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A Science of Qualities

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Abstract The apparent dichotomy between qualitative versus quantitative dimensions in science intersects with the domain of several disciplines, as well as different research fields within one and the same discipline. The perception of qualitative as "poor quantitative," however, is methodologically unsustainable, because there are perfectly rigorous ways to conduct qualitative research. A somehow different question is whether a science of qualities per se is possible: that is, whether a science of appearances can be devised, what its observables are, and its methodological implications. The article deals with this last issue, and especially from the point of view of experimental phenomenology. The weakness of the current approach to perception is discussed, and an alternative view that goes beyond veridicalism is presented. The analysis tackles crucial issues such as color and spatial appearances, the qualitative dimension of perceived depth, and the role of visual meaningful gestalten as information tools for the survival of living beings in the environment. If developed, a science of the qualitative dimensions of appearances may contribute to revising the ecological theory of perception by making its natural semantics more explicit.

Keywords Appearances · Experimental phenomenology · Illusions · Qualitative · Quantitative · Veridicalism

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Introduction

The difference between qualitative and quantitative pertains to the foundational aspects of science. Factually, however, most of the sciences avoid addressing the question because it is apparently unnecessary for their current development, and because different sciences silently rely on their own meanings of the terms. A preliminary step might be to distinguish carefully among the several meanings of the qualitative/quantitative conundrum as used in different ways by different sciences, or at least in their particular research field. This action, which would require some sort of glossary of the terms and their synonyms, would be of prime utility for the advancement of the sciences by defining the boundaries and the correlations among the various sciences themselves and reducing the ambiguity of the references within their fields. "Qualitative" and "quantitative," in fact, can have very different meanings even within the hard sciences or mathematics, where "qualitative" can mean "graph-theoretic" or represented in the form of a periodic table. Indeed, there is a huge qualitative section of mathematics—from algebra to topology (Weeks 1985; Boi et al. 1992), from logic to category theory—dealing with qualitative issues (Mac Lane 1986). It is therefore important to realize that the connection between "quantitative" and "rigorous" is at best a myth and at worst a piece of old-fashioned ideology. There are also perfectly rigorous ways to conduct research on qualities, an example being correspondence analysis, a multivariate statistical method commonly used to scale a set of objects on the basis of the attributes that they possess (Canal and Micciolo 2013). Adopting a rigorous methodology in experiments on qualities, and specifically in ones dealing with subjective judgments, concerns not only data analysis but also the design and the conduct of the test itself. The perception of "qualitative" as "poor quantitative" is therefore methodologically unsustainable.

A first advancement of science would be an effort to provide a scientific explanation of the subjective aspects of experience as rigorous as those of the kindred disciplines of psychophysics and neuroscience. A second advancement would be to gain a clearer view on the question of levels of reality in both the epistemological and ontological senses. The main unasked question in science, in fact, is still that of the levels of reality and the sciences correlated to each different level; and of the methodology/ies to adopt in scientific research according to the (ontologically) different observables under consideration.

A point at issue is also whether it is possible *to develop a science of qualities* based on internal subjective parameters rather than a mapping on external stimuli: in other words, whether qualities can or cannot be objects of scientific inquiry per se (Albertazzi 2013b). As is well known, qualities are classically distinguished among primary or physical properties (spatiality, solidity, hardness, weight, shape, size, position, motion) (Galileo [1623]1957), secondary ones (colors, tastes, smells, sounds) (Hume 1975), and tertiary ones (affordances and expressive qualities) (Metzger 1941; Rausch 1966). However, Galileian science denies in principle the possibility of a science of secondary qualities (and tertiary qualities such as affordances as well), because "*they belong to consciousness*" (Galileo [1623]1957, p. 274), and in so doing it considers only the analysis of primary qualities to be scientific. Yet, when perceiving we have *direct awareness* of qualities which provide us with immediate information on how to behave. We do not perceive stimuli as physical radiations or frequencies as such, but multifarious color appearances, sounds, and noises. Developing a science of qualities per se is a great endeavor and a challenge because there is no general consensus as to what it may be, what its proper observables are, its constants, its units of measurement, its metrics (if any), and so on. Strictly speaking, a science of qualities should explain what happens in an act of presentation (such as an act of *seeing* a ball, for example), a very brief extension of subjective space–time (see, for example, Kanay 2014; Pöppel and Bao 2014), whose nature is still largely unknown and for which a frame of analogies is difficult to conceive. Such a science requires a largely critical stance on the mainstream view of an objective trustable reality (such as, for example, the existence of a ball supposed to be "such" in the physical realm) universally founded and univocally expressed in quantitative terms and in third-person account, i.e., from the viewpoint of a "universal" observer able to retrieve its objectual features.

