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Perceptual reversals and creativity: is it possible to develop divergent thinking by modulating bistable perception?

Reversibilidades perceptuales y creatividad: ¿es posible desarrollar el pensamiento divergente mediante la modulación de la percepción biestable?

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Abstract

The purpose of this article was to examine the relations that exist between bistable perception and divergent thinking, taking as a reference that flexibility emerges in both mechanisms, perceptually or cognitively. To achieve the objective, a literary review was carried out using six databases. The keywords used were: bistable perception, perceptual reversals, insight, creative cognition, creative flexibility, perceptual flexibility. 19 articles on the relationship between bistable perception, flexibility and creativity were found. 44 studies regarding both bistable perception and the mechanisms that are involved while cognitive flexibility emerges were considered. 2 reviews on bistable perception were also included. 6 articles related to creativity as a cognitive phenomenon were collated, plus another 3 on perceptual processes. After having made the analysis, it is concluded that the modulating mechanisms of bistable perception have a possibility of being incorporated to develop creativity from perceptual reconfiguration processes that involve flexibility mechanisms.

Keywords: bistable perception, divergent thinking, perceptual reversals, creative cognition.

Resumen

Este artículo tuvo por objeto examinar las relaciones que existen entre la percepción biestable y el pensamiento divergente, tomando como referencia que en los dos mecanismos hace emergencia una flexibilidad, sea perceptual o cognitiva. Se realizó una revisión literaria utilizando seis bases de datos. Las palabras clave utilizadas fueron: percepción biestable, reversibilidades perceptuales, perspicacia, cognición creativa, flexibilidad creativa, flexibilidad perceptual. Se encontraron 19 artículos sobre la relación entre la percepción biestable, la flexibilidad y la creatividad. Sobre la percepción biestable y sobre los mecanismos que se implican mientras emerge la flexibilidad cognitiva, se consideraron 44 estudios. Se incluyeron 2 revisiones sobre percepción biestable. También se cotejaron 6 artículos relativos a la creatividad como fenómeno cognitivo, más otros 3 sobre procesos perceptivos. Se concluye que los mecanismos moduladores de la percepción biestable tienen una posibilidad de ser incorporados para desarrollar la creatividad a partir de procesos de reconfiguración perceptual que involucren mecanismos de flexibilidad.

Palabras clave: percepción biestable, pensamiento divergente, reversibilidades perceptuales, cognición creativa.

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1. Introduction

Bistable perception is a perceptual phenomenon where an observer interprets the same stimulus in two different manners (Gori, Giora & Pedersini, 2008; Grossmann & Dobbins, 2006; Pressnitzer & Hupé, 2006; Sterzer, Kleinschmidt & Rees, 2009). While the stimulus is maintained invariable, the observer changes from one interpretation to the other one, given the fact that the stimulus offers two different possibilities for interpretation (Liu, Tzeng, Hung, Tseng, & Juan, 2012; Schauer, Kanai, & Brascamp, 2016). As regards, the two stimuli cannot be perceived simultaneously (Rodríguez & Castillo, 2018a).

Given that a bistable visual stimulus allows for two possible percepts (Baker, Karapanagiotidis, Coggan, Wailes-Newson & Smallwood, 2015), it can also be called ambiguous image (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). The leap from one percept to another one is known as perceptual reversal (Clément & Demel, 2012; Rodríguez-Martínez, Marroquín-Ciendúa, Rosa & Castillo-Parra, 2022; Sandberg et al., 2014).

According to scientific literature (Blake & Palmisano, 2021; Laukkonen & Tangen, 2017), being able to see the two different percepts that can be interpreted from a bistable visual stimulus is a fact that is correlated to perceptual flexibility, a condition that is sometimes useful to create novel ideas (Rodríguez, 2016). From a cognitive perspective, flexibility is also implied in mechanisms in which it is necessary to change from one perspective to a different one. As such, there are examples in which cognitive flexibility emerges, like bilingualism (Bialystok & Shapero, 2005), or also when an individual is sorting out problems by using divergent thinking (Taranu & Loesche, 2017).

According to Rodríguez and Castillo (2018b), the features of bistable stimuli allow them to be used as a research paradigm within the scope of various psychological phenomena. For instance, studies on bilingualism related to perceptual skills have found a fundamental mechanism in perceptual bistability (Bialystok & Shapero, 2005). This has been demonstrated due to the fact that there is an analogous flexibility in bilingual minds that is similar to the perceptual flexibility implied in making perceptual reversals (Bialystok & Shapero, 2005; Rodríguez & Castillo, 2018b).

