



## RESEARCH ARTICLE

### BOTTOM-UP MODULATION WITHIN THE SCOPE OF CONSUMERS' VISUAL PERCEPTION: THE EFFECT OF PREVIOUS OCULAR FIXATIONS ON THE PERCEPTION OF BISTABLE LOGOTYPES

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#### ABSTRACT

**Background:** Bistable images are visual stimuli that have the particular characteristic of being interpreted in two different ways. Due to their physical characteristics, these images, while being observed, encourage the observer to make perceptual alternations, in such a way that it is never possible to perceive the two possible percepts simultaneously. The defining lines and contours of a bistable image, along with all its characteristics, can influence its perception, as well as the areas of the image that are observed. Thus, the fixation points that direct attention to specific areas become modulating factors of the bottom-up type. This phenomenon applies to advertising logos of bistable type. **Objective:** the study aimed at establishing the influence that a fixation point shown previously can exert on the perception of two bistable logotypes. Thus, it was wanted to find if there is (or not) a bottom-up modulation effect caused by eye-fixations on a particular area of the images that might be related to one of the possible percepts of the bistable stimuli. **Method:** Using a fixed 120-Hz eye-tracking device, two bistable logos were observed by thirty-five participants in optimal mental health conditions. A fixation point was manipulated at the beginning of the observation of each logo to contrast the perceptions reported in that condition with the interpretations given when the logos were observed without any fixation point that could modulate the observer's attention. An intrasubject design was conducted so that the two bistable logotypes used could be observed by all the participants. The presentation of bistable stimulus was counterbalanced so as to control the effect that the order of images could make. **Results:** The data was not distributed normally. By using a non-parametrical statistical test (U-MannWithney), it was found that the fixation point had a significant effect on the interpretation of the percept associated with the area where such point was placed. There is some evidence that lends support to the fact that the observed areas of a bistable stimulus have an impact on its interpretation. **Conclusions:** It is possible to influence the perception of a bistable logo by means of bottom-up modulators. The brain processes visual sensory information by focusing on specific features of bistable stimuli that can modulate the perception. By drawing the observer's attention to areas that can influence visual perception, it is possible to direct bistable perception favoring one of the possible percepts to be perceived over the other one.

#### INTRODUCTION

Bistable perception is a perceptual phenomenon, through which an observer perceives a stimulus in two different ways (Borisyuk, Chik, & Kazanovich, 2009; Clément, & Demel, 2012; van Loon, Knapen, St. John-Saaltink, Donner, & Lamme, 2013; Gori, Giora, & Pedersini, 2008; Grossmann & Dobbins, 2006; Pressnitzer, & Hupé, 2006; Sterzer, & Rees, 2009; Weinhhammer, Ludwig, Sterzer, & Hesselmann, 2014). While the stimulus remains invariable, the observer changes from one interpretation to the other one as the stimulus has two different possibilities to be interpreted (Baker, Karapanagiotidis, Coggan, Wailes-Newson, & Smallwood, 2015; Liu, Tzeng, Hung, Tseng, & Juan, 2012; Schauer, Kanai, & Brascamp, 2016). As regards, the two possible percepts cannot be perceived simultaneously (Rodríguez, & Castillo, 2018).

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Given the fact that bistable visual stimuli allow for two possible percepts, they can also be called ambiguous images (Gijs, & van Ee, 2006; Okazaki, Kaneko, Yumoto, & Arima, 2008). Similarly, the phenomenon of perceptual visual bistability can also be called visual bistability (Intaité, Kovisto, & Castelo-Branco, 2014), whereby the leap from one percept to the other one is known as perceptual reversal (Clément, & Demel, 2012; Sandberg, Barnes, Bahrami, Kanai, Overgaard, & Rees, 2014). Bistable perception implies two internal mental states that are called transition and maintenance (Sen, Daimi, Watanabe, Takahashi, Bhattacharya, & Saha (2019). The transition state lasts a short time whereas maintenance state is comparatively longer and is related to the stabilization of one of the two possible percepts after having experienced the transition (Sen et al., 2019). This transition is the so-called perceptual reversal (Rodríguez, & Castillo, 2018). The study of bistable perception has led to categorizing several types of bistable images (Bialystok, & Shapero, 2005). Long and Toppino (1981) identified three different types of bistable images (see in figure 1): 1.