Science and Measurement of Psychic Phenomena

The objects of psychology are psychic phenomena such as seeing a color or a landscape, hearing a sound, or feeling an emotion, i.e., eminently qualitative mental states. Scientific psychology was born with psychophysics, which consists in a series of methods for both determination of the degree of sensitivity of the sense organs and measurement of sensations, and a series of psychological operations of judgment, for example, comparison or evaluation between perceived stimuli. The problem is clarifying *what* is being measured in the particular case, how it is being measured, and what is meant by the concept of *perceived stimulus*. The method developed by Fechner (1860) for psychophysical measurement was based on determination of a certain number of differential thresholds. The unit of measurement of psychophysics (the "just noticeable difference" or JND), is the minimum amount of a physical magnitude required for the subject to notice a perceptual difference, i.e., that the two perceptions are different. The aspect that is not problematized is that, in the definition of JND, "the amount something must be changed" pertains to physics, while "for a difference to be noticeable" pertains to psychology/perception. It is therefore necessary to determine a correspondence between the two stimulations and the two sensations, which also gives rise to many further problems like adaptation. Finally, when two perceptions are distinct from a JND, the consequence is that there cannot be an intermediate perception. On this basis, Fechner considered the difference between two consecutive perceptions (separated by a JND) distinguished by "equal" leaps because they are indivisible. Obviously, as in many other fields, the definition of a unit of measurement involves a conventional tolerance, and the measurement of sensory/perceptual sensitivity involves the minimum physical difference (and therefore those two different measurements) that makes the subject consider the two different corresponding perceptions as different in 50 % of cases. There is always a degree of uncertainty in the perceiving subject and an uncertainty in the measurement; and the systematic errors of judgment immediately evidence that also the psychological operations of judgment have a role in the measurement. Subsequently, Stevens (1957) modified psychophysical investigation using the method of estimating magnitude by observing that subjects are able to express the intensity of their sensations through answers like "more or less heavy," "more or less good" (which I would call "qualitative" rather than "quantitative" because they are not metric in the strict sense: see Wertheimer 1938). Sensations can be *measured* with several methods: for example, by assigning numbers to them in proportion to their intensity or by the bisection method (presenting two sensations and indicating them as very weak and very strong, and asking the subject to produce a third one midway between the two). Also in this framework, however, there are problems: the psychophysical *explanations* of perceived quality (for example, "more or less heavy," "more or less good," or "more or less round") are still made in terms of integration between perceived variables (good, round, heavy) and imperceptible correlates (retina and brain); every single sensation is determined by several physical variables (Marks 1974); some properties (for example color) are not reducible or *explainable* solely in terms of physical properties. It is true that psychophysical objectives have recently been extended with integration information theory (Anderson 2001), but the nature of the primitives to be measured is still ambiguous: are they metrical cues or qualities (a color, a sound) and configurations of qualities (a landscape, a melody) as they appear and are experienced in the subjective awareness? Recent developments in cross-modality (Spence 2011) show the existence of associations among perceptual stimuli of different fields, but the associations are mainly analyzed and explained at the level of sensory–sensory integration, i.e., again at the level of metrical cues.

One must ask whether the models currently available and from which scientific research begins are sufficient to *explain* the nature of the primitives of appearances as they are given in visual awareness. What could be, for example, the scientific validity of a model of the perceiver's moments of psychic time or the stretches of spatial looking if it is based on instants or points as elements of Euclidian geometry (Albertazzi 2006a, b, 2015; Jaśkowski 2014); or the validity of a model of the modes of appearances of color, connotative dimensions included, if based on a trichromatic theory of color vision or analyzed in the framework of colorimetry? It would seem more rational to proceed in reverse by first identifying and defining the primitives of a subjective space–time (what does it mean to visually perceive "squareness," rather than "recover" a metric square or "detect" a metric edge?), the contextual nature of appearances (for example to distinguish among surface, film, and volume colors; see Katz 1935), and a specific methodology with which to analyze them (subjective judgments in first person account). In psychophysics, for example, very common methods are those of two alternative forced choices (the subject is required to make binary choices), and the double-blind method (applied to any experimental situation in which there is a possibility that the results will be affected by conscious/unconscious bias on the part of both researchers and participants): neither of the methods addresses the qualities or the meaning of what the subject is supposed to be judging. The "explanation" of qualities (qualia), in this frame of reference, is given in terms of sensory signals that fulfill a certain preestablished criterion of certainty, so that the system labels the event as "beyond a reasonable doubt," which is essential for taking decisions and subsequent processing (Gazzaniga et al. 1997; Ramachandran 2003). These, however, are explanations at the level of unconscious mechanisms that do not "explain" what qualia really are: that is, what a phenomenal warm red is, or a phenomenal cold blue for a *conscious* perceiver.

