accordance with the realistic ones represented on given figures (including all others in which the foci of interest are monumental architectural buildings that commonly represent urban dominants).

Furthermore, it is necessary to bear in mind that none of these limitations question the validity of this model, because it offers an adequate presentation of realistic spaces with similar morphological features (in the relevant field), and takes into account that the process of structuring respected all "general requirements" introduced in previous sections, which were, in fact, the main descriptors of exactly these spaces.

Given that in morphologically more complex realistic spaces there are routes of a more complex geometry, where the dynamic perception of the setting (in motion), is most often characterized by the presence of "variable" markers (that may be located even farther from the focus), the research of this phenomenon in the function of these (more complex) facts, will be the subject of future research, based on the results of this paper.

PROVING THE HYPOTHESIS

The visual phenomenon as an actual phenomenon: physical facts

It is empirically proved (in a realistic setting) that the change in the relation between the "upper" marker line and the "upper" contour line of the focus is clearly visible from greater distances. To research a seeming change of the focus volume with respect to the marker volume, according to the SDIH hypothesis, actual/physical visual angles "V" (in degrees) were used, under which the observer perceives the lines, moving along the route. Naturally, it is evident that as concerns smaller distances between the existing marker/focus and the observer, the visual change of depth-planes to which they belong (in the function of the station point change) is recognizable at every perceivable motion-parallax change between the marker line and any other sufficiently visible composition-related focus element (element of secondary or third façade decoration). The seeming change of the focus volume "F" with regard to marker volume "R" will be considered in this paper by following the seeming change of the height of the upper focus line and upper marker contour line.

To research this phenomenon with a view to proving the hypothesis, a model of the setting with previously described/general geometrical

marker is chosen to be less than the height of the focus (which is common in architectural and urban scenes when the focus represents the space determinant of outstanding monumentality). The length of the observer's route depends on these sizes so that its dimensioning is a consequence of the level of the change of actual perceived visual angle values "V" of the marker, i.e. focus (given the fact that this change is less than 1° from positions 8-9-10 and further). On the other hand, the number of station points (and their mutual distance), is chosen in accordance with the perceived change rate in the sizes of the analyzed angles "V" (so it is significant for each two successive observer's positions).

Figure 7 shows the lateral view of the described model, with actual/physical visual angles "V" of the upper (horizontal) focus contour line "k(F)" (a) and the upper (horizontal) marker contour line "k(R)" (b), perceived for each of 11 observer's positions.

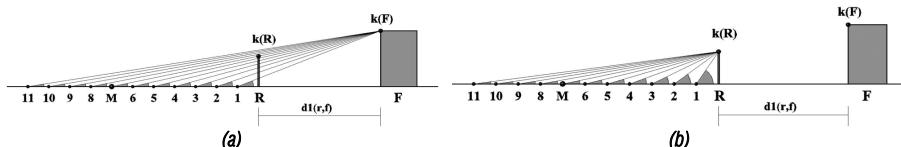


Figure 7: Lateral views of the chosen model of the surroundings with traced actual visual angles "V" of the upper (horizontal) focus contour line "F" (a) or marker "R" (b)

Table 1 features actual values (in degrees) of considered visual angles "V" of the upper (horizontal) marker and focus contour lines ("R" i.e. "F"), in the function of a specific observer's position.

Table 2 features the increase rate "Ψ" of actual values (in degrees) of visual angles "V" of the upper (horizontal) marker and focus contour lines for every two successive observer's positions : "i" and "i+1" (Ψ=Vi+1-Vi).

Figure 9 shows comparative charts that illustrate the change of the increase rate "Ψ(R)" or "Ψ(F)" of analyzed visual angles of the upper (horizontal) marker contour line (visual angles) (in degrees), responsible for every two successive observer's positions: "i+1" and "i" (Ψ=Vi+1-Vi).⁶

The following facts can be observed on the chart represented in figure 8.

The increase (decrease) of the values of actual visual angles "V" (in the function of the observer getting closer (getting farther away)), is present as well with the marker "R" and the focus "F", which shows that their perception is determined by a law of linear perspective (in the sense that closer objects seem larger). However, this occurrence of a major increase (decrease) of these values with the marker can be supported by the fact that the observer intensively experiences the perspective change (as a consequence of a perspective deformation) on the perceived elements that are closer to him (Zdravković-Jovanović, 1995).

