DOI: 10.26387/bpa.2025.00006

Does color preference influence its perception? A pilot study

Valeria Cioffi[1], Chiara Scognamiglio[1], Lucia Luciana Mosca[1], Enrico Moretto[1], Ottavio Ragozzino[1], Enrica Tortora[1], Francesco Marino[1], Giovanni Salonia[2], Claudia Montanari[3], Oliviero Rossi[4], Claudio Billi[5], Paolo Quattrini[6], Alexander Lommatzsch[7], Antonio Ferrara[8], Stefano Crispino[9], Elena Gigante[10], Mariano Pizzimenti[11], Roberta Melis[12], Efisio Temporin[13], Nelson Mauro Maldonato[14], Raffaele Sperandeo[14]

[1] SiPGI - Postgraduate School of Integrated Gestalt Psychotherapy, Torre Annunziata, Italy
[2] Gestalt Therapy Institute - H.C.C. - Human Communication Center - KAIROS, Ragusa, Italy
[3] ASPIC Scuola di Psicoterapia, Roma, Italy
[4] IPGE Istituto di Psicoterapia della Gestalt Espressiva, Roma, Italy
[5] Scuola di Specializzazione in Psicoterapia della Gestalt CGV Centro Gestalt viva Claudio Naranjo, Livorno, Italy
[6] IGF Istituto Gestalt Firenze, Scuola di Specializzazione in Psicoterapia della Gestalt a Orientamento Fenomenologico-esistenziale, Firenze, Italy
[7] IGP Istituto Gestalt di Puglia, Arnesano, Italy
[8] IGAT Istituto di Psicoterapia della Gestalt e Analisi Transazionale, Napoli, Italy
[9] IGA Istituto Gestalt Analitica, Roma, Italy
[10] SIPGI Scuola in Psicoterapia Gestaltica Integrata, Trapani, Italy
[11] SGT Scuola Gestalt Torino, Torino, Italy
[12] SinaPsi Istituto di Psicoterapia della Gestalt, Cagliari, Italy
[13] IGR Istituto Gestalt Romagna, Ravenna, Italy
[14] Department of Neuroscience and Reproductive and Odontostomatological Sciences, University of Naples "Federico II", Naples, Italy

dr.valeria.cioffi@gmail.com

ABSTRACT. In accordo con i moderni modelli neurobiologici, la Gestalt considera la percezione come il risultato dell'integrazione tra segnali corporei (interocettivi e propriocettivi) e stimoli sensoriali esterni, un processo che avverrebbe nella Zona Incerta. La soggettiva percezione cromatica emerge da questa integrazione corpo-sensi. Questo studio pilota ha messo in relazione la percezione dell'immagine ambigua di un famoso 'vestito' con la preferenza cromatica, rilevando una correlazione tra colore preferito e colore percepito e suggerendo che le preferenze influenzano direttamente l'esperienza percettiva.

SUMMARY. According to modern neurobiological models of consciousness, Gestalt psychotherapy theory views perceptual experience as a phenomenon emerging from the interaction between interceptive and proprioceptive processes on the one hand and exteroceptive information on the other. This interaction, from a neurobiological perspective, can be imagined as occurring within the integrative activity of the thalamus, where information from both the body and the sensory organs converges in its nucleus, known as the Zona Incerta. The ambiguous image of a 'dress', which went viral in 2015, provides an additional tool to investigate color experience as some people see the dress as blue and black, others yellow and white. The present pilot study related the perception of the dress image to color preference using the Lüscher Color Test. The survey evidence is strongly suggestive that color preference closely related to the body and emotions directly modifies perceptual experience.

Keywords: *Perceptual experience, Body-senses integration, Color preference, Gestalt psychotherapy theory, Lüscher color test, Zona incerta*

INTRODUCTION

Researchers agree that preverbal mental states (emotions, proprioception and enteroception), intervene in perceptual processes (Carvalho & Damasio, 2021; Pessoa, 2022). Early Gestalt psychology studies had already shown that object-related emotions substantially altered the perception of those objects (Wagemans et al., 2012) by changing their basic properties (brightness, color saturation and size) (Bruner & Postman, 1949). However, actually there is still no agreement on the mechanism underlying this effect. Understanding whether mental states determine the quality of experience by acting directly on perceptual processes (thus being an integral part of perception itself), or by altering the cognitive representation of perception, directs dramatically different solutions to what Chalmers called the "hard problem of consciousness" (Chalmers, 1997).

Gestalt psychotherapy believes that the influence of the body and emotions on perception is determined by a complex process called "es" that incorporates perceptual-motor memories and emotional states and constitutes the subject-referable (subjective) dimension of the perceptual field (Robine, 2006). The "es" function is based on bodily and emotional experiences, influences perception and is in turn modified by perception itself, which modulates bodily and emotional responses, according to an incoercible and inseparable circularity (Francesetti, 2015).

Aesthetic appreciation fosters the formation of a perceptual Gestalt from an ambiguous and undifferentiated perceptual environment. This statement, in the context of Gestalt psychotherapy, has three complementary directions: the preceptive aspect (figure emergence), the phenomenal aspect (insight emergence) and the phenomenological aspect (sense revelation).

Aesthetic meaning in Gestalt psychotherapy is seen as a catalyst for perceptual experience in chaotic contexts. This manifests itself as a possibility of creative transformation of the field that makes what was previously confused or latent spiky (Sarasso et al., 2020).

This is the framework for the present work with the aim of clarifying that mental states, encompassed in the concept of the "es" function, although acting at a level subsequent to the transduction of stimuli participate totally in the genesis of perceptual experience (Gestalt) and do not influence only its cognitive representation. We developed a pilot study on color perception using the strange perceptual phenomenon determined by an image of a dress posted in 2015 on a social network service and quickly went viral. The phenomenon revealed unpredictable differences in the human perception of colors that in our opinion clarify how mental states, perceptual processes and subjective consciousness of the same are different sides of an identical inseparable phenomenon. We studied the dress photo using the Lüscher Color Test (LCT), which assesses color preferences and the emotional states underlying them. The results allowed us (although still a pilot study) to capture the direct effect of mental states on color experience.