In *figure-ground reversals*, whereby a possible percept can be recognized in the background while the other is salient relative to the background (as an example, the image *The vase-face illusion*); 2. Images *In perspective reversal*, that allows observers to perceive changes in both orientation and sense of perspective (e.g. the Necker cube); and, 3. *In meaning-content reversals*, bistable images understood as images that alternate between two percepts at the same level of salience where each of them is different in terms of shape and meaning. *My girlfriend or my mother-in-law* by Boring (1930) is an example of this type of bistable images.

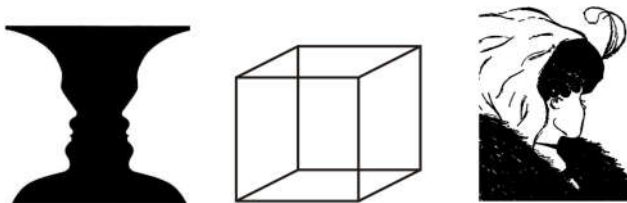


Figure 1. The three types of bistable images. On the left is *The vase-face illusion* (in figure-ground reversals). In the center is being shown the Necker cube (in perspective reversal). On the right is *My girlfriend or my mother-in-law* (in meaning-content reversals). Source: Rodríguez, & Castillo, 2018.

The factors which allow bistable images to have more than one possible interpretation have been widely studied (Rodríguez, & Castillo, 2018). Firstly, it has been stated that the physical features of bistable images generate ambiguity so that the resulting perceptual configuration depends not only on the way in which the stimulus is being observed, but also on the areas of the image upon which the eyes are fixed as well as on the visual path followed by the observer during ocular fixations (Gale & Findlay, 1983; García-Pérez M., 1989a; García-Pérez M., 1992; Hsiao, Chen, Spence, & Yeh, 2012). Providing that the physical characteristics of visual stimulus are able to exert an influence on perception (as shared contours for the two possible interpretations, indefinite planes, contrary and complementary tonalities, etc.), it is inferred that these issues underscore a modulation of visual perception, in this case, implying the *bottom-up* modulating effect (Hsiao et al., 2012; Meng, & Tong, 2004;).

Secondly, it has been stated that perceptual configuration of a bistable image also depends on isolated information processing of the stimulus' physical characteristics (Brouwer, & van Ee, 2006). Besides, there is also an influence exerted by concepts and ideas previously recorded in memory which are linked to the perceptual process in such a way that the final percept is built. In terms of basic psychological processes, this is what is called *top-down* processing (Firestone, & Scholl, 2016), in which the interpretation of a bistable stimulus is established by both previous stored information (or knowledge) that is recorded in memory, and information which can foray suddenly into the human perceptual system so that an interpretative echo emerges as the percept is semantically defined (Pitts, Gavin, & Nerger, 2008). Just as was stated by Intaité et al. (2014), visual perception can easily be understood as a dynamic brain function which is modulated equally by basic sensorial processes (*bottom-up*) and also by outside references to the distal stimulus, which come into play in its interpretation (*top-down* processing). In other words, the alternation between one percept and the other is, many times, involuntary (especially when *bottom-up* modulations are exerting their influence).

However, perceptual reversals are also voluntary, especially when observers can manage attention control so as to direct their perception (Gijs & van Ee, 2006; Intaité, Koivisto, Rukšėnas, & Revonsuo, 2010). It is important to state that *perceptual reversals* have the chance of being explained by the high and low level theoretical model. As found in Sterzer, & Rees (2009), there is a correspondence between high-level theory and low-level theory. As can be seen in figure 2, there are two ways in which a perceptual reversal is able to occur: alternative A, associated with *low level* theory, which suggests that spontaneous alternation take place in the visual cortex. This alternation is based on the so-called *bottom-up* process. The *bottom-up* theory explains that perceptual bistability is founded on the fact that a *perceptual reversal* occurs by means of an adaptation in the sensorial mechanisms so that the activity of a perceptual mechanism sustains a specific perceptual configuration until, as an effect of fatigue, the competing percept emerges, supported by another mechanism (Intaité et al., 2010; Kogo, Hermans, Stuer, van Ee, & Wagemans, 2015).

