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Synesthesia: a return to the body

Abstract. Synesthesia is a neurological phenomenon whose nature and etiology remain unknown. In this paper, I apply the neurophenomenological perspective to reflect on the very nature of inducers and concurrents, including their perceptual and conceptual dimensions and their stability over time. Additionally, I analyze the role of attention and its influence over synesthesia, which contributes to the difficulties that we, synesthetes, find when sharing our personal experiences with non-synesthetes. Finally, I expose some examples of the current neuroscientific data and propose some insights into the embodied character of synesthesia, stressing the key role of its emotional component. I conclude describing the clinical applications of the findings in the field of synesthesia and their implications for the understanding of cognition in general.

Keywords: synesthesia; neurophenomenology; emotion; consciousness; cognition.

“Picture yourself in a friendly conversation. You comment about the redness of the letter A and people stare at you as if you were an alien. It seems they cannot see the greenness of number 3, they cannot see the beautiful violet of the violins at the beginning of Rachmaninov’s Piano Concerto nº. 2. They do not see any color for Monday, they do not know it is on the left of Thursday and a little below Sunday. And, indeed, someone suddenly affirms

that number 3 is definitely yellow! You are about to faint. Once at home, the Internet brings you back to reality: only a small percentage of people perceives like you do. They are called synesthetes and you are one of them. You and your friend who is 'mistaken' about the color of number 3" (Melero 2013).

How Synesthesia Feels

I was born a synesthete. Synesthesia is what I feel, what I perceive and what I think. However, I did not realize my perception had any peculiarity until I was 23 years old. Before that day, the word *synesthesia* stood for a type of beautiful literary metaphor that I used to enjoy – and create myself – but that was all. When I realized that the colors of my letters and numbers were an oddity for others, I was bewildered. However, it was the tip of the iceberg. The Synesthesia List (Day 2013) provided me with lots of questions about what I had taken for granted throughout my life: the color of each instrument, the color of each of my friends, the deep pleasant touch in my chest elicited by the bending sound of a guitar, the colors of pain and pleasure, the invasive and sinuous "blue curtains" of sadness... They all became new, because now I knew this was something other people could not experience. And this was the seed of my research to understand what was so extraordinary about my ordinary perception. In this path, there were others, synesthete and non-synesthete researchers, who were struggling together to unravel the mystery that hides inside the synesthetic brain. On one side or the other, we were all facing up to the same great challenge: to reflect on experience – our own and others' – and thus use the scientific method to go beyond our own flaws, in order to understand the neuronal secrets of, among other processes, perception.

How to Unravel the Mysteries of Synesthesia

The efforts of psychology and cognitive neuroscience have provided the scientific community with empirical evidence about the reality of synesthesia (Ward and Mattingley 2006). And, at this point, the accumulated data from research work have helped redefine the phenomenon (Cohen Kadosh and Terhune 2012; Eagleman 2012; Simner 2012a, 2012b) and have posed new questions. My contribution to the field has had two main aims: 1) to emphasize the usefulness of the neurophenomenological perspective in this area; 2) as a consequence of point 1, to stress the relevance of the emotional component to fully understand synesthesia as a multilevel consciousness experience.

1) Neurophenomenology of synesthesia

One of the main contributions of synesthesia to the study of cognition in general is to bring to the front the topic of individual differences in non-pathological cognitions. Due to its idiosyncratic nature, the definition of the phenomenon requires a deep analysis of individual experiences. To build this definition, commonalities are essential, but the variability among synesthetes allows mappings of the different elements of the neural network involved in synesthesia (Eagleman and Goodale 2009). Neurophenomenology is the suitable framework to marry personal experience and objective scientific approaches, and its potential contribution to the study of synesthesia has been previously pointed out (Sidoroff-Dorso 2009). From this perspective, it is important to go in depth into several questions: a) the nature of inducers and concurrents; b) the spaces ("real space" or "the mind's eye") where synesthesia appears; c) the stability of the concurrents; d) the role of attention; and e) the ability of synesthetes to share detailed information about their own experiences.

A) *Nature of Inducers and Concurrents:* the nature of inducers (sensory or conceptual) and concurrents (internal or external) has been long discussed and still remains unclear. As other authors have argued previously (Ward et al. 2007), a dichotomized explanation based on their perceptual-conceptual nature and/or association-projection factors is misleading if individual differences are not taken into account. The next box compiles empirical evidence from several studies and personal accounts about the nature of the inducers and the concurrents in relation to the sensory-perceptual-conceptual continuum:

	SENSORY/PERCEPTUAL	CONCEPTUAL
INDUCER	Case affects color (E = green; e = red: Ramachandran and Hubbard 2003) Nature of some inducers: vision, sound, touch, smell, taste, visual form of numbers (but not set of dots), orgasm? Variations in color due to the source of sound (headphones vs. radio aloud) 24-hour clock (16:00 induces the color of sixteen, not that of 4 p.m. though you read it as “four”) Different colors for the same concepts due to the colors of the word in different languages: *cantar vs. sin*g	Different fonts elicit the same color (e.g. handwriting vs. Times New Roman) Roman numbers look grey (instead of inducing a color for each letter) Nature of some inducers, not strictly defined as senses: pain, temporal sequences, meaning of words, feelings Influence of context and attention: 5 vs. S (Dixon et al. 2006) and Navon-type figures (Palmeri et al. 2002) Ideasthesia: concept to percept association (Nikolic 2009), easily understood in the case of spatial sequence synaesthesia, useful for comprehending abstract concepts (Sagiv and Ward 2006) Some symbols’ colors depend on meaning: & is golden as Y, instead of purple as 8
CONCURRENT	Involuntariness and automaticity (Cytowic 2003) Nature of some concurrents and its specificity: color?, form, sound, taste, touch, smell Synesthetic colors behave like *real* colors (sensory nature), as concluded from several psychophysical tasks: visual search, visual masking and perceptual grouping tasks. However, the neural concomitants of synesthetic colors are found in extra-striate visual areas (perceptual nature) beyond the early processing stages generally thought to mediate contrast and adaptation effects in color vision (Hong and Blake 2008) Early activation of parietal, TPO and fusiform regions that could be responsible for binding of color and form in *associators* (Melero and Campo 2009)	Nature of some concurrents, not strictly defined as senses: personalities (OLP), movement, orgasm/pleasure, pain Synesthetic concurrents with the same inducer can become directly associated at an implicit level and affect performance in cognitive tasks (Simner and Hubbard 2006) *Martian* colors: synesthetic colors differ from *real* colors (Ramachadran and Hubbard 2003) Some subjects localize synesthetic experiences in subjective sensorial places (i.e.: *flavor subjectively located in my mouth*) or even just “*know the correspondent flavor*”, not localized anywhere (Ward et al. 2007)

The data presented in this table suggest that a pure dichotomized classification, as the proposed *higher-lower* one (Ramachandran and Hubbard 2001), is difficult to reach. From a neurophenomenological approach, the higher-lower distinction must be reconsidered, not as a dichotomy but as a demonstration of the multiple states that the complex synesthetic network can adopt.

Regarding the term *ideasthesia*, it has helped to revise the limits of the "umbrella" that synesthesia had become. The authors who coined this term suggest that several modalities do not fit into a pure synesthetic definition (i.e., a sensory inducer elicits a sensory concurrent). They believe that grapheme-color and lexical-gustatory synesthesias are examples of this new concept. Nevertheless, the term *ideasthesia* cannot account for several peculiarities of the synesthetic experience (Table 1: first quadrant). Neurophenomenology leads us instead to reconsider our general definition of the sensory-perceptual-cognitive continuum without forgetting the emotional component, as we explain below (Section 2).

