Foundations of Science
https://doi.org/10.1007/s10699-022-09869-7

Philosophical, Experimental and Synthetic Phenomenology: The Study of Perception for Biological, Artificial Agents and Environments

Carmelo Calì[1]

Accepted: 5 August 2022

Abstract
In this paper the relationship between phenomenology of perception and synthetic phenomenology is discussed. Synthetic phenomenology is presented on the basis of the issues in A.I. and Robotics that required to address the question of what enables artificial agents to have phenomenal access to the environment. Phenomenology of perception is construed as a theory with autonomous structure and domain, which can be embedded in a philosophical as well as a scientific theory. Two attempts at specifying the phenomenal content of artificial agents are discussed. Concepts and experimental evidence on the independence of perception and the coordination of motion and appearances are set out to submit that phenomenology of perception makes a contribution to synthetic phenomenology.

Keywords Phenomenology · Perception · Machine consciousness · Psychology · Artificial intelligence · Robotics

1 Introduction

This paper spells out what is characteristic of the phenomenological study of perception to define the relationship between phenomenology in philosophy and psychology, on the one hand, and the so-called synthetic phenomenology, on the other. Synthetic phenomenology is the name devised for a research program in A.I. and Robotics. According to it phenomenal consciousness, namely the capability to having experience of something, is as fundamental a property of artificial agents as it is of living biological systems. Synthetic phenomenology claims that addressing questions about the phenomenology of perceptual experience has great advantages for the computational description, the algorithmic design and the implementation of artificial agents that sense and cope effectively with the environment. Accordingly, this claim blurs the distinction between biological and artificial systems as it is often the case when the description of a domain is considered adequate if built at an abstract level that prescinds from anything but the property of the system under scrutiny.

✉ Carmelo Calì
carmelo.cali@unipa.it

[1] Dipartimento di Scienze Umanistiche, Università degli Studi di Palermo, Palermo, Italy

Published online: 06 September 2022

Moreover, the very prospect of synthetic phenomenology is likely to sound odd to our intuition of a biological basis for an agent to have appearances, that is to have phenomenal access to the environment through perception. Finally, that claim may seem disputable if one holds that phenomenology is bound to a first-person description of experience that is not consistent with the standard third-person account of science. Therefore, even regarding human subjects, either phenomenology cannot but being a source of qualitative data for psychophysics or science must face radical changes to study the correlates of phenomenological experience (Gallagher & Sørensen, 2006; Horst, 2005; Overgaard, 2004).

Contrary to this view, this paper argues that phenomenology is as abstract as any theory or science is and, in particular, that phenomenology of perception is characterized by specific commitments about its structure and domain, according to which it may be embedded in the philosophical or the experimental study of perception. In this sense, phenomenology is consistent with standard science. Conversely, synthetic phenomenology is presented as a research program that can refer to the phenomenology of perception for the prospect of providing constructs and evidence in the domain of artificial agents.

This paper is divided in two parts. In the first part, synthetic phenomenology is introduced, the demands of phenomenology arisen in A.I. and Robotics are highlighted, and phenomenology of perception is presented as a study at the adequate abstract level to account for perception as an independent mode of cognition of the environment. The introduction of synthetic phenomenology is limited to tracing its historical and conceptual roots. The presentation of phenomenology aims to specify the commitments that qualify its study of perception, that can be embedded in philosophical and psychological research. In the second part, two examples are given of problems that require artificial agents to have phenomenal access to the environment. This section aims at outlining the common basis for the study of perception in biological and artificial agents. No mechanisms and architectures are mentioned except for those suggested in the context of the early definition of the scope of synthetic phenomenology as discussed in the first part.

Finally, it is argued that the independent evidence of the experimental phenomenology of perception makes an important contribution to synthetic phenomenology.

2 Synthetic Phenomenology

The term "synthetic phenomenology" was introduced by J. Scott Jordan during a workshop held at the Max Planck Institute for Psychological Research (Munich) in October 1998. He claimed that as synthetic biology combines science and engineering to construct biological functions and systems that are not found in nature, so synthetic phenomenology aims at modeling, designing and developing conscious systems, including their states and functions, on artificial hardware. The terms "phenomenology" and "consciousness" suggest that the capability for having experiences, namely of having states whose phenomenal content enables the artificial agent to have access from its point of view to the surrounding world, is crucial to move, make decisions and carry out actions effectively. Let us assume that an autonomous mobile robot has to find its way safely through a room, where objects like chairs, chests of drawers, and desks put up hurdles between it and the door. Pylyshyn (2000) comments that neither propositional representations nor analogical representations would enable the robot to navigate this environment effectively and successfully. In the logical formalism of propositional representations objects are lists of properties, collected in categories. This form of representation is inefficient, due to costs of cognitive resources and time, and more importantly it does not serve the robot's behavior. Motion and actions need that the agent picks up the relevant objects in the environment. Instead, logical formalism allows only to derive objects as something that fall under some category through inferential relations of subsumption and inheritance that have the "is_a" form. Analogical representations are built in terms of mental images or internal world models. Objects are represented in the same way a picture or a photo of the scene would do. As the standard objection of the homunculus goes, this would require an inner observer, that which would bear additional representational costs. Pyslyshyn submits that since any agent, be it biological or artificial, is situated in the world, its visual representations have deictic pointers that connect them to objects in a direct and pre-conceptual manner. Such pointers would pick up objects indexed in terms of the place they hold in the surrounding environment and this information binds them with the potentialities of motion and action of the agent. Pylyshyn's hypothesis is not discussed in this paper, but it is interesting for the questions it is deemed to answer.

