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EDICIONES COMPLUTENSE

Traces of knowledge and use of cues of sensory processing in ancient Greek art

Antonio M. Duarte[1]; Niki P. Constantinidi[2]

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Abstract. This study aimed to find evidence of the presence, in ancient Greek art, of cues (triggers) for sensory processes involved in the appreciation of visual arts, within the framework of the psychology of art. The presence of such cues in ancient Greek art can suggest the existence of knowledge about them, together with their use, already by ancient Greek artists. For the study, a sample of image reproductions of ancient Greek art (from the archaic to the Hellenistic period — ca. 7th — 1st century BC) was submitted to a thematic-content analysis. This analysis revealed the presence of all most relevant known cues that trigger specific sensory processes involved in visual arts appreciation. Results suggest an intuitive knowledge of these processes by ancient Greek artists (probably based both on personal experience and social sharing), which aligns with the seminal role of ancient Greek art both in the extended use of those cues in western art and in the modulation of a "western way" of appreciating art.
Keywords: ancient Greek art; psychology of art; senses; sensory processing.

[es] Rastros de conocimiento y de uso de señales de procesamiento sensorial en el arte griego antiguo

Resumen. Este estudio, en el marco de la psicología del arte, tuvo como objetivo encontrar evidencias de la presencia, en el arte griego antiguo, de señales (desencadenantes) de procesos sensoriales involucrados en la apreciación de las artes visuales. La presencia de tales claves en el arte griego antiguo puede sugerir ya la existencia de conocimiento sobre ellas, junto con su uso, por parte de los artistas griegos antiguos. Para el estudio, se sometió a un análisis temática de contenido una muestra de reproducciones de imágenes del arte griego antiguo (desde el período arcaico hasta el helenístico, entre los siglos VII y I a.C.). Este análisis reveló la presencia de todas las señales más relevantes conocidas que desencadenan procesos sensoriales específicos involucrados en la apreciación de las artes visuales. Los resultados sugieren un conocimiento intuitivo de estos procesos por parte de los artistas griegos antiguos (probablemente basado tanto en la experiencia personal como en el intercambio social), que se alinea con el papel fundamental del arte griego antiguo tanto en el uso extendido de esas señales en el arte occidental como en la modulación de una "manera occidental" de apreciar el arte.
Palabras clave: arte griego antiguo; psicología del arte; procesamiento sensorial; sentidos.

Summary. 1. Introduction, 2. Method, 3. Results, 3.1. Contour lines, 3.2. Variation of brightness, 3.3. Contrast between figures and background, 3.4. Appeal to several senses, 3.5. Multisensory stimulation, 3.6. Three-dimensionality, 3.7. Continuous stimulation, 3.8. Overstimulation, 4. Discussion, References

[1] Universidade de Lisboa (Portugal)
Email: amduarte@psicologia.ulisboa.pt
https://orcid.org/0000-0002-9497-7204

[2] Evening General High school of Rhodes (Greece)
Email: alinaconstantinidi@gmail.com
https://orcid.org/0000-0003-2517-8318

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1. Introduction

Psychology of art stresses that art involves an active psychological "negotiation" between artists and their audiences through art works (Arnheim, 1986; Gombrich, 1977; Melcher & Cavanagh, 2013). Specifically, from the point of view of the spectator, art appreciation demands that she or he react emotionally, cognitively, and behaviourally to the work of art based on several "cues" anchored on it. These "cues" constitute certain physical elements that can be present in the work of art (e.g., contour lines in painting), and that, functioning as stimuli, activate specific psychological responses to art (e.g., visualization of objects). Symmetrically, from the artist's side the task is to anchor (or not) in the work of art "cues" that involve (or not) the spectator in a certain experience. In this line, the artist is seen as possessing an intuitive knowledge on how spectators naturally react to the work of art to arrange or subtract those "cues" in ways that allows certain experiences (Gombrich, 1977; Leder, 2013; Leder et al., 2004; Melcher & Cavanagh, 2013). Those "cues" are directed to a variety of psychological processes, including audiences' sensory processing of the work of art, which constitutes the specific and sole focus of the empirical study that follows. The framework of such study is a more extensive investigation that also considers audiences' emotion, behaviour, attention, perception, memory, comprehension, and interpretation toward the work of art. This article is therefore the report of one of the studies of a research program on the presence of cues for the psychological processes involved in the appreciation of ancient Greek Art. The article follows a previously article published in this same journal, and that focus on cues of attention to ancient Greek art (Duarte & Stefanakis, 2015).

Parallelly to psychology of art, cognitive archaeology considers both the process and factors of the origin of art creation and appreciation, especially considering pre-history (e.g., Dissanayake, 1992; Lewis-Williams, 2002; Mithen, 1990, 1996) and, with more rare tries, considering the ancient world period (e.g., Gonçalves et al., 2013; Lewis-Williams & Pearce, 2005). With particular relevance, a program of studies of "archaeology of the senses" has been exploring the possible sensory experiences (including those of art) in the ancient world (e.g., Hamilakis, 2014).

Within the perspective of cognitive psychology of art and considering the program of a cognitive archaeology, our research question is: What are the traces in ancient Greek art of the cues that trigger the sensory dispositions implicated in the sensory processing of visual art, and that therefore might give evidence for the knowledge and use of them by ancient Greek visual artists?