It has also been stated that bistable images have been used so as to study insightfulness and creativity (Doherty & Mair, 2012; Laukkonen & Tangen, 2017; Taranu et al., 2019). With this regard, people who are able to decode the two percepts of a bistable image are also good at solving creative problems (e.g. Laukkonen & Tangen, 2017).

The aim of this theoretical study was to find the links that connect bistable perception with the perceptual and cognitive capacities that contribute to the development of divergent thinking. For this purpose, a narrative review was carried out, based on the following descriptors: bistable perception, bistable images, creative cognition, flexibility and divergent thinking.

2. Methodology

A systematic search of sources was done by using the following databases: PubMed, Science Direct, Scopus, DOAJ, Google Scholar, and WOS. The key-words used were: bistable perception, perceptual reversals, insightfulness, creative cognition, creative flexibility, perceptual flexibility. It was aimed at finding articles mainly published from 1980 to 2021.

The texts that referred to methodological, technical and/or research paradigm factors were considered, with reference to studies on bistable perception and their relation with both creativity and divergent thinking. Through automatic and manual procedures (combined), repeated sources were identified, which, immediately afterwards, were duly removed.

For the purpose of analyzing the information found in the studies, we wanted to include only the information that accounted for the links between bistable perception, perceptual flexibility, and also the flexibility involved in cognitive processes of a creative nature. In this sense, the essential notions that are interwoven between perceptual mechanisms and creative cognition were detected, so as to contribute to the discussion regarding pedagogical strategies that can be used to develop divergent thinking. After refining the information collected, we proceeded to articulate the essential findings, interconnecting the notions that underlie both bistable perception and the development of divergent thinking.

At the end of the analysis, it is proposed that modulating mechanisms of bistable perception could contribute to the stimulation of creative thinking. The information found was classified into three thematic axes: A. Bistable perception: top-down and bottom-up modulating factors; B. Perceptual reversals and insightfulness; C. Modulating factors and their possible effect on the development of cognitive flexibility. The information was collated and organized in such a way that the notions referring to the modulation of bistable perception and the occurrence of perceptual reversals were related to creative cognition, flexibility (perceptual and cognitive), and divergent thinking. As regards, 19 articles concerning the relation among bistable perception, flexibility and creativity were found. In relation to the articles that were about bistable perception and the mechanisms that are implied while cognitive flexibility emerges, 44 studies were considered.

It was necessary to remove most of the articles about bistable perception that were focused on neurological issues. Thus, a total of 56 articles were removed. Two reviews about bistable perception were included, one published in 1999, the other one in 2018. It was necessary to include 6 articles in which creativity was studied as a cognitive phenomenon, as well as 3 articles concerning perceptual processes. These last 9 articles were selected by considering that information relating to perception and creative cognition was necessary to connect statements found in studies whose main topics were perception and creative thinking. The search equation described here is displayed in figure 1:

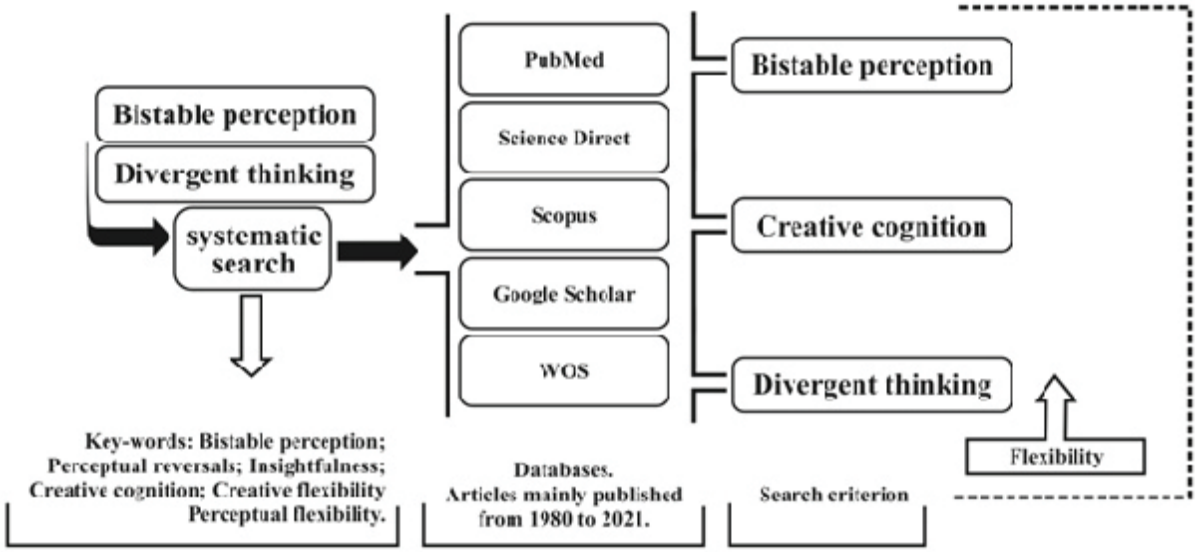

Figure 1. The search equation used for the systematic search.

3. Results and discussion

3.1 Bistable perception: top-down and bottom-up modulating factors

The study of bistable perception has led to the categorization of various types of bistable images (Bialystok & Shapero, 2005; Rodríguez & Castillo, 2018b). Long and Toppino (1981) identified three different types of bistable images (as can be seen in figure 2): 1. In figure-ground reversals, recognized by a possible percept located in the image background, while the other is salient, with respect to the background (take, as an example, the image "C", known as The vase-face illusion); 2. Images In perspective reversals, for which, apparently, the percept changes its orientation and sense of perspective (see The Schröder's staircase (A), and The Necker cube (D); and 3. In meaning-content reversals, bistable stimuli conceived as images that alternate between two percepts at the same level of salience, where each of them is different in terms of both form and meaning. Examples of this last category are The rat-man (B), and My girlfriend or my mother-in-law (E).

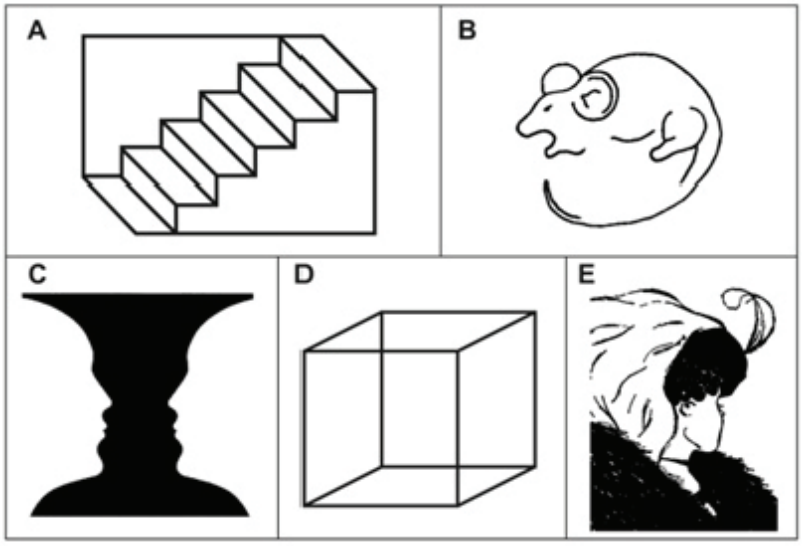

Figure 2. Examples of bistable images (A, C, D and E, were adapted from Rodríguez and Castillo (2018b); image B was adapted from Taranu and Loesche (2017)).

The diverse factors which allow for this type of images to have more than one possible interpretation have been widely studied. Firstly, it is clear that the physical characteristics of bistable images generate ambiguity, such that the resulting perceptual configuration depends on the way in which the stimulus is being observed. Besides, the perceptual configuration of the recognized percept is also dependent on areas of the image upon which the eyes are fixed, and also on the visual path followed by the observer during the corresponding observation (Gale & Findlay, 1983; García-Pérez, 1989; García-Pérez, 1992; Hsiao, Chen, Spence & Yeh, 2012).