Color perception

Color is a ubiquitous feature of our psychological experience, and as a basic aesthetic process it plays a role in many aspects of human behavior. For example, color allows us to distinguish between objects of similar shape, facilitates the emergence of the figure from the background and the recognition of the environment (Gegenfurtner & Rieger, 2000; Osorio & Vorobyev, 1996). What is still missing, however, is a definitive neural and psychological theory that explains, in a comprehensive way, the perception of color and psychologically relevant hues (Emery, Volbrecht, Peterzell, & Webster, 2017).

The color of the visible world is related to the wavelength of light rays reaching the receptors in the retina. In the case of a blue-colored object, for example, the surface of the object mainly reflects electromagnetic waves with a length around 500 nanometers. The human being's retina possesses three types of cones that respond to wavelengths between approximately 400 and 700 nm; each of the cone populations responds maximally to a specific frequency, but variably responds to other frequencies as well. Thus, light reaching any part of the retina is translated into three neuronal responses, the combination of which generates a three-dimensional color space that allows the experience of some 26,000 different colors that we can distinguish from one another even if we cannot name them all. However, it should not be assumed that there is substantial identity between specific wavelengths and specific colors (Wolfe et al., 2023). In the words of Steven Shevell, "there is no red in 700 nm light"; color, like pain, is the result of the interaction between a physical stimulus is a specific biological system (Shevell, 2003).

Among the main theories explaining the experience of color, we will give relevance in this paper to Hering's theory of color oppositeness, which clarifies that some color pairs, defined as opposites, cannot be perceptually combined. The opposite color pairs are: the green/red pair and the blue/yellow pair. It is not possible to see a green tending to red and a blue tending to yellow while it is possible to see a green tending to yellow is a red tending to blue (Stockman & Brainard, 2010).

We know that the experience of colors is generated in the visual cortex but it is not clear how this happens. During the last century, researchers had identified a population of color-related neurons in the occipital V1 area (Zeki, 1983). These cells were sending inputs to V2 area and V4 area proposed by Zeki as specialized for color (Livingstone & Hubel, 1988). These cells, however, were shown to respond to polymodal stimuli (color, light intensity and orientation) and it is unclear therefore, whether we can separate color processing the other perceptual processes (Shapley & Hawken, 2011). However, the existence of cases of achromatopsia following brain damage documents the existence of specific central processing of color experience (Zeki, 1990).

More recently, numerous neurobiological models of psychic functions have highlighted the importance of thalamic and truncated brain areas in determining the subjective experience of perception. In this sense, the Zona Incerta (ZI) (Wang, Chou, Zhang, & Tao, 2020), a largely inhibitory subthalamic region that connects to many brain areas, appears to play a relevant role in the integration of sensory and emotional processes within visual and auditory experiences (Arena et al., 2023).

Color preference

Color preference is an important aspect of visual experience. Thanks to modern well-calibrated displays and standardized computer-generated colors, scholars have established that there are indeed, in human samples, reliable and repeatable patterns of color preference (Sokolova, Fernández-Caballero, Ros, Latorre, & Serrano, 2015). These preference patterns are evident if preference is studied in the three primary dimensions of color experience: hue, saturation and brightness (Whitfield, & Wiltshire, 1990). Decades of research have documented, in fact, that on average, adults in the United States and the United Kingdom prefer shades of blue more and shades of yellow-green (especially dark) less.

Some research has suggested explanations of the phenomenon based on biological adaptations. Hurlbert and Ling's (2007) study, for example, found a female tendency for reddish shades. The authors argued that this difference could be evolutionarily attributed to foraging behavior carried out predominantly by females.

Other studies have emphasized the link between emotions and color. It has been widely documented that color characteristics such as saturation, hue or brightness induce emotional reactions (Franklin, Bevis, Ling, & Hurlbert, 2010; Teller, Civan, & Bronson-Castain, 2004), and that chromatic images convey emotional information better than achromatic ones (Schloss, Strauss, & Palmer, 2013). The green, for example got the most links to positive emotions, followed by yellow, blue, red and purple. The basic hypothesis is that people can appreciate colors to the extent that they appreciate the emotions that are evoked or associated with those colors (Schloss et al., 2013).

Another interesting explanation of color preferences comes from the ecological valence theory (EVT), which proposes that adults like colors according to these colors are associated with liked objects. EVT states that people tend to like blue and cyan because they like clear skies and clean water and tend to dislike brown and olive colors because they dislike feces and rotting food. Then preference crystallizes because it is adaptive for organisms to approach objects and situations associated with colors they like and avoid objects and situations associated with colors they dislike (Niranjana, 2020).

Finally, a relationship between color preference, anxiety and depressive states, schizophrenia, gender, and character traits has been documented (Del Longo, 2011; Jung, Mahmoud, El Samanoudy, & Al Qassimi, 2022; Tao et al., 2015). It is likely that the presence of anxiety states or major emotions, even nonconscious ones cause color preference to vary as has been documented by Lüscher in his color test (Del Longo, 2011).

The fundamental question of how color preference arises is still unanswered. It is evident, however, the link between mental states and color preference (Taylor & Franklin, 2012).

Color preference is an aspect of mental state to the extent that at the same time, it reflects and modulates affective and emotional dimensions of the individual. Numerous studies have shown systematic associations between colors and emotional states, suggesting that color choices are not arbitrary but related to underlying psychological processes

(Bloom, 2003; Francesetti, 2012; Sarasso et al., 2022; Sarasso et al., 2024; Spagnuolo Lobb, 2023)

There is no doubt that aesthetic experience arises in perception at an early level, but we wondered whether the reverse is also true, that is, whether perception is formed early within a matrix determined by the complexity of the mental state of which aesthetic preference is an expression.

Studying color preference

Preference for a given sample of colors can be measured by simultaneously showing observers all the colors on a color table and asking them to rank them from most preferred to least preferred (Palmer, & Schloss; 2015). Color tests using color tables are useful tools for studying people's emotional state and proprioceptive body experience (Kadlubovich & Chernyak, 2022).