Regarding alternative B (*high level*), in order for the perceptual reversals to operate, that is, the occurrence of them, there is a dependence on central processes which may involve the frontal area of the brain among others (Sterzer, Kleinschmidt & Rees, 2009). It is widely known that perceptual reversibility is closely linked to these two types of processes (Long & Toppino, 2004; Yamamoto & Yamamoto, 2006).

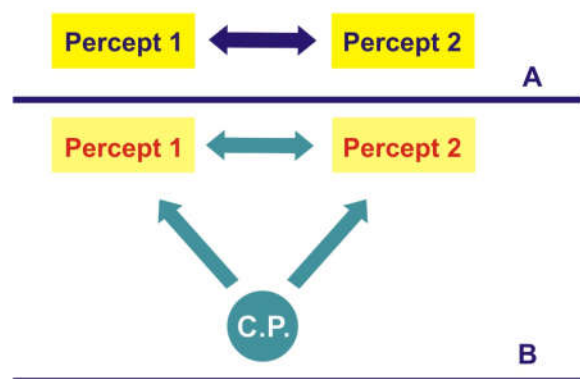
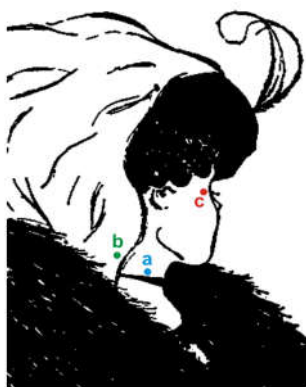


Figure 2. Low level (A), and high level (B) processes (adapted from Sterzer, & Rees, 2009)

In addition, it should be considered that various studies reinforce the idea that both *top-down* processing and *bottom-up* processing imply an effect on perception (Intaité, Noreika, Šoliūnas, & Falter, 2013). For instance, research projects conducted to study the phenomenon of perceptual reversibility show the importance of these two types of processing (Gale & Findlay, 1983; Hsiao et al., 2012; Kornmeier & Bach, 2005; Kornmeier & Bach, 2006; Kornmeier, Hein, & Bach, 2009; Long & Toppino, 1981; Long & Toppino, 2004). Evidence of the impact of *top-down* and *bottom-up* procedures have also been reported, when in the review of perceptual reversibility, an image which does not accept perceptual reversibility is presented to subjects; after that, the ambiguous figure is exposed, in such a way that knowledge gleaned by means of the review of the first supports the perception of the alternative percept in the bistable image, which involves an adaptation effect (Intaité et al., 2014; Kornmeier & Bach, 2005; Qiu, Dongtao, Hong, Caiyun, Ting, & Quinglin, 2009; Rock, Hall, & Davis, 1994).

**Fixation points as bottom-up perceptual modulators for bistable images and logotypes:** Taking into account that eye movements tracking are substantially important within the understanding of parameters of visual search, researchers in this area, being aware that without an accurate control of variables certain results would be taken as spurious, managed to acquire techniques and paradigms, simplifying visual stimulation to the maximum in comparison with the ecological natural field of everyday life, in such a way that tasks regarding controlled saccades movements are included (Brouwer, Reuderink, Vincent, van Gerven, & van Erp, 2013; Dandekar, Ding, Privitera, Carney, & Klein, 2012), as well as tasks of visual search with artificial stimulation (Kamienkowski, Ison, Quiroga, & Sigman, 2012). With regard to the specific study of the incidence of ocular fixation points in the perceptual configuration of bistable images, there are several studies conducted with eye-tracking techniques such as Gale & Findlay (1983) and Hsiao et al. (2012).