Similar problems arise in attempts to "explain" the nature of qualities starting from a top-down point of view, and assuming phenomenology to be a branch or a part of sociological and/or anthropological research. For example, although studies conducted on sensory perception among cultures (see the works by the Concordia Sensory Research Team (CONSERT): http://www.david-howes.com/senses/) are very interesting from a relativistic viewpoint, they do not exhaust the field of phenomenological research as such. An example will help. Consider the antonyms used to describe different perceptual dimensions, such as beautiful/ugly, warm/cold, high/low, etc. Culture may play a role in choosing different pairs of antonyms to address the same phenomenon: for example, Western music construes pitch according to an up/down spatial relationship, i.e., "high" and "low" (Pratt 1989), while in Bali and Java pitches are "small" and "large," and among the Suyá of the Amazon basin, they are "young" and "old" (Seeger 1987). These facts raise questions such as the following: What kinds of dimensions are mapped by the scales of antonyms? What similarities do patterns such as high/low, small/large, young/old share? What a phenomenological science should explain is *what these different pairs of antonyms have in common*, what is perceptual and not merely linguistic. In principle, we can skip the linguistic category labels and analyze the associations in purely perceptual terms. Briefly, one issue concerns the number, type, and order of categories that can differ from one language to another (due to culture, myth, environment, etc.) (Lakoff 1987); another issue is the kind of phenomenological perception as such due to universal traits pertaining to the qualitative patterns of experience itself, for whatever culture and whatever language user (Rosch and Lloyd 1978; Da Pos and Albertazzi 2010). Anthropological research certainly has fundamental implications for a conception of a general "science of qualities" and an interest in what qualities we perceive or how we perceive, but it is *top-down* research, because higher cognitive processes are in play at that level (due to language, culture, etc.), which may have a feedback at a certain level of thinking, but not at the level of perceiving (Kanizsa 1991).

Psychophysics, neurophysiology, anthropology, and language studies are different fields of research considering and explaining *correlated* observables, although they are non-reducible to one another from either the bottom-up or top-down viewpoints. Working together towards a comprehensive view on the complexity of the real does not require the sciences to conflate the different observables. Vice versa, from a systematic viewpoint, what has to be explained is the laws of dependence among the (ontologically) different levels (Poli 2001, 2006).

From a scientific point of view there are three main questions to answer: Can psychophysics expand to encompass phenomenology? Does phenomenology have its own observables, different from those of psychophysics? Can there be a phenomenological science per se? If it is assumed that there can be a science of phenomena or qualities not reducible to neural correlates or external stimuli, then it is necessary to seriously address the problem of a *general theory* of space, time, and phenomenological primitives based on the subject's qualitative experience of them, their genesis in the time of presentness, and their possible measurement and modelling. It is not enough to want psychophysics to *incorporate* phenomenology for its subsequent adaptation, or neurophysiology to explain consciousness and qualia in terms of electrochemical stimuli. It is necessary to found a science of phenomenal qualities *as they are perceived* by subjects.

Here I shall address the question of the relationship between quantity and quality, providing some examples of the complexity of an analysis of qualities and limiting my treatment to the field of vision science. For both a more systematic framework and specific experimental studies I refer to my works in the field (see, for example, Albertazzi et al. 2012, 2013, 2014a, b; Albertazzi 2013a, b).

A Myth to be Debunked

Current vision science usually and essentially means by the "visual field" of objects the field of optics: that is, the physics of wavelengths, the reflectance of light from surfaces, the metric properties of the observables, and so on. The main trend in current vision studies—besides the ecological theory of perception (Gibson 1979), which still plays a (minor) role—is now the theory of perception as inference, which assumes that information is already wholly organized in the physical external environment (Marr 1982; Rock 1983; criticism in Albertazzi et al. 2010). According to the inferential approach, the *metric cues of the physical reality* are picked up by the different sensory modalities endowed with an internal coherence of their own, which excludes, at a low level, every subjective and qualitative integration. In other words, information is already "there" in the external *physical* world and our sensory system has nothing else to do than *re*-present it in quantitative terms. The main explanation for both computational and neurophysiological versions of inverse optics is given by the concept of inference or inductive leap. Because of the externalization of meaning outside the device (or the observer, which is the same in this case), the content, the conceptual attribution of meaning and its verification are assessed in terms of external physical reference, and the entire *informational content becomes a set of metric values* (Vishwanath 2005). However, in this set there is no semantic distinction between those meanings assigned to the *stimulus* and those assigned to the *perceived* visual field, *simply because they coincide*! There is no active interface between the physical and the experienced world, nor assignment of meaning or emotional tone by human and nonhuman.