Given that physical aspects of the stimulus can impact perception (as shared contours for the two possible interpretations, indefinite planes, contrary and complementary tonalities, etc.), it is inferred that all of them underscores a modulation of visual perception, in this case, of the bottom-up variety (Hsiao et al., 2012; Marroquín-Ciendúa, Rodríguez-Martínez & Rodríguez-Celis, 2020; Meng & Tong, 2004). Secondly, it has been demonstrated that the perceptual configuration of a bistable image also depends on isolated information processing for the stimulus' physical characteristics (Brouwer & van Ee, 2006), or even on the concepts and

predispositions which are integrated into the perceptual process. When information that is external relative to the visual stimulus itself is the one that modulates visual percepts, what is implied, in terms of basic psychological processes, is the so-called top-down modulating process. Thus, the interpretation of the bistable stimulus is established by information that has previously been stored in the memory, or by information which also forays into the perceptual system. As regards, an interpretative echo emerges as the percept is semantically understood (Rodríguez & Castillo, 2018b).

Just as presented by Intaité et al. (2014), visual perception can easily be understood as a dynamic brain function which is modulated 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 occur). However, it can also be voluntary, especially when the observer executes attentional control in order to direct their own perception (Gijs & van Ee, 2006; Intaité, Koivisto, Rukšėnas & Revonsuo, 2010).

Associated with the above, it has to be considered that perceptual reversals have the possibility of being explained by the high and low levels theoretical model. As has been stated (see Sterzer, Kleinschmidt & Rees, 2009), on one hand, there is a correspondence between the low-level theory and bottom-up modulating processes. On the other hand, the high-level theory is related to top-down perceptual processes.

As can be seen in figure 3, there are two ways in which a perceptual reversal occurs: alternative A, associated with the low-level explicative 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 perceptual reversals happen by means of an adaptation in the sensorial mechanisms. As regards, the activity of perceptual mechanisms sustains a specific perceptual configuration until, as an effect of fatigue, the competing percept emerges, supported by another mechanism (Kogo, Hermans, Stuer, van Ee & Wagemans, 2015).

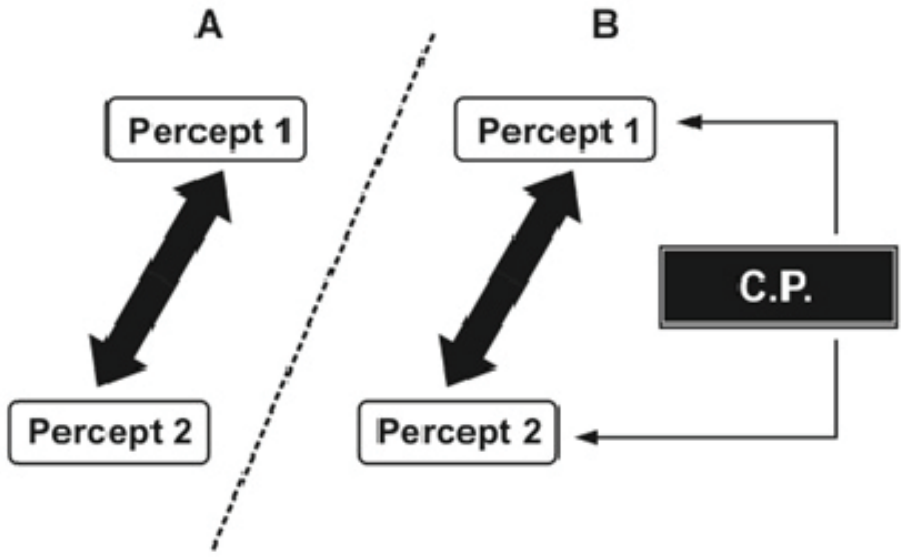

Figure 3. High and low levels theoretical model. A: low level model; B: high level model (adapted from Sterzer et al., 2009).

Regarding alternative B (high level), in order for the perceptual reversals to work, that is, the occurrence of perceptual reversals, there is a dependence with a central process which may involve the frontal area of the brain, among others (Sterzer et al., 2009). From the proposal of this last model, top-down processes emerge, which, simultaneously, relate to psychological aspects of the individual (Barrera & Calderón, 2013).

As a matter of fact, it is widely known that perceptual reversibility is closely related to both bottom-up and top-down modulating processes (Long & Toppino, 2004; Yamamoto & Yamamoto, 2006). Additionally, it should be considered that various studies reinforce the idea that both top-down and bottom-up processing imply an effect on perception (Intaité, Noreika, Šoliūnas & Falter, 2013). For instance, studies conducted in order to study perceptual reversibility phenomenon 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; Leopold & Logothetis, 1999; Long & Toppino, 1981; Long & Toppino, 2004).