It is noticed from the review of these studies that there are critical areas of ocular fixation that favor a certain perceptual configuration of the ambiguous image of Boring (1930), *My girlfriend or my mother-in-law* (image in which it is possible to recognize to both a young woman or an old woman). From the study conducted by Gale & Findlay (1983), it was stated that both certain points and specific areas of eye fixation allowed participants to recognize the percept of a young woman, while for the other possible perceptual configuration other areas of the image were stated so as to favor the old woman percept. Hsiao et al. (2012) took into account these findings and, having identified and manipulated experimentally those points of fixation modulators of perception (see in figure 3), inquired about the effect of semantic congruence, recognizing that it is present in the observation of any bistable image. The chance of bottom-up modulations emerges, owing to the characteristics of the stimulus and/or by the way in which they are captured depending on the position of the receiving organs with respect to the visual stimulus. In that study, the bistable image was exposed using a neutral fixation point (see blue dot on the bistable image shown in figure 3). This fixation point does not favor the perceptual configuration of any of the two possible percepts that the image offers. On the other hand, the point that is green favors the perception of the elderly woman, whereas the red one, located at the top right on the image, helps the young woman to be perceived (see figure number 3).



**Figure 3.** The bistable image “My girlfriend or my mother-in-law” and three different fixation points: the green one, the point that is considered to be neutral. The blue one is the point that exerts an influence on the old-woman percept. The young-woman percept can be modulated by the red point. Source: Hsiao et al. (2012).

In fact, it has been stated that ocular fixation points necessarily interfere in the way in which a bistable visual stimulus is interpreted (Gale, & Findlay, 1983; Meng, & Tong, 2004), which leads to the conclusion that those who design reversible images with the purpose of transmitting to a target audience two different meanings (from the perceptual configuration of each of the possible admissible perceptions by the bistable figure) will have to recognize, beyond possible semantic modulations that may impact on the perceptual configuration, the influence that can be exerted by bottom-up type modulations, which are based on the ocular fixation points.

Regarding this, graphic designers of this type of images can consider the insertion of fixation points that modulate the interpretation of ambiguous stimuli, for example, in a piece of audiovisual advertising communication. Therefore, it should be estimated that it is strategic to design logos and brand visual identifiers that allow various perceptual configurations in such a way that it is possible to modulate their final perception (and, consequently, the message that is going to be conveyed). This modulation can be mediated by bottom-up modulators as fixation points linked to the determination of critical areas that favor a certain perceptual configuration with its corresponding semantic load.

## MATERIALS AND METHODS

Thirty-five healthy volunteers participated in this study (57%=female; 43%= male; age ranging between 18 and 37 years old; mean age= 25.14; SD= 6.43). All of them were naive of the purpose of the experiment, and all were healthy and had normal or corrected-to-normal vision. All participants provided written informed consent. The experiment was conducted in a dimly-lit experimental chamber. Participants had to view the logotype of the brand FedEx. The image of the logotype was in color on a gray background (RGB= [127, 127, 127]). Each participant was able to view the image twice, at a viewing distance of 60 centimeters. The image was presented on an eye-tracker device (120 Hz., Tobii technology). On the first occasion, when participants viewed the image, there was no fixation point that could exert an influence on the way they were going to start to view the logotype. The second time, they viewed a point of fixation 250 milliseconds (ms.) before the bistable logotype were exposed. Both options (logotype with and without point fixation) were presented randomly, so as to obtain counterbalanced exposure. Participants clicked the mouse buttons, so as to report which percept was being perceived by them during image presentation (each exposure lasted 15 seconds).

Thus, each button was marked with a specific letter and color, in such a way that participants were able to report the corresponding percept. All data was processed by using Tobii Studio and SPSS (v.23). The aim of the study was to observe prevalence of attention in certain defining areas of the percepts of each of the bistable advertising logos (duration of each perception taken from one report to the next one referred to the opposite percept), locating fixing points that modulate the attention in critical areas of the logotypes that were used (see points marked with "X" both in the “La Alquería” logo and in the FedEx logo, in figure number 4). These fixation points were placed previously to the exposure of the images, and their permanence on the screen was 250 ms., which is a time usually used in studies of eye-movements activity records to condition the attention of the observers towards certain specific area.