Against Veridicalism

A theory of perception alternative to the dominant inferentialist approach claims that our psychophysical system evolved to provide us with an interface for adaptive interaction with the environment. From this viewpoint, the veridicality between the qualities of our visual experience and the features of the outside world no more needs to be correspondent. There is a large body of evidence that a correspondentist theory of reality does not hold. For example, the depth, distance, and direction *subjectively* perceived in visual space are considered to be the same informational constructs as depth, distance, and direction in some *objective* external world. In the framework of the inferentialist approach, models are increasingly powerful from a computational viewpoint; however, they are not able to *explain* the complexity and richness of what it *means* for a living being to have a visual *pre*sentation. The "visual field" in seeing, in fact, is not merely patterned on the laws of optics. Perceived depth is a quality as well, and can be experienced not only in binocular disparity but also in monocular vision (Vishwanath 2005, 2013, 2014; Koenderink et al. 2011; Koenderink 2013; Vishwanath and Hibbard 2013). A persuasive example of this state of affairs is the viewing of a pictorial image with only one eye through a reduction aperture (see Vishwanath 2005, 2014, pp. 152–153). Depth perception is indeed a case study for the difference between qualitative and quantitative, where the ambiguity of the terminology and the lack of distinctions between quantitative and qualitative aspects of depth are paramount. In fact, quantitative depth is conventionally derived by combining estimates from individual depth cues in some statistical manner, while the egocentric perceptual depth estimate is an internal parameter functionally suited to human interaction with the environment (Vishwanath 2014, p. 175). Distinctions should then be made between stereopsis (which literally refers to the vivid appearance of a graspable, solid form immersed in negative space) (Barry

2009, 2011) and stereoscopic vision (binocular depth perception based on a quantitative 3-D structure). Moreover, different perceivers do not necessarily see in an identical manner, although it is presently known that the difference among individuals can be measured (Koenderink et al. 2010). Seeing is a *process* where space, more than being a static sequence of planes, is bodily situated in a frame of basic egocentric directions—such as right/left, above/below, in front of/behind—with a biologically based normative aspect (above is "better" than below, in front is "better" than behind, etc.).

The standard approach in vision science brackets qualities by default, and makes them inaccessible; and bracketed with them is also the entire phenomenal world. The main concern of current vision science is syntax: algorithmic processes that are applied to optical data, and transformations of (meaningless) data into (meaningless) structures (Koenderink 2013).

Heuristically, the first step in analysis of perceiving from a qualitative viewpoint is to bracket off physics and its conceptual framework and consider the subject matter of the inquiry to be visual appearances. Bracketing off physics does not mean to deny the existence of a physical realm of reality, obviously! By "appearances" is meant what appears, is phenomenally manifest, the ways in which things appear to us, and exactly how they do so: in vision science, the world in its pure visibility (Hering [1920]1964), imbued with meaning and the laws of seeing (Metzger 2009; Mausfeld 2013); in other words, a complete species-specific *Umwelt* (von Uexküll 1909) for humans.

Observables

Developing a science of qualities raises the question of both the *reality* and the *nature* of its observables. Experimental phenomenology is a science that addresses this issue (Albertazzi 2013a). Appearances are not physical entities: they have a multifarious nature, dimensions, positive and negative characterization, and even *degrees* of reality (Metzger 1941, 2009; Mausfeld 2010), in the sense that they are perceived as more or less real (which is nonsense for physics). In this approach inferentialism, mainly based on Helmholtzian ideas (von Helmholtz 1867), can play a role only insofar as the nature of the *transcendent* world is concerned: in fact, appearances, the sole objects of our experience, have only an extrinsic relationship with entities and unknown processes. Appearances are presented with incontrovertible evidence. For this reason, a science of qualities does not need to verify/justify the veridicality or illusoriness of appearances with respect to the stimuli, because appearances are experienced as evidently given in actual perceiving: they are not a product of *recovery* of the "veridical metric structure of the physical world." Neurophysiological aspects, however correlated, are not relevant to this kind of inquiry, which concerns itself only with the modes of appearance of perceptive objects. The realm of appearances is reducible neither to external nor to internal physiological psychophysics (Wackermann 2010): it is a primary, conscious, evident, qualitative level made up of perception of colors, shapes, landscapes, movements, balls, and whatever else may appear in awareness, hallucinations included. Each component of the *Umwelt* of a living being is imbued with meaning in terms of its functionality to the subject, based on phenomenal properties that act as meaning-carriers for survival. Here the concept of functional tone and affective resonance (von Uexküll [1934]1992) may replace the abused and deformed concept of affordances in terms of dispositions (for the debate see Chemero 2003). A disposition is, for example, the physical property of H_2O for ice at a certain temperature, or the property for a material to be fragile: as such, in principle, a disposition might have nothing to do with human-environment interactions.