B) *"Real Space" or "The Mind's Eye":* there are different spaces where synesthetic experiences appear. Though this peculiarity has been used to classify synesthetes (Dixon et al. 2004)**,** one synesthete can describe different spaces, even when the concurrents that she experiences share the same inducer:

INDUCER	CONCURRENT	SYNESTHETIC SPACE
Temporal Sequence	Spatial Configuration	Projected spatially around subject
	Color	Mind's Eye

So, *associator-projector* categories are not effective enough to understand how the unified synesthetic reality takes place. Moreover, these terms can describe the experience itself (e.g., a projected synesthetic concurrent), but cannot be used to classify synesthetes, at least those with mixed experiences. This has led other authors to propose alternative models of individual differences (Ward et al. 2007).

C) *Stability over Time:* the stability of the concurrents has been used as an indicator of developmental synesthesia. Nevertheless, the measure of stability depends on several factors:

Stability of the inducer (letter > voice > orgasm)
Ability of the subject to describe the concurrent (e.g., sexual pleasure as a result of sound)
Incongruent context (how do *real* colors or other parameters modify what we can call "unstable letters"? E.g., '*J*' (red or blue, why?)

These and other issues regarding stability/consistency of the concurrents (Simner 2012a) help redefine the criteria to select synesthetes in order to perform scientific research.

D) *Role of Attention*: obviating the controversy about the relevance of attention in the generation of synesthetic experiences, it is important to stress three issues:

Attention to inducer allows concurrent description
Attention to concurrent makes it blur/disappear: what does it mean for bidirectionality?
Does the fact of discovering a new synesthesia make it more accessible to consciousness?

These questions attempt to emphasize the intrinsic interrelation of the inducer and concurrent. If a synesthete focuses attention on music, her ability to discriminate its color, texture and movement increases. When it comes to describing this experience to non-synesthetes, the synesthete focuses on the concurrent. But then her colors fade away, because attention is not on the eliciting stimulus anymore. Moreover, even if she uses memory to describe them, sometimes she could not find the proper words for the "colors", the "moving spaces", the "transitions". The attempt to apprehend and describe them disrupts the flowing of moving colors. This speaks about the complexity of the synesthetic concurrent when it comes to verbal description. Indeed, bringing to consciousness the fact that others do not share our perception can modify the conscious nature of synesthesia. So, what is the underlying neural mechanism that supports these variations in the level of consciousness of our perceptions? Only by considering the indissoluble relation between the inducer and concurrent (i.e., two aspects of the same stimulus) can we overcome the notions of "an additive sensation" or "a mixture of the senses", which poorly described the coherency and complexity of the synesthetic cognition.

E) *Ineffability*: the difficulties to describe the synesthetic experience are more related to the conscious nature of the phenomenon rather than to its unshared characteristics (among synesthetes, and/or non-synesthetes). It is rather a *Nagel effect* problem: *what is like to be a synesthete?*

Taking all these reflections into account, it is clear that we still need a structured methodology where subjective experiences and neuroscientific data can mutually constrain each other. Neurophenomenology can be the basis for this purpose and the first step is to "*explicitly ground the active and disciplined insight of the subject about her/his own experience*" (Rudrauf et al. 2003). In order to apply this viewpoint, we can focus attention on the conscious components of grapheme-color synesthesia:

CONSCIOUS COMPONENTS OF GRAPHEME-COLOR EXPERIENCE
- the denotative meaning associated with the grapheme/word
- the connotative meaning associated with the grapheme/word
- the sound associated with each syllable
- the *knowledge/vision* that each letter/word has its own color
- the difference between *real* and synesthetic color (different "hue")
- the *knowledge* of which one belongs to the external world and which one does not (different "location")
- a pleasant feeling for congruent graphemes or monochromatic writing (preferably, but no necessarily achromatic)
- an unpleasant feeling for incongruent graphemes or polychromatic writing that can be avoid to concentrate in meaning
- a pleasant or unpleasant feeling related to the color of a letter/word, independently of its common emotional connotation