The Lüscher Color Test (LCT) is one of the most widely used psychological reagents by humanistic therapists and in the arts to explore the relationship between mental states and color preferences. The main advantage of this test is its ease of administration (Lüscher, 1997). Although its validity, as a descriptive instrument of psychic functioning, has often been considered, by methodologically questionable studies, to be insufficient or too low (Braun & Bonta, 1979; Donnelly, 1974; French & Alexander, 1972; Singg & Whiddon, 2000). Its effectiveness as an instrument capable of assessing the impact of psycho-physiological-emotional states on color preference is unquestionable. Some studies have shown that the TCL has more than 80% agreement with other personality assessment instruments in detecting in subjects the presence of psychological distress (Donnelly, 1977; Ledford, & Hoke, 1981). In addition, concordance, although low, has been found between this test and the MMPI (Holmes, Wurtz, Waln, Dungan, & Joseph, 1984). The LCT identifies the four the basic colors of Hering's pairs of opposites and considers them indicators of both basic emotional functioning and that determined by people's current life situation. The basic colors are arranged by subjects in the first two preferred positions (+ function) if the current life experience is flatly and fluidly colored by the specific emotion related to the color. If the psycho-physiological-emotional experience connected with the specific color conflicts with the current life experience, the color is placed in the last two preference positions indicative of color rejection (- function).

AIMS OF THE STUDY

The quality of psycho-physiological-emotional experience related to life events, which can be defined as mental state is an unconscious process and is described in equivalent ways by the theory of self of Gestalt psychotherapy (Francesetti & Roubal, 2020), Damasio's concept of proto-se (Damasio & Damasio, 2023) and recent work by Luiz Pessoa (2023). The authors of the present paper believe that the mental state directly modulates perceptual experiences and that this action is detectable through the study of color preferences.

In 2015, a photo of a dress went viral on the web. This photo referred to as 'the dress' showed a stylish dress with stripes of two colors. A percentage of people who see this picture assert that the stripes are blue and black, another, slightly smaller percentage of people say the stripes are white and gold, and finally to an even smaller number of people the dress appears blue and yellow. Some studies have attempted to give an answer to the mystery, but a clear explanation has not yet been obtained (Gegenfurtner, Bloj, & Toscani, 2015; Wallisch, 2017). Conway believes that such chromatic dispersion is related to the shades of light in the photo that causes people's perceptual system to eliminate blue frequencies or yellow frequencies (Lafer-Sousa et al., 2015).

The phenomenon of the dress image provides an opportunity to investigate the link between color preference and color perception by using the LCT, an easy-to-use instrument, to assess the color preference of individual subjects.

The aim of this research is to investigate the relationship between color perception and basic psycho- physiological-emotional state by evaluating the relationship between the results obtained from the Lüscher test and the perception responses generated by the photo 'the dress'.

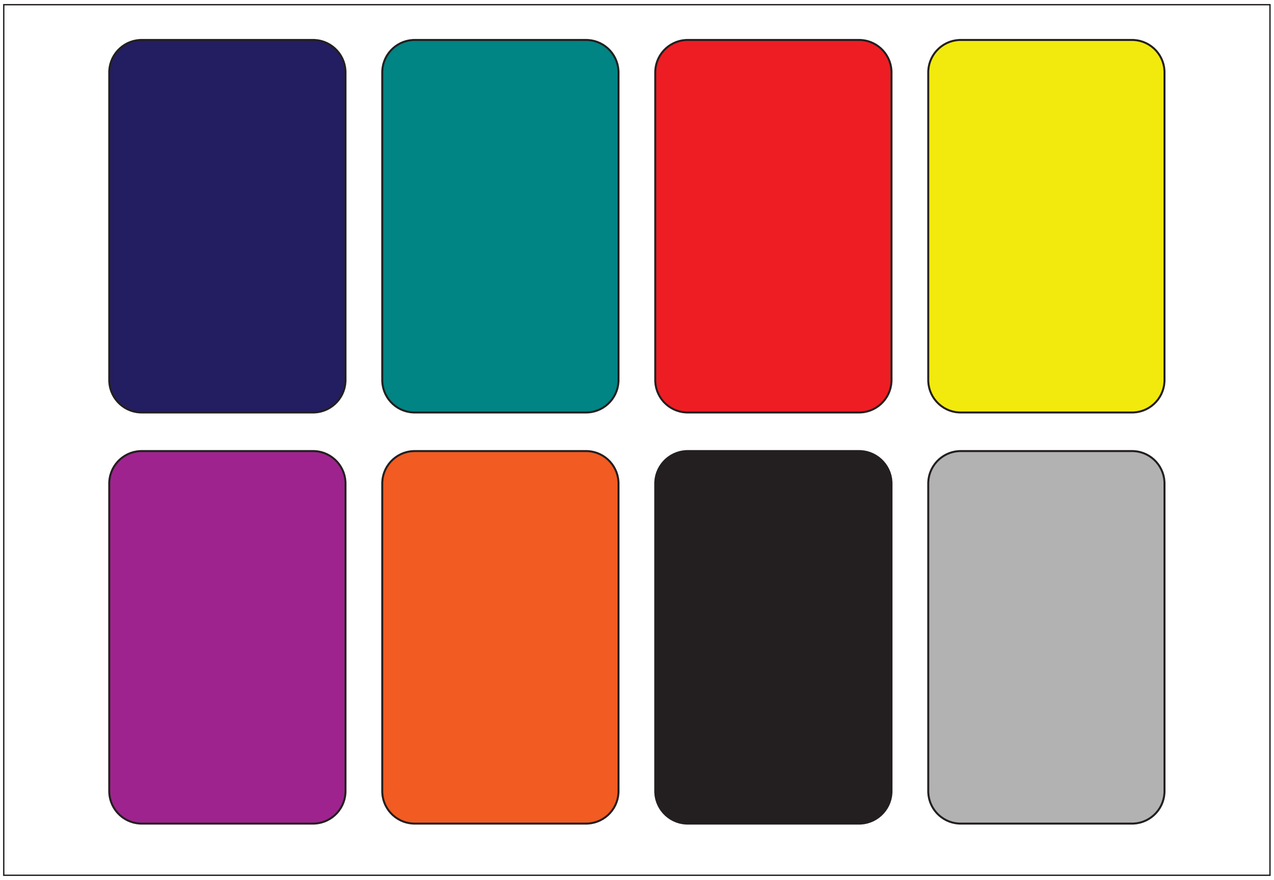
This is a pilot study that opens up the possibility of further investigating the link between mental states and perceptual processes with the ultimate goal of defining a descriptive model of subjective conscious experience.