Sensory processing of the work of art occurs at the level of sensory organs and their interface with the brain and is responsible for the capture and transformation (*transduction*) of the physical stimuli that compose the work of art (e.g., light in the case of visual art) in nervous impulses that reach certain areas of the (e.g., visual) cortex (e.g., Leder et al., 2015; Solso, 1996). At this most basic level of processing the focus is directed towards the formal configurations or effects, which are on the "surface" of the work of art and are relatively independent from the representational

content (Persson, 2003). While sensory processing of art is mostly hard-wired in the nervous system it is not independent from higher cognitive (top-down) influence and probably also not of the cultural context, considering the effects culture might exert on perception (Masuda, 2010). For example, as observed by Segall, Campbell and Herskovitz (1966), comparatively to urban populations the ones of forest or rural areas tend to be more precise in their sensing of crooked and slanted lines.

A basic condition for the sensory processing of the work of art is that the work's physical energy is above the sensory limit (*superliminal*) that is needed in order it can be detected (Solso, 2003). Assured that the work of art is detected, despite a differentiation on sensory precision, which in the case of visual art is higher for the elements focused in the centre of the eye (Livingston, 2002), a diversity of sensory dispositions are potentially activated by a variety of activating cues: contour lines; variation of brightness between areas; contrast of figures with backgrounds; appeal to several sensory modalities; combination of stimuli of different sensory modalities; three dimensional modelling; continuous stimulation; and overstimulation. Sensory processing of a work of art involves therefore a projection on art appreciation, of sensory analysis patterns which we have a propensity to mobilize in reaction to certain physical cues. Research on these most relevant activating cues in visual arts, and on their correspondent sensory dispositions, is revised hereafter.

A first cue relates with the fact that humans have a remarkable ability in "reading" visual art representations that only use contour lines to depict objects (Kandel, 2012; Melcher & Cavanagh, 2013; Stevens, 2001). As a matter of fact, those contour lines do not exist in the real world, due to the abstention of clear demarcation lines between objects and background (Kandel, 2012; Melcher & Cavanagh, 2013). Besides, seeing contour line drawings of tools can activate brain areas implicated in organizing grabbing actions (Melcher & Cavanagh, 2013). The ability in visualizing concrete or abstract objects through confront with artistic representations based on contour lines is due to our visual-sensory system natural tuning with lines, related to the fact that visual cortex neurons react better to lines, due to the shape of their receptive fields in bar form, instead of circles (Kandel, 2012, 2016). Functionally, minimal artistic representations, based in contour lines (e.g., *Portrait of Igor Stravinsky*, by Pablo Picasso, c. 1920), might facilitate the correspondent processing (and therefore not "spoil" appreciation) by reducing the demand of an intrinsically limited attention (Ramachandran, 2011). Indeed, as pointed out by Melcher and Cavanagh (2013), representations that depict all lines of an object might confuse sensory processing.

Another human sensory disposition that contributes to the "reading" of objects in visual arts is the tendency to visualize limits between areas of contrasting brightness. For instance, when in a painting the areas of certain brightness are contiguous to areas of a different brightness (e.g., *The Circus*, by Georges Seurat, 1890-91), we tend to perceive lines between these contrasting areas, even when these lines do not exist. This phenomenon is experimentally tested by exposure to the so called "Mach's bands" (a panel of four vertical rectangles with crescent chromatic intensity) and is explainable by a neurological process of "lateral inhibition" (the suppression of neural activity of retina cells that are adjacent to other retinal cells being stimulated by light from a certain area) (Kandel, 2012; Seeley, 2020; Solso, 1996).

Besides, "lateral inhibition" also explains what is known as "bright contrast illusion" — the sensation that light intensity from an object or surface varies as a function of the light intensity of the object's background or neighbouring

surfaces (Robinson et al., 2007; Solso, 1996). This illusion explains why a darker background in a painting increases the sensation of a figure's clarity (e.g., *Saint John the Baptist in the Wilderness*, by Caravaggio, 1604-05), while lighter backgrounds (e.g., *Nude Against the Light*, by Pierre Bonnard, 1908) reduces it (Solso, 1996).

Moreover, sensory processing of a work of art through a given sensory modality (e.g., vision) might trigger not only the correspondent sensations but also indirectly conjure sensations that correspond to a different sensory modality (e.g., audition) (Solso, 2003; Ward, 2013). As an example of such an experience, Solso (2003) observes that when looking to a painting like *The Raft of the Medusa*, by Théodore Géricault, 1819, we can also internally "hear" the sound of the wind on the sail, of the waves on the raft and of the castaways' cries for help. More precisely, this refers to a phenomenon designated as "pseudo or artistic synaesthesia", which distinguishes form "actual synaesthesia" (Cavallaro, 2013; Ward, 2013), that implies a literal involuntary, conscious, and normally pleasant experience of simultaneously sensing a given sensory modality stimulus (e.g., visual form) in a different sensory registry (e.g., touch). Following the example of Solso (2003), it can be hypothesized that works of art that physically stimulate one sensory modality (e.g., vision) but that include content which appeals to other modalities (e.g., hearing, touch) might induce "pseudo or artistic synaesthesia". Being its underlying processes unknown, this might be related with the processes involved in "actual synaesthesia", which is tentatively explained as the result of a possible information trade between brain areas with different sensory specializations (Ramachandran & Hubbard, 2001). Alternatively, it is hypothesized as the result of a possible reduction on the arousal inhibition that a brain area with a certain sensory specialization tends to exert on specific adjacent areas with other sensory specializations (Cytowic & Eagleman, 2009; Grossenbacher, 1997).