The analysis of the conscious components of grapheme-color synesthesia leads to the conclusion that synesthesia is a complex multilevel phenomenon of consciousness, whose intrinsic characteristics get lost when the result instead of the process is analyzed. Therefore, in order to better understand the conscious nature of synesthesia, the first step is to comprehend the embodied character of consciousness. Varela stated "*consciousness depends crucially on the manner in which brain dynamics are embedded in the somatic and* *environmental context of the animal's life*" (Thompson and Varela 2001). When addressing grapheme-color synesthesia from this perspective, the body is considered as a whole. Likewise, the organism-environment interaction (the conditions where grapheme-color synesthesia arises, namely reading), and the intersubjective interactions (that let us "know" differences in perception) cannot be obviated.

So, understanding the relation between the inducer and the concurrent is not a question of sensory/conceptual, external/internal characteristics, but a matter of *radical embodiment***.** This approach maximizes the success of cognitive neuroscience in the field of unusual perception, and therefore contributes at great length to the enrichment of the science of consciousness in general.

2) The Key Point of Synesthesia: The Emotional Binding System

One direct consequence of the study of synesthesia from a neurophenomenological viewpoint is the "rescue" of its more subtle components. A particularly interesting component is the emotional strength that synesthetic experiences exhibit. Emotion was considered the key to the binding between inducers and concurrents in the last decade of the 19^{th} century (Calkins 1895). A century later, the emotional component of synesthesia has been reconsidered from a neuroscientific perspective. There have been hypotheses about the hyperconnectivity between limbic and extra-striate regions (Ramachandran and Hubbard 2001) and about the existence of emotionally mediated synesthesias (Ward 2004). Behavioral experiments provided evidence about synesthetically elicited affective reactions in grapheme-color synesthetes (Callejas et al. 2007) and functional neuroimaging showed unusual activity in retrosplenial cortex (Nunn et al. 2002; Weiss et al. 2001) and insula (Melero and Campo 2009; Sperling et al. 2006). The emotional component has been emphasized in recent publications (Cytowic and Eagleman 2009) and synesthetes' accounts reveal that emotion can act as an inducer but also as a concurrent (Day 2013). Moreover, in the last years, neuroanatomical research has found variations in areas of the synesthetic brain that participate in the emotional processing of the world (Hupé et al. 2011; Jäncke et al. 2009; Melero et al. 2013). Nevertheless, at present, emotion is still not fully integrated in explanatory neurocognitive models.

This is a great undertaking, given that cognitive neuroscience is just beginning to understand the role of emotion in cognitive processes. Though emotional processing has been a recursive topic in the history of psychology, its contribution to the high-level processing is still unknown. Nevertheless, some authors have integrated emotion in their models of cognition. Varela believed that "all cognitive phenomena are also emotional-affective" (as cited in Rudrauf et al 2003). He said that "*mind is fundamentally something that arises out of the affective tonality, which is embedded in the body*" and claimed that "*affect is primordial in the sense that I am affected or move before any 'I' that knows*". Damasio (1998) has provided a theory that can help overcome the reason-emotion dichotomy in order to understand how our decision-making takes place out of affective reactions that are unconsciously generated in our body. As has been outlined above, synesthesia constitutes a perfect expression of embodied cognition (more obviously, for example, in mirror touch, as pointed out by other authors: Sagiv and Ward. 2006). Therefore, a deeper analysis of the role of emotion in the synesthetic brain will open a road to the redefinition of sensory, perceptual and cognitive processes.