METHODS AND MATERIALS

Lüscher Color Test

The Lüscher Color Test is a widely used instrument to assess an individual's personality through his or her color preferences. Created by Max Lüscher in 1947, this test is based

Figure 1 – Lüscher chart of card colors



on the idea that color choices reflect aspects of an individual's personality and emotional state. In the 8-color test, published in 1969, eight color cards are used, each representing a possible choice by the participant. These colors are red, green, yellow, blue (primary colors), purple, brown, gray and black (auxiliary colors) (see Figure 1). The participant is presented with the 8 colored cards and asked to sort the colors according to his or her preferences, starting with the color he or she prefers most. After a first administration, a second administration is to be carried out shortly afterwards, assuming that it is to be considered the most reliable one.

According to the author, the arrangement and order of the colors chosen provide psychological information about an individual's personality and emotional state. For example, red is often associated with a dynamic and energetic personality, green may indicate harmony and adaptability, yellow may reflect an optimistic attitude, and blue is commonly associated with a reflective nature (see Table 1).

For the purpose of our study, the colors preferred by the subject and placed in the first and second positions are important (see Table 2).

Photo of 'the dress'

The dress in the photo is of two colors, but surprisingly some people see it as blue and black, others white and yellow-gold, still others see it as blue and brown.

A large-scale study of the dress published in *Current Biology*, involving 1400 people, showed that 57% of participants saw the dress blue-black, 30% white-gold, 11% blue-brown, and 2% reported seeing it other colors (Gegenfurtner et al., 2015).

In our study, the picture of the dress displayed in three distinct ways allowed us to divide the sample into three subgroups based on the color the subjects reported perceiving.

Table 1 – The meaning of colors in Lüscher's Color Test

N.	Color	Meaning
1	Blue	*Depth of feelings*
2	Green	*Elasticity of will*
3	Red	*Force of will*
4	Yellow	*Spontaneity*
0.	Grey	*Non-involvement*
5	Violet	*Identification*
6	Brown	*Bodily senses*
7	Black	*Renunciation*

Table 2 – The four functions described by Lüscher's Color Test

Symbol	Functions	Position
+	Appropriate behavior enabled for desired goals	1° and 2°
X	Appropriate behavior activated during the existing situation	3° and 4°
=	Inappropriate behavior deactivated in the existing situation	5° and 6°
–	Rejected or repressed behavior in the existing situation	7° and 8°

Sample and procedures

The study was conducted in a sample of 100 adult subjects aged 20 to 64 years (average age 36), 68 females and 32 males. Subjects with pathological personality traits and those with color blindness were excluded from the research.

Prior to the administration of the LCT, the perception of colors in the image of 'the dress' was assessed for each of the subjects. Subjects after observing 'the dress' on a laptop computer screen indicated the colors they had displayed in the image on a 120-color HSB (Hue-Saturation-Brightness) color spectrum presented simultaneously on the same computer screen.

Subsequently, the same subjects were administered the Lüscher Color Test as per the prescribed protocol.

Color preferences were initialed according to Lüscher's standard protocol of categorizing the position of the eight colors in the 4 features and the abnormal placement in the last 3 positions of the main colors. However, for the purpose of the pilot phase of the study, only colors placed in the first 2 positions considered indicative of a color preference were used.

Figure 2 – The dress original photo

Statistical methods

The subjects, who displayed in the image 'the dress' the yellow and white colors, were assigned to group 1, those who displayed in the image the brown and blue colors were assigned to group 2 finally, those who displayed in the image the blue and black colors, were assigned to group 3.

Then the sample was divided into three groups based on preferred color. This classification resulted in the following groups: an A group that preferred the yellow, a second B group that preferred the blue, and a third C group that preferred another color.

First, the *t*-test was used to determine if there were any differences in the age of the sample subjects with respect to both the color sight (yellow or blue) and the preferred color (yellow or blue).

In addition, the color sight and the preferred color were compare trough Chi-squared test by excluding the group of subjects who preferred another color.

Then, considering the preference for the yellow or blue colors as a predisposing condition for viewing in the dress figure the yellow (outcome number 1) and the blue (outcome number 2), respectively, the Odds Ratio for the two outcomes was calculated.

Participants were divided into three distinct groups based on their perception of the colors of the image known as 'the dress'. Subjects who reported seeing the dress as white and gold were assigned to group 1; those who saw it as brown and blue to group 2; and those who perceived it as blue and black to group 3.

Separately, subjects were also categorized according to self-reported color preference, generating three additional groups: group A (preferred yellow), group B (preferred blue), and group C (preferences other than yellow or blue).

To analyze any differences in mean age between the groups, independent samples *t*-tests were used. The analysis was conducted in two separate comparisons:

– to assess age differences between those who perceived the image as white-gold and those who perceived it as blue-black;
– to compare age between those who preferred yellow and those who preferred blue.

The *t*-test was chosen because it allows comparison of the means of two independent groups, assuming that the data follow an approximately normal distribution and that the variances are similar.

To explore the association between color perception and color preference, the Chi-squared test with Fisher's Exact Test was used for both the inter sample and for males and females. This test allows us to assess whether there is a statistically significant relationship between two categorical variables, in this case color perception (yellow *vs* blue *vs* yellow and blue together) and color preference (yellow *vs* blue). For the purpose of this analysis, subjects in group C (with different preferences) were excluded, so as to structure a 3x2 contingency table, aiding the interpretability and statistical robustness of the test.

Finally, to quantify the strength of the association between color preference and perception of dress color, the odds ratio (OR) was calculated. In this analysis, the exposure variable was color preference (yellow *vs* blue), while the outcome was dress color perception (yellow-based *vs* blue-based perception). The odds ratio estimates the odds of perceiving the dress as white-gold in subjects preferring yellow versus those preferring blue. This measure is commonly used in observational studies to assess relative risk in the presence of dichotomous variables.

All statistical analyses were performed using SPSS version 25, and the statistical significance threshold was set at $p<.05$.

RESULTS

Table 3 describes the perception of the dress colors of the sample subjects. 36 subjects, who displayed in 'the dress' image the yellow and white colors, were assigned to group 1; 22 subjects, who displayed in 'the dress' image the blue and yellow colors, were assigned to group 2; 42 subjects, who displayed in 'the dress' image, the blue and black colors, were assigned to group 3. This distribution in three groups approximately corresponds to that found in the literature.

Table 4 shows the classification of the sample according to the subjects' color preference: a group A of 46 subjects who preferred the yellow, a second group B of 33 subjects who preferred the blue, and a third group C of 21 subjects who preferred another color.