Evidence of the impact of top-down and bottom-up mechanisms have also been reported, when in the review of perceptual reversibility on these types of figures (bistable ones), an image that does not accept perceptual reversibility is presented to subjects. After that, the ambiguous figure is shown, in such a way that the knowledge gleaned with the review of the first, supports the perception of the alternative percept of the bistable image. It involves a learning-adaptation effect: what is learnt in the first experience exerts an influence on the perception of the bistable stimulus (Intaité et al., 2014; Kornmeier & Bach, 2005; Qiu et al., 2009; Rock, Hall & Davis, 1994).

As has been stated (see Hsiao et al., 2012), it is possible to use crossmodal stimulation to convey semantic context. That context can favor the perception of one of the possible percepts of a bistable image. In this sense, there can be semantic keys that can operate as modulating factors. They, in turn, might condition perception. Besides, semantic context can be presented via expositions of auditory stimuli while the image is exposed for an extended period of time (Rodríguez-Martínez et al., 2021). As a consequence, there is a top-down modulating effect on the perception of the bistable image, and it is possible to observe the conveyance of semantic congruence by using, for instance, tones of voice (Smith, Grabowecky & Susuki, 2007). Regardless of speech comprehension, the mere tones of voice have the capacity to modulate visual perception, if the semantic content of the tone (not of the words) has some relation to the content of the observed visual stimulus. What is operating here is a top-down modulating process (Hsiao et al., 2012).

Consider the semantic congruence phenomenon: when an observer is looking at a bistable image such as In meaning-content reversals, observer's perception of possible percepts for the image can be influenced if, at the same time, he or she is listening to an audio which makes reference to that particular percept. Here, due to a crossmodal stimulation model (where there is stimulation in two different sensorial modalities, visual and auditory, simultaneously), semantic congruence is marked by the relation in terms of the similarity between the content of the auditory stimulus and the semantic load of the image (Feist & Gentner, 2007; Goolkasian & Woodberry, 2010; Hsiao et al., 2012; Smith et al., 2007).

Having regard to the above, it is possible to use a short story (auditory stimulation) in such a way that it (the content) modulates the perception of a bistable image. As can be assumed, the semantic content of the story will have to be related to the semantic content of one of the possible interpretations of the bistable image (Balcetis & Dale, 2007; Rodríguez-Martínez et al., 2021). The foregoing implies that when observers are looking at a bistable figure such as My girlfriend or my mother-in-law, they can perceive the young woman if, for example, there is a simultaneous modulating audio, which could be the voice of a young woman (Hsiao et al., 2021;

Rodríguez-Martínez et al., 2021). Conversely, if the modulating audio is the voice of an elderly woman, the observer may note the presence of an elderly woman, due to semantic congruence (Hsiao et al., 2012; Marroquín-Ciendúa et al., 2020).

3.2 Perceptual reversals and insightfulness

Perceptual reversals, that is, the changes between the percepts of a bistable image, are supposed to have a correlation with the flexibility implied in creativity (Taranu & Loesche, 2017). This statement is supported by the fact that individual's creative capacity is related to their ability to think divergently, to be open to new experiences (McCrae, 1987). Given that divergent thinking implies jumping from one perspective to another to find logical alternatives relative to the usual way of understanding a problem (Romo, 1986), this way of thinking also implies changes in perspectives, a fact that also occurs when observers make perceptual leaps when they look at visual stimuli (Rodríguez, 2016). With this regard, it has been shown that there are correlations between the ability to do perceptual reversals and the perceptual and cognitive flexibility involved in the use of divergent thinking (Taranu & Loesche, 2017).

Besides, it has been suggested that divergent thinking influences the perception of ambiguous visual stimuli (Blake & Palmisano, 2021). Despite the fact that some studies may disregard these correlations due to the difficulty in recording perceptual reversals through self-report (Doherty & Mair, 2012), it is recognized that the perceptual flexibility that is necessary for the manifestation of perceptual reversals can contribute with the flexibility that is required for divergent production of ideas (Rodríguez, 2016). Indeed, several studies show that the ability to change the perspectives of bistable images seems to be associated with the ability to solve problems (Doherty & Mair, 2012; O'Brien, Harris & Higgs, 2013).