Visual Appearances

Appearances as observables comprise a huge range of items, such as standard visual objects in the environment, but also the wide field of the so-called visual illusions (Gregory 2009; Shapiro and Todorovic 2014) (after all, there are reasons for perception being such an intriguing field of research). Dimensionality is certainly one of the characteristics of spatial appearances in the visual field, but dimensions cannot be understood in the metrical or purely geometrical sense. Take the case of visual points. These are not zero-dimensional, but may be one- or bidimensional (consider a very thin and short line reduced to its minimum, or imperceptibly circular or even oval). Visual points are colored, may have internal structure (i.e., parts), borders of various types (knurled or frayed), and undergo slight modification so that a point in a 3-D space may become a sphere (a star in the sky) or extend in a dashed line. Moreover, the contours of triangles are vividly present in the total absence of any stimulus indicating such lines (Kanizsa 1979); arrays of triangles can spontaneously "point" as a group in a selected direction (Attneave 1968; Palmer and Bucher 1982); objects appear in such a manner as to seem physically "impossible" (Penrose and Penrose 1958); Euclidean squares are perceived as slightly tilted, i.e., rectangular (Albertazzi 2012); while objects which are impossible from a geometric viewpoint are perceived as physically plausible (Huffman 1971; Kulpa 1987). Developing a thorough phenomenology of visual spatial primitives is a task still to be accomplished (Albertazzi 2015). Examples of the perceptual "sloppiness" (Perkins and Cooper 1980) of observers in perceiving abound. They evidence how much of what we experience is not induced by any outside stimulus, however much it may be perceptually experienced as real. On observing animal behavior, for example, Lorenz's attention focused on the nature of subjective phenomena as they were experienced by animals, hallucinations included (Lorenz 1973). Not surprisingly, therefore, geometrical illusions such as the Ponzo, the Müller-Lyer, and the horizontal-vertical illusions seem to be perceived by species as diverse as apes (Tudusciuc and Nieder 2010; see also Fujita 1996), ungulates (e.g., horses, Timney and Keil 1996), birds (Rosa Salva et al. 2013; Nakamura et al. 2014); pigeons (Fujita et al. 1991, 1993; Nakamura et al. 2009); grey parrots (Pepperberg et al. 2008); and fish (Sovrano et al. 2013). One may conclude that, in the perceiving of the environment by living beings, "errors" seem to be the norm, and not the exception, which raises the issue of a "geometry" of the human and other species of mind (Allen and Bekoff 1997). The evidence of similar perceptions in species so different as mammals, birds, and fish suggests that it may reflect the presence of homologous traits inherited from a common ancestor, or otherwise the rediscovery of analogous frames by otherwise very different species.

Case Studies

A case in point for a science of qualities is the study of color, the "matter" of appearances, even more substantial than shape itself (Hering [1920]1964). Color studies currently range from colorimetry (wavelength-receptor mapping, prediction of physical color mixing, etc.), which plays the major role, to the semantic dimensions of color appearances. This should make us aware that endogenous meanings can appear even in the professional use of the term (are we considering the quality of the color or the manipulation of intensities of channels?). What is needed is precise terminology according to the different levels of analysis, relative to the different color observables (radiations or appearances), and consequently the distinction and the proper use of the terms (they may have different meanings, such as "primary" or "unique colors"), and of their properties (brightness, hue, saturation), that are not always univocally addressed (Kuehni 2003; Albertazzi and Poli 2014). In color science, color properties make explicit reference to the relation between given stimuli, i.e., hue correlated with wavelength, brightness correlated with luminance, saturation correlated with purity. However, it is also often taken for granted that those properties are attributes of the color *as perceived*, what they are correlated with, and what they correspond to; and that they form a 3-D space where each of them represents a distinct dimension. The various color systems, however, convey different quantitative or qualitative information, and they are substantially irreducible to each other. Color qualia can only be classified purely phenomenologically (on the basis of their visual similarity, for example using the Natural Color System atlas, or the original Munsell atlas), but neither of these differences apparently derives from either physical properties of radiation or physiological processes. Colorimetry (Boynton 1979; Brainard 1995) does not deal with this issue. On the other hand, semantic chromatic dimensions—such as warmth/coldness, pleasantness/unpleasantness, lightness/heaviness, wetness/dryness, etc.—are so widespread as to suggest an adaptive response to the environment by which we perceive and remember objects and relations (De Moulpied 1924; Fogden and Fogden 1974; Fox 1979; Changizi et al. 2006; Hurlbert 2013). Because of their value, expunging qualitative and semantic color dimensions from science and relegating them to the realm of aesthetics is a weak solution. Indeed, an experimental aesthetics would be very close to an experimental phenomenology, i.e., it would be a branch of perception science (Albertazzi 2006a, 2013a; Metzger 2009). That beauty, along with, for example, grouping or camouflage, is one of the factors involved in animal survival has been recently discussed (Rothenberg 2012).