An initial analysis of the sample, considering the gender of the subjects, revealed no statistically significant differences in either color vision or color preference between males and females. Similarly, no statistically significant differences were found with respect to the age of the subjects: the age of the subjects did not change between those who preferred yellow and those who preferred blue, nor between those who saw yellow and those who saw blue.

Next, a Chi-squared test, the Fisher's exact test, was performed to compare the color sight and the preferred color, taking into account the gender of the subjects in the sample, examining only the group of individuals who expressed a preference for the yellow (group A) and the group of individuals who expressed a preference for the blue (group B). This analysis showed a significant correlation between the

Table 3 – Colors displayed in the image "the dress"

	N. subjects	Colors displayed in the image "the dress"
Group 1	36	WHITE - YELLOW (OUTCOMES No. 1: vision of the color yellow in the dress)
Group 2	22	BLUE - YELLOW (OUTCOMES No. 1 and 2)
Group 3	42	BLUE - BLACK (RESULT No. 2 vision of the color blue in the dress)

Table 4 – Preferred color

	N. subjects	Preferred color
Group A	46	YELLOW
Group B	33	BLUE
Group C	21	OTHER COLORS

color sight and the preferred color for both males and females (see Table 5).

From the results gender did not seem to influence the correlation between the color sight and the preferred color.

Relative to the visualization of the yellow and blue colors, observation of the dress image (since the second group perceives both yellow and blue) produced two possible outcomes: 27 subjects had outcome 1 "the dress is yellow", 35 subjects had outcome 2 "the dress is blue". Table 6 describes the calculation of the odds ratio (OR) for outcome 1 at the observation of the photo: "the dress is yellow".

33 subjects in the examined sample indicated yellow as their favorite color in the Lüscher test by placing it in the first or second position. 20 of these 33 subjects (two-thirds) saw yellow in the dress photo. 29 subjects in the sample did not choose yellow as their preferred color by inserting it in the third to eighth positions of the LCT; of these 29 subjects, 7 (one-third) see yellow in the dress picture. Considering the yellow color preference as a condition that predisposes to the perception of the yellow in the dress photo, the OR was calculated showing that among subjects who prefer the yellow, the perception of this color is a 4,83 times more frequent occurrence.

Table 7 describes the calculation of the odds ratio (OR) for outcome 2 at the observation of the photo: "the dress is blue".

Twenty-nine subjects in the surveyed sample indicated blue as their favorite color in the Lüscher test by placing it in the first or second chosen position of the test. 22 of these 29 subjects (three-quarters) saw blue in the dress picture. 33 subjects in the sample did not choose blue as their preferred color by inserting it in the third to eighth positions of the LCT, of these 33 subjects, only one-third (No. 3) see blue in the dress picture. Considering the preference of the blue as a condition that predisposes to the perception of the blue in the dress photo, the odds ratio was calculated showing that among subjects who prefer the blue, the perception of this color is a 4,83 times more frequent occurrence.

Table 5 – Chi-squared test

Gender			Color vision			Total	X^2 Fisher's Exact Test	*p*	Confidence Interval 99%	
			yellow	blue	yellow/ blue				LL	UL
F	Color preferred	yellow	15	9	7	31	6.833	.029	0.024	0.033
		blue	4	14	4	22				
	Total		19	23	11	53				
M	Color preferred	yellow	5	4	6	15	7.393	.024	0.020	0.028
		blue	3	8	0	11				
	Total		8	12	6	26				
M and F	Color preferred	yellow	20	13	13	46	11.511	.003	0.002	0.005
		blue	7	22	4	33				
	Total		27	35	17	79				

Table 6 – Frequency of outcome 1: "the dress is yellow" in relation to yellow as the preferred color

Preferred color	They see yellow in the photo	They don't see yellow in the photo	Total
They prefer yellow	20	13	33
They don't prefer yellow	7	22	29
Total	27	35	62
OR: 4.83 - IC 99% (LL = 1.327 – UL = 18.263)			

Table 7 – Frequency of outcome 2: "the dress is blue" in relation to blue as the preferred color

Preferred color	They see blue in the photo	They don't see blue in the photo	Total
They prefer blue	22	7	29
They don't prefer blue	13	20	33
Total	35	27	62
OR: 4.835 - IC 99% (LL= 1.135 - UL = 20.583)			

DISCUSSION AND CONCLUSIONS

Our sample has 3 subgroups derived from the color perception of the dress photo; the first of them perceives yellow, the third perceives blue, and finally the second has the perception of both colors. The first reflection that emerges from observing the data is related to the fact that the subjects in the study perceive opposite colors in the dress photo according to the theory of color oppositeness. Consequently, the perception of either the blue or the yellow (opposing colors for which no intermediate color combinations are allowed) cannot be generated by a different saturation of the color stimulus due to the different response intensities of the S-cones and L-cones. Basically, it is not conceivable that in the group that perceives yellow, for example, there is a response intensity of the L-cones (responding to waves of the length between 570 and 630 nm-yellow color) so great that it covers the response of the S-cones (responding to waves of the length between 450 and 500 nm-blue color). The perception of yellow or blue, in fact, is not determined by the interaction of the response intensity of these two populations of cones; if both S-cones and L-cones are stimulated in an image, both colors are generally perceived (although each person may perceive a different saturation of them), as also documented by subgroup 2 of our sample that perceives both yellow and blue (Krauskopf, Williams, & Heeley, 1982).

The Chi-squared comparation of the color sight and the preferred color, between the group of individuals who expressed a preference for the yellow (group A) and the group of individuals who expressed a preference for the blue (group B), showed a significant correlation between the color sight and the preferred color for both males and females. Specifically, subjects who perceived yellow more frequently had a preference for the yellow while subjects who perceived blue preferred the blue. This obvious link between preference of one of the two opposite colors and perception of the same in the dress picture is also documented by the OR: the subsample of subjects who prefer the yellow sees, in the picture image, this color 4,8 times as frequently as the group of subjects who do not prefer the yellow; at the same time the subsample of subjects who prefer the blue, sees this color in the picture 4,8 times as frequently as the population who do not prefer blue.

