Phenomenology of Augmented Environments

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ABSTRACT

In this article I analyze the notion of augmented environment from a phenomenological point of view. Referring to the work of J. von Uexküll, I will define environment as the set of perceptual and operational possibilities that a living being projects into its surroundings. Recalling the distinction between world and environment proposed by Scheler and Heidegger, I will show that augmented perception implies a redefinition of the openness that defines the human world.

1. *Describing Technology and Describing Experience*

Phenomenology is based on a methodological premise: it is necessary to distinguish the reality of things from the way we experience things. This distinction is fundamental in order to analyze augmented environments. An augmented environment is the object of an augmented perception. But what does augmented perception mean? In the scientific literature, the most common expression to describe this complex range of phenomena is "augmented reality" (AR). This expression, however, is misleading. Generally, the expression "augmented reality" refers to a certain type of technology which has developed considerably over the last ten years and is likely to become increasingly important in the near future. By using this technology, a subject can have several different experiences. One must therefore be careful not to confuse the description of a certain technology, in terms of hardware, software, technical problems, etc., and the description of the experiences that are made possible by this technology. While the first issue is outside the research field of aesthetics, conceived as a theory of sensible experience, the second is absolutely relevant from a philosophical point of view, and it is the issue that I am going to analyze in this essay.

To illustrate the fundamental difference between the description of a certain technology and the description of the experience made possible by a technology, I would like to consider a type of images to which we have long been accustomed, namely television images. What kind of experience do I have when I watch a football match on television? In some ways it is a perceptual experience, because my eyes actually see something – the images of the match – and my ears actually hear something – the voice of the commentator. The images that I see and the sounds that I hear are not fantasy images: in phenomenological terms they are not "represented" images. However, the experience that I have when I watch a football match on television is different from "natural" perception and has something in common with the experience of a representation: the objects I am looking at are absent, they are not actually "present". The players are not in my room even though I see them. I hear the noise of the supporters, but they are not actually with me. I listen to the commentator, but I do not see his face and I know that he is not "present" either, because the players cannot hear him.

In the lessons on *Phantasy and Image-Consciousness,* from 1904/1905, Husserl proposes to distinguish between "phantasy" and "imagination". He calls imagination the experience that we have when we represent something absent on the basis of the perception of an image (Husserl 2005, p. 89). Imagination is partly similar to perception, because it is grounded in the presentation of an intuitive content, but it is also similar to phantasy, because it represents something absent. It is important to note that the phenomenological distinction between different types of intuitive act does not necessarily correspond to the ontological distinction between real and unreal objects. Normally, perception is the intuitive experience that allows us to know reality. However, it is possible to have a perceptual experience that does not correspond to the reality of things: this is the case, for example, with optical illusions. In the same way, even if pure phantasies are representations, not all representations represent unreal objects. Recollection, for example, is a representation that posits the reality of its object. When I close my eyes and I remember the face of someone I know well, the experience that I have from a phenomenological point of view is similar to the experience of pure phantasy: nevertheless, the object that appears in the recollection is a real object (Feyles 2013). The correspondence between experience and reality is not even automatic in the case of imagination. When I watch a football match on television, images of a real event appear to me. On the contrary, if I watch a science fiction movie on television, the images that I

perceive do not represent a real object or situation. As a result, we cannot consider television images real or unreal in themselves. Through the same medium, i.e. through the same technology, one can either experience something real (for example the Juventus players) or something fictional (for example the Avengers)[1].

These remarks help us understand why the notion of AR is misleading and why it is more useful, from a philosophical point of view, to talk about augmented environments and augmented perceptions. As a matter of fact, the technology that makes AR possible can be used in very different ways and provoke very different experiences. The first step of any phenomenological analysis of augmented environments is to recognize this variety. Jon Peddie rightly pointed out that AR "is not a thing, it is a concept that can be used by many things, and it will be a ubiquitous part of our lives just like electricity" (Peddie 2017, p. 4). Electricity makes television and radio possible, but it would make no sense to ask whether "TV reality" or "radio reality" are actually real or not.

The relevance of these remarks becomes clear if we consider four different examples of augmented environments that can already be produced with current technology: (a) let us imagine an individual who needs to visualize precisely how much space is occupied by a table that he wants to buy: instead of taking measurements and trying to mentally imagine the new table in his kitchen, AR technology allows him to superimpose the three-dimensional image of the table on the real space in his kitchen and evaluate the effect it has (Arnaldi, Guitton, Moreau 2018, p. XXVI); (b) let us imagine a surgeon who has to perform a complex surgery to remove a tumor from a patient's brain: in this case, identifying the exact location of the tumor requires a great deal of spatial reasoning and a high degree of sensorimotor skill. Using an AR device, the surgeon can visualize an image that overlaps with the real image of the patient's brain, an image in which the exact location of the tumor is highlighted (Peters, Linte, Yaniv, Williams 2019, pp. 6-7); (c) let us imagine a

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[1] The taxonomy of mixed reality proposed by Milgram and Kishino (Milgram and Kishino 1994), although interesting and accurate, has no value from a phenomenological point of view, precisely because it is based on the description of different technological devices rather than on the description of different experiences. If we assume the taxonomy proposed in their article, when I look at two people inside the well-known Ames room, what I see is a real environment. However, the height of the two people I perceive in such a case is not "real": I am not "really" looking at a dwarf and a giant. It is an illusion. Moreover, according to the taxonomy proposed by Milgram and Kishino, the two cases (b) and (c) that I presented should be placed at the same point of the "virtually continuum". However, the experience of the surgeon who operates using an AR device is an experience of relationship with reality, while the experience of the boy playing an AR video game is a fictional experience.

boy playing one of the many available zombie videogames: instead of looking at a fixed screen, the boy moves freely around his house, shooting at the monsters, which appear in his living room or in the kitchen; (d) let us imagine a driver who needs to reach a place that he does not know: instead of repeatedly looking at the screen of a navigation device, with all the risks that this entails, thanks to AR technology he can see bright arrows on the road, that give him the correct directions; he can also see indicators in his environment that give him information about traffic, shops nearby, points of interest, etc. (Arnaldi, Guitton, Moreau 2018, p. 36).

In all these four cases we have imagined augmented environments, but the experience made by the subject is different in each case: in case (a) the subject is visualizing the future, something that is not yet real (the new table in his kitchen). This kind of experience is equivalent to what Husserl calls "expectation", i.e. the positional phantasy that is directed to the future (Husserl 1991, p. 57). The difference is that in this case it is not a pure phantasy, but a mix of imagination (the representation of the table based on the perception of an image of the table itself) and perception (the vision of the kitchen environment). In case (b) it is not a matter of anticipating the future, but we are still dealing with reality. The virtual image that overlaps with the natural perception of the real brain makes the surgery more efficient, and surgery has very real effects. In case (c), instead, augmented perception puts the subject in relation with a fictional world. Certainly, the zombies' graphic rendering may be very realistic and the environment in which the game takes place is "real" and familiar. However, a game experience of this kind is a fictional experience, (hopefully) associated with the consciousness of unreality. From a phenomenological point of view, this kind of experience is not different from the experience we have when we watch the Avengers on television, being well aware that Scarlet Johansson is a real person and that she is not "really" jumping on a spaceship together with the Hulk[2]. Finally, case (d)

[2] Nicola Liberati proposed a phenomenological analysis of some games based on AR, in particular Pokemon Go. I agree with him when he says: "Even if the digital objects have the everyday world as a background on which they are superimposed, they are not part of the surroundings as other objects. They are part of the game generated by the device. These Augmented Reality games still produce 'digital fantasies' even if now the digital objects are visualized in the surroundings" (Liberati 2018, p. 218). On the contrary, I'm not convinced that "the intertwinement between digital and everyday world aimed by Augmented Reality is not achieved yet because these objects are still fictitious and they are not part of the everyday world" (Liberati 2018, p. 229). In fact, it seems to me that the misunderstandings linked to the ambiguity of the notion of Augmented Reality remain present in Liberati's text because there is no clear distinction between the description of a technology and the description of the experience of reality that a technology makes possible.

might seem similar to case (b), because the interaction between the subject and the environment is real also in this case: the imaginary driver is not playing a video game, he is "really" driving a vehicle. However, a difference needs to be highlighted here, for in this latter case the information that overlaps with the natural perception is not simply perceptual, but rather it is a mix between symbolic information (the arrows) and verbal information (the indications about the shops nearby, the traffic, etc.).

Considering these distinctions, it is clear that there can be several different phenomenological problems related to augmented environments. The most interesting questions arising from the analysis of cases (a) and (c) are related to the complex relationship between perception, imagination and reality. Probably, the most urgent question is the following: since technological advances make it possible to produce increasingly perfect virtual environments and augmented environments, is it possible that subjects will end up losing the ability to distinguish between fiction and reality? Are we "murdering the reality"? (Baudrillard 1995) Will the reality be completely absorbed in the "spectacle"? (Debord 1967) Although these issues are certainly crucial, in the remainder of this paper I will focus on some different problems. Indeed, it seems to me that the specific novelty of augmented environments is rather related to the subject-environment interaction which is exemplified in cases (b) and (d). In the two situations that I have described (AR surgery and AR driving) and in similar ones that will be more and more produced, the subject has a clear and well-founded awareness that he/she is acting in reality. In both cases, the danger of a confusion between illusion and perception or fiction and reality does not seem relevant. I will therefore refer to *non fictional augmented environment*s to designate situations similar to those I have described in cases (b) and (d).

2. *Environment and World*

In order to analyze the experience the subject has when dealing with non fictional augmented environments, it is necessary to clarify the theoretical meaning of the notion of environment in the first place. The notion of environment has been investigated since the beginning of phenomenology, especially by Heidegger and Scheler. Both refer explicitly to Uexküll's research. Heidegger openly recognizes the philosophical importance of the work of the Estonian biologist:

> It would be foolish if we attempted to impute or ascribe philosophical inadequacy to Uexküll's interpretations, instead of recognizing that the engagement with concrete investigations like this is one of the most fruitful things that philosophy can learn from contemporary biology. (Heidegger 1995, p. 263)

What can the philosopher "learn" from Uexküll? First, he can learn that the animal-environment connection is an essential relationship, which precedes and founds the distinction between the two terms of which it is composed. The environment is not simply a physical space within which an individual is placed, just as an object is placed in a box. Uexküll calls this neutral space that has no essential relation with the percipient subject "surroundings" (*Umgebung*) (von Uexküll 2010, p. 43). The environment is clearly distinguished from the surroundings. The environment is the experience horizon of the living being, which essentially belongs to it. The most remarkable consequence of this conception is that different living beings inhabit different environments, even if they are in the same physical place. The same object, which from the point of view of a physical description remains a single entity identical to itself, can therefore "appear" substantially different in the environment of different animals. The example that Uexküll presents in the final chapter of *A Foray into the Worlds of Animals and Humans* is enlightening. An oak tree appears to the forester as a pile of wood to be axed. But for the fox who has built his den among the roots of the tree, the oak appears as a protection. For the owl the oak also appears as a protection, but it is not the roots but the branches that are "significant" in its environment. For the squirrel, the same branches have a different significance, because they are passages and springboards. For the ant, on the other hand, the oak tree never appears in its entirety, because what appears to it is only the bark "whose peaks and valleys form the ants' hunting ground" (von Uexküll 2010, p. 131).

> In accordance with the different effect tones, the perception images of the numerous inhabitants of the oak are configured differently. Each environment cuts out of the oak a certain piece, the characteristics of which are suited to form the perception-mark carriers as well as the effect-mark carriers of their functional cycles. (von Uexküll 2010, pp. 130-1)

Each animal "cuts" the same reality in a different way, by selecting different significant aspects in the same object. These cuts and selections are not only different, but also contradictory:

> In the hundred different environments of its inhabitants, the oak plays an ev-

er-changing role as object, sometimes with some parts, sometimes with others. The same parts are alternately large and small. Its wood is both hard and soft; it serves for attack and for defense. (von Uexküll 2010, p. 132)

It is important to highlight the correlation established by Uexküll between perception and operational possibilities. The oak "appears" differently to the fox, the forester and the ant, because the operations they can perform in the environment are different. Uexküll speaks in this regard of an "effect image", which is an integral part of the perceptual image.

How do we notice the sitting of the chair, the drinking of the cup, the climbing of the ladder, which is not given to the senses in any case? We notice in all objects that we have learned to use the act which we perform with them, with the same assurance with which we notice their shape or color. (von Uexküll 2010, p. 94)

This correlation between perception and the operational possibilities of a living subject allows us to determine a first definition of environment: *the environment is the set of perceptual and operational possibilities that a living being projects into its surroundings*. This definition is particularly significant because it represents a point of intersection between different research fields, namely biosemiotics, ecological psychology and phenomenology. There is a remarkable similarity between the ideas we can find in *A Foray into the Worlds of Animals and Humans* and Gibson's analysis of perception. The notion of "effect image", mentioned above, corresponds precisely to the notion of "affordance" elaborated in *The Ecological Approach to Visual Perception*. While reductionist psychology tries to explain perception as an aggregate of sensations caused by an aggregate of objective qualities, ecological psychology recognizes that we never perceive objective qualities; we perceive affordances, that is, possibilities of interaction with the environment. In his analysis of perception, Gibson highlights the priority of the animal-environment relationship (Gibson 2015, p. 4) and insists on an idea that may reach reaches the unanimous consensus of phenomenologists: the animal-environment complementarity is not reducible to the classical opposition between the mind and the physical space (Gibson 2015, p. 129). The animal is not simply a mind, because it is always in an environment. The environment, on the other hand, is not simply a physical space, because it is in relation to a living being. For Gibson, it is clear that every animal has its environment and for this reason the affordances that it perceives "have to be measured relative to the animal. They are unique for that animal" (Gibson 2015, p. 120). Affordances are not abstract physical properties that

have an objective value independently of the subject's perception; even though it is equally true that perception of the affordance is not modified by the particular individual's need and therefore the affordance has its own peculiar objectivity (Gibson 2015, p. 130).

Long before Gibson, Heidegger had already highlighted the originally pragmatic character of perception in *Being and Time*[3]. While classical metaphysical and anthropological tradition considers the relationship between man and world first and foremost as a cognitive relationship, characterized by a purely theoretical attitude of observation, for Heidegger things manifest themselves primarily as "useful things". The relationship with useful things is not a "blind" connection without any understanding. Understanding a useful thing means perceiving its "what for": for example, understanding what a hammer is means understanding what operations can be carried out with that particular instrument. Certainly, this understanding is a form of knowledge; but it is a knowledge oriented towards action and completely distinct from "science". Heidegger calls "circumspection" this form of understanding of the "handiness" or usability of the useful thing (Heidegger 1996, p. 65).

The relationship with the beings encountered in the surrounding world that is made possible by circumspection is not limited to so-called artificial things, such as the hammer. The Heideggerian notion of the useful thing does not coincide with the common sense notion of an instrument. The distinction between environment and surroundings elaborated by Uexküll and that between physical space and environment proposed by Gibson correspond to the difference between world and nature in *Being and Time*. While the world is the set of the useful things which the *Dasein* is related to, the nature of physical science is conceived as a set of simply present things. But the original relationship of the *Dasein* with nature, for Heidegger, is never the simple observation of natural properties.

> "Nature" is also discovered in the use of the useful things, "nature" in the light of products of nature. But nature must not be understood here as what is merely objectively present, nor as the *power of nature.* The forest is a forest of timber, the mountain a quarry of rock, the river is water power, the wind is wind "in the sails". (Heidegger 1996, p. 66)

There is, however, an important difference that is made in Heidegger's analysis. The useful thing, as it is described in *Being and Time*, is never isolated. The usability of the useful things is possible

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[3] "Our perception of the world, as Heidegger's notion of the 'ready-to-hand' and Gibson's notion of affordances show, is of an environment that affects us and elicits our action" (Gallagher and Zahavi, p. 100).

only in relation to the totality of the useful things. For this reason, the structure of the what-for, which is characteristic of the useful thing, is defined by what Heidegger calls "reference". Each useful thing refers to the other useful things with which it is in relation: a pen makes sense, i.e., it can be what it is, only in a world where there are sheets of paper and ink, and where the operation of writing or drawing is possible (Heidegger 1996, p. 64). This interdependence between the part and the whole introduces a further layer to our analysis. The structure of the reference is also the structure of the sign. Indeed, Heidegger shows that the world is formed according to a structure that he calls "significance". Significance is the ontological basis of language and word (Heidegger 1996, p. 82). In this way, an essential relationship is envisaged, which will be further developed in Heidegger's later texts: namely, the fact that being in the world means being in the language (Heidegger 1971, p. 93; 2000, p. 56).

We can understand, consequently, why Heidegger uses a specific terminology: being in the world is not the same as being in the environment. The world is something "more" than the environment. The difference is provided by language. The correlation between perception, operation and environment, which Uexküll first and Gibson then highlight, is a feature of the experience of any animal able to have complex perceptions. But for Heidegger, only in the case of the man a meaning that language can express is recognized in perceptual experience. Human perception always interfaces with language. We can therefore infer that human perception, unlike animal perception, is always an "augmented" perception. Since the human experience is defined by being in language, the human world is not simply an environment. *But can we also affirm that the human world is always an "augmented" environment*?

3. *Augmented Environments and Experience*

The most commonly accepted definitions of AR highlight the increase in information that occurs in the perception of the environment, through the mediation of a specific technology.

The goal of AR is to enrich the perception and knowledge of a real environment by adding digital information relating to this environment. This information is most often visual, sometimes auditory and is rarely haptic. In most AR applications, the user visualizes synthetic images through glasses, headsets, video projectors or even through mobile phones/tablets. The distinction between these devices is based on the superimposition of information onto natural vision that the first three types of

devices offer, while the fourth only offers remote viewing, which leads certain authors to exclude it from the field of AR. (Arnaldi, Guitton, Moreau 2018, p. XXVI)

According to these definitions, the subject interacting with an augmented environment perceives a real environment, but the specificity of AR is the overlap of information on the basis provided by natural perception. Clearly, the language we find in technical publications dedicated to AR is most of the time inadequate from a phenomenological point of view: for example, a phenomenologist could hardly accept the notion of "information" used by Arnaldi in the passage quoted above. However, these terminological problems, which conceal conceptual problems, should not prevent us from grasping the issue that is implicit in the idea of an increase in information present in perception. Language is certainly an extraordinary source of information for the perceiving subject. Framing a certain intuitive experience in linguistic terms means categorizing an object. Categorizing an object means having additional information available. Strictly speaking, this additional information is not "present" in intuitive data. This is the reason why we can argue that *human perception is always an augmented perception*[4]. When I look at a tank of gasoline and I recognize that it is gasoline, mainly thanks to an olfactory perceptual mark, I immediately perceive a complex set of affordances. For example, I know that I can use gasoline to fuel my car. But I also know that gasoline can easily catch fire and explode and that it is a toxic liquid. Where do I get this additional information from? I did not find it in the intuitive content of perception. I cannot infer the operational possibilities of gasoline from its color or smell. Nor can I say that I have extract this information from a previous experience: in my life I have never seen gasoline set on fire or explode and I have never heard of anyone who was intoxicated by drinking it. This information is part of my linguistic competence, of what Umberto Eco would call the "encyclopedic competence" of a speaker. Understanding the word "gasoline" does not mean knowing its chemical composition or the technological process by which it is produced in the first place. Rather, a proper understanding of the word "gasoline" implies that I know some "schemes of action" (Eco 1997, p. 70): for instance, that we cannot

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[4] As noted by A. B. Craig, it is correct to speak of AR only when the information superimposed on the perception of the world is digital information (Craig 2013, p. 16). However, Craig shows that in a wider sense it can be argued that even "primitive" instruments produce augmented environments: in this sense, we can say that a didgeridoo player adds an artificial sound to his environment and that road signs transform the highway into an augmented environment. This broad meaning of the notion of augmented environment allows us to understand the thesis I want to argue for: verbal language has always been the most powerful instrument that "augment" human-environment interaction.

drink it and that it is flammable. Our encyclopedic competence increases as we gain linguistic competence. Indeed, a small child may have only a partial understanding of the word "gasoline" and he may not know that it is toxic.

Let us now return to the two cases (b) and (d) that I presented earlier. Usually a surgeon knows exactly where to operate. How does he know that? Because he studied, but mostly because he has experience. We can expect, however, that the surgeon, unlike the forester, has no idea where it is necessary to hit the oak with the axe to cut it properly. These skills, which are linked to effect images or perceptions of the affordances, derive mainly from experience. So what can we expect from the development of AR technologies? The hypothesis of a forester performing a complex surgical procedure tickles my personal sense of humor, but I have to admit that it is a very unlikely hypothesis. It seems plausible, however, that in the future the operational skills we are talking about will be less and less determined by experience. We can also expect that the dangerous properties of gasoline will be showed in advance to the children of the future when the object enters the field of vision of their AR devices. It is possible, therefore, that the encyclopedic competence made available by language may be progressively less necessary.

However, this is not the most interesting problem. We have already noticed that Heidegger claims that there is an essential difference between world and environment. One year after the publication of *Being and Time*, Scheler returns to the problem in a reference text for contemporary philosophical anthropology, in which he tries to restate the difference between man and animal: *Die Stellung des Menschen im Kosmos*. The animal, for Scheler, is a prisoner of the limits of his environment. The operational possibilities that he can glimpse in his surroundings are predetermined. The morphological form, the structure of tendencies and the perceptual system form a "rigid functional unit" in the animal. So, the way in which the fox or the squirrel can see the oak is predetermined. On the contrary, man is "open to the world": his relationship with things is therefore always open.

Das Tier hat keine "Gegenstände": es lebt in seine Umwelt ekstatisch hinein, die es gleichsam wie eine Schnecke ihr Haus als Struktur überall hinträgt, wohin es geht – es vermag diese Umwelt nicht zum Gegenstand zu machen. Die eigenartige Fernstellung, diese Distanzierung der "Umwelt" zur "Welt" (bzw. zu einem Symbol der Welt), deren der Mensch fähig ist, vermag das Tier nicht zu vollziehen […]. (Scheler 1998, pp. 40-41)

This ability to distance the environment and objectify the entities encountered is only proper to the man. This ability is closely linked to his ability to speak. Language is the "instrument" of this distancing and objectification. But, at the same time, it is important to note that the openness of the human world is determined by the relationship that the man establishes between the perceptual-operational dimension and the language dimension. Let us return once again to the oak of Uexküll. The forester observing a branch of the oak is able to see different configurations of usability. He is able to see the branch as an instrument for striking, as a support for walking, or as a material suitable for light a fire. These three different ways of seeing correspond to three different ways of categorizing the entity that the forester is observing: "club", "walking stick", "firewood". Human language does not imply that only one of these categorizations is correct. This is the reason why human perceptual world always remains an open world. Now, what possibilities can we see when we imagine the augmented environments of the future? Is it a world where labels have already been stuck on everything? If so, we would have to admit that the augmented environments, while greatly enhancing our operational possibilities, make the world more closed.

References

Arnaldi B., Guitton P., Moreau G. (eds.), *Virtual Reality and Augmented Reality. Myths and Realities*, Wiley/ISTE, Hoboken/London 2018.

Baudrillard J., *Le crime parfait*, Galilée, Paris 1995.

Craig A. B., *Understanding Augmented Reality. Concepts and Applications,* Morgan Kaufmann, Waltham 2013.

Debord G., *La société du spectacle*, Buchet/Chastel, Paris 1967.

Eco U. *Semiotica e filosofia del linguaggio*, Torino, Einaudi 1997.

Feyles M., *Recollection and phantasy: The problem of the truth of memory in Husserl's phenomenology,* in "Phenomenology and The Cognitive Sciences", 12 (4), 2013, pp. 727-746.

Gallagher S., Zahavi D., *The Phenomenological Mind An Introduction to Philosophy of Mind and Cognitive Science,* Routledge, New York 2008.

Gibson J.J., *The Ecological Approach to Visual Perception*, Psychology Press, New York 2015.

Heidegger M., *Being and Time*, trans. by J. Stambaugh, State University of New York, Albany (NY), 1996.

Heidegger M., *Elucidations of Hölderlin's poetry*, trans. by K. Hoeller, Prometheus Book, Amherst 2000.

Heidegger M., *On the Way to Language,* trans. by P.D. Herz, Harper & Row Publisher, New York 1971.

Heidegger M., *The Fundamental Concepts of Metaphysics. World, Finitude, Solitude*, trans. by W. McNeill and N. Walker, Indiana University Press, Bloomington and Indianapolis, 1995.

Husserl E., *On the Phenomenology of the Consciousness of Internal Time (1893-1917)*, trans. by J.B. Brough, Kluwer, Dordrecht, 1991.

Husserl E., *Phantasy, image consciousness, and memory: 1898-1925*, trans. by J. B. Brough, Springer, Dordrecht 2005.

Liberati N., *Phenomenology, Pokémon Go, and Other Augmented Reality Games. A Study of a Life Among Digital Objects*, in "Human Studies", vol. 41 (2018).

Milgram P., Kishino F., *A Taxonomy of Mixed Reality Visual Displays*, IEICE Transactions on Information Systems, vol. E77-D, n.12, December 1994.

Peddie J., *Augmented Reality. Where We Will All Live*, Springer, Cham 2017.

Peters T. M., Linte C.A., Yaniv Z., Williams J. (eds.), *Mixed and Augmented Reality in Medicine*, CRC Press, Boca Raton, London, New York 2019.

Scheler M., *Die Stellung des Menschen im Kosmos*, Bouvier, Bonn 1998.

Uexküll J. von, *A Foray into the Worlds of Animals and Humans with A Theory of Meaning*, trans. by J. D. O'Neil, University of Minnesota Press, Minneapolis/London 2010.