Likewise, we sought to make an observation about the total of eye fixations, in order to propose some reflections on the way in which visual identifiers of bistable nature are observed. As mentioned before, the time-prevalence of each percept was taken by considering the time that passed from the report of one percept and the switch to the other one.



Figure 4. Fixation points (see the two letters “x”) that were used to drive the attention as bottom-up modulators. As for the case of the logotype of the brand “La Alquería”, the fixation point was placed in a critical area for the recognition of the "head of cow" percept (consider that the other possible percept of this bistable logo is a milk jet). Regarding the logo of FedEx, the fixation point was placed to favor the perceptual configuration of the arrow that is constructed from the contours of the letters “E” and “x” of the corresponding identifier (it is assumed that the other possible percept for this logo bistable is the word or set of letters, without notice of the recognition of the arrow that is formed between letters E and x).

**RESULTS**

As can be seen in table 1, the percepts that were modulated by placing a fixation point (in the “Arrow” for the FedEx logotype, in the “cow head” for the “La Alquería” logo) had higher prevalence with respect to the percepts that were reported when the observation was made without using the fixation point. For the FedEx logo, with fixation point there was a statistically significant difference in prevalence between the "arrow" percept and the "word" percept (M.D. = 4.8317, Mdn = 9.727, U = 0.734, p = 0.037).

Without fixing point, the difference was also in favor of the "arrow" percept, but in a lesser proportion and without statistical significance (M.D. = 1.369, Mdn = 6.306, U = 0.727, p = 0.394). In the case of the "La Alquería" logo, when the fixation point was exposed in the area of the head of the cow, a significant difference was given in favor of the modulated percept, that is, "cow head" (MD = 3.1779 ; Mdn = 9.632, U = 0.184, p = 0.043). On the other hand, without a fixation point, a slight difference was given in favor of the "cow head" percept, but the difference was not significant (M.D. = 0.0828, Mdn = 5.111, U = 2.932, p = 0.85).

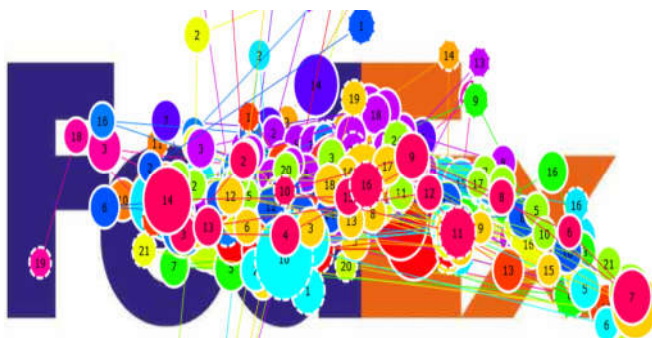


Figure 5. Fixations-map that depicts eye-fixations after having exposed a point fixation just in the middle of the arrow

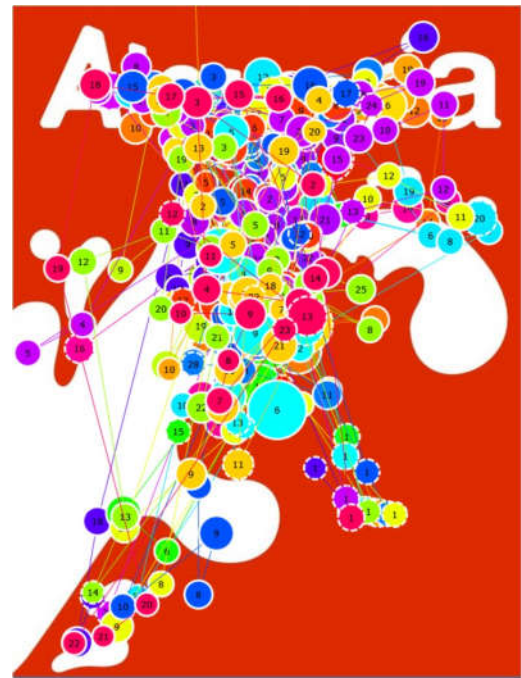


Figure 6. Fixations-map that depicts eye-fixations after having exposed a point fixation in the center of the head of the cow

In figure 5, it is shown the eye-fixations map in which eye-fixations were located after having exposed a point fixation just in the middle of the arrow that is formed between letters “E” and “x”. It can be noticed how the full stop at the end of the logotype drives the attention. On the other hand, figure number 6 shows the map relating to the eye-fixations that occurred after having exposed a fixation point in a central position with respect the head of the cow.