Considering color preference as a multimodal process that takes place at the level of the diencephalon and telencephalon, (Csillag, Kabai, & Kovach, 1985) it is a reliable hypothesis that both linguistic and cognitive as well as emotional and bodily processes converge to determine it. In this sense, color preference emerges as an essential part of the perceptual process of colors; in our opinion, this phenomenon may represent one of the ways through which body states and emotions modulate perception.

To explain the phenomenon of the perception of two different colors, we must hypothesize the presence of higher-order chromatic mechanisms by which the brain infers the color of its subjective experience of the image from the mosaic produced by the activity of the cones (Brainard, 2015).

Although in nearly 30 years of research there has been no agreement on higher-order mechanisms related to color preference, (Eskew Jr, 2009) it seems impossible to rule out the existence of these processes. We propose an interpretation of the central order phenomenon with processes located in the interaction between the functions of the brainstem and those of the thalamus. We believe that processes occur at this anatomical level that totally exclude access to the sensory cortical areas, and thus to consciousness, of the response of the cones to electromagnetic frequencies related to yellow or blue.

In the following paragraphs we will develop a hypothesis explaining the mechanism underlying this direct impact of emotional and body states on perception.

Most theories of emotion and body states (pre-verbal mental states) agree that an emotional episode begins with a sensory experience, such as a visual perception, that elicits a cascade of affective, cognitive, physiological, and/or behavioral responses (Panksepp & Biven, 2014). However, there is currently a tendency to assume that the perception–emotion relationship is, in fact, bidirectional, with emotion also intervening in the perceptual process (Fuchs, 2020).

Damasio, moving beyond the idea that emotion affects perception and introducing the concept of proto-self, describes this interaction in this way: “In my view, the essential change in the proto-self results from its instant-by-instant involvement, triggered by whatever object is perceived. The involvement takes place in close temporal proximity to the sensory processing of the object” (Carvalho & Damasio, 2021). It seems indeed that emotions and body states color every aspect of our experiences by a multimodal mechanism (Jertberg et al., 2019).

For example, the simple act of identifying an emotionally relevant stimulus in a visual, auditory or tactile task induces subtle but systematic changes in heart rate. Perception thus affects the regulation of heart rate. Interestingly, the connection also goes in the opposite direction: interoceptive neural activity at the time an external stimulus is presented influences the fate of the external stimulus, making it, for example, more or less likely that a neutral visual or somatosensory stimulus will be detected (Schaefer & Gray, 2007).

Gestalt psychotherapy, with its theoretical model strongly rooted in Gestalt psychology (Goldstein, 2014), offers an interesting interpretation on how exteroception and enteroception interact producing the experience of es (Goldstein, 2014). Exteroceptive perception, proprioception and enteroception are closely intertwined. The way we perceive a face, facial expression or scene is influenced by the muscular, vegetative, affective and emotional tone of our body and affects our behavioral response (Perls, Hefferline, & Goodman, 1951). According to gestalt psychotherapy, es related perceptual coding simultaneously involves multiple levels of self-representation, including physiological homeostasis, the body’s physical integrity, its morphology and position. The close interaction between enteroception and exteroception implies that perceptual scenes are always affectively colored. Enteroception, i.e., perception of the physiological state of the body, operates in conjunction with exteroception and cognition to restore homeostatic balance. Interoceptive signals interact with the perception of external stimuli as also documented by recent evidence showing interoceptive influences on cognition and perception.

Relative to neurophysiological mechanisms a specific thalamus area appears to fulfill this important integrative function. The Zona Incerta, a region of the subthalamus (which appears to be a continuation of the ascending root formation of the brainstem) receives afferents, from the sensory cortices and the brainstem itself, and projects efferences to the reticular nucleus of the thalamus and the superior colliculi. This area seems to have the right anatomotopographic location to act directly on visual perception. Its afferents and efferences hint at its role in integrating proprioceptive and interceptive information collected by the thalamus with the exteroceptive information sent by the sensory cortices and modulating perception through the reticular nucleus and superior colliculus (Shaw & Mitrofanis, 2002), More clearly, the ZI seems to play a function of harmonizing polymodal stimuli, starting inside and outside the organism, which generates the preverbal sense of Self on which the conscious experience of reality and thus also the consciously perceived color in an image largely depends (Chometton, Barbier, & Risold, 2021).

The perspective presented in this paper suggests that perception is the product of the interaction between many brain areas. Very interesting is the role of proprioception and enteroception and emotionality, which as processes located in the body and the biology of the person provide the subjective coloring of perceptual experience. This subjective dimension contains both the history and current state of the body and imprints individual differences in perceptions (Braun & Bonta, 1979). According to Gestalt psychotherapy, the emergence of subjective experience is the first stage of consciousness on whose fluidity and ability to rebalance homeostasis the person's adaptive capacity depends.

Limitations of the study and future developments

The small sample size (it requires major expansion to enable us to make a strong statement of the value of the evidence that has emerged) allows us to use this scientific investigation as a pilot study that offers interesting perspectives for further research correlating color preference, mental state, and color perception in the dress picture.

However, our work has some limitations: the first limitation is having explored as the only correlate in the perception of blue or yellow in the dress pictures, the subjects' automatic preference using only the TCL to assess it. Moreover, color preference was considered, based on literature data as an adequate indicator of an individual's mental state. Of course, these two items are approximations, but in our opinion, they are acceptable, as the research is proposed as an exploratory investigation that need of significant expansion.

The second limitation concerns the lack of a control group with the sequence of test administration reversed to test the possible influence of color perception in 'the dress' task on the subsequent test of preference (TCL).

At a later stage a study will be expanded in three directions: increasing the number of subjects and using mental state assessment tools and further methods to assess the preferred color of the sample members by associating, for example, colors with an object and using color cards with different brightness and saturation and ultimately introducing a control group to assess the possible influence of one measure on the other.

However, even with the limitations we have just clarified the present study allows us to clearly propose the relationship between brainstem and thalamic processes and perception as an explanatory element of the difference of subjective experience in the world, recognizing how preverbal nonconscious psychic phenomena can determine, in accordance with gestalt psychotherapy an important part of the perceptual experience in which psychopathological mechanisms can be identified.