What is the relation between objects' affordances to the robot and its states such that the robot can be on the right track to the exit? What is the appropriate nature of such relation, for it to enable a successful behavior with low cost of time and representational resources? What processes bring that relation about? At which scale do processes operate that pick up what is salient and detect relevant changes? How do such processes connect objects and robot's sensing and locomotory potentialities? What is the scale at which they operate to enable retaining and anticipating information in time?

It is noteworthy that similar questions have spurred the research in Robotics. A case in point is the research program defended by Brooks (1990). Starting from the assumption that "evolution already created intelligence", Brooks claims that intelligence essentially consists of "being and reacting" and that robots need mobility, vision and tasks that are related to survival. He designed robots with interacting layers of functional units. Each layer is an activity producing system that connect inputs and outputs, sensing to acting. Complex intelligent behavior is achieved through interaction among them under the constraints of the niche of the environment where the robot must survive.

From the synthetic phenomenology standpoint, Gamez (2008) holds that answering those questions requires studying the conditions at which artificial agents are conscious of the environment and finding how to describe the phenomenal states such consciousness consists of. Those questions put the tenet into question that for a biological or artificial agent to be intelligent and have a mind, it must have token-representations with a form that makes them distinct at least for a feature, apply to them operations admitted by self-consistent rules, and derive information from its transition across internal states (Haugeland, 1985). Consequently, meaning is not a property of representations or states. It is appended to the world, from which they are functionally independent, and is assigned to information by interpretations that connect the result of operations and transitions to the world. Instead according to synthetic phenomenology, meaning is a property of the states of the agent, which derives from the aspect of the world that falls under the content of the representation. Those questions challenge also the alternative view of analogical interpretation. Chrisley and Parthemore (2007) remark that having an image of something does not endow the agent with the experience of that thing. Having an image may be tantamount to sensing the proximate cause of the experience of the imaged thing, but that does not imply that the agent has phenomenal access to it, namely that it is conscious of seeing it.

Therefore, synthetic phenomenology aims at describing the phenomenal content of experience, that is what inherently confers intentional, semantic and referential properties on agents' representations and actions. Chrisley and Parthemore (2007) make a distinction between "synthetic phenomenality" and "synthetic phenomenology". The first term applies to agents that mimick having an experience of something. Those agents are designed to behave in such a way that an observer is likely to attribute the capability of experience to them, even if in fact they do not have phenomenal access to the world (as for the intentional stance of Dennett, 1987). The second term applies instead to agents that really have experiences, because the information upon which their behavior is grounded derives from the phenomenal content of their states that represents how the world looks to the agent. The distinction rests upon the argument that for an artificial agent to have experience of or phenomenal access to the world like a biological agent, it is not sufficient that a functional equivalence is found between them, namely that the effects of their behavior are similar under some respects. Rather the condition holds that the processes underlying their observable behavior are equivalent, in the sense that they map the world through appearances of ordered qualities and magnitudes. At the junction between A.I. and Robotics, Aleksander and Morton (2007a) claim that a system S is 'synthetically phenomenological', if and only if it contains a machinery that represents what the world and the system S within it seem like, from the point of view of S. For this reason, in this research program 'phenomenological' refers to the consciousness of an aspect of the outside world, rather than to *qualia* or sensory data. Accordingly, studying agents' experience implies studying the phenomenal structure through which they become adapted to the environment, rather than a private state.

In the following section, phenomenology is construed as an abstract theory that can be embedded in the philosophy or the science of perception. This will set the ground for it to provide constructs and evidence for synthetic phenomenology.

3 The Structure and the Domain of the Phenomenology of Perception

Phenomenology is as abstract as any theory or science, in the sense that it builds its conceptual or experimental structure to capture the properties and the relations of its domain. Its aim is to make the sense of perception explicit, that is to analyze or provide experimental evidence of the form of perception that enables perceivers to fix a referent under a perceptual modality and to understand it through distinct modes of appearing. Therefore, the structure of phenomenology must not include theoretical posits of non-ordinary entities, like *qualia* or sensations, constructs and evidence of other sciences, for instance drawn from physics or neuroscience, and common-sense beliefs like the assumptions that the appearances of an object are either only the effect of its material properties or subjective seemings. The domain of phenomenology coordinated with the structure consists of the intrinsic properties of appearances. Therefore, phenomenology qualifies as the study of perception 'from within' like intrinsic geometry is the science of surfaces independently of the space they are embedded in.