**DISCUSSION**

The results show a tendency in the sense that the perceived percepts (their prevalence in time) have an association with the location of the fixation point that is placed in an area that can favor such percepts.

The prevalence of the duration of the percept that is related to the placement of the fixation point was greater in the observations given to the two logos that were studied. Several questions should be considered here: firstly, the study outlined here is an intrasubject-counterbalanced one and it does not allow to draw definitive conclusions because it is not facing an experimental design of repeated measures that allows to establish with relative certainty the incidence that various areas of ocular fixation may have on the final perceptual interpretation. Secondly, bottom-up modulation, whose modulators are both the physical characteristics of visual stimuli (García-Pérez, 1989a) and the critical areas of attentional modulation (Gale, & Findlay, 1983; Rodríguez, & Castillo, 2018), is linked to the shapes, lines and contours that define the observed bistable image. In this sense, it is recognized that the FedEx logo is different from the “La Alquería” brand because of the fact that the image is shaped by letters converted into a brand identifier. Secondly, "La Alquería" logo contains an icon of bistable nature, whose referents are a jet of milk and the head of a cow. This typological dissimilarity between the two logos makes a difference, so the results expressed between the two observations was to be expected.

Given that constitutive aspects of the visual stimuli such as edges, angles, line thicknesses and textures, contribute to get their final perception (as well as the areas and points of ocular fixation), it must be understood that in the present study the results for each logo can be reviewed independently, thus incorporating the model of a descriptive type of research. The case of the FedEx logo turns out to be very telling in that the placement of the fixation point within the shape of the "arrow" does imply that this percept is mostly interpreted. In figure number 7 it can be seen the whole area of the logotype (cluster 1) covered by the ocular fixations taken altogether



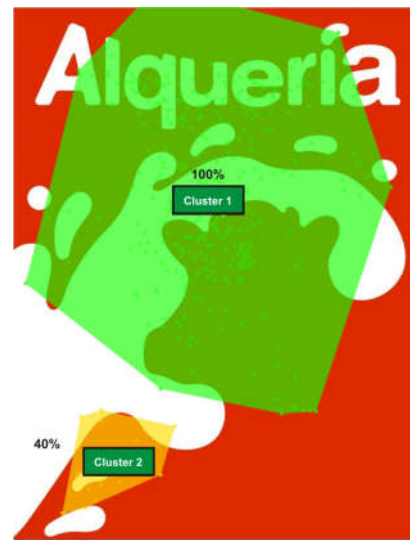
**Figure 7. Visualization of the observed zones (all participants who observed the FedEx logo with previous positioning of the fixation point in the area of the "arrow" configured between the letters "E" and "X").**

In this sense, there is a disambiguation of the bistable image, where both attention and fixation within these parts encourage one of the two alternatives of interpretation to be perceived, configuring bottom-up modulation (Kornmeier, & Bach, 2005).

Take into account, in addition, that the modulator factor used involved sensory processing without the provision of exogenous contextual information that could elicit a priming effect (Meng, & Tong, 2004). It must also be considered that one of the difficulties in conducting studies on the relationship that may exist between observed areas and configured percepts is the lack of homogeneity during the process of observing the bistable stimulus (García-Pérez, 1989a).

There are many factors that make a person move their eyes, so that the visual pathways do not necessarily have the same pattern between person and person, beyond the conditions that may exist, derived from the instructions given in function of reporting one percept or the other one. Visual homogeneity is understood by considering that a sustained and focused perception of a given stimulus within the context of the entire visual information flow emerge while viewing. In order to reach homogeneity, it is necessary that the focus area be rather constant during the observation process of an image, which also implies greater permanence of the ocular fixations (García-Pérez, 1989b).