The relationship between perceptual reversals and the development of cognitive flexibility is not explanatory, but correlational (Doherty & Mair, 2012; Schooler & Melcher, 1995). One notion that is involved when traying to establish a bond between bistable perception and creative thought is dynamic representation (Freyd & Pantzer, 1995). This concept is understood as a way to switch from one perspective to a different one while recognizing and understanding images and ideas. It leads to see how subjects could misremember one point of view so as to arrive at a different perspective. According to Freyd and Pantzer (1995), this also raises the chance that underlying dynamics could play a role in the interpretation of bistable images.

On the other hand, the study of the flexibility involved in the use of divergent thinking, but in relation to the ability to make perceptual reversals, normally contemplates two different types of problems: non-insight problems, and insight-problems (Doherty & Mair, 2012; Laukkonen & Tangen, 2017; Riquelme, 2002; Wiseman, Watt, Gilhooley & Georgiou, 2011). Likewise, it is recognized, on the one hand, that there are problems that imply perceptual reinterpretations (e.g. Laukkonen & Tangen, 2017; Rodríguez, 2016). On the other hand, it has been shown that some problems imply re-interpreting conceptual information (Schooler & Melcher, 1995; Riquelme, 2002). As regards, insight-problems are those that need a perceptual or a conceptual redefinition so that they can be solved (Dow & Mayer, 2004).

For their part, non-insight problems do not require a break in the use of the archetypal notions that define the problem, but rather a continuum of logical and learned steps that lead to an agreed solution (Gilhooly & Murphy, 2005). As a consequence, the use of divergent thinking is necessary for the resolution of insight-problems (Patrick & Ahmed, 2014). Taking this into account, the use of divergent thinking is more clearly associated with the resolution of problems whose type is insight-problem. Indeed, several studies are aimed at establishing the relation between bistable perception and problem-solving abilities. To conduct these

studies, it is normally used a paradigm based on problems that demand changes in perspective, or also problems that imply a restructuring of information (Rodríguez, 2016; Taranu & Loesche, 2017; Taranu et al., 2019).

3.3 Modulating factors and their possible effect on the development of cognitive flexibility

The modulations that can be exerted on bistable perception involve learning and adaptation processes (Rodríguez & Castillo, 2018b). When an observer is taught to look at certain areas of a bistable stimulus to recognize a specific percept, he/she is being given the possibility of increasing their flexibility in terms of making perceptual reconfigurations (Rodríguez, 2016). Therefore, this learning could be involved in acts of perceptual reconfiguration that were intended to stimulate problem solving by encouraging divergent thinking (Rodríguez, 2016; Ali, Moroso & Breazeal, 2019). In this case, it is the bottom-up modulating process that operates as a possible stimulator of perceptual flexibility. That stimulation can be related to cognitive flexibility, providing that there is an insight experience when a bistable image is solving, that is to say, when the ambiguous visual stimulus can be totally decoding by making perceptual reversals (Laukkonen & Tangen, 2017).

When bistable visual stimuli are being seen by the eyes, conscious perception can spontaneously alternate across the competing percepts, which, in turn, implies a dynamic perceptual mechanism (van Loon et al., 2013; Weilnhammer, Ludwig, Sterzer & Hesselmann, 2014). The spontaneous switches between the two possible interpretations might indicate a connection between bistable perception and the dynamic interaction of brain networks (Mao et al., 2020). As regards, by increasing the alternations in bistable images, it is possible to trigger cognitive processes that, in turn, can improve subsequent insight problem-solving (Laukkonen & Tangen, 2017). On the other hand, the semantic modulation effect by which the interpretation of a bistable image is influenced, can also be assumed as a trigger for perceptual flexibility, only by means of top-down processing (Hsiao et al., 2012; Marroquín-Ciendúa et al., 2020).

In view of the foregoing, the learning that is acquired to exercise perceptual flexibility contributes to the cognitive processes involved in problem solving. This occurs because a coherent perception results in an effective cognitive process (Arecchi, 2010). In this regard, creative thought is involved due to creativity is understood as the recording that lengthens the time over which information is lost (Arecchi, 2007), until new understandings of the problem emerge so as to produce the so-called insight moment (Kounios & Beeman, 2009). What is implied here is the fact that the modulations made on bistable perception, by contributing to the occurrence of perceptual reversals (Rodríguez & Castillo, 2018b), can improve the development of creative cognition in consideration to the relationship between divergent thinking and visual interpretations (Rodríguez, 2016; Ward, 2007).