Data availability statement: The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author. **Ethics statement:** The studies involving human participants were reviewed and approved by Consiglio del Dipartimento 11/26.05.2020 Prot. n. 46540. The patients/participants provided their written informed consent to participate in this study.
Author contributions: VC, EM, OR, FM, and LM contributed to conception and design of the study. ET and OR organized the database. RS and VC performed the statistical analysis. CS, VC, CM, FM, and LM wrote the first draft of the manuscript. VC, EM, and LM wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version. **Supplementary material:** The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.671790/full#supplementary-material

References

ARENA, G., LONDEI, F., CECCARELLI, F., FERRUCCI, L., BORRA, E., & GENOVESIO, A. (2023). Disentangling the identity of the zona incerta: A review of the known connections and latest implications. *Ageing Research Reviews*, 102140.

BLOOM, D. (2003). Tiger! Tiger! Burning bright-aesthetic values as clinical values in Gestalt therapy. In M.S. Lobb, & N. Amendt-Lyon (Eds), *Creative license*. Wien: Springer. doi.org/10.1007/978-3-7091-6023-7_6

BRAUN, C.M., & BONTA, J.L. (1979). Cross-cultural validity, reliability, and stimulus characteristics of the Lüscher Color Test. *Journal of Personality Assessment*, *43* (5), 459-460.

BRAUNER, J., & BONTA, J.L. (1983). Cross-cultural validity of color interpretation. *International Journal of Psychology*, *18* (4), 215-228.

BRUNER, J.S., & POSTMAN, L. (1949). On the perception of incongruity: A paradigm. *Journal of Personality*, *18* (2), 206-223.

CARVALHO, G.B., & DAMASIO, A. (2021). Interoception and the origin of feelings: A new synthesis. *BioEssays*, *43* (6), 2000261.

CHALMERS, D.J. (1997). *The conscious mind: In search of a fundamental theory*. Oxford Paperbacks.

CHOMETTON, S., BARBIER, M., & RISOLD, P.Y. (2021). The zona incerta system: Involvement in attention and movement. *Handbook of Clinical Neurology*, *180*, 173-184.

CSILLAG, A., KABAI, P., & KOVACH, J.K. (1995). Effects of diencephalic lesions on approach responses and color preferences in quail. *Physiology & Behavior*, *58* (4), 659-664.

CSILLAG, A., & KOVACH, J.K. (1998). Further insights into color preferences. *Behavioral Science*, *43* (2), 345-352.

DEL LONGO, N. (2011). *Il test dei colori di Lüscher: Manuale di diagnostica per l'età evolutiva*. Franco Angeli.

DEL VECCHIO, A. (2014). *Il colore e la psicologia*. Milano: Franco Angeli.

DONNELLY, F.A. (1974). The Lüscher Color Test: Reliability and selection preferences by college students. *Psychological Reports*, *34* (2), 635-638.

DONNELLY, F.A. (1977). The Lüscher Color Test: A validity study. *Perceptual and Motor Skills*, *44* (1), 17-18.

EMERY, K.J., VOLBRECHT, V.J., PETERZELL, D.H., & WEBSTER, M.A. (2017). Variations in normal color vision: VI. Factors underlying individual differences in hue scaling and their implications for models of color appearance. *Vision Research*, *141*, 51-65.

ESKEW Jr, R.T. (2009). Higher order color mechanisms: A critical review. *Vision Research*, *49* (22), 2686-2704.

FRANCESETTI, G. (2012). Pain and beauty: from the psychopathology to the aesthetics of contact. *British Gestalt Journal*, *21* (2).

FRANCESETTI, G. (2015). From individual symptoms to psychopathological fields: Towards a field perspective on clinical human suffering. *British Gestalt Journal*, *24* (1), 5-19.

FRANCESETTI, G., & ROUBAL, J. (2020). Field theory in contemporary gestalt therapy, part 1: Modulating the therapist's presence in clinical practice. *Gestalt Review*, *24* (2), 113-136.

FRANKLIN, A., BEVIS, L., LING, Y., & HURLBERT, A. (2010). Biological components of colour preference in infancy. *Developmental Science*, *13* (2), 346-354.

FRENCH, C.A., & ALEXANDER, A.B. (1972). The Lüscher Color Test: An investigation of validity and underlying assumptions. *Journal of Personality Assessment*, *36* (4), 361-365.

FUCHS, T. (2020). The circularity of the embodied mind. *Frontiers in Psychology*, *11*, 538478.

GEGENFURTNER, K.R., BLOJ, M., & TOSCANI, M. (2015). The many colours of 'the dress'. *Current Biology*, *25* (13), R543-R544.

GEGENFURTNER, K.R., & RIEGER, J. (2000). Sensory and cognitive contributions of color to the recognition of natural scenes. *Current Biology*, *10* (13), 805-808.

GOLDSTEIN, E.B. (2014). *Sensation and perception*. Belmont, CA: Wadsworth Cengage Learning.

GOLLIN, E.S. (1971). The Lüscher Color Test revisited. *Journal of Experimental Psychology*, *89* (3), 402-410.

HOLMES, C.B. (1973). Lüscher and color perception: Reliability and underlying assumptions. *Journal of Experimental Psychology*, *87* (2), 304-311.

HOLMES, C.B., WURTZ, P.J., WALN, R.F., DUNGAN, D.S., & JOSEPH, C.A. (1984). Relationship between the Lüscher Color Test and the MMPI. *Journal of Clinical Psychology*, *40* (1), 126-128.

HURLBERT, A.C., & LING, Y. (2007). Biological components of sex differences in color preference. *Current Biology*, *17* (16), R623-R625.

JUNG, C., MAHMOUD, N.S.A., EL SAMANOUDY, G., & AL QASSIMI, N. (2022). Evaluating the color preferences for elderly depression in the United Arab Emirates. *Buildings*, *12* (2), 234.

KADLUBOVICH, T., & CHERNYAK, D. (2022). Color preferences as a means of studying the personality and its surrounding reality. In *Challenges and Prospects of the Implementation of Political, Historical, Philosophical, and Sociological Research Amidst Digitalization*. Baltija Publishing, Riga.

KRAUSKOPF, J., WILLIAMS, D.R., & HEELEY, D.W. (1982). Cardinal directions of color space. *Vision Research*, *22* (9), 1123-1131.

KWON, Y., & HONG, S. (2019). Validity of color interpretation in psychological assessments. *International Journal of Psychology*, *34* (5), 499-512.

LEDFORD, R.S., & HOKE, W.E. (1981). Self-report as a validity check for the Lüscher color test. *Perceptual and Motor Skills*, *53* (2), 545-546.