Visual homogeneity is also explained by the relative static quality of the eyes during a sustained fixation at the point of focus within the Panum fusion area, that is, the set of points in the visual space that have their corresponding projected image in points in the two retinas (Lakshminarayanan, Rajaram, & Joseph, 2002). The fact that visual homogeneity is not stable is associated with the binocular disparity produced by the perception of depth (stereoscopy). In addition, visual homogeneity is limited to Panum's fusion area around the horopter.



**Figure 8. Visualization of the observed zones (all participants who observed the "La Alquería" logo with previous positioning of the fixation point in the area of the "head of cow").**

It should be considered that the length of the vertical line of the visual field (vertical horopter) is usually perceived in a linear dimension (length), different from the horizontal one (horizontal horopter), configuring an apparent asymmetry; likewise, this asymmetric interpretation of the visual field is defined by internal mechanisms of perceptual representation (Lipshits, McIntyre, Zaoui, Gurfinkel, & Berthoz, 2001).

This fact is not minor, because the selected logos have different proportions in the wide-high relation. As can be seen in figure 8, as for the "La Alquería" logotype, there were two clusters relating to areas that were covered by the observer's eyes. It means that in cluster 2 there were salient shapes of the visual stimulus that were able to grab the attention significantly. It is possible that the proportion in the wide-high relation could have exerted an influence on this fact. Likewise, some characteristics of the stimulus might have had an effect. As regards, there is a relationship among visual non-homogeneity, eye movements and multistable perception (García-Pérez, 1989a), in such a way that ocular saccades impact on the lack of homogeneity, whereas fixations impact on the detection of edges and characteristics of the stimulus, which, in turn, plays a fundamental role in the visual processing of forms (Biederman, & Ju, 1988; Goldman, 2018). Additionally, the emphasis placed on strokes, lines and constituent segments of the logos (in order to help identify one or the other percept), favors a disambiguation of the image by suppressing one of the possible percepts. This fact supports what Chastain and Burnham (1975) had referred to in the sense that by emphasizing certain traces of the bistable stimulus it is possible to further favor the perceptual configuration of one of its possible percepts. Reviewing the areas that were observed for the two images under study, it is evident that the eyes are released from the area originally modulated by means of the fixation point (see Figure 7). This implies that attentional control is momentary and that the characteristic of being stochastic that corresponds to bistable perception phenomenon (Rodríguez, & Castillo, 2018) plays a role in both the observation and decoding of bistable visual stimuli. It should be noted that in the case of "La Alquería" logo, there was also a greater prevalence of the time of the percept consistent with the location of the fixation point that modulated the attention towards such percept.

Table 1. Averages of prevalence of time per percept, considering use or absence of fixation point (FP=Fixation point; WP=Without fixation point)

	FedEx FP time mean arrow vs. word	FedEx WP time mean arrow vs. word	Alqueria FP time mean cow head vs. milk	Alqueria WP time mean cow head vs. milk
Arrow/head	10.2961	8.6588	9.1148	8.1091
Word/Milk jet	5.4644	7.2898	5.9369	8.0263

Regardless of the fact that these logos are different considering both their physical characteristics and their disposition within visual space, the phenomenon of bottom-up modulation emerged.

## Conclusion

For purposes of conducting research on the relation between fixation areas observed in a bistable image and the configuration of percepts, it is necessary to have control over the recording of oculomotor activity, trying to determine what percept is configured in relation to pre-established areas of analysis of the bistable stimulus. Likewise, the manipulation that is made in relation to directing attention to one or another area of the bistable image exerts an influence on what is perceived by the observer, allowing, furthermore, to infer that the first glance determines the perception of the ambiguous stimulus, if the observed area favors one of the possible percepts of the bistable stimulus. According to the findings reported here, it is possible to influence the perception of a bistable logo by means of bottom-up modulators. This fact must be assumed as important for professionals who are involved in designing this type of images with the aim of conveying different semantic loads by using a single visual stimulus. Further studies will have to carry out so as to continue stating the ways in which fixation points that drive the attention operate in the context of bistable perception.

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