When an observer reinterprets a bistable visual stimulus, what is also implied is a configurational change (Kornmeier & Bach, 2004). This change implies a process called perceptual reconfiguration, which can be mediated by learning processes, where both bottom-up and top-down modulations are present (Rodríguez, 2016).

Another issue that has to be addressed is that the occurrence of perceptual reversals has additional explanations: on the one hand, there are the slow adaptation parameters, where, from one stable state, the observer passes to another one (hysteresis). On the other hand, a symmetry break has been recognized where an irregularity is manifested due to perceptual alternations (noise). Besides, there are mechanisms of transition and processes of complex perceptual dynamics (Borisyuk, Chik & Kazanovich, 2009; Rodríguez & Castillo, 2018b). These processes involve transitional phases that entail perceptual bistability and the occurrence of perceptual reversals.

Likewise, probabilistic models are considered (which describe bistable perception based on randomized variables), as well as complex systems (complex dynamics in a deterministic system), where reversals are irregular and also dependent on a series of dynamic properties of visual perception consisting of two states of interpretation (Borisyuk et al., 2009).

As far as the bottom-up modulating process is concerned, the modulators include physical features of visual stimuli (García-Pérez, 1989), and also critical areas of attentional modulation (Gale & Findlay, 1983; Marroquín-Ciendúa et al., 2020). In this sense, constitutive aspects of the visual stimuli, such as edges, angles, line thicknesses and textures, contribute in terms of directing the final perception, as well as ocular fixation points do (Meng & Tong, 2004).

Regarding the characteristics of the stimulus, several studies have lent support to the fact that they can be disaggregated into various constituent entities (Biederman & Ju, 1988; Patel & Holt, 2000). The decomposition of a certain visual stimulus to recognize its constituent parts has been widely developed and studied, to the point of establishing a system called Component Recognition Model (Biederman & Ju, 1988; Rodríguez & Castillo, 2018a). Based on that model, visual objects consist of constituent parts (components) that make up a small set, such as cones, cylinders, lines, etc. Biederman and Ju (1988) called these constituent elements geometric icons. This model not only provides a set of primitive features that make up an object, but it also makes it possible to explain some of the phenomena involved in identifying objects (Patel & Holt, 2000). This is how ambiguous images such as Necker's cube or My girlfriend or my mother-in-law bistable image can be disambiguated: through a mediation of constituent parts of them, whereby attention and fixation on said parts encourages the perception of one of the two possible percepts. Subsequently, a bottom-up modulating process emerges (Kornmeier & Bach, 2005). It should also be mentioned that, apart from the physical features of the stimulus, such as edges, protruding elements, shared contours, among others, the way in which the observer sees a bistable image affects the interpretation that he/she makes of the stimulus itself.

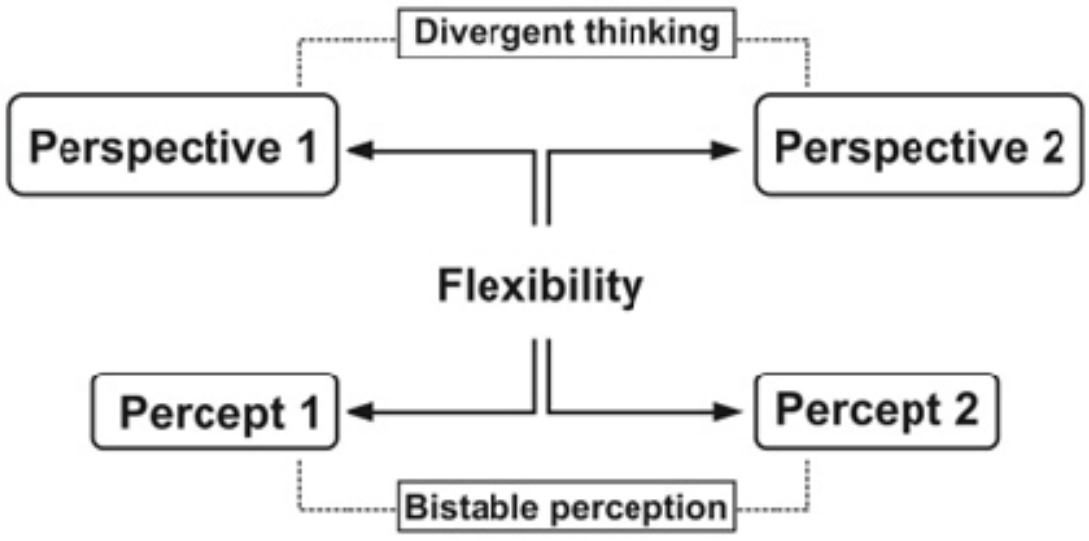

Figure 4. Flexibility and its role in both bistable perception and divergent thinking.