The fact that phenomenal qualities are not reducible (and explicable) in terms of the third person account adopted by psychophysics or the neurosciences raises the more general issue of the methodology/ies to adopt in scientific research according to the (ontologically) different observables under consideration.

From a systematic and a methodological viewpoint, a science of qualities opposes the positivist and (computational) model approach to vision. The viewpoint adopted by an experimental study of appearances may agree with the idea maintained by the model observer-dependent theory (see Walsham 1993; Hawking and Mlodinow 2010), according to which it is in principle impossible to obtain an observer-independent view of the world. Different observers, as said, may prove to perceive in a more or less different manner (also, in the case of so-called optical illusions, see Wackermann and Kastner 2010) The main difference with respect to a model-based theory of perception, however, consists in the fact that the level of reality of the appearances that we experience is immediately given as real and incontrovertible: appearances are imbued with a salience, certainty, and emotional value which cannot pertain to stimuli. Stimuli are only *indirectly* known through definitions, and they are tested with instruments of measurement. Asking whether or not a model of what we perceive is real, starting from an inferential viewpoint according to which our brain interprets the input from our sensory organs by making a model of the world, is senseless for observables such as appearances.

Testing and Measuring Appearances

It is widely believed that measurement of subjective experiences or the development of procedures that implicate a mathematical representability of appearances is impossible. The reasons for this opinion are, among others, the contextual nature and the great variety of appearances, the difficulty of identifying the boundary between phenomenal and conceptual components, their intrinsic cross-modality, and even their degree of naturalness or artificiality; last but not least, the impossibility of giving an (objective) rendering of appearances in third person account because they are subjective experiences. The question of methods with which to measure appearances is still far from being satisfactorily clarified; but this is due to the ambiguity that surrounds the status of appearances themselves.

Elementaristic approaches have a much easier task to accomplish, because they instead start from the excitation of the receptors by a luminous stimulus. Such sensations are supposed to be transformed, modified, and organized in successive stages of processing with the purpose of satisfying particular requisites of a cognitive nature. According to elementarism, perceptive presentations such as surface colors consist of simple color sensations organized by secondary high-level processes; and modifications of color sensations are due to context-dependent, top-down factors. A phenomenological approach, instead, searches for regularities within the phenomena themselves rather than relying on extrinsic mechanisms. If one has to develop a methodology for the analysis of appearances, for example for a study of spatial shapes and their interrelation with colors, one must start from the global impression of the shapes and colors in the particular context in which they are observed. It is scientifically more economical, simple, true, and elegant to avoid constant recourse to top-down processes as putatively explanatory of phenomena. Experimental phenomenology searches for regularities or explanations within the phenomenon itself rather than relying on extrinsic mechanisms: the explanation must derive from the phenomenon itself. Furthermore, it also considers, besides the chromatic aspect of that phenomenon, the subjective space–time and the 3-D aspect as determinant of and essential to its appearance. As regards colors, following Hering ([1920]1964), the task of a qualitative methodology in color studies is to classify the great multiplicity of color and light impressions in order to acquire a systematic perspective on them. An ideal phenomenological study should be able to designate the colors with descriptions so precise and comprehensible that a person can apply them to his or her own internal chromatic world (unique hues and their combinations), without need of an external atlas because the descriptive characteristics used refer directly to the qualities of this chromatic world that every person has (Da Pos and Albertazzi 2010).

Specifically, one cannot rely, as in psychophysics, on measurement units such as the just-noticeable difference, because in the realm of appearances they would concern entities that can be metrically identical but perceptually different, or entities irreducible to their metric properties. Furthermore, in seeing, the perceiver is presented with a distribution of the qualities of the perceptual field on many inner scales and which simultaneously comprises information at different levels of resolution and is modified by attentional shifts. Last but not least, appearances are cross-modal, which means that there are qualities that in perceiving are naturally associated with others in another modality (such as color and shape, sound and shape, taste and touch, etc.) or even within the same dimension (color and shape).

When conducting studies on what a subject perceives, the temptation is always to shift towards the physical or the neural correlates of the subjective experiences that are supposed to be in the focus of attention. In fact, most of current science does so, thus avoiding the problem. As regards cross-modal associations, for example, one interpretation has sought to explain them in terms of direct synaptic connections between neurons (representing the inducer and the concurrent); another interpretation, instead, is based on high-level processes due to language, culture, abstract symbolization, learning, etc. (Simner et al. 2006; Ward et al. 2007; Jürgens and Nikolić 2012; Meier 2013; Tomson et al. 2013). A third interpretation, of Gestalt derivation (Albertazzi 2013b), explains associations in terms of *patterns of qualitative similarity* present in different sensory modalities and perceived as such. For example, hot and cold, sad and happy, and pleasant and unpleasant, are connotative properties of both sounds and colors, not semantic information projected top-down into other domains, but qualities intrinsic to perceived phenomena. This interpretation, adopted in studies on the associations between color and shape in the general population (Dadam et al. 2012; Albertazzi et al. 2013, 2014a, b), does not exclude correlated investigations at the psychophysical and neurophysiological level: it maintains, however, that different analyses deal with different observables. One understands the nature of the problem from these examples, because having a specific viewpoint on the observable to be analyzed implies also a different choice of methodology, measurements, and so on.

Methods

Methods of measurement obviously exist: consider the Munsell system for the identification of color units. In this system, the interval between one gray and the next on the white/black scale appears to be of the same magnitude as the difference between the latter and its immediate successor, thus forming a purely perceptual unit for the measurement of grays. The Munsell solution is not perfect, however, in that this unit is one-dimensional and its application to different dimensions, such as hues or chroma, is not homogeneous. Despite these difficulties, the Munsell system has been successfully used in studies on color (e.g., Guan and Luo 1999).

Another traditional method employed to determine the semantic content of perceptual objects is Osgood's semantic differential. Given that semantic dimensions find ample expression in the adjectival descriptions of natural languages, differential semantics (Osgood 1956; Osgood et al. 1957) has been to date the most appropriate method by which we can try to establish correlations between qualitative aspects of perception and their intersubjective meanings. Osgood's semantic differential uses the associations made by the observer between the object under study and qualities expressed in linguistic form, normally adjectival. The subjects are asked whether or not a certain adjective is appropriate on a discrete scale of categorical evaluation (often converted into a continuous scale for the purposes of statistical processing). Or again, the subject may be asked to indicate, on a bipolar scale whose extremes are two adjectives regarded as opposites, whether an object is associable more with one than the other. The main advantages of this method are that it enriches the qualitative description of the semantic meaning with a sufficiently long list of adjectives, and makes it possible to group the different scales used into factors each of which is characterized by scales closely correlated with each other and little correlated with scales extraneous to that factor. Factor analysis, therefore, is often a natural complement to analysis conducted with the semantic differential. The results obtained with this method are very useful because they develop and deepen the qualitative aspects under which an observed object is actually experienced. However, despite its effectiveness, use of differential semantics may always encounter problems of translating linguistic categories from one language to another, given that in no case are these univocally and universally connoted terms, and they are often loaded by linguistic use. The adjectival categories of a language are not simple labels "attached" to stimuli: the actual referents of terms are not always transparent except to a native *and* competent speaker, and the boundaries among the categories are not always well defined. These differences are usually annulled when the terms of different languages are translated into the Anglo-American vocabulary of Osgood's semantic differential, when they undergo a sort of semantic "normalization."

A development of the semantic differential, to complement the traditional one and overcome its limitations, would be based not on linguistic scales but sensory ones. The use of verbal language to describe sensory experience and to produce judgments about its characteristics, in fact, involves a rather complex step of a representative nature after direct perception. A method recently adopted by studies on perception (Da Pos and Pietto 2010) almost completely excludes the use of verbal language, which is only used by the experimenter to specify the task to be performed. This revised semantic differential procedure consists in presenting the subject with pairs of opposite perceptions which must be evaluated as to the extent they are associable with the studied target. This evaluation can be made in a visual way by using a pencil to cut a segment into two parts corresponding to the degree of associability of the target with the two extremes. For example, instead of using words like "warm" and "cold," the subject is asked to put his or her left (or right) hand in cold water and the other hand in warm water. The subject must then evaluate the extent to which the target is associable with the left and right sensations. In this way, it is possible to use opposite perceptions pertaining to different sense organs (vision, hearing, touch, taste, and smell). This procedure has been found to be highly discriminative and able to yield a wide range of graded qualifications about specific perceptual experiences. It therefore seems particularly suitable for testing appearances (Murari et al. 2014).

How to Proceed

To sum up, the study of appearances requires two distinct phases. The first relies on the most accurate description of the observables. This requires that the subjects must undergo specific "training" so that they can spontaneously distinguish between what is *seen* and what is hypothesized (i.e., *thought*) to be the underlying mechanism (Kanizsa 1979), and thus become able to study the former aspect without worrying about the latter: exactly as a painter must learn to see in order to understand how to represent something on the canvas.