In other cases, the work of art (e.g., a sculpture, an installation, a building) comprehends stimuli that physically affect different senses. Aesthetic appreciation, and savouring in general, can be intensified in these situations of "multisensory stimulation", that simultaneously involve different sensory modalities in the appreciation of a work of art, or any experience (Bryant & Veroff, 2007). Multisensory appreciation of art works (e.g., appreciating sculptures through vision, touch, and hearing) seem to allow a more complete and richer processing of them, with different sensory modalities complementing and contrasting each other (Christidou & Pierroux, 2019). Besides, in comparison with the *unisensory* experiences that compose them, multisensory experiences tend to be felt with higher pleasure and to be more memorable (Spence, 2013). "Multisensory stimulation" induces what is called "multisensory integration", the combination of information across different sensory modalities, which is grounded on the extensive interactions that exist among the senses (Spence & Ho, 2015). For instance, as mentioned by Kandel (2016), the sensory processing of a painting starts by being visual and then integrates (in the upper regions of the brain), with the processing of other sensory modalities, resulting in its multisensory representation. That author gives as an example the processing of texture in paintings with high roughness, such as those by Chaim Soutine, Willem de Kooning or Jackson Pollock, that will involve integration of visual and tactile sensations. As an instance of intensified appreciation due to multisensory stimulation, Bryant and Veroff (2007) also observe the possible sensory processing of many movies, where

music intermingles with visual details, using dual sensory modes, as in *Fantasia*, by Walt Disney, 1940.

Furthermore, partly based on what is known as the phenomenon of "binocular stereopsis" (i.e., disparity of the images received by each retina), sensory processing allows a full appreciation (at until six meters of distance) of deepness in three-dimensional works of art (e.g., sculptures, buildings). This psycho-neurological mechanism relates to the fact that the brain interprets disparity of the images received by each retina (that are compared by the visual cortex neurons) as a cue of deepness (Kandel, 2012; Parker, 2019; Shimamura, 2013; Solso, 1996).

Also, with implications for art appreciation, it is considered that the attributes of the reaction to any stimulation are not invariant during the exposure to it (Houston & Houston, 2015). Specifically, when humans are confronted with a stimulus in a continuous way, they tend to drop their sensivity to it, in a phenomenon designated as "adaption" or "neural fatigue" (Solso, 1996). Visual adaptation particularly occurs when the visual system is processing an unchanged stimulus during a continued time that can go from seconds to minutes (Carandini, 2000). This phenomenon is explained in terms of a possible fatigue of the neurons involved in that processing that would respond less than usually, after a certain time of the sensory organ continuous exposure to the same stimulus (Maffei et al., 1973). Furthermore, a continuous stimulation by a constant stimulus induces the slow reduction of the implied sensory nerve excitability, in a process named "accommodation" (Reber & Reber, 2001). Sensory adaptation might play a significant role in the sensory processing of a work of art or some of its elements. For instance, accordingly to Solso (1996), adaptation would explain our gradual tendency for a perception of an undifferentiated grey field when continuously exposed to a pattern of aligned repetitive black lines in a white background, as depicted in the abstract op-art painting *Current*, by Bridget Riley, 1964. Following this example, it can be expected that repetitive stable patterns in art facilitate sensory adaptation.

Finally, when the work of art involves an overstimulation (e.g., a bright form or coloured shape) it might induce a sensory experience after its appreciation (e.g., a brief "afterimage" of that form or a complementary coloured shape in its absence), creating the impression that the aesthetic experience prolongs beyond the encounter with the work. It was remarked that this might happen, for instance, after contemplation of some of Georges Seurat's pointillistic paintings (e.g., *A Sunday Afternoon on the Island of La Grande Jatte*, 1884-86), when the simultaneous exposition to green and yellow stains can induce the experience of "afterimages" of purple- or violet-coloured shapes (Kandel, 2012; Marmor & Ravin, 2009). "Afterimages" seem to result from the same phenomenon previously mentioned as "adaptation" or "neural fatigue", at the retinal level (i.e., bleaching of photoreceptor pigments) or cortical stage (Shimojo et al., 2001).

Following the previously mentioned research question, the goal of the present study is therefore to identify in ancient Greek fine painted pottery, sculpture, and architecture (from the archaic to the Hellenistic period - ca. 7th -1st cent. BC), the presence of most important cues that trigger sensory processing of the work of art - i.e., contour lines; variation of brightness between areas; contrast of figures with backgrounds; appeal to several senses; multisensory stimulation; three-dimensionality; continuous stimulation; and overstimulation. Considering the central role of ancient Greek art in the further development of western art,

identification of such cues in the former might explain their extended use in the latter. Moreover, pondering that sensory processing of art can also be partly "educated" by the cultural context, identification of its cues in ancient Greek art might also partly help to explain how a western sensory processing of art consolidated until now in the way it has.