The figure 4 shows that flexibility is implied in both bistable perception and divergent thinking. If the individual is flexible in perceptual terms, he/she will jump easily from one percept to another, a fact that is related to the cognitive flexibility involved in the use of divergent thinking (Taranu & Loesche, 2017). Flexibility, in the context of creative cognition, is understood as the ability to abandon old ways of approaching a problem and knowing how to recognize each situation from different perspectives (Rodríguez, 2016; Romo, 1986; Runco & Acar, 2012). Thus, the ability to make perceptual alternations is just a change of perspective (Laukonnen & Tangen, 2017). A mental restructuring is recognized both, in the use of divergent thinking, and also in the perceptual alternations typical of perceptual bistability (Taranu & Loesche, 2017). This restructuring operates in a similar way both in perceptual bistability processes, and in processes related to changes in perspectives concerning divergent thinking (Schooler & Melcher, 1995).

This unequivocal relationship between the two processes is what has supported that knowing how to do perceptual reversals impacts the way of thinking creatively (Laukkonen & Tangen, 2017; Taranu & Loesche, 2017; Wu, Gu & Zhang, 2019). Based on the aforementioned, the modulating processes (bottom-up and top-down) that are made to encourage the effective performance of perceptual reversals, may have an echo in the creative performance of individuals. In this spirit, learning to make perceptual reconfigurations can contribute to the development of divergent thinking (Rodríguez, 2016). In other words, using modulating perceptual mechanisms that facilitate perceptual alternations may be useful for improving people's creative performance.

In line with the above, it has to be taken into account that some evidence has been found concerning the relation between creative skills and perceptual abilities. Empirical research normally probes creativity by considering the potential for problem solving with novelty, a process known as divergent thinking. However, it is also possible to assess creativity through the lens of perceptual abilities. In this sense, it has been stated that creative individuals are better at perceiving recognizable forms in ambiguous visual stimuli (Bellemare et al., 2022; Diana et al., 2021). Besides, the illusory perception of patterns while observing bistable stimuli might be a potentially useful paradigm to assess creativity (Diana et al., 2021). As regards, new empirical research should be carried out in order to probe and discover why perceptual skills related to making perceptual reversals are linked to creative thought.

By considering what was said before, future research will have to be carried out in order to measure how bistable perception modulating processes can exert a positive impact on the development of people's creativity. Subsequently, it has to be taken into account the close relationship that exists between the perceptual flexibility required for doing perceptual reversals and the changes of conceptual perspective that are also necessary to think creatively. Considering that creativity and bistable figure reversals are related (Wiseman et al., 2011), the need of establishing if the modulation of perceptual processes that enhance bistable perception can influence the dynamics implied in divergent thinking (Arecchi, 2010) emerges, within the context of understanding mental processes that involve flexibility.

4. Conclusions

The ability to do perceptual alternations while observing a bistable image is related to people's creative skills. The perceptual flexibility involved in performing the perceptual reversals is a condition that is related to the cognitive flexibility that is necessary while thinking divergently. With this regard, teaching to do perceptual reversals could contribute to the development of the flexibility necessary for creative cognition. Given that perceptual alternations imply perceptual reconfigurations, it is plausible to think that the learning related to the realization of these reconfigurations can contribute to the development of divergent thinking.

Although a purely causal relationship between bistable perception and creative thinking has not been stated, it is possible to suggest that the processes that encourage the realization of perceptual reversals can contribute to the creative flexibility of individuals, or, at least, be related to this. Thus, the modulating mechanisms of bistable perception (bottom-up and top-down) have a possibility of being incorporated as part of the pedagogical strategies that can be implemented to try to teach how to develop creativity based on perceptual processes that involve flexibility mechanisms.

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