The second phase concerns the methods with which to bring to light underlying and potentially unknown aspects of qualities. Color (and color perception), for example, is typically a qualitative variable, where ordering and distance have no substantive meaning. However, it is likely that there are underlying (and unknown) aspects of such qualities and there are substantively interesting ways to define intervals between colors yielding quantified values where both the distances between the categories and their ordering have substantive meaning. Some recent experiments in the field of cross-modality (Albertazzi et al. 2012, 2013, 2014a, b), mentioned above, and conducted with the method of correspondence analysis show, for example, that non-random relations exist between colors and shapes, and that these relations are reproducible. Correspondence analysis shows that shapes are arrayed in color space along a series of bipolar scales characterizing the chromatic system: the first is warm versus cold, with greens and blues on one side and reds and yellows on the other; the second is dark versus light. This interpretation of the two factorial axes is due on one hand to the well-known subdivision of hues between warm and cold and, on the other, to the fact that the different hues have a different natural lightness (Spillmann 1985).

Besides measurement, a science of qualities (i.e., of the subjective perceptions of the surrounding world) raises the question of a specific metrics, although how and to what extent it can be reasonably applied is still problematic, given our current knowledge of the nature of mind. There are a few examples, such as a qualitative metrics based on similarity (Kubovy and Wagemans 1995). What experimental phenomenology would need, however, is a metrics concerning what occurs in a presentation, i.e., in extremely brief durations, developing in phases, and where phenomena of temporal and spatial dislocation occur. Until a unified theory of subjective space and time and of their units of representation becomes available, it will be very difficult to address the metrical issue properly.

Conclusions

One may ask why so much effort should be devoted to what is often considered to be an almost impossible task, if compared with the enormous success achieved by the current approach to the science of vision. The answer is simple: because current science, be it dressed in the guise of classical ecological approach or of probabilistic inferentialism, gives only a partial explanation of what it means to perceive; and, in several respects, it does not work. Essentially reductionist, those approaches exclude, and hence do not explain, the meaning of what we see, which is essentially qualitative and imbued with value and emotional tones.

A phenomenological viewpoint in the science of vision starts from within, to see what is correlated with the outside, not vice versa. What we have developed (or inherited) as living beings, in fact, are gestalten for action like those offered primarily by what we *qualitatively* and *globally* encounter in the environment and which provide us with immediate information on how to behave. One of these gestalten is the capacity to see multiplicity in unity (Bohm 1994), i.e., meaningful configurations, or aesthetic pleasure, which is essential for surviving also in the animal realm (Rothenberg 2012). Obviously, some components of these gestalten may be pre-wired due to biological selection and evolution, while others may be due to learning, because of repetition by the same individual subject. The process develops on more than one dimension, and it is certainly not linear. That said, it is likely that if the analysis of the semantic dimensions is conducted systematically, it will contribute to revision of the ecological theory of perception (Gibson 1979) in qualitative terms. What a human and/or a living being *perceives*, in fact, is not reducible to physical information, but comprises those aspects in perception that make sense for the individual. An internalist approach lies at the basis of ethological enquiries (Lorenz [1941]1982; Tinbergen 1963). In this regard, the role of experimental phenomenology would be complementary to that of biology in, for example, analyzing and testing the semantics of natural shapes in the environment. It has been recently shown, for example, that subjects in the general population group natural shapes on the basis of specific visual qualitative characteristics: specifically, non-spiculed, non-holed and flat forms are experienced and classified as harmonic and static, while rounded forms are classified as harmonic and dynamic, and elongated forms as somewhat disharmonious and somewhat static (Albertazzi et al. 2014a, b). On the basis of these findings, one can assume that dynamicity and harmony are affordances or invariants playing the role of general semantic information *clues*, which makes perfect sense in a framework of an ecological approach to perception.

Overall, more than the opposition between qualitative and quantitative, what should be questioned is the value of a strict formalistic viewpoint according to which semantics (such as, for example, the meaning of a triangular shape or of the vivid red of a cherry that I see) (Hurlbert 2013) can always be effectively replaced by more syntactic rules (sets of meaningless symbols, a set of rules combining the symbols into formulas, a set of rules for the transformation of formulas): the question is *what* and *how many aspects* may be excluded by such operations. Furthermore, the fact that each individual case can be formalized does not imply by default that there exists a universal algorithm covering all the possible observables. It appears, however, that a substantial proportion of the contemporary literature accepts, either implicitly or explicitly, that algorithmic models are the only possible explanations of perceptual and mental phenomena, because these are considered *algorithmic* processes. Last but not least, there is the question of the scientific presuppositions (often in terms of visions of the world) underlying scientific and social research. Starting from a mechanical (algorithmic or syntactic) point of view or from a perceptual-phenomenological point of view matters, not the least in terms of the different sense-making capacities of living beings.

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