2. Method

The aimed identification of sensory processing cues was performed by analysing image reproductions of ancient Greek fine painted pottery, sculpture, and architecture (from the archaic to the Hellenistic period - ca. 7th-1st century BC). Analysis was performed through "thematic / content analysis" research technique (Miles & Huberman, 2013). Firstly, cues (categories) that activate sensory dispositions involved in art appreciation were listed (along with corresponding dispositions) based on the literature review presented in the Introduction (Table 1). The cue of *Contour lines* refers to the fact that the objects represented in the work of art are depicted through outline lines. *Contour lines* triggers the sensory disposition of *Visualization of objects*, the competence in picturing concrete or abstract objects through confront with artistic representations based on outline lines. The cue of *Variation of brightness* stands for a difference of clarity between distinct areas of the work of art. *Variation of brightness* triggers the sensory disposition of *Visualization of limits,* the tendency to perceive lines between those contrasting areas. The cue of *Contrast of figures with backgrounds* implies that figures' brightness which are represented in the work of art contrast with the one of their background. *Contrast of figures with backgrounds* triggers the sensory disposition of *Visualization of brightness,* the tendency to sense that an element's light intensity varies as a function of the light intensity of its background or neighbouring surfaces. The cue of *Appeal to several senses* means the content of the work of art refers to more than one sensorial modality (e.g., visual, and acoustic). *Appeal to several senses* can trigger the sensory disposition of *Pseudo-synaesthesia*, the possibility to imagine sensations (e.g., sound) from a different sensory modality the work of art uses (e.g., light). The cue of *Multisensory stimulation* means the work of art stimulates several senses (e.g., vision, audition, touch, etc.). *Multisensory stimulation* might lead to *Intensified appreciation,* a higher pleasurable and memorable sensorial experience. The cue of *Three-dimensionality* stands for the fact that the work of art exploits height, width, and depth. *Three-dimensionality* triggers the sensory disposition of V*isualization of deepness*, the full appreciation of depth in that kind of works. The cue of *Continuous stimulation of a repetitive pattern* means the work of art is composed of a rhythmic stable pattern. *Continuous stimulation of a repetitive pattern* can promote the sensory disposition of A*daptation*, the sensorial disposition to drop sensibility to the stimulus that present such attributes. Finally, the cue of *Overstimulation* refers to the fact that the work of art comprises intense stimulus (e.g., bright forms or coloured shapes). *Overstimulation* might trigger the sensory disposition of *After-visualization*, the possible sensory experience of an "echo" of those stimuli immediately after their withdrawal.

Table 1:

Sensory dispositions in art appreciation and correspondent activating cues.

Activating cues	*Sensory Dispositions*
Contour lines	Visualization of objects
Variation of brightness	Visualization of limits
Contrast of figures with backgrounds	Visualization of brightness
Appeal to several senses	Pseudo-synesthesia
Multisensory stimulation	Intensified appreciation
Three-dimensionality	Visualization of deepness
Continuous stimulation of a repetitive pattern	Adaptation
Overstimulation	After-visualization

Table 1

Secondly, cases of ancient Greek works of art (from the archaic to the Hellenistic period - ca. 7th -1st century BC) that contain one or more listed cues were searched for. This search followed the principles of "document analysis" (the works of art were taken as products of human activity) (Duffy, 2005) and "case study" (occurrences of illustrative works of art were picked as units of analysis) (Yin, 1989). Illustrative cases were selected by a first analyst from a random sample of reproductions of ancient Greek art. This sample was constituted by "screening" specialized books and websites on ancient Greek art. "Screening" consisted in locating cases with presence of one or more of the cues listed in table 1.

Identified cases were then independently and blindly categorized by a second analyst, regarding the presence *versus* absence of each of the same listed cues. The second analyst's categorization was performed based on a category system, which states: each listed sensorial cue; a description of each cue; an example of a work of (post-ancient Greek) art that involves each cue - examples alluded in the specialized literature that appears in the Introduction, and all referring to modern art (see Attachment). This category system was discussed with the second analyst previously to its appliance. Cases that were not validated by both analysts were rejected and replaced by other cases, then exposed to the same validation process.

As a way to concretize and elucidate the used methodology of thematic / content analysis, an example of its employment is specified to one of the chosen sources — the illustrated monography titled "The Art of Vase-Painting in Classical Athens", by Roberston (1996): Each figure of the book, which depicted a reproduction of an ancient Greek work of art, was thoughtfully analysed regarding the presence or absence of each of the eight cues itemized in table 1; every work reproduction found of comprising one or more of the listed cues — as it was identified for the "bilingual" amphora painted by painted by the Andokides Painter (c. 520-510 BC), depicted here in figure 2 and 3 (Robertson, 1996, p. 10), concerning the cues of *Variation of brightness* and *Contrast between figures and background* — were registered and compiled

with comparable works present in other consulted fonts; from this group the work judged to be the best illustration on the occurrence of the correspondent cues was chosen (e.g., the mentioned Andokides amphora), in order to be independently scrutinized by the second analyst regarding the presence or absence of each of the same eight sensorial cues; if both analysts would support the occurrence of the same cues (e.g., as it was the case with Andokides amphora) the work of art would be judged has an testimony of the presence of such cues.

3. Results

Results consist of cases of ancient Greek works of art that contain cues which prompt dispositions implicated in the sensory processing that is involved in art appreciation. Such cues testify ancient Greek classical artists' knowledge and use of such cues.

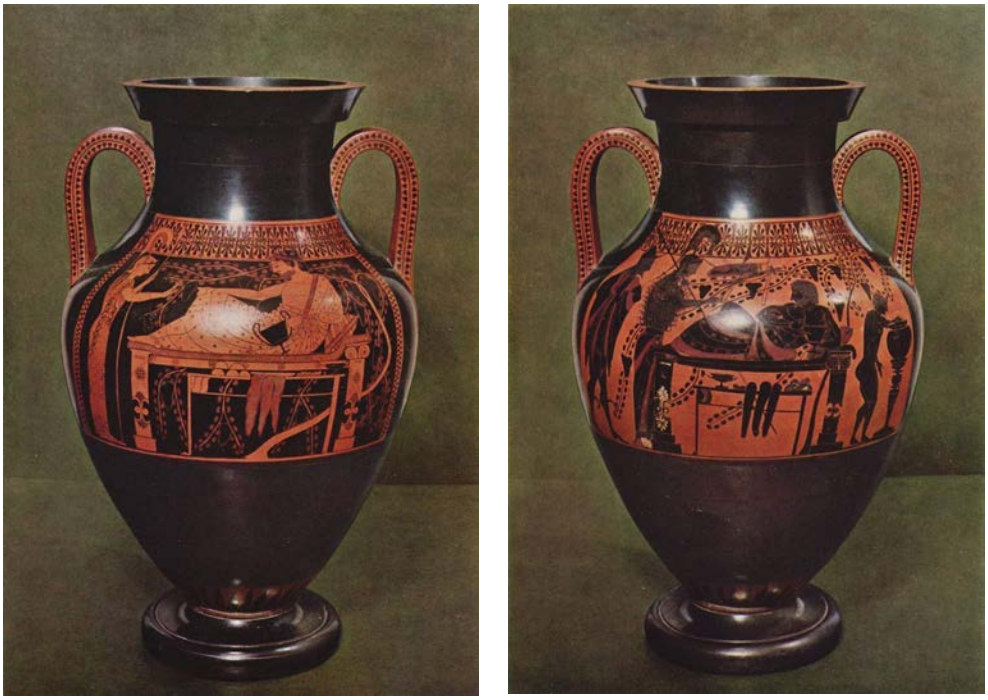
3.1. Contour lines

Regarding the use of contour lines in visual art as a cue for the viewer's "reading" of representations, ancient Greek art is prodigal. Effectively, most of the ancient Greek drawings, like the ones used in ancient Greek vases, use simple or pure contour lines to successively depict objects, without recurring to shades and in combination with the use the cue of variation of brightness between areas, lately mentioned. As an example, see a votive tablet (Figure 1), called "pinax", found at Penteskouphia, near Corinth (unknown artist, c. 7th century — 500 BC). The tablet depicts a potter (named Onymon) facing an oven while carrying a hook used for closing its chimney (Alexandra, n.d.). As it can be observed, the "reading" of the represented objects is made possible by the minimal contour lines used to depict the male's musculature and the kiln doors, as by the variation of brightness between figures and background. Furthermore, the minimal schematism of the representation allows a direct evocation of the represented elements, together with the depicted context and action that takes place there, allowing a reduced information processing.

Figure 1. Unknown artist, Votive Tablet, c. 7th century - 500 BC.

3.2. Variation of brightness

Variation of brightness between areas is also frequently present in ancient Greek vases. Effectively, besides contour lines, the typical huge contrast between figures' colour (black or red) and that of its background (correspondent red or black) heavily contributes to the vision of the figures' clear limits. Rich ancient Greek examples of the polyvalent use of this cue in a same work of art are the so called "bilingual vases", where a same figure is depicted on both sides but alternating between the black and the red-figure technique (for references on the "bilingual" painters of the late archaic period see Cohen, 1978, 2006). An illustrative example is an amphora from Vulci (Figures 2 and 3) painted by the Andokides Painter (c. 520-510 BC), where a scene with Herakles and Athena is depicted with both techniques. Further, it is possible to see "bilingual vases" both as an experimentation on different ways of representing figures based on their contrast with the background, and as an assertion that this contrast allows the visualization of figures.



Figures 2 and 3. Andokides Painter, Amphora, c. 520-510 BC.

3.3. Contrast between figures and background

Variation of brightness between areas seems then correlative, in ancient Greek art, with the widely used cue of contrast between figures and background, which tends to activate the previously mentioned "bright contrast illusion". When contrast of Greek vase figures with background is done accordingly with the later red-figure technique (i.e., background in black and figure in red), this might often result in an impression that those figures "glow" in the darkness, like being illuminated by a focused light.

Oppositely, when the earlier black-figure technique is used (i.e., background in red and figure in black), this might result in a feeling of those figures as silhouettes seen against a strong light. Both cases are present again in Greek bilingual vases that so richly illustrate the versatile use of the cue of contrast between figures and background. See for example the already mentioned amphora from Vulci (Figures 2 and 3) painted by the Andokides Painter (c. 520-510 BC), where a scene with Herakles and Athena is depicted with both techniques. As such, bilingual vases can be almost taken as a theoretical statement on the cue of contrast between figures and background.

3.4. Appeal to several senses

Concerning the cue of appeal to several senses, which hypothetically can induce an experience of "pseudo-synaesthesia", several cases can be identified in ancient Greek painting that depict the playing of music. For example, the possible internal "hearing" of the sound of strings can eventually happen when appreciating a painting like *Muse Tuning Two Kitharas*, from an unknown artist, c. 465 BC (Figure 4). The figure is painted in a cup found in a tomb and portrays a seated woman that tunes two instruments on her knees. Furthermore, the same painting can possibly also evoke an internal haptic image (i.e., the touch of the fingers on the strings), in an empathic mirroring of the portrayed character's sensory experience. Besides its appearance in painting, the appeal to several senses in *unisensory* works of art might have been also present in other ancient Greek art domains, like sculpture, literature, music, theatre, and body adornment.

Figure 4. Unknown artist, Muse Tuning Two Kitharas, c. 465 BC.

3.5. Multisensory stimulation

Regarding the cue of multisensory stimulation, which tends to intensify the sensory experience of the work of art, its use can naturally be observed in ancient Greek sculpture, that eventually allows integration of vision and touch, and in architecture which promotes the crossing of vision, proprioception, hear, touch and smell. Examples of the use of multisensory stimulation through architecture are ancient Greek fountains, from which the one called Peirene, in Corinth, from unknown author, 2nd century BC. is an instance (Figure 5). The place is described by Pausanias, who travelled to Corinth around the middle 2nd century A.D.:

> […] The legend about Peirene is that she was a woman who became a spring because of her tears shed in lamentation for her son Cenchrias, who was unintentionally killed by Artemis. The spring is ornamented with white marble, and there have been made chambers like caves, out of which the water flows into an open-air well. It is pleasant to drink, and they say that the Corinthian bronze, when red-hot, is tempered by this water, since bronze […] the Corinthians have not. Moreover, near Peirene are an image and a sacred enclosure of Apollo; in the latter is a painting of the exploit of Odysseus against the suitors (as cited by Robinson, 2011, p. 206).

It can be inferred the multisensory experience of someone in ancient Greece that besides gazing the Peirene fountain, would have the chance to move inside its space, touch and feel the temperature of its surfaces, smell it, hear flowing and splashing water and tasting the liquid.

Besides, multisensory stimulation is also naturally present in ancient Greek performing arts, like theatre or dance, that through light, sound, odour, and space allow their audience to experience multisensory spectacles.

Figure 5. Unknown artist, Peirene Foutain, 2nd century BC.

3.6. Three-dimensionality

Appreciation of deepness partly due to "binocular stereopsis" can evidently happen in face of all ancient Greek works of art that involve three-dimensionality, like buildings or sculptures. Actually, this might be more pronounced with sculptures that present a rich variety of planes - like *The Winged Nike*, a famous sculpture dated to the first half of the 2nd century BC (Figure 6), from an unkown presumably Rhodian artist, who superbly depicts the body of a winged woman.

Besides, appreciation of deepness of ancient Greek three-dimensional artworks probably also involves a kinaesthetic and haptic experience that results from the potential acts of moving and touching in relation to those works. Appreciation of an ancient sculpture like *The Winged Nike*, or of an ancient Greek building, might entail the possibility of walking around or inside, of stepping, and of touching the work.

Figure 6. Unknown artist, The Winged Nike, first half of the 2nd century BC

3.7. Continuous stimulation

Any kind of ancient Greek art, as all art works, potentially falls under continuous stimulation, leading to sensory adaptation. Besides, following the previously mentioned hypothesis that repetitive patterns facilitate sensory adaptation, ancient Greek works of art the present that same structure might be particularly prone to induce

adaptation. Probably the best examples are some ancient Greek mosaics that depict abstract patterns in repetitive rhythms, like a cubic floor mosaic in a house of the Sanctuary of Delos, island of Delos, from unknown author, 2nd century BC — 476 (Figure 7).

Furthermore, sensory adaptation probably also occurs at the haptic and kinaesthetic level, when visiting most ancient Greek buildings, due to the relatively continuous haptic and kinaesthetic stimulation such visits tend to entail.

Figure 7. Unknown artist, Floor mosaic, Sanctuary of Delos, island of Delos, 2nd century BC — 476.

3.8. Overstimulation

Finally, overstimulation and correspondent inducement of "afterimages" might potentially occur, under favorable conditions, with some ancient Greek works of art. Considering the ancient Greek vase painting typical use of red figures against black backgrounds, which illusorily increases figures' brightness (e.g., *Red-Figure Fish Plate*, from unknown author, 4th century BC; Figure 8), it might happen, specially under certain conditions (e.g., visualization after not being exposed to light and with dark background), that a time of intense focus on such figures can facilitate "afterimages" of them.

Hypothetically, overstimulation induced "afterimages" of works of art might be occur not only on the visual modality, but also in other sensorial modalities or inter-sensorially. For instance, it is not possible to rule out the possibility that the painting of the mentioned *Red-Figure Fish Plate* (Figure 8) can induce a "pseudo-synes-

thetic" "after-image", that besides comprising a kind of vision of the fish, could also include a kind of internal "scent" of it or of the surrounding water.

Figure 8. Unknown artist, Red-Figure Fish Plate, 4th century BC.

4. Discussion

Results suggest evidence, already in ancient classic Greek art, of knowledge and use of all the cues that trigger psychological dispositions involved on sensory processing of visual art and that lately appear along the history of art.

With reference to sensory processing, it was possible to identify, in the same sample, the occurrence of all the cues of sensory processing. Specifically: Contour lines as a prompt to visualization of objects; variation of brightness between areas as a prompt to visualization of limits; contrast of figures with backgrounds as a prompt to visualization of brightness; appeal to several senses as a prompt to pseudo-synaesthesia; multisensory stimulation as a prompt to intensified appreciation; three-dimensionality as a prompt to visualization of deepness; continuous stimulation as a prompt to adaptation; and overstimulation as a prompt to after-visualization.

Specifically, presence of the cue of contour lines in ancient Greek art corroborates the fundamental functionality of that cue in facilitating a direct and easy visualization of represented objects (Kandel, 2012; Melcher & Cavanagh, 2013; Stevens, 2001), based on the visual-sensory system natural setting with lines (Kandel, 2012, 2016), which reduces processing overload (Ramachandran, 2011).

Similarly, occurrence of the cue of variation of brightness between areas testifies for an early use of a way to prompt visualization of limits, partly since such response is brain-wired (Kandel, 2012; Seeley, 2020; Solso, 1996). Nevertheless, it cannot be

excluded that, adding to this, there might also have been a possible symbolism of such formal device.

Manifestation of the cue of contrast of figures with backgrounds suggests an ancient employment of such device to control audiences' sensation of an object's light intensity. Despite the point that this aligns with the fact that such reaction has a neurological basis (Robinson et al., 2007; Solso, 1996), it might also reflect an early projection of theatricality in the visual arts.

Presence of the cue of appeal to several senses might testify for an early use of a way to prompt pseudo-synaesthethic experiences (Solso, 2003; Ward, 2013). This aligns with the suggestion of Day (2013b) that specific Cretan Minoan reliefs with floral decoration (from non-identified species) might had already been a way to provoke a pseudo-synaesthethic olfactory experience. More directly, the evidence of such a cue is also convergent with the hypothesis of McCormack (2020) that an ancient Greek visual work of art, like the statue known as the *Laocoön and His Sons* (attributed to Athanadoros, Hagesander and Polydoros, from Rhodes, c. 27 BC - 68 AD), might conjure an aural imaginary experience from its spectators — the hearing of the scream of *Laocoön,* struggling with his sons against two divine serpents. Observation of the cue of appeal to several senses consolidates a basic possibility (Solso, 1993) that a work of art in a certain sensory registry might also potentially conjure sensations of different sensory modalities.

Occurrence of the cue of multisensory stimulation not only suggests the ancient use of that aesthetic strategy to intensify appreciation (Bryant & Veroff, 2007), but also consolidates the notion that works of art, as material things in general, have a multi-sensorial nature that goes beyond vision (Day, 2013a; Hamilakis, 2013; Levent & Pascual-Leone, 2014; Smith, 2007). Furthermore, the specific work of art that instantiates here the cue of multisensory stimulation (i.e., the *Peirene Foutain*, 2nd century BC), opens the possibility to consider an art appreciation response with involvement of smell and taste. This is in line with Bradley (2014), who refers that during the Greco-Roman classic period visitors of temples and theatres would have then been able to smell and taste from their fingers saffron that was sprayed or that coated the surface of some buildings, as well as plants and flowers existing in its interiors. Besides, that sensory experience would also have involved a "sense of place", kinaesthetically mediated by the body, derivable in memories of that place (Hamilakis, 2013).

Presence of the cue of three-dimensionality expresses a continued use of a trigger for visualization of deepness, which naturally preceded Greek art, mobilizing humans' neurological apparatus that allows "binocular stereopsis" and the brain interpretation of images disparity (Kandel, 2012; Parker, 2019; Shimamura, 2013; Solso, 1996). Nevertheless, in line with the analysis of Gombrich (1977) on the "Greek Revolution" in art, this shift will have brought a more extensive and in-depth use of the above-mentioned cue, by breaking the tense posture of the characters represented in the sculptures, and so by extending their amplitude. Moreover, considering that ancient Greek statues probably were then not only seen (many in exuberant colours) but sometimes also touched, as signs of wearing indicate, and smelled, if perfumed or decorated with flowers (Bradley, 2014), their appreciation would have been richly multi-sensorial.

Manifestation of the cue of continuous stimulation denounces the presence since antiquity of aesthetic patterns that particularly induce sensory adaptation. Still, con-

sidering that such adaptation might be mainly provoked by repetitive aesthetic patterns (Solso, 1996), and attending to the ancient Greek innovation of pebble mosaics decorating floors (Boardman, 2016), many of which with geometric designs, it can be hypothesized that the referred trigger might have had a significant importance in that time.

Finally, presence of the possible sign of the cue of overstimulation, that seems to have preceded ancient Greek art, testifies for a continued use of a prompt for after-visualization. Nevertheless, the potentiality of "afterimages" in art, which are also explainable by neural fatigue, both at retinal and cortical level (Shimojo et al., 2001), might had been particularly stimulated by the ancient Greek invention of vase painting red figures against black backgrounds (Boardman, 2016), which pronouncing contrast can increase the sensation of light that comes from those figures.

Knowledge and use of most important known cues that induce known sensory dispositions involved in visual arts appreciation seems therefore to exist already among ancient Greek classical artists, which can also mean a probable knowledge of such dispositions in the same group. The origin of this knowledge might be related both with the fact that those artists also reacted with the same sensory dispositions both toward the reality they wanted to represent and to the works of other artists. This aligns with the fact that sensory reactions to art are fundamental competencies largely hard-wired in the human nervous and cognitive systems, while also being not exempt of higher order cognitive and cultural influence. Besides, knowledge of sensory reactions to art and of the cues that predispose them might have also been socially transmitted and learned among artists of the ancient Greek art community, within aesthetic canons or style and eventually from external sources, without disregarding the relative free choice of individual artists. Moreover, the presence of all those cues in ancient Greek art probably helps to explain both their extended use in further western art and the modulation of a partly "western way" of sensorially processing art.

Besides, the results reinforce the notion, in line of what is defended by *Sensory History* and *Sensory Archaeology* (e.g., Day, 2013a; Hamilakis, 2013; Smith, 2007), that the sensorial experience of ancient art involves a variety of senses, potentially intermingled, instead of restricting to sight. Actually, more than half of the cues of sensory processing identified by this study involve, at least potentially, more senses than just sight.

Nevertheless, our conclusions should be obviously taken as informed guesses since we are inferring about ancient Greek artists' psychological processes through the analysis of their works. Besides, these works of art are accessible to us after being subject to significant transformation due to the passage of time. Moreover, considering that sensorial experience is partly dependent of historical period, being influenced by culture, as well as of collective memory (e.g., Day, 2013a; Hamilakis, 2013; Smith, 2007), the results of the analysis here conducted, of cues for sensory processing, must be carefully taken, pondering that it reflects a contemporary look on ancient works of art. Probably we can never be sure how those cues were used by ancient Greek artists and audiences in comparison with the way we use them now. Additional studies of the same type should explore sensory cues for ancient Greek arts other than the visual arts, as well as eventual cues used in the same epoch for prompting cognitive and emotional responses that go beyond sensation. Furthermore, the scope of such studies would be broadened by interdisciplinary integrating the perspectives of other disciplines like

history, archaeology, anthropology, or sociology of art. Since art is a multifaceted phenomenon, its study requires an interdisciplinary perspective, with single disciplinary perspectives on it inevitably being partial.

The study contributes to Psychology of Art by confirming that in ancient Greek visual artworks, there was already the presence of the most important known cues for sensorial processing. The study also adds to previous research by extending the program *of Sensory Archaeology* and *History*, which proposes the historical and archaeological study of the role of the (inter)sensory experience in the past (e.g., Day, 2013a; Hamilakis, 2013; Smith, 2007), to the Archaeology and History of Art. Specifically, by empirically revealing the presence of cues for sensorial processing in ancient Greek art, the study contributes in the attempt to envision the sensorial experience of such art in that time.

Moreover, the used methodology of analysing works of art, through "thematic / content analysis" research technique, can and needs also to be used in the future to explore the degree in which the known cues for prompting the psychological responses to art are present in works of art of different historical periods and cultures. The explored sensory cues (and correspondent used categories of analysis) are the main ones identified by research in psychology of art until now for visual arts; nevertheless, considering the constant changes in the type of works of art that the history of art brings, we cannot exclude the possibility that new prompting cues emerge, for the same or even new sensorial responses to art. Furthermore, the used methodology may be also of interest to other empirical studies that aim at a controlled characterization of works of art or of aesthetic expressions of personal perspectives, like beliefs, representations, or attitudes. For instance, the same "thematic / content analysis" research technique could be used to characterize both how thematically oriented works of art express artists' representations of certain topics, or how works of art comprehend certain formal or content characteristics.

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Attachment

Cue	***Description***	***Example***
Contour lines	The objects represented in the work of art are depicted through contour lines	*Portrait of Igor Stravinsky*, Pablo Picasso, c. 1920
Variation of brightness	There is a variation of brightness between different areas of the work of art	*The Circus*, Georges Seurat, 1890-91
Contrast of figures with backgrounds	The figures' brightness contrast with their backgrounds' brightness	*Saint John the Baptist in the Wilderness*, Caravaggio, 1604-05
Appeal to several senses	The contents of the work of art appeals to several senses (e.g., vision, sound, etc.)	*The Raft of the Medusa*, Théodore Géricault, 1819
Multisensory stimulation	The work of art stimulates several senses (e.g., vision, audition, touch, etc.)	*Fantasia,* Walt Disney, 1940
Three-dimensionality	The work of art has three dimensions (height, width, depth)	*Between the Taurus and the Sphere*, Richard Serra, 2003 -05
Continuous stimulation of a repetitive pattern	The work of art is composed of a repetitive stable pattern	*Current*, Bridget Riley, 1964
Overstimulation	The work of art comprises intense stimulus (e.g., bright forms or colored shapes)	*A Sunday Afternoon on the Island of La Grande Jatte*, Georges Seurat, 1884-86