The restrictions over the structure and the domain are justified by the assumption that perception is a mode of cognition, namely a mode to extract information from the environment, that can be studied from an extrinsic and an intrinsic standpoint. From the extrinsic standpoint, one may study the properties of the information about external referents, for instance the degree of accuracy or error, even in connection with other sciences that deal with the boundary conditions of perception, e.g. the physics of material things or the neurobiology of perceptual areas of the brain. However, from the intrinsic standpoint, the object of study is the form of perception that endows appearances with the rules and order that allow them to convey information. This requires that the reference of perception is set to zero, as it were. It is true that external things are that without which perception is bound to remain 'unsaturated' in the respect of providing access to the world. However, if the aim is studying the form through which perception satisfies this function, things that are its external referents are considered as mind-independent objects, yet only within the limits of perception. Brentano (1874, 1982) emphasizes this methodological point with the introduction of the concept of immanent objects, the distinction of correlates in perceptual acts and the argument that the concept of colors and sounds is not relative, in the sense that it is consistent to conceive of colors or sounds regardless of their actually being perceived. In the same vein, Hering (1905) distinguished between "visual things" and external things, yet he claimed that colors are properties through which things perceived as external pieces of the world are segregated from and stand out against one another. The distinction was brought in to prevent that the knowledge drawn from other sciences was prejudicial to the collection and observation of phenomenal data. The 'principles' stated by Husserl (1913) and Metzger (1941) are a generalization of this assumption that restricts conceptual analysis and experimental work to observable data, even if the latter contradicts common-sense or the knowledge acquired on the non-phenomenal conditions of perception.

In general, the study of the information one gets by perceptual acquaintance with things is replaced with the investigation of the appearances that convey it, which are treated as something taking place outside of perceivers. As Bozzi (1978) claimed, external referents are treated as perceivable things that consist of the 'logical sum' of the configurations of observable elements given the number of their possible arrangements. An example of shifting the study of perception from the extrinsic to the intrinsic standpoint is the conceptual and experimental analysis of figure/ground structure in Rubin (1921). Rubin manipulates observable factors that induce changes of belongingness of the contour and associated changes of segregation, stratification, and completion of visual regions. To show that the figure/ground structure is perceptual by nature, rather than being a mental content added to a sensory one or dependent on attention, Rubin brings in terms and employs variables that do not make reference to the things of the ordinary world, and designs cases of figure/ground inversion. However, Rubin claims that the evidence he aims to obtain must live up to ordinary world, because the figure/ground structure underlies important properties of things. Without it the edges of things could not delimit their shapes, while changes due to the motion of visually surrounding regions or to colors would alter their shape.

Notwithstanding the single perceptual occurrences cannot really be detached from the characteristic of being a first-person experience, since appearances are bounded to the perceiver's standpoint, phenomenology of perception is not interested in first-person data as such, rather in the order of appearances by which they hold well-behaving relations. Duncker (1932/33) emphasized this point in the field of psychology. He remarked that no appearance can differ arbitrarily across subjects. Let the ordering $a > b > c$ be the object of perception for the subjects S and R. If it appeared to S to display the relation 'greater than', while it appeared to R to display the relation 'immediate neighbor of', then R could never perceive the inequality $a > c$. Besides, whatever difference may occur as to something appear to S and R, this difference must consistently occur with another one under a coordinated respect. If S saw an inversion of the black–white series after wearing spectacles, then S would see a consistent inversion of the lightness-darkness series, and so should R. Being a first-person experience plays for phenomenology the same role as drawing figures for geometry. Since perception is accounted for if the order and the invariance of appearances are discovered, Duncker concludes that first-person data can be treated as an interpretation of the ordered system of appearances just as points, lines, surfaces are interpretations of geometrical axioms. First-person differences due to physiological causes may matter as transformations of the properties of order. Even in this case, research should concern what equalities of appearances are preserved. This argument highlights the difference between the phenomenological commitment to the study of perception as it is construed in this paper and that defended by Dennett (1991, 2003, 2007) for the scientific investigation of the wider domain of mental phenomena and consciousness. The research program Dennett dubs heterophenomenology is aimed at the interpretation of subjects' first-person reports as "raw data" to build a collection of the beliefs about what it is looking like to them. The rules of interpretation are assumed to build a bridge to fill the gap between the content of those beliefs and the third-person objective methods of science. Besides, in the light of the intentional stance that content is construed as a 'theorist's fiction'. This is at odds with the claim that the relevant content of perceptual appearances is obtained by the abstraction of the properties of order and structure, irrespective of their first-person experience as such.

4 Philosophical and Scientific Embedding of Phenomenology

To account for perception, the phenomenology of perception can be embedded in a philosophical or scientific and experimental theory. Since the aim is to make the form of perception explicit from an intrinsic standpoint, philosophical and scientific theories need to bring in terms, predicates, and experimental variables to decompose perception from within. Therefore, conceptual and scientific constructs must be defined in direct or indirect connection to observable qualities and magnitudes.