On the other hand, in the observer's position "11", the actual visual angle of the focus "F" is somewhat larger than the visual angle of the marker "R", which implies that (from that station point) it is perceived as being somewhat higher than the marker. As the observer moves from position "11" to position "M", the actual visual angles of the marker and the focus are simultaneously increasing, but the increase of these angles is more significant with respect to the marker than to the focus

Table 1: Actual values (in degrees) of visual angles "V" of the upper (horizontal) marker and focus contour lines ("R" i.e. "F"), in the function of a specific observer's position.

| V (°) | Numbers of the observer's positions along the route | | | | | | | | | | |
|-------|---|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| | 11 | 10 | 9 | 8 | M | 6 | 5 | 4 | 3 | 2 | 1 |
| V(R) | 7.742 | 8.505 | 9.434 | 10.588 | 12.059 | 13.995 | 16.651 | 20.498 | 26.495 | 36.785 | 56.228 |
| V(F) | 9.248 | 9.882 | 10.470 | 11.209 | 12.059 | 13.045 | 14.203 | 15.582 | 17.248 | 19.299 | 21.875 |

Table 2: Increase rate "Ψ(R)" or "Ψ(F)" (in degrees) of actual visual angles V(R) or V(F), for every two successive observer's positions

| Ψ (°) | Segments of the observer's route between each two successive observer's positions | | | | | | | | | |
|---|---|-------|-------|-------|-------|-------|-------|-------|--------|--------|
| | 11/10 | 10/9 | 9/8 | 8/M | M/6 | 6/5 | 5/4 | 4/3 | 3/2 | 2/1 |
| Ψ(R)=V(R) _{i+1} -V(R) _i | 0.763 | 0.929 | 1.154 | 1.471 | 1.936 | 2.656 | 3.847 | 5.997 | 10.290 | 19.443 |
| Ψ(F)=V(F) _{i+1} -V(F) _i | 0.574 | 0.648 | 0.739 | 0.850 | 0.986 | 1.158 | 1.379 | 1.666 | 2.051 | 2.576 |

characteristics was used. As regards specific sizes of the model elements, the mutual distance between the focus and the marker is arbitrarily dimensioned, where the height of the

Figure 8 shows comparative charts that illustrate actual values of analyzed visual angles "V(R)" and "V(F)", in the function of each of 11 chosen observer's positions.

⁶ In order to obtain a better visibility of the charts, the values of angles "Ψ" have been enlarged two times (Author's note)

(figure 8). Consequently, from station point "M" the observer perceives a levelling of the actual visual angles of the marker and focus, which results in a seeming levelling of their heights. As the observer gets is getting closer to the focus (henceforth, to the marker), the described tendency of the increase of actual visual angles of the marker and focus continues, and the visual angle of the marker is

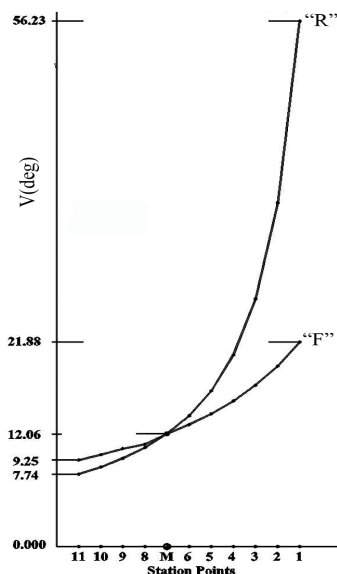


Figure 8: Actual values of visual angles "V(R)" and "V(F)" (°) in the function of the observer's position

significantly increasing compared to the visual angle of the focus. The consequence is the fact that, from position "M" to position "1", there is an impression of a major increase of the marker height with respect to the focus.

As these visual changes in the relationship between the height of the focus and its visually competitive marker are the consequence of a perception of corresponding mutually different visual angles (except in point "M"!)(figure 8), and mutually different rates of visual angle changes between each two station points (figure 9), these facts clearly express a specific dynamic relationship (in the visual sense) between the focus and the marker - revealed when the observer moves (gets closer or farther away).

The visual phenomenon as a visual "size illusion" i.e. "angular size illusion": perceptual facts

In view of the professional orientation of the author of this paper, which determined the approach to this research, the interpretation of the analyzed phenomenon as a visual "size illusion" or "angular size illusion" will be elementary – kept on the

level of commenting on the cues which qualify it as such. On that occasion, the arguments set forth will correlate with a "corrected" perceptual approach (based on the "new" SDIH hypothesis), because of its contribution to a comprehensive explanation of the phenomenology of controversial visual "size illusions" of 2D and 3D spaces (mentioned at the beginning).