LIVINGSTONE, M., & HUBEL, D. (1988). Segregation of form, color, movement, and depth: Anatomy, physiology, and perception. *Science*, *240* (4853), 740-749.

LÜSCHER, M. (1969). *The Lüscher Color Test*. Random House.

LÜSCHER, M. (1997). *Il test dei colori: diagnostica e terapia*. Armando Editore.

MULLINS, P. (1997). Color psychology and emotional responses: A review. *Psychological Studies*, *22* (1), 55-68.

NIRANJANA, C.N. (2020). *A comparative assessment of emotional association with colour preference and anxiety levels in children: A cross-sectional study*. Doctoral dissertation, Rajiv Gandhi University of Health Sciences, India.

NOLAN, C. (2015). Lüscher's color theory in psychological practice. *Psychological Reports*, *45* (3), 887-898.

OSORIO, D., & VOROBYEV, M. (1996). Colour vision as an adaptation to frugivory in primates. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, *263* (1370), 593-599.

PALMER, S.E., & SCHLOSS, K.B. (2010). An ecological valence theory of human color preference. *Proceedings of the National Academy of Sciences*, *107* (19), 8877-8882.

PALMER, S.E., & SCHLOSS, K.B. (2015). *Color preference. Encyclopedia of Color Science and Technology*. Springer Science + Business Media.

PANKSEPP, J., & BIVEN, L. (2014). *Archeologia della mente: Origini neuroevolutive delle emozioni umane*. It. ed. edited by A. Clarici & A. Alcaro. Milano: Raffaello Cortina.

PERLS, F.S., HEFFERLINE, R.F., & GOODMAN, P. (1951). *Gestalt therapy: Excitement and growth in the human personality*. Dell Publishing.

PESSOA, L. (2022). *The entangled brain: How perception, cognition, and emotion are woven together*. MIT Press.

ROBINE, J.M. (2006). *Il rivelarsi del sé nel contatto: studi di psicoterapia della Gestalt*. Franco Angeli.

ROMANO, A., & FERRARA, M. (2018). Practical applications of color psychology in clinical settings. *Behavioral Science*, *38* (4), 255-263.

SARASSO, P. et al. (2020). Beauty in mind: Aesthetic appreciation correlates with perceptual facilitation and attentional amplification. *Neuropsychologia*, *136*, 107282.

SARASSO, P. et al. (2022). Beauty and uncertainty as transformative factors: A free energy principle account of aesthetic diagnosis and intervention in Gestalt psychotherapy. *Frontiers in Human Neuroscience*.

SARASSO, P. et al. (2024). Nature heals: An informational entropy account of self-organization and change in field psychotherapy. *Physics of Life Reviews*.

SCHLOSS, K.B., STRAUSS, E.D., & PALMER, S.E. (2013). Object color preferences. *Color Research* & *Application*, *38* (6), 393-411.

SHAPLEY, R., & HAWKEN, M.J. (2011). Color in the cortex: Single- and double-opponent cells. *Vision Research*, *51* (7), 701-717.

SHAW, V., & MITROFANIS, J. (2002). Anatomical evidence for somatotopic maps in the zona incerta of rats. *Anatomy and Embryology*, 206, 119-130.

SHEVELL, S.K. (2003). *The science of color*. Elsevier.

SINGG, S., & WHIDDON, T.L. (2000). Relationship between preference for red and locus of control. *Perceptual and Motor Skills*, *91* (1), 84-86.

SOKOLOVA, M. (2020). The role of color in emotion regulation. *Journal of Behavioral Psychology, 12* (3)*, 123-145.*

SOKOLOVA, M.V., FERNÁNDEZ-CABALLERO, A., ROS, L., LATORRE, J.M., & SERRANO, J.P. (2015). Evaluation of color preference for emotion regulation. In *Artificial Computation in Biology and Medicine: International Work-Conference on the Interplay Between Natural and Artificial Computation*, IWINAC 2015, Elche, Spain, June 1-5, 2015. Springer International Publishing.

SPAGNUOLO LOBB, M. (2023). The construct of aesthetic relational knowing. *Gestalt Theory*, *45* (1-2), 139-152.

STOCKMAN, A., & BRAINARD, D.H. (2010). Color vision mechanisms. In *The Optical Society of America Handbook of Optics*. McGraw-Hill Education.

TAYLOR, C., & FRANKLIN, A. (2012). The relationship between color-object associations and color preference: Further investigation of ecological valence theory. *Psychonomic Bulletin* & *Review*, *19*, 190-197.

TELLER, D.Y., CIVAN, A., & BRONSON-CASTAIN, K. (2004). Infants' spontaneous color preferences are not due to adult-like brightness variations. *Visual Neuroscience*, *21* (3), 397-401.

WAGEMANS, J., ELDER, J.H., KUBOVY, M., PALMER, S.E., PETERSON, M.A., SINGH, M., & VON DER HEYDT, R. (2012). A century of Gestalt psychology in visual perception: I. Perceptual grouping and figure-ground organization. *Psychological Bulletin*, *138* (6), 1172-1197.

WALLISCH, P. (2017). Illumination assumptions account for individual differences in the perceptual interpretation of a profoundly ambiguous stimulus in the color domain: “The dress”. *Journal of Vision*, *17* (4), 5.

WANG, X., CHOU, X.L., ZHANG, L.I., & TAO, H.W. (2020). Zona incerta: An integrative node for global behavioral modulation. *Trends in Neurosciences*, *43* (2), 82-87.

WHITFIELD, T.W., & WILTSHIRE, T.J. (1990). Color psychology: a critical review. *Genetic, Social, and General Psychology Monographs*, *116* (4), 385-411.

WOLFE, J.M., KLUENDER, K.R., LEVI, D.M., BARTOSHUK, L.M., HERZ, R.S., KLATZKY, R.L., ... & ZANI, A. (2023). *Sensazione* & *percezione*. Zanichelli Editore.

YOUNG, M. (2021). A historical perspective on Luscher’s color theory. *Journal of Historical Psychology*, *30* (2), 311-328

ZEKI, S. (1983). Colour coding in the cerebral cortex: The reaction of cells in monkey visual cortex to wavelengths and colours. *Neuroscience*, *9* (4), 741-765.

ZEKI, S. (1990). A century of cerebral achromatopsia. *Brain*, *113* (6), 1721