The structure of a phenomenological theory may consist of primitives, such as boundary and continuum in the conceptual analysis of the spatial and temporal properties of perception in Brentano (1976). The structure may specify relations by which philosophical and scientific theories describe the order of appearances, such as dependence, belongingness, betweenness, connection, parthood, and foundation (Brentano, 1982; Husserl, 1900/1901; Husserl, 1918–1926; Köhler, 1920; Rausch, 1966; Stumpf, 1873; Wertheimer, 1922). The structure may admit of operations that act on primitives and relations. At a meta-theoretic level, operations are the arbitrary substitution *salva veritate* of terms of propositions that describe the relations between primitives to obtain the laws about the structure of appearances (Husserl, 1900/1901; Stumpf, 1873), and the free variation of appearances that produces altered copies or counterfactual conditions across which invariant properties emerge (Husserl, 1913, 1939). At the conceptual level, operations are the transformations of coordinate systems that account for the shape of visual things and space (Husserl, 1907). At the experimental design level, examples of operations are the transformations underlying the grouping of visual elements (Wertheimer, 1923) or the transformations through orthographic projections of elements put in motion (Metzger, 1935) that allow to see rigidity, once deformations are discounted.

When phenomenology is embedded in scientific theories, the structure consists of the experimental paradigm, such as (1) the one contrived by Wertheimer (1912) to extract the optimal values of time intervals across their continuous variation at which the clear-cut perception of motion is obtained, independently of the physical boundary conditions; (2) the setting devised by Köhler (1917) to study animal problem solving in ecologically valid conditions; (3) the Ganzfeld set up assembled by Metzger (1929) to study depth and three-dimensionality of visual space by minimizing non-phenomenal factors; (4) the method of concomitant variation and conflicting stimuli systems suggested by

Michotte (1962) to eliminate the influence that familiarity, habits, past experience, and memory have on perceptual variables.

If constructs are introduced through a definition or a design by which they are connected in a direct or indirect manner to observable qualities and magnitudes, then a domain of phenomena emerges that is coordinated to the structure of philosophical and scientific theories. Phenomena are the placeholder for perceptual occurrences and appearances within the scope of the theory. Unlike the tradition that is traced back to Kant and in accord with Brentano (1982), the term 'phenomenon' denotes any object, state, event, and process that appears in such a way to be ascertainable and thus may be counted as fact.

The coordination between the structure and the domain in the phenomenology of perception can be noticed in many philosophical and scientific theories. In general, in a philosophical theory terms and predicates are defined as constituents of descriptive propositions, and phenomena are introduced as placeholders for specifiable arrays of repeatable properties and connections of appearances. Parts and features of phenomena can even be disjointly instanced in many perceptual occurrences and in any perceptual scene. Admitted operations, whose application can be defined according to rules in logical and mathematical terms, are applied on propositions to obtain descriptions or models of the parts and composition of phenomena. If naive subjects' perception in ordinary experience satisfies the description or provides an interpretation of the model, then the theory accounts for the form that allows perceptual reference to things in the daily life world. Outstanding examples are Meinong (1903) and Stumpf (1883). Meinong describes the abstract solid model that represents the perception of colors, which is embedded in a more extended abstract space of color. He derives the properties that colors have in ordinary experience according to the place they hold on the surface and inside the solid as well as to the relations that stem from the geometrical properties of the model. The dimensions along which colors vary, the distance between colors, and the direction of color transitions provide a map of the appearances of color of naive subjects. Stumpf describes the perceptual attributes along which tones vary and the relations they hold. He studies the algebraic relations that correspond to their ordering as well as the geometrical properties of the abstract space that maps the properties of perceived sound. In a scientific theory of perception, constructs and variables are defined to design the experimental conditions at which the resulting phenomena replace the appearances of ordinary experience, to make them testable and observable in a controlled and repeatable manner. Koffka (1921) argues that this conceptual substitution fulfills an explanatory function. On the basis of the correlation between phenomenal variables, one may discover the parts, the connection and the order that enable subjects to 'react' to the environment and gain phenomenal access to it through their naive experience. The examples of experimental research in which phenomenology of perception is embedded are many and varied (Albertazzi, 2013; Calì, 2017; Smith, 1988). A list of the historical roots of this research would include at least last Century's psychologists based at Graz (von Ehrenfels, Meinong, Benussi), Berlin (Wertheimer, Köhler, Koffka, Lewin, Gelb, Metzger, Goldmeier, Rausch), Vienna (Bühler, Brunswik, Kardos, Heider), Louvain (Michotte, Fraisse, Knops), Padua and Trieste (Musatti, Kanizsa, Metelli, Bozzi, Vicario), to whom the work of Stumpf, Katz, Rubin, Burke, and Brown should be added. Albeit in a quite independent way, all those researchers have worked on the building blocks of the perceivable world such as the modes of appearing of color and touch, sound, figure/ground, shape, space, depth, time, permanence, movement, velocity, and mechanical intentional relations). Each block can be considered at the same time as a perceptual module that enables naive subjects to have phenomenal access, and as a basic structure of the perceivable world, whose values are distributed over the perceptual occurrences of common-sense daily life.

In the next section, two examples of equivalent problems in synthetic phenomenology are presented to see whether some concepts and evidence of phenomenology of perception can be extended to the issues of the modules required for artificial agents to have phenomenal access to their environment, and of the form their composite perceptual capability should have.

5 Architectures and Models for Artificial Agents with Phenomenal States

Chrisley (2009) distinguishes two types of research in synthetic phenomenology, which however are not mutually exclusive. The first type aims to specify the phenomenal content that artificial agents could bear, be they a neural net, a virtual machine or a robot. The second type takes artificial agents as models that specify the phenomenal content so that it can be communicated to and scrutinized by cognitive systems designers.

The axiomatic consciousness theory (ACT) of Aleksander (2005), Aleksander and Morton (2007a) and the design of an architecture where it can be suitably implemented (Aleksander & Morton, 2007b) are examples of synthetic phenomenology that straddles the first and the second type. The ACT is intended as an extension of phenomenology to A.I. It spells out the interlocking components that jointly build an equivalent of intentional consciousness in vision, which supports the sense of a self who sees the world being within it. The components are: (1) a feeling of presence; (2) a recursive process such that states and transitions between states, which are first activated during perception, can be reactivated even in the absence of the original perceptual conditions, thus building a sense of continuous experience; (3) the ability to focalize perception to regions of the visual field attentively; (4) the ability to anticipate the perceptual outcomes of actions; (5) the ability to evaluate those outcomes affectively.

The implementation of ACT in a digital net architecture has the value of an experimental test or of a simulation in a technical sense. For that to be the case, the distinct modules or functional units of the architecture and the connection between them and with inputs and outputs must be specified. The functional units are a perceptual module (PM), an action module (AM), a memory module (MM) and an emotion module (EM). The PM yields the proprioceptive experience of the self, the feeling of focussing and shifting vision to what is salient in the environment, and the views of the external world. The AM controls the parameters and variables of PM, and assigns to each view an index that links any appearance to a movement with reference to one of the agent's bodily motion coordinates. Thus, the AM subserves properties binding and selects the couple formed by a state of the PM and a movement of the AM that can become an actual phenomenal state. The MM stores and retrieves perceptual states, processes them in sequences through imagery, and may enter the PM to supplement its processing. The recursive interaction of the MM and the PM builds the sense of being able to have experiences that is the core of awareness. The EM gives an affective value to the states of the PM and the outcomes of the AM. The scope of the ACT and its implementation is the theory of artificial or machine consciousness. However, in this paper only the issues of perception will be taken into account.

What would an artificial agent be able to experience with this architecture to get an effective and successful phenomenal access to its environment? If we assume that its view corresponds roughly to an $n \times n$ matrix of the visual sensor (eye) that can be moved on the regions across the visual field, then for each region the matrix captures what the PM extracts by inspecting each region through eye motions. What is perceivable to the agent unfolds along the directions of eye motion, hence the state that is current in the PM undergoes a transition to other states, and each state is indexed by the AM. At the center of matrix the index is always zero, because what appears in that position of the visual field requires no eye movement and the gaze is still and directed straight ahead. The center of the matrix works as a reference value for what is captured by other cells, whose appearances will bear positive or negative index values according to the sense of eye motion along a determined direction. As the sensor (eyes) move, the MM learn the succession of the couple built out of a state of the PM and an action of the AM, which has become a phenomenal state. Then, the MM can have access to the PM and supplement the transition of perceptual states with retrieved couples that serve as imaged phenomenal states, on whose grounds those appearances are anticipated that are likely to occur if sensors (eyes) are steered along determinate directions.

For such an agent, the feeling of being present in an 'out-there world' will emerge because what it is to be perceived is always characterized by an index in terms of the coordinates of the agent's mobile sensors and effectors. Indexing appearances and actions through a common reference system for motion makes explicit 'what the world and the system seem like from its point of view' in a third-person format. Therefore, the first-person visual experience that can be ascribed to the agent can be also studied according to the standard methodology of science.

Chrisley and Parthemore (2007) and Chrisley (2009) give an example of the second type of research in synthetic phenomenology. They compiled a program for basic visual abilities and maintenance of expectations, that was implemented in the robot Aibo ERS-7, and developed the model SEER-3 to specify the robot's visual experience with a phenomenal content for external observers. In general, the content captures the sense in which a representation takes the world to be. In this particular case, the phenomenal content captures how perception presents the world as being to the robot. For that to be communicable to external observers, the phenomenal content is derived by a mapping function that from can be dubbed as a "depiction" of robot's visual experience for the external observers.

Let us assume that the robot is moving in a room until it stands still and a section of the surrounding space falls within the scope of its visual sensor. The robot scans the corresponding region of the visual field by moving its head on which the sensor is mounted, thus obtaining a view whose acuity decreases from the foveal area to the surrounding ones. It focuses and steers its gaze on the basis of (1) the current sensory input; (2) the expectations of what sensation would obtain for a given head motion; (3) the detection of change of the sensory input; (4) the check of its consistency with prior expectations and of its extension to a local part or to the whole region of the visual field.

SEER-3 generates a map of how the space falling in the visual field looks to the robot. For instance, for a color hue that is expected to fill a particular place in the visual field, in the model a mark will be produced for the location determined by the x- and y-values that represent how much the robot should move its head along the horizontal and the vertical axis to focus its gaze on it. The values may be expressed in degrees with respect to origin corresponding to the foveal radius r of (x, y). The mark may encode further information, like for instance the lightness of that color. As the gaze shifts over the region of interest, SEER-3 will map each value that results from the sum of sensation and expectation onto a mark in such a way that the position of the latter in the map will correspond to the position of that value in the visual field. Since each sensation is obtained by head motion and the resulting value is encoded according to foveal coordinate systems, overlapping regions on the map will correspond to correlated regions of the visual field, scanned by connected motions. Likewise, greater regions on the map will correspond to greater areas of the visual field explored by the robot. The marks satisfy the function of designators whose location and arrangement are the same as the location and arrangement of sensations in the visual field according to the motions. In this sense, the order of expected sensations indexed by motion is the same as the order of position of marks on the map, so that the map returns a phenomenal content that is isomorphic to the visual experience of the robot. Thus the model generates a dynamic and temporally extended map of an enacted phenomenal content that can be inspected and studied from a third-person perspective.

6 An Assessment of Synthetic Phenomenology for Future Research

Synthetic phenomenology addresses questions about artificial agents that are equivalent under many respects to those faced by the phenomenology of perception about human subjects. Bearers of perceptual systems are indeed different, but in either research field perception is studied at the abstract level that specifies its phenomenal content and the form that enables them to have an efficient and successful access to the environment. Moreover, synthetic phenomenology could be construed as an extension of Duncker's claim about the indifference of first-person data as such. For phenomenology of perception is an explanatory endeavor that is carried out at an abstract level, be it through conceptual analysis or experimental work, and is consistent with the third-person perspective of standard science, its constructs and evidence can make a contribution to synthetic phenomenology. Furthermore, the phenomenology of perception can provide arguments to assess some issues that are not satisfactorily addressed by synthetic phenomenology, because of an underspecified account of perception.

First of all, there is well-known phenomenological evidence of the independence of perception from memory and expectations. One outstanding example is amodal completion, which Kanizsa (1961) considers a phenomenon that allows to draw a clear-cut distinction between what perceiving is and what it is not. For every instance of the amodal completion, one can design many transformations of the properties of the pattern, which can be defined by material operations performed on well defined parts of it. Transformations will have completion either remain unchanged or disappear, but such results will crosscut what observers remember, expect to see or know about it. If a transformation was sufficient to make the phenomenon disappear, it will always be possible to reverse it for completion to pop out again in a compelling way. The repeatable array of properties that rule this phenomenon is independent of the 'interpolation' of what it could have been looking like, on the grounds of memory or expectations. This point may be sufficient to note that the phenomenology of perception and the prospects of its contribution to synthetic phenomenology are independent of the attempt to make the ability to directing one's attention inward an introspective method consistent with science (Weger & Wageman, 2015).

Second, movement or action is not a determinant factor of appearances. Rather, it is functionally coordinated with the transformations of the order that binds appearances to the perceptual field. The perceptual field is an ordered system of positions. It is simply connected, congruent with itself, finite, and bounded. Positions are distinguished only by the discontinuities between the qualities of appearances that fill them. Conversely, appearances are marked by positions so that regions of the visual field and parts of appearance delimit one another. The movements of the perceiver's body can belong to different classes. For each class of movements, a subset of positions of the field change and a subset of appearances that fill them pass into one another, preserving or changing the qualities they display. Therefore, each class of movements induce transformations of the field onto itself and such transformations have the meaning for the perceiver of transformations of mobile appearances onto themselves. Movement is coupled to the field and functionally coordinated with appearances. However, the factors from which perceivers extract the properties to which they refer are the order of the field and the invariance of appearances (Husserl, 1907; Metzger, 1966).

The first point suggests to revise the design of the phenomenal architecture that requires integration of the PM by the MM. The second point suggests to replace the sensory-motor contingency theory (O'Regan & Noë, 2002) upon which the SEER-3 model is based.

Finally as far as the prospects of future research are concerned, experimental phenomenology can be used to design the controlled conditions and the simulations that specify what perceptual states of an agent become active and for what combinations of features in the environment. Since phenomena are defined as an array of repeatable properties or sets of possible configurations, their instances can replicated by setting parameters of space, time, and motion. For the concomitant and random variation of their values, observations can be made on states, states transitions and their functional connection to a repeatable array of features. Contrary to the null hypothesis, one may submit that there will be subsets of states for distinct combinations of values recorded by the sensors, among which a subset of stable states may occur. Tests on the equivalence between biological and artificial agents across conditions can be carried out. If a pattern of consistent behavior is observed, a meta-language can be used to describe the phenomenal content of such states. The choice of the meta-language needs to be justified only by formal consideration of the expressive power of the language (Gamez, 2006). That could also allow for deflating the argument for a depictive mapping of content.

7 Conclusion

Synthetic phenomenology is a sound research program. It addresses fundamental questions arisen from research in A.I. and Robotics. It shares with phenomenology the claim that experience has a structure that enables those who have the capability for it to have phenomenal access to the world, which is not reducible to private states or non-ordinary entities. The reconstruction of the commitments on the structure and the domain of the theory of perception qualifies the phenomenology of perception as abstract as any theory can be. This has implications on its epistemological autonomy, by which it can be embedded in philosophical and scientific endeavors to study perception, provided that those commitments are met. Under this condition, the structure and the domain of the theory are defined to make the form of perception explicit. As the experimental work shows, this condition is consistent with the third-person perspective of standard science. Phenomenology of perception and synthetic phenomenology can share a common ground of conceptual analysis and simulation. Future research may make scientific capital out of the findings on the independence of perceptual modules, which can be specified in terms of controlled parameters, and on their connection with movement abilities through which information from the environment is derived in a phenomenal format.

Funding Open access funding provided by Università degli Studi di Palermo within the CRUI-CARE Agreement.

Declarations

Conflict of interest The Author states to hold no conflicting financial or non-financial interests and that this work does not require a study-specific approval by an ethics committee for research.

References

Albertazzi, L. (2013). Experimental phenomenology. An introduction. In L. Albertazzi (Ed.), *Handbook of experimental phenomenology. Visual perception of shape, space and appearance* (pp. 1–36). Wiley-Blackwell.

Aleksander, I. (2005). *The world in my mind, my mind in the world: Key mechanisms of consciousness in humans, animals and machines*. Imprint Academic.

Aleksander, I., & Morton, H. (2007a). Why axiomatic models of being conscious? *Journal of Consciousness Studies, 14*, 15–27.

Aleksander, I., & Morton, H. (2007b). Axiomatic consciousness theory for visual phenomenology in artificial intelligence. In *AAAI fall symposium: AI and consciousness*.

Bozzi, P. (1978). L'interosservazione come metodo per la fenomenologia sperimentale. *Giornale Italiano Di Psicologia, 5*, 229–239.

Brentano, F. (1874). *Psychologie vom empirischen Standpunkt*. Duncker & Humblot. English translation by A. C. Rancurello, D. B. Terrell & L. McAlister. (1973). *Psychology from an Empirical Standpoint.* Routledge.

Brentano, F. (1976). *Philosophische Untersuchungen zu Raum, Zeit und Kontinuum*. Meiner. English translation by B. Smith. In S. Körner & R. M. Chisholm (Eds.), (1988). *Philosophical Investigations on Space, Time, and the Continuum*. Routledge.

Brentano, F. (1982). *Deskriptive Psychologie*. Meiner. English translation by B. Müller, (1995). *Descriptive Psychology*. Routledge.

Brooks, R. (1990). Elephants Don't Play Chess. *Robotics and Autonomous Systems, 6*, 3–15.

Calì, C. (2017). *Phenomenology of perception. Theories and experimental evidence*. Brill.

Chrisley, R. (2009). Synthetic phenomenology. *International Journal of Machine Consciousness, 1*(1), 53–70.

Chrisley, R., & Parthemore, J. (2007). Synthetic phenomenology: Exploiting embodiment to specify the non-conceptual content of visual experience. *Journal of Consciousness Studies, 14*, 44–58.

Dennett, D. C. (1987). *The intentional stance*. MIT Press.

Dennett, D. C. (1991). *Consciousness explained*. Boston.

Dennett, D. C. (2003). Who's on First? Heterophenomenology explained. *Journal of Consciousness Studies, 10*(9–10), 19–30.

Dennett, D. C. (2007). Heterophenomenology reconsidered. *Phenomenology and Cognitive Science, 6*, 247–260.

Duncker, K. (1932/1933). Behaviorismus und Gestaltpsychologie. Kritische Bemerkungen zu Carnaps "Psychologie in physikalischer Sprache". *Erkenntnis*, *3*, 162–176.

Gamez, D. (2006). The XML approach to synthetic phenomenology. In *Proceedings of AISB symposium on next generation machine consciousness,* Bristol, UK.

Gallagher, S., & Sørensen, J. B. (2006). Experimenting with phenomenology. *Consciousness and Cognition, 15*, 119–134.

Gamez, D. (2008). Progress in machine consciousness. *Consciousness and Cognition, 17*, 887–910.

Haugeland, J. (1985). *Artificial intelligence: The very idea*. MIT Press.

Hering, E. (1905). *Grundzüge der Lehre vom Lichtsinn*. Springer. English translation by L. M. Hurvich & D. A. Jameson (1964). *Outlines of a Theory of the Light Sense*. Harvard University Press,.

Horst, S. (2005). Phenomenology and psychophysics. *Phenomenology and the Cognitive Sciences, 4*, 1–21.

Husserl, E. (1900/1901). *Logische Untersuchungen*. In U. Panzer (Ed.), (1975). *Husserliana XVIII*. Nijhoff. English translation by J. N. Findlay (2001). *Logical Investigations*. Routledge, vol. 2.

Husserl, E. (1907). *Ding und Raum*. In U. von Claesges (Ed.), (1973). *Husserliana XVI*. Nijhoff. English translation by R. Rojcewicz (1997). *Thing and Space: Lectures of 1907*. Kluwer Academic Publisher.

Husserl, E. (1913). *Ideen zu einer reinen Phänomenologie und phänomenologischen Philosophie I. Allgemeine Einführung in die reine Phänomenologie*. In K. Schumann (Ed.), (1950). *Husserliana III/1–2*. Nijhoff. English translation by F. Kersten (1983). *Ideas pertaining to a Pure Phenomenology and to a Phenomenological Philosophy I*. Kluwer Academic Publishers.

Husserl, E. (1918–1926). *Analysen zur passiven Synthesis*. In M. von Fleischer (Ed.), (1966). *Husserliana XI*. Nijhoff.

Husserl, E. (1939). *Erfahrung und Urteil. Untersuchungen zur Genealogie der Logik.* Academia. English translation by. J. S. Churchill & K. Ameriks, (1975). *Experience and Judgment. Investigations in a Genealogy of Logic*. Northwestern University Press.

Kanizsa, G. (1961). Cosa si intende per percezione. In *Atti del XIII Congresso degli Psicologi Italiani*. Editrice Universitaria, 22–28.

Köhler, W. (1917). Intelligenzprüfungen an Anthropoiden. *Abhandlungen der Preussischen Akademie der Wissenschaften. Physikalische Mathematiker Klasse*, 1. English translation (1927). *The Mentality of Apes*. Kegan Paul, Trench, Trübner.

Köhler, W. (1920). *Die Physischen Gestalten in Ruhe und im Stationären Zustand*. Vieweg. Partial english translation in D. W. Ellis (Ed.), 2001. *A Source Book of Gestalt Psychology* (3rd edn., pp. 17–54). Routledge.

Koffka, K. (1921). Zur theorie der Erlebnis-Wahrnehmung. *Annalen Der Philosophie, 3*(1), 375–399.

Meinong, A. (1903). Bemerkungen über den Farbenkörper und das Mischungsgesetz. *Zeitschrift für Psychologie und Physiologie der Sinnesorgane*, *33*, 1–80. Reprinted in (1969–1978). *Gesamtausgabe* (pp. 495–576). Akademische Druck- und Verlagsanstalt, 1.

Metzger, W. (1929). Optische Untersuchungen am Ganzfeld II: Zur Phänomenologie des homogenen Ganzfelds. *Psychologische Forschung, 13*, 6–29.

Metzger, W. (1935). Tieferscheinungen in optischen Bewegungsfeldern. *Psychologische Forschung, 20*, 195–260.

Metzger, W. (1941). *Psychologie: die Entwicklung ihrer Grundannahmen seit der Einführung des Experiments*. Steinkopff.

Metzger, W. (1966). Das einäugige Tiefensehen. In W. Metzger and H. Erke (Eds.), *Allgemeine Psychologie I. Der Aufbau des Erkennens* (pp. 556–589). Hogrefe.

Michotte, A. (1962). Théorie de la causalité phénoménale: Nouvelles perspectives. In A. Michotte et collaborateurs (Eds.), *Causalité, Permanence et Réalité Phénoménales* (pp. 9–90). English translation (1963). *The Theory of Phenomenal Causality: New Perspectives* (Appendix II). Methuen.

O'Regan, K., & Noë, A. (2002). A sensorimotor account of vision and visual consciousness. *Behavioral and Brain Sciences, 24*, 939–973.

Overgaard, M. (2004). On the naturalizing of phenomenology. *Phenomenology and the Cognitive Sciences, 3*, 365–379.

Pylyshyn, Z. W. (2000). Situating vision in the world. *Trends in Cognitive Science, 4*(5), 197–206.

Rausch, E. (1966). Das Eigenschaftsproblem in der Gestalttheorie der Wahrnehmung. In W. Metzger & H. Erke (Eds.), *Allgemeine Psychologie I. Der Aufbau des Erkennens* (pp. 866–953). Hogrefe.

Rubin, E. (1921). *Visuell wahrgennomene Figuren. Studien in Psychologischer Analyse*. Gyldendalske Boghandel.

Smith, B. (1988). Gestalt theory: An essay in philosophy. In B. Smith (Ed.), *Foundations of gestalt theory* (pp. 11–81). Philosophia Verlag.

Stumpf, C. (1873). *Über den psychologischen Ursprung der Raumvorstellung*. Hirzel.

Stumpf, C. (1883). *Tonpsychologie*, vol. 1. Hirzel. Reprinted edition (1965). Bonset

Weger, U., & Wageman, J. (2015). The challenges and opportunities of first-person inquiry in experimental psychology. *New Ideas in Psychology, 36*, 38–49.

Wertheimer, M. (1912). Experimentelle Studien über das Sehen von Bewegungen. *Zeitschrift Für Psychologie Und Physiologie Der Sinnesorgane, 61*, 161–265.

Wertheimer, M. (1922). Untersuchungen zur Lehre von der Gestalt I. *Psychologische Forschung*, *1*, 47–58. Partial English translation (2001). In D.W. Ellis (Ed.), *A Source Book of Gestalt Psychology*. (3rd edn., pp. 12–15). Routledge

Wertheimer, M. (1923). Untersuchungen zur Lehre von der Gestalt II. *Psychologische Forschung*, *4*, 301–350; Partial English translation (2001). In D.W. Ellis (Ed.), *A Source Book of Gestalt Psychology*. (3rd ed., pp. 71–88). Routledge.

Carmelo Calì is associate professor at the University of Palermo. His research interests are in the philosophy and psychology of perception, and in the scientific study of picture, music perception and design problem solving. He is also engaged in an interdisciplinary unit that carries out research on the perceptual and cognitive foundations of human-robot and human-humanoid interactions. He is scientific and managing co-director of the Medical Humanities Lab.