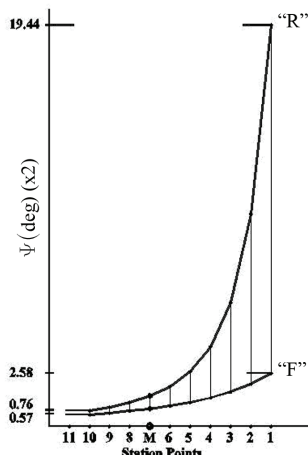


Figure 9: Concurrent illustration of the increase values "Psi(R)" and "Psi(F)" (°) for each two successive observer's positions

With regard to the fact that the perception of the setting elements equals the perception of their visual angles "V" (as corrected actual visual angles "V" under the influence of available (visible) distance/depth cues)⁷, which

⁷ On this aspect (as it belongs to the visual perception domain) the scaling of the perceived distances "D", except for the monocular and binocular facts, can also be influenced by: (i) their "equidistance assumptions" (McCready, 1965, 1985) or their "equidistance tendencies" (Gogel, 1965) or (ii) "familiar" distance sizes/equidistances (Bolles and Bailey, 1956; Ono, 1970; McCready, 1965, 1985), while the scaling of the perceived linear sizes "S", except for the monocular and binocular facts, can also be influenced by: (i) "familiar" linear sizes (but this time as an efficient cue to linear sizes "S" (Bolles and Bailey, 1956; Ono, 1970) or (ii) "assumed" or "suggested" linear sizes (Colheart, 1970; Hastorf, 1950).

Also, one has to take into account that important determinants of visual perception of the setting in the domain of visual illusions also are: (i) "equal linear size assumption" "S" of its constituent elements (McCready, 1965, 1985) – as the responsible relative angular size cue to distance on the basis of which the visual system assumes that it is about the same object ("identity constancy"- Piaget, 1954; "equidistance tendency" - Gogel, 1965; "perceptual constancy" - Epstein, 1973; Rock, 1977; Rock et al., 1978) and (ii)

implies multi-stage computing of these angles' sizes, following a comparative scaling of the perceived distances "D" and perceived sizes "S" (Visual Processing Model, McCready, 1965, 1985), the qualification of this phenomenon will be as follows.

Consequently, when the observer moves, the impression that the perceived linear sizes of the focus and the marker are changing in a manner that "seems" contrary to the law of linear perspective (in the sense of expected increase - by getting closer or decrease – by getting farther away), is the result of a simultaneous perception of their visual angles "V" – in a manner that implies correction of corresponding actual visual angles "V(F)" and "V(R)" (actually analyzed here), under the influence of available (visible) contextual signals. In that sense, the said correction may be the impact of one of the three facts mentioned in the footnote (as specific depth/distance cues): (i) the equidistance assumption/equal linear size assumption of the perceived objects, (ii) familiar size and (iii) oculomotor micropsia/macropsia.

Namely, before the observer sets in motion, according to his location/position in the setting and his specific interest, he perceives the visual angles "V" of its constituent elements (i.e. linear sizes "S") that attracted his attention (by scaling the perceived size-distance relationship "S"- "D" under the influence of available distance/depth cues). The final results of their visual angle-size-distance perception are not only sizes "S" and "D" scaled individually, but an impression of their spatial inter-relations (i.e. their "relative" mutual distances). Such perceived values become part of the visual experience. On that occasion, if the observer is already familiar with the setting, the influence of "familiar" sizes on his subsequent perception confirms the validity of the regained impression,

oculomotor micropsia (i.e. macropsia) as a phenomenon that may lead to actual changes of the perceived focus's angular sizes "V" (its decrease i.e. increase), because of eye accommodation and/or convergence with regard to objects located between the focus and observer (i.e. behind the focus); the conducted correction "diverts" the perception system in one of three ways - perceived linear sizes "S" may be seen: (i) as smaller ones (i.e. larger ones), (ii) as farther ones (i.e. closer ones) or (iii) as smaller and farther ones (ie. as larger and closer ones) (McCready, 1965; Ono, 1970; Ono et al., 1974; Komoda and Ono, 1974; Roscoe, 1989)

recognizing the previously acquired visual experience (Visual Processing Model, McCready, 1965, 1985).

After the observer sets in motion, he has a defined focus of interest (which, by the way, he may dynamically change – a circumstance contrary to this study!), while the objects from the setting that are visually competitive with respect to the focus (one or more), establish a visual marker (become part of the marker volume). If the observer, as he moves, does not change the focus of interest and the visually acquired marker (and if other requirements and limitations mentioned in this paper are met), the dynamic relationship between them (in the visual sense) has characteristics displayed in chart on figures 8 and 9. Accordingly, the visual presentation the observer has of the perceived setting while moving is illustrated in figure 10.

Comparing these figures (as simplified representations of successively generated visual fields), considering the actually present impression of increase of the marker and focus heights (as the natural consequence of the

perspective deformation in the function of getting closer), it is possible to see that as the observer gets closer to the focus, the visual relationship between marker and focus becomes more inconsistent (figures 9 and 10). The fact that the rate of the marker's seeming increase is much more significant than is the focus' (figures 9 and 10), makes the marker a more visible rival of the focus and, therefore, an important cue to its distance from the observer (and a paradoxical one!).

Namely, as the space perceived by the observer is realistic (architectural and urban) – the shape, size, color and position of its constituent elements are largely physical constants (which refers to the focus and marker as well), the visual system (despite initiated motion and present "dynamics" changes" – especially visible on objects closer to the observer) has a tendency to hold them as such (treating them as perceptive constants – "identity constancy", "perceptual constancy"). Accordingly, the focus and the marker (as integral parts of the perceived space) are also treated as perceptive invariants. Consequently, the marker becomes a specific depth cue

(because it "behaves as visually expected" – according to the laws of linear perspective). In case the observer cannot perceive other depth cues, the size of the marker remains the only available cue. In order to preserve the presentation of the perceptive constancy of all physically invariable objects in the visual field (and therefore make the perceived to be similar to the initially acquired visual experience), the marker size can cause a correction of the actually perceived distance of the focus with respect to the observer (in the direction of its increase). According to the "new" SDIH hypothesis, the correction of the perceived size of the actual distance of the focus with respect to the observer (which is causally connected with the size of the perceived visual angle "V"), causes a correction/decrease of the angle of the actual perception "V" and, therefore, a decrease in the perceived focus' size/height (while its linear size "S" remains constant).

As the observer gets closer to the focus, the disbalance between the rate of seeming marker increase and the rate of seeming focus increase becomes more significant (in favor of

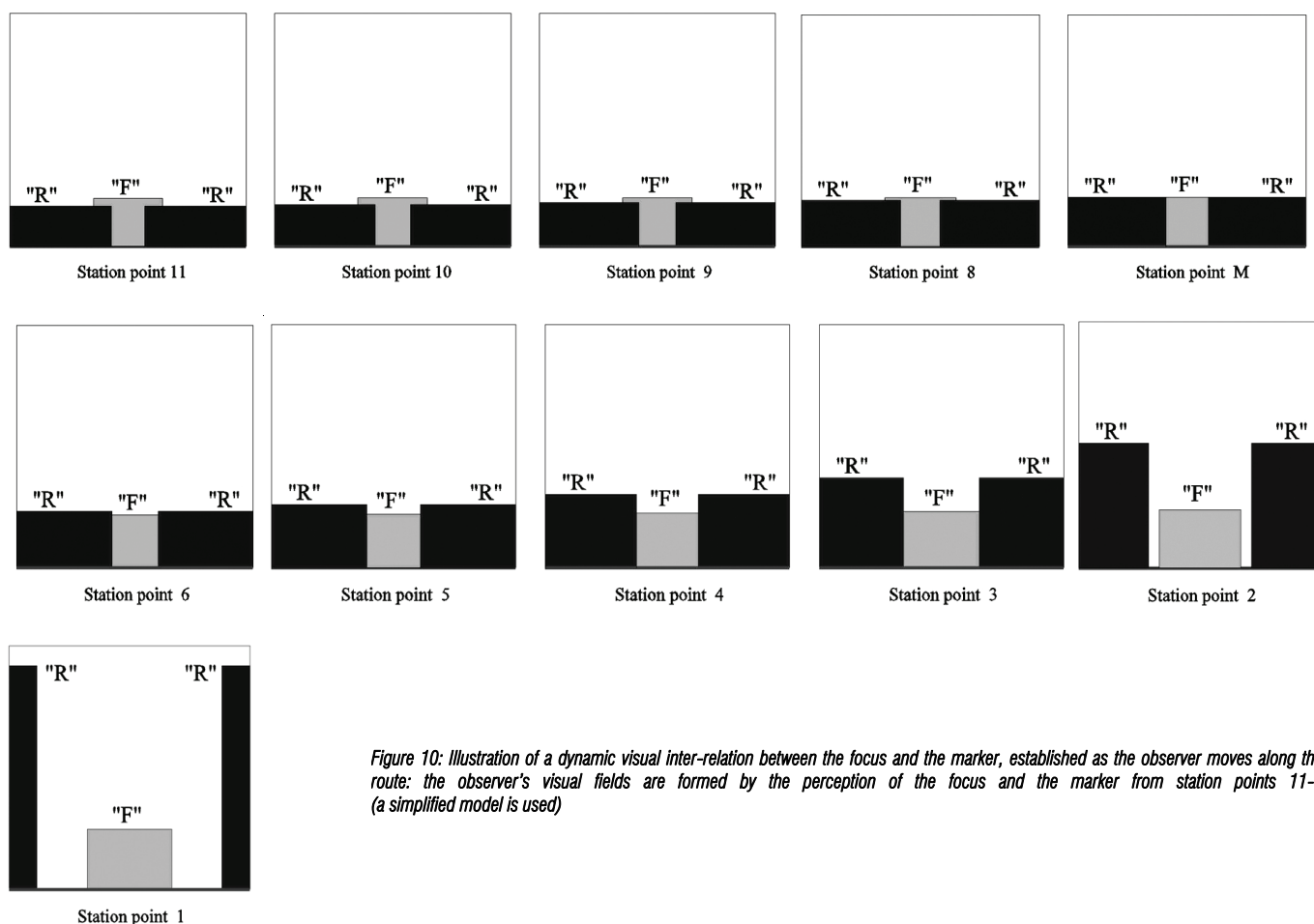


Figure 10: Illustration of a dynamic visual inter-relation between the focus and the marker, established as the observer moves along the route: the observer's visual fields are formed by the perception of the focus and the marker from station points 11-1 (a simplified model is used)

the marker as the "activated" cue of the focus distance from the observer), the above mentioned can be the reason why, from every following position (closer to the marker), the distance between the observer and the focus is scaled more and more (figures 9 and 10). The consequence is an impression that the focus volume/size/height is getting smaller and smaller (relatively – with regard to the marker). According to its role to correct actual focus visual angle sizes, it is possible to tell that, in this phenomenon, the marker represents a specific relative angular size cue to focus distance.

Given that (as underscored at the beginning) in the process of perception of an architectural and urban setting, a large number of objects constitute the marker, their unique marker volume represents a unique relative angular size cue to distance used to scale the distance between the focus and the observer. When the marker contour line seemingly "frames" the focus (not rare in realistic spaces), the observer has the impression that the focus is not decreasing relatively, but generally – as if this impression is determined by all objects within the surroundings that frame the focus partially or completely.

Consequently, the described mechanism of visual perception of the focus creates in observers a powerful impression that, as they get closer to the focus, the focus significantly "escapes" from them.

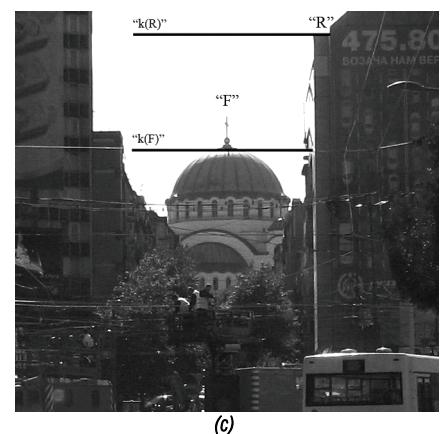
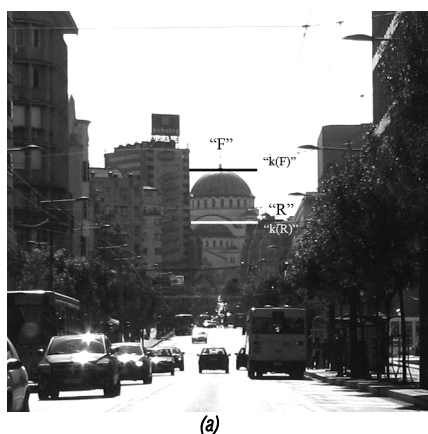


Figure 11: Seeming change of dimensional relation between the marker and focus occurs when the observer approaches the focus: (a) the observer is at the far end of the focus: the focus is seemingly perceived as "higher" than the "right" marker object (b) the focus "catches up with" the marker in height and (c) observer is the closest to the focus: the focus is seemingly perceived as "lower" than the "right" marker object (focus: St. Sava's Temple in Belgrade - Serbia)

The intensification of the impression that the focus "retreats" (i.e. decreases and/or both) as the observer gets closer, can be influenced by an oculomotor micropsia activated in parts of the route where the marker volume is in the

immediate proximity of the observer (with regard to which "adjustment" of the oculomotor system "to the proximity" will be done). If the described requirement is met, while the observer is getting closer to the focus, the visible seeming change of the marker volume/size/height intensifies – exponentially grows larger (figure 9) and the additional influence of the oculomotor micropsia on the focus perception (at every position) leads to a further decrease of its already corrected perceived visual angles – causing more significant "decrease" of focus volume/size/height (i.e. the impression that the focus is obviously "lagging" in "growth")⁸.

Given that all described perceptual factors cause a seemingly continuous decrease of the focus volume (i.e. its perceived visual angles "V") as the observer gets closer, they are all responsible for the creation of the illusion of the focus decrease in the process of closing in on it (despite the fact that, under these conditions, it is really perceived as being even larger). Because the described occurrence is contrary to the laws of linear perspective, this phenomenon represents a specific visual size illusion. However, as this occurrence actually influences the true perception of the analyzed perceived visual angles "V", it is, in fact, an angular size illusion.

It is obvious that the same effect (but of opposite visual impression), is possible as the observer moves farther from the focus (for example, the perception from the back platform

of a bus or by looking in the rear mirror of the car...). Then too the marker would be a relative angular size cue to focus distance but the occurrence of the oculomotor micropsia (according to its phenomenology), this time, would defy the significant increase of the focus volume as the observer moves farther away (in the sense of a certain decrease of the sizes of the perceived focus' visual angles).

Consequently, one can conclude that an intense dynamic relationship between the focus and the marker (in a visual sense) creates an impression that the focus volume changes in a manner that "seems" contrary to the law of linear perspective (with respect to the created impression of the volume decrease – by getting closer or increase – by getting farther away). If the marker and focus are located in the same depth-plane, the rates of their actual visual angle changes (increase/i.e.decrease) for every specific position of the observer would be mutually proportional, so that this "dynamics" would not take place and, consequently, nor would the relevant illusion. This supports the starting hypothesis.

Naturally, when, in addition to the marker presence (as a significant relative angular size cue to focus distance), there are other available (visible) depth cues, with regard to them, the level of corrections of the focus perceived visual angles "Vi" (from each of the "excessive" station points "i" close to the marker) would be variant.

⁸ Bear in mind that marker is the subject of micropsia oculomotor accommodation/convergence (remark by the author)

Bearing this study in mind, it is clear that it makes no difference whether the marker is an architectural and urban object situated before or behind the focus (as regards the phenomenology of their dynamic relationship on the visual field):

the result of such an inversion is that the analyzed visual illusion will no longer relate to the focus but to the marker and, instead of the influence of the oculomotor micropsia, oculomotor macropsia would be a relevant "corrective" mechanism present during the focus perception.

In support of the hypothesis, the actual existence of this illusion was confirmed through the used model but also in all realistic architectural and urban settings with identical morphological features, as illustrated in figure 11 [illusion of focus volume change (St. Sava's Temple in Belgrade, Serbia) with regard to the marker (Slavija-Luks Hotel), in the function of the observer's motion along Kralja Milana Street)].

CONCLUSIONS

The results of this study have a broad applicability in designing architectural and urban space. It is possible to achieve the effects of this illusion on an already developed matrix, when designing new objects that need to be integrated in the existing setting and when planning and designing completely new urban structures.

Namely, when already constructed architectural and urban objects are to become objects of the illusions, it is possible to intervene on their physical setting so as to make the illusion visually detectable.

Consequently, when designing new objects, by incorporating them into an existing context (with an appropriate modelling, dimensioning and positioning), it is possible to ensure a perception that guarantees the activation of this illusion.

When planning and designing a new urban matrix, one has available the same spectrum of parameters that initialize this illusion, but it is possible to program its effects with less restrictions: not only by modelling, dimensioning and positioning of architectural and urban objects (as the focus of the illusion), but with an adequate modelling, dimensioning and positioning of a broad spectrum of elements located in their closer or more distant setting.

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Received October 2009; accepted in revised form April 2010