Neuroscience of Synesthesia

The neurophenomenological approach emphasizes the emotional component of synesthesia. So, how does this knowledge guide neuroscientific research?

a) The neuroanatomical dimension

Recent research has provided evidence of structural variations in the synesthetic brain (Hänggi et al. 2008; Hänggi et al. 2011; Hupé et al. 2011; Jäncke et al. 2009; Melero et al. 2013; Rouw and Scholte 2007, 2010; Weiss and Fink 2009). Nonetheless, it is still too soon to conclude if these variations (direct and/or indirect, anatomically and/or functionally altered pathways) are present in every synesthete. Currently, taking into account neurodynamics and the emotional component emphasized above, the regions of interest have been extended. In order to complete the synesthetic brain puzzle, the emotional networks, including the subcortical nucleus, have been explored and a neurocognitive explanatory hypothesis, namely the *Emotional Binding System* hypothesis, has been proposed (Melero et al. 2013). Nonetheless, neuroanatomical information is not sufficient to understand the dynamics of synesthesia

b) The functional dimension

As an embodied phenomenon of consciousness, the functional reality of synesthesia can be studied in terms of time. Varela pointed out that large and short scale integration of brain activity was the path to understand how consciousness emerges (Varela et al. 2001). Experiments on the temporal course of synesthesia also point in this direction, given that activations at higher and lower levels of the implicated networks occur early and simultaneously (Brang et al. 2010; Melero and Campo 2009). In the same vein, several synesthesia researchers (Cytowic 2003; Sidoroff-Dorso 2009) have chosen the distributed systems perspective. This perspective can be useful for addressing the controversial implication of the color region (i.e., V4) in color synesthesias. Though functional magnetic resonance experiments have tried to localize the source of activity responsible for the synesthetic color, data are not conclusive. Therefore, several authors have hypothesized about its nature, suggesting that the underlying mechanisms could be related to other processes (e.g., emotion; Melero et al. 2013) and/or exhibit neural mechanisms not localized in real-color sensitive areas (Hupé et al. 2011). In order to deeply understand the mechanisms at the root of the phenomenon, other modalities are being explored.

c) Beyond lexical inducers

So far, 65 types of synesthesia have been classified (Day 2013) and most of them remain unexplored. The questions analyzed here came out mainly from the study of lexical inducers, which seem to be the most common (62.51% of synesthetes exhibit grapheme-color synesthesia: Day 2013). In the field of neuroimaging, methodological constraints have given priority to the components of synesthesia that are more easily controlled (e.g., visual attributes, attentional networks). However, in recent years, other characteristics such as emotion have come to the front and the number of modalities under study has increased. It is the case of emotion-induced synesthesias (e.g., emotion-color) as well as those elicited by pain and pleasure (e.g., pain-color and orgasm-color synesthesias). The underlying neural mechanisms of these modalities remain unknown, but their phenomenology and potential clinical contributions have already been described (Melero 2013). In the referenced paper, I analyzed the similarities between the concurrents elicited by pain and pleasure (e.g., the most painful experience elicits the same color as the most pleasurable one) which suggest a synesthetic bridge between these two experiences. The study of the neural mechanisms that underlie this intrinsic relation can be useful in the field of chronic pain.

The contribution of synesthesia to the understanding of human brain

The study of synesthesia has been beneficial in the clinical, artistic, philosophical and scientific domains. The clinical applications of the study of pain-color and emotion-color synesthesia have been mentioned above as a proposal for the future. However, synesthesia has contributed to the field of sensory substitution already (e.g., the synthetic vision software called the vOICe: Meijer 1992). Additionally, the combined effort of scientists, artists and educators has contributed to the worldwide diffusion of the phenomenon, providing doctors and psychologists with the ability to recognize synesthesia and differentiate it from psychotic disorders. In the field of arts, musicians, poets and visual artists have benefited from synesthesia as a tool to develop new forms of expression. Furthermore, the study of synesthesia has favored the "crosstalk" between philosophy and science, crystallizing in the combination of phenomenological analyses with empirical neuroscientific data. As a result of this combination, synesthetic associations are understood not as an additive component to cognition and/or perception, but as a function intrinsically embedded in our neural dynamics. Furthermore, the idea that the emotional component is at the root of this kind of perception has brought to the front the contribution of emotion to cognition, not only in synesthesia but also in other conscious processes. A joint effort to deeply develop this neurophenomenological approach to the very nature of synesthesia, and of perception in general, will undoubtedly open a new road to understanding the mysteries of human consciousness.

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