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Phenomenology and Artificial Life: Toward a Technological Supplementation of Phenomenological Methodology

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Abstract The invention of the computer has revolutionized science. With respect to finding the essential structures of life, for example, it has enabled scientists not only to investigate empirical examples, but also to create and study novel hypothetical variations by means of simulation: 'life as it could be'. We argue that this kind of research in the field of artificial life, namely the specification, implementation and evaluation of artificial systems, is akin to Husserl's method of free imaginative variation as applied to the specific regional ontology of biology. Thus, at a time when the clarification of the essence of our biological embodiment is of growing interest for phenomenology, we suggest that artificial life should be seen as a method of externalizing some of the insurmountable complexity of imaginatively varying the phenomenon of life.

1 Introduction

Even though Husserl conceived of phenomenology as a strict science that could provide the necessary foundations for the natural sciences, so far there has been surprisingly little effort by either of these research programs—phenomenology or the natural sciences—to engage each other in a mutually informative dialogue. We argue that this lack of communication is largely the result of historical factors rather than due to an essential incompatibility: (i) as a novel enterprise phenomenology was primarily concerned with providing its own foundations first, and (ii) the natural

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sciences were blind to their apparent ‘crisis’ because of unprecedented empirical and technological breakthroughs.

However, the times are changing. At least in the relevant domains, the success of natural science is dampened by the intractable phenomenality of *lived* being (consciousness), and the now-established discipline of phenomenology is challenged, in ways that we will specify, by the empirical complexity of *living* being (organic life). Since both of these problems relate to the phenomenon of life, it should be possible to develop an integrated framework in response (Hanna and Thompson 2003). This paper complements recent efforts in this direction by arguing for a particular form of methodological continuity: traditional phenomenological methodology can benefit from modern technological supplementation, especially from research practices in the field of artificial life.

1.1 An Opportunity for Mutual Enlightenment

It is clear that phenomenology and natural science can (and frequently do) differ in their epistemic goals. Given Husserl’s anti-naturalism, one might expect phenomenology to reject the scientific mode of inquiry. However, it must also be remembered that one of Husserl’s driving motivations for the conception and continued development of phenomenology was its apparent potential to provide a secure foundation for the natural sciences. In addition, his methods aim to establish an ‘enlightened’ form of science, namely one which reflects upon its own conditions of possibility, its assumed premises, and inherent attitudes. Indeed, phenomenology can inform the sciences about the scope of their methodology, help to delimit the proper boundaries of their specific ontological regions of investigation, and help to uncover the sense of its empirical findings by bracketing the presuppositions of our natural attitude.

However, while Husserl often explicitly stated that one of the aims of phenomenology was to ground the sciences in this manner, it is also evident that this project has not succeeded. On the one hand, phenomenology’s history has been characterized more by the struggle to establish itself as a well defined research program in its own right. Seeking to establish a fruitful relationship with the natural sciences was only occasionally on the agenda. On the other hand, despite the apparent ‘crisis’ of these natural sciences (Hua VI), they have continued to expand their domains of research and recently have even begun to encroach upon phenomenology’s home turf, with consciousness named as one of the most important outstanding challenges of science (Miller 2005).

Why have phenomenology and science been talking past each other in this way for the last century? Already in 1929 Heidegger saw the unfulfilled potential that was entailed by a failure of phenomenology and the sciences to properly engage with each other. He reprimanded the philosophers for their arrogance and aloofness from the empirical facts, and criticized the scientist for failing to see that philosophical clarification of their work was actually in their best interest. He then demonstrated the possibility of a reciprocal relationship by analyzing the essence of the phenomenon of life while drawing on suitable empirical research, thereby illuminating both phenomenology and biology at the same time (Heidegger 1929).

This seminal study was followed by some other notable efforts to establish a mutually informative dialogue by engaging with both traditions on their own terms (e.g. Merleau-Ponty 1961; Jonas 1966). However, it is still the case that Heidegger's warnings have remained largely unheeded by phenomenologists and scientists alike.

It is of course unfortunate that this potential relation between two major knowledge traditions has not come to fruition. Nevertheless, perhaps the best explanation for this apparent failure is that this historic attempt was just premature. On the one hand, phenomenology was just being explicated. It still needed to go through several phases of internal struggle in order to fully establish itself as a major research program in its own right, and this struggle consumed most of its energy. On the other hand, science itself was still fully absorbed by its own success in both theoretical and practical (technological) terms, making any warnings about a supposed 'crisis' sound like minor annoyances of jealous academia. Thus, during their respective periods of development and accomplishment, engendered by the ongoing opening and exploitation of new regions of research, both phenomenology and the sciences had neither the need nor the ability to engage in any serious dialogue with each other.

We therefore suggest that this failure of communication was not due to some inherent incompatibility between the two traditions, or the necessity that their epistemic goals always and in every case remain different, but rather an outcome of the historical conditions of their first encounter. There is no evident a priori reason why first-person and third-person research should not be able to be combined into a framework that encompasses them both. This does not mean that first- and third-person accounts are interchangeable or reducible, one to the other, but that using more than one vocabulary is sometimes useful for gaining a full and nuanced understanding of phenomena. This, at least, does not contradict Husserl's view. He suggested, quite clearly, that "every analysis or theory of transcendental phenomenology—including […] the theory of the transcendental constitution of an objective world—can be developed in the natural realm, by giving up the transcendental attitude" (Hua I, Sect. 57).

If this is an accurate assessment of the historical situation surrounding the development of the phenomenological tradition during the last century, then perhaps there is still hope for mutual enlightenment. Indeed, it appears that we are slowly beginning to enter into a new historical phase that is going to be more conducive for this endeavor. On the one hand, phenomenology has matured. It has continually been defined and redefined by several generations of great thinkers, and survived in a form that still enjoys a strong following today. Moreover, we now have the advantage of being able to stand beyond its turbulent first years, on a foundation that is solid enough for us to shift our attention to what lies outside of phenomenology proper, especially science. Here lies a vast body of knowledge that has not yet been properly addressed in a phenomenological framework, especially with respect to the phenomenon of embodiment and organic life. Gaining a better understanding of biological embodiment might turn out to be a crucial challenge for the continued development of phenomenological ontology (e.g. Barbaras 2008).

On the other hand, it is becoming increasingly evident within the natural sciences that despite their history of impressive practical successes, they may have yet to face their biggest challenge. At least according to some, the final frontier of science is not to be found ‘out there’, behind the farthest reaches of the universe or within the realm of the tiniest sub-atomic particles. Instead, this final frontier is to be found ‘in here’, in the domain of our own lived experience which, as our personal means of relating to the world, can be understood as a necessary condition of possibility for scientific practice as such. This experiential domain has already begun to be charted by the developing science of consciousness. Accordingly, the natural sciences are potentially in the process of rediscovering the crisis that Husserl (Hua VI) had spoken of, namely the problem of securing a proper foundation for science, but as a crisis that has been brought forth by activities endogenous to scientific progress itself.

1.2 Phenomenology and the Cognitive Sciences

While any encounter between the two knowledge traditions will be largely driven by immediate practical concerns, it will also require stepwise work on both sides of the divide to overcome engrained prejudices and foster collaborative work that transcends traditional academic boundaries.

To many researchers working in the cross-disciplinary cognitive sciences this assessment will not be new. In fact, there has already been some considerable effort in establishing just this kind of mutually informative dialogue between phenomenology and the cognitive sciences (e.g. Varela et al. 1991; Gallagher 1997, 2005; Roy et al. 1999; Varela and Shear 1999; Bitbol 2002; Zahavi 2005; Thompson 2007), especially in the context of Varela’s neuro-phenomenology research program (e.g. Varela 1996, 1999; Lutz 2002; Gallagher and Varela 2003; Petitmengin et al. 2007). To be clear, this mutual dialogue is a two-way street. The empirical study of cognition has started to pay more attention to phenomenology, and to incorporate phenomenological insights and methods into experimental protocols (e.g., Lutz et al. 2002; Gallagher and Sørensen 2006). In this paper we want to focus on one way that we can move in the other direction. Specifically we wish to consider the role of technology in this endeavor. While modern science is unthinkable without technological research tools, the relationship between phenomenology and technology, in contrast, has traditionally ranged from mere indifference to a rather critical assessment. To be sure, by developing a mutually informative relationship with the sciences, the tradition of phenomenology has already encountered the use of technological research tools, albeit indirectly, in as much as these are needed to gather the empirical data.

Here we want to go further by suggesting that certain technological developments can be of help in a more direct manner. It is not enough that phenomenology tries to accommodate philosophically clarified *empirical data* into its framework; it must also make a similar attempt to come to terms with appropriate scientific *research methods*. In particular, we will argue that one of the central methodologies of phenomenology, the intuitive grasping of essences via free imaginative variation (*Wesensschau*), can benefit from *technological supplementation* that is based on ongoing research in the fields of embodied-embedded artificial intelligence and artificial life (cf. Froese and Ziemke 2009).

1.3 Overview of the Paper

The rest of the paper will unfold as follows: First, we briefly review how Husserl originally conceived of the method of *Wesensschau*, and highlight some of its shortcomings (Sect. 2). Then we will discuss this method's relation to the data gained by factual variations, in particular due to the study of non-ordinary others (Sect. 3). Then we introduce the field of artificial life with a specific focus on how its method of simulation can serve as a form of technological supplementation to Husserl's original method (Sect. 4). Finally, we present some concluding remarks (Sect. 5).

2 Phenomenology as a Strict Science

In this section we introduce Husserl's method of *Wesensschau*, the intuitive grasping of essences via free imaginative, or *eidetic*, variation. This is followed by a discussion of some of this method's potential shortcomings, and we then turn toward a consideration of the possibility of extending the method so as to include knowledge of *factual* variation, an extension that has been proposed by later phenomenologists. Some final reflections on phenomenological methodology then set the stage for an incorporation of certain kinds of technological developments.

2.1 The Phenomenological Method of *Wesensschau*

It is well known that the natural sciences are focused on obtaining essential invariants, that is, to derive the necessary and sufficient lawful regularities that govern the structures of a particular realm of phenomena which they have chosen to study. Similarly, Husserl conceived of phenomenology to be a science of *pure* essences (Moran 2000, pp. 132–136). As such, phenomenology's methods must abstract from the merely contingent, factual features of our experience in order to obtain the essential invariants of that experience (Hua III/9). However, since our concrete lived experience, our *Erlebnis*, is the starting point of all our investigations, what is needed is a method which can reliably yield the universal (essential) on the basis of the individual (contingent).

In this regard the method of 'essential seeing', or *Wesensschau* (Hua IX, pp. 72–87), was an important aspect of the early phenomenology of Husserl (Zahavi 2003, pp. 37–39). The possibility of such a method depends to a large extent on the realization that purely ideal phenomena, which for Husserl form a vast and unexplored phenomenological region (cf. Hua XVII), can also be directly given in our experience. We are not only able to intend particular spatio-temporal objects, but we can also intend that which characterizes all physical objects *as* physical objects, or even all possible objects *as* objects of our experience. It is thus important to realize that Husserl does not conceive of this process of ideation in terms of abstraction, but rather as a method which helps us to directly grasp the essence of a particular phenomenon

(Moran 2000, p. 135). In this sense it is akin to other lived experience, such as seeing, but targeted at the universal:

> Ideenschau ist selbst ein Analogon der schlichten Erfahrung, insofern sie ein freilich höheres und aktiv erzeugendes Bewußtsein ist, in dem eine neuartige Gegenständlichkeit, das Allgemeine, zur Selbstgegebenheit kommt. (Hua IX, p. 83)

In other words, it is a question of providing the conditions for the ideal phenomenon to appear as self-given in our experience. This process, which Husserl (1973, p. 346) also sometimes referred to as *ideation*, is characterized by three principal steps:

1. The productive activity which consists in running through the multiplicity of variations.
2. The unitary linking continuous coincidence.
3. The active identification which brings out the congruent over against the differences (Husserl 1973, pp. 346–347).

The foundation of this method of ‘essential seeing’ is the first step, which consists of a so-called free or *eidetic variation*. For Husserl this variation begins with a particular exemplar of the phenomenon to be investigated, conceived as one possible variant among endless others, which then forms the basis for our imagination to generate new variants. It does not matter whether this imaginative variation is “due to the aimless favor of association and the whims of the passive imagination” or obtained “by our own pure activity of imaginative invention from our original model” (Husserl 1973, p. 343). Sometimes the variants will appear as instances of the same phenomenon and sometimes our imagination will generate a variation which turns the phenomenon into something else. By keeping this variability and its consequences in mind, it is possible to obtain an essential insight, a *Wesensschau*. The disclosure of structural invariants which make up the essence of an object occurs when we succeed in establishing the horizon within which the object can vary without losing its identity as a thing of that type (Zahavi 2003, p. 39).

While this description might sound rather abstract and complicated, it is actually closely related to the everyday scientific practice of *interpolation*, which also requires the use of imaginative free variation—at least in the intervals between the values that have been effectively verified (Merleau-Ponty 1961, p. 71). In order to further illustrate this method of imaginative free variation we can take an example which Husserl provides in his *Cartesian Meditations*.

> Starting from this table perception as an example, we vary the perceptual object, table, with a completely free optionalness, yet in such a manner that we keep perception fixed as perception of something, no matter what. Perhaps we begin by fictionally changing the shape or the colour of the object quite arbitrarily. […] In other words: Abstaining from acceptance of its being, we change the fact of this perception into a pure possibility, one among other quite “optional” pure possibilities—but possibilities that are possible perceptions. (Hua I, p. 104)

Before we proceed further it is important to avoid any potential misunderstanding of the method proposed by Husserl. In particular, we need to resist the temptation to interpret the essence of a phenomenon, its *eidos*, in metaphysical terms (Hua IX, p. 73). In contrast to Platonic philosophy, and in line with the characteristic phenomenological return 'to the things themselves', Husserl does not reify the *eidos* as an *idea* in some mind-independent realm. Instead, he approaches it as something to be intended in our experience like any other intentional relation. Accordingly, the aim of his methodological *Wesensschau* is to bring this essence to immediate and intuitive givenness (*Gegebenheit*). In other words, the intuition of essences involves the emergence of (universal) truth in and through the (concrete) psychological event (Merleau-Ponty 1961, p. 53). It is not a matter of positing a purely abstract ideality as metaphysically existent, but rather of grasping or 'seeing' the universal in the individual (Moran 2000, p. 135).

2.2 Limitations of Thought Experimentation

We have seen that the crucial element of Husserl's method of essential seeing is that it depends on our ability to imagine eidetic variations. If I can vary an object in my imagination, then this variant, if it is not practically or physically possible, is at least possible in principle, that is, conceptually possible. In other words, the eidetic variation takes place "in a pure world of imagination, a *world of absolutely pure possibility*" (Husserl 1973, p. 351). However, while the method of *Wesensschau* has at times been taken to constitute one of the most distinctive features of Husserlian phenomenology, it is arguable that this interest in essential structures is actually common throughout the history of philosophy (Zahavi 2003, p. 37).

Indeed, in current analytic philosophy one of the most popular methods for testing the validity of philosophical analyses has been to devise thought experiments which, if they are conceivable, can be employed as invalidating counterexamples. However, it should be clear that if this way of doing philosophy, as well as science, is productive (Gendler 2004), it is also not without its problems. Thought experiments can produce intuitions that run counter to those evoked by alternative methods and produce ambiguity, conflict or inconclusive results (cf. Gendler 2007). Is it even legitimate to draw substantial philosophical conclusions from the mere fact that certain scenarios are imaginable? In other words, is our imagination trustworthy to the extent that it attests to metaphysical possibility, or might it occasionally reflect nothing but our own ignorance on the subject matter, or the limits of our imagination (Zahavi 2005, pp. 140–142)?

In order to minimize the possibility that our thought experiments are groundless, they must be conducted with sufficiently high attention to detail and must include all the relevant constraints that would be faced by the experiment under real-world conditions. It is important that we make the right abstractions such that the imagined scenario tells us something useful for our understanding of the philosophical problem. As Wilkes (1988, pp. 2–6) points out, these requirements for a systematic thought experiment demand that we keep track of a lot of variables and parameters. This is problematic because with an increase in complexity it may become impossible to draw any clear conclusion from the experiment, especially since we can no longer be sure which changes are responsible for the outcome.

3 The Turn Toward Factual Variability

While the possibility of imagining exceptional cases can be very useful to probe our intuitions, there are nevertheless limits to our imaginative capacity. Moreover, sometimes these limits are not even noticeable since they can be covered over by our own ignorance on the topic. Fortunately, the subversive element that is characteristic of a good thought experiment does not necessarily depend on our imagination. Factual (counter-) examples can also do the trick:

> Real-life deviations can serve the same function as thought experiments. If we are looking for phenomena that can shake our ingrained assumptions and force us to refine, revise, or even abandon our habitual way of thinking, all we have to do is to turn to psychopathology, along with neurology, developmental psychology, and ethnology; all of these disciplines present us with rich sources of challenging material. (Zahavi 2005, pp. 141–142)

In this manner imaginative variation is supplemented by factual variation. Indeed, though great care must be taken when interpreting any empirical facts, as their interpretation usually depends on the theoretical framework within which one is operating (Zahavi 2005, p. 142), their use to inform philosophical discourse can be very effective (e.g. Gallagher 2005; Zahavi 2005). This turn toward factual variation can thus resolve some of the shortcomings associated with general thought experimentation.

Could such a shift in perspective toward factual variations supplement Husserl's method of *Wesensschau*, which also crucially depends on the establishment of pure possibility via our capacity for imaginative variation (Hua IX, pp. 75–76)? To answer this question we need to employ Husserl's distinction between *formal* and *material ontology* (Hua III, p. 37). While the former denotes the study of the necessary characteristics of objectivities as such (e.g. object, relation, property, etc.), the latter investigates structures which are essential to a particular kind of ontological region (e.g. physical process, living being, mental object, etc.). Thus, even though the consideration of *factual* variations is largely irrelevant when it comes to investigations of formal ontology, they are necessary when the aim is to explicate a certain ontological region of material ontology, such as those explored by the natural sciences. We will here focus on the latter kind of investigation.

Husserl, at least from the point of view of his earlier work, would probably insist that even in the case of material ontology the only role for a factual instance is to provide us with an exemplar on the basis of which we can begin our free variation. And even this role is not necessary as the exemplar is only grasped in terms of possibility, and thus a tone, for example, can equally well be heard or just imagined (Hua IX, p. 73). However, this insistence on the separation of the process of ideation from empirical considerations makes Husserl's method vulnerable to the same problems faced by generic thought experimentation discussed earlier.

Thus Husserl claims, for example, that colors and sounds cannot change into each other (Hua IX, p. 75). But just because he cannot *imagine* this possibility does not necessarily mean that it is *actually* impossible. For instance, research on synesthesia, a condition which involves a peculiar mixing of the senses, has demonstrated that this regional (ontological) boundary between colors and sounds can be more malleable than might be ordinarily expected (cf. Ward 2008). This turn toward factual variation becomes all the more important if we extend our interest beyond abstract considerations, such as an isolated tone, to encompass our whole existence. Thus, as the phenomenological tradition developed further, especially in terms of recognizing the importance of embodiment and situatedness, it became crucial to develop a methodology that was more adequate to the concreteness of actual existence.

One popular approach in this regard, pioneered by Merleau-Ponty (1945) and Gurwitsch (1966), and continued by others today (e.g. Gallagher 2005; Zahavi 2005), is to turn to empirical psychology in order to analyze case studies of pathological conditions. These represent a kind of factual variation of human existence which can help us to determine essential aspects of consciousness that would be difficult (if not impossible) to simply intuit imaginatively. For example, what would we imagine the loss of a limb to be like if no one had ever experienced and reported such a loss? Would we have imagined the possibility of phantom limbs and their peculiar experiential properties (cf. Ramachandran et al. 1995)? Most real-world phenomena, and living bodies in particular, especially those with highly developed brains, are just too complex and unpredictable—i.e. emergent, causally spread, non-linear, etc.—for us to vary them imaginatively. Accordingly, pathological conditions can be useful factual variations on the basis of which it becomes easier to determine the essential structures of human existence. Of course, investigations based on neonates and young infants (e.g. Merleau-Ponty 1960; Sheets-Johnstone 1999; Gallagher 2005) as well as non-human life (e.g. Heidegger 1929; Jonas 1966; Sheets-Johnstone 1999) can be of similar help.

There is, however, an important limitation involved in factual variation, especially in regard to the study of pathologies. A good example of this can be found in Merleau-Ponty's (1945) use of Gelb and Goldstein's patient, Schneider. For empirical reasons the case of Schneider was always rather murky, even in Merleau-Ponty's discussion of it. It is never clear whether Schneider maintains what Merleau-Ponty calls motor intentionality, or not. Dreyfus (2007a), for example, much like Merleau-Ponty, seems to maintain an ambiguity on this point, yet they agree that to whatever extent Schneider might be said to employ motor intentionality, it is not fully intact. In contrast, Sean Kelly contends that Schneider's motor intentionality remains intact, "a kind of pure motor intentionality", a pre-reflective, skillful coping ability that is actually close to normal (Kelly 2000, p. 168; 2004, p. 75). In a case as complicated as Schneider, however—and perhaps more generally as a caution about factual variation of any sort—it is important to keep in mind a point made clearly by Tony Marcel (2003). He notes that we need to be careful to distinguish between normal functions that manifest themselves more clearly in pathological cases, and functions that emerge as compensatory within the pathology.[1]

[1] For further enlightened discussion of the Schneider case along these lines, see Jensen (2009).

Nevertheless, even with this caution, and despite examples of successful cross-disciplinary studies that employ factual variations, it should also be noted that the exploration and exploitation of the space of empirical variability is hardly systematic and is necessarily constrained by factual circumstances. To be sure, in the case of non-human organisms it is often possible to circumvent these constraints to some extent via invasive interference with the organism and/or its environment. Also, much factual variation can be obtained from human beings by designing clever experimental protocols. But especially in the case of human beings even this range of possibilities is limited. It is never certain that experimental controls introduced for good scientific reasons don't change the phenomenon under observation. As we have just seen, similar questions pertain even more in the case of variation based on pathology. Thus here we encounter once more the problem of factual contingency, which Husserl tried to avoid by recourse to pure imagination. But if the phenomenon of interest is too complex for imaginative variation, and is of limited empirical variability, what can one do? We will now argue that this shortcoming of empirical data, especially in relation to aspects of biological embodiment, can be alleviated to some extent by research procedures used in the study of artificial life.

3.1 The Turn Toward Technological Variability

As the preceding discussion has shown, we can distinguish between two major kinds of variation depending on the target phenomenon's mode of givenness or, more precisely, on the perspective we take toward the target: third-person empirical variation or first-person imaginative variation. However, this distinction should not be misunderstood as some kind of absolute incommensurability between these two modes. On the contrary, in terms of *Wesensschau* it is irrelevant whether the source of variation is given in the one mode or the other, as long as the variants those sources provide are approached in the attitude proper to eidetic variation, namely as equally pure possibilities:

> Ein reines Eidos behandelt die faktische Wirklichkeit der in Variation erzielten Einzelfälle als völlig irrelevant; eine Wirklichkeit wird behandelt als eine Möglichkeit unter anderen Möglichkeiten, und zwar als beliebige Phantasiemöglichkeit. (Hua IX, p. 74)

Notwithstanding other important differences between first- and third-person perspectives, with specific respect to this kind of task there is no *in principle* difference between a particular variant that was obtained through imaginative variation, lived through as a first-person experience, or encountered as a third-person case study. As Merleau-Ponty emphasizes in his defense of a mutually informative relationship between phenomenology and the sciences of man: "Reflection on the meaning or the essence of what we live through is neutral to the distinction between internal and external experience" (Merleau-Ponty 1961, p. 65). All modes of variation can help us to disclose essential structures, though some may more reliably do so *in practice*. And it is to this dependence on practical possibility that we turn next.

We have seen that Husserl's method of pure eidetic variation faces difficulties, especially when it is employed to determine the essential structures of ontological regions belonging to the material world. Our inability to do justice to the complexities of real-world phenomena using just our imagination has motivated some in the phenomenological tradition to supplement purely imagined possibilities with possibilities based on relevant actualities (as we see, for example, in Merleau-Ponty). The relevance of the actual examples is determined by the extent to which they challenge our preconceptions and whether they enable us to disclose essential structures. Thus, it is important to find non-ordinary variations and boundary cases, and use them carefully, as these have the potential to most clearly show the necessary structures that must hold under normal conditions.

In the next section we will make use of this distinction to propose further ways of supplementing the phenomenological method. The novelty of this proposal lies in its explicit reliance on recent technological developments, namely research in what has been called 'sciences of the artificial', in particular the field of artificial life.

4 Artificial Life: Externalizing Imagination as Simulation

In this section we first introduce the field of artificial life in more detail by looking at its history, some of its methods, and some examples. Then we argue that the methodology of artificial life is akin to an externalized form of Husserl's imaginative variation. Finally, it should be noted that there are, nevertheless, some essential differences between the being (ontology) of *imagined* entities and *simulated* entities.[2] These differences are considered from a phenomenological perspective.

4.1 What is Artificial Life?

Artificial life is an interdisciplinary field of research that investigates the phenomenon of life and cognition via artificial means (mainly in terms of computer simulation, robotic hardware, or bio-chemistry). Within this diverse field at least two general trends can be distinguished, according to whether the focus of the study is (i) on the self-constitution of a living being—for example, in terms of its metabolism—or (ii) on the agent's regulated relation to its environment—i.e., adaptive behavior (Froese et al. 2007). Research on the constitutive basis of life by means of computer simulations has been around for a while (e.g. Varela et al. 1974), but it really started to blossom in the late 1980s when the name of the field "Artificial Life" (Alife) was coined by Langton (1989). Since then Alife has

[2] In fact, the field of artificial life also includes methods that rely exclusively on organic and chemical building materials (e.g. Luisi 2003). However, the difference between these methods and those of synthetic biology are not well defined. Here we only focus on those examples of artificial life that involve some form of digital computer component in their realization. These we will broadly refer to as 'simulation models'.

generated a wide variety of research programs which are generally united by their common interest in accounting for the specificity of life and mind within a mathematical framework of non-linear dynamics and the concepts of self-organization and emergence (cf. Bourgine and Varela 1992; Langton 1995; Boden 1996).

Alongside the establishment of Alife as a more or less well defined field of research there was a related transformation in robotics toward a biologically inspired consideration of embodiment and situatedness (cf. Brooks 1991). This new robotics movement shared much of the conceptual framework of Alife and generally has now become a part of the field, though it focuses its efforts more on understanding the emergence of embodied cognition (e.g. Steels 1994), rather than on the organization of life per se. Today the field of such biologically inspired robotics has established itself as a viable alternative to more traditional engineering approaches (Pfeifer et al. 2007). A particularly important breakthrough occurred when this approach was combined with the insights gained from research in evolutionary algorithms (e.g. Holland 1975; Goldberg 1989), which is a class of optimizing algorithms that is loosely based on Darwin's theory of evolution by natural selection. Since the early 1990s this combined approach is referred to as "Evolutionary Robotics" (e.g. Cliff et al. 1993; Nolfi and Floreano 2000; Harvey et al. 2005), though it also often involves computer simulations of artificial agents rather than actual robotic hardware implementations. The theoretical and practical differences between these styles of implementing Alife systems need not concern us here.[3]

Since we will be presenting some illustrative examples of the use of evolutionary robotics (ER) at the end of this section, it is worth describing the methodology in more detail (cf. Froese 2009, pp. 114–124). This methodological exposition will include indications of how evolutionary robotics differs from the field that is widely known as artificial intelligence (AI). It is important to clarify from the start that although ER and AI share some similarities in as much as they both use computer technology as their tool of choice, they are actually widely different enterprises. While ER is most often used as a novel scientific tool to study cognition (cf. Harvey et al. 2005), AI is more usually part of an engineering endeavor and can be considered a branch of applied informatics (cf. Russel and Norvig 2002). When AI does purport to be relevant to cognitive science, it does so by appealing to the computer metaphor of the mind. However, as Dreyfus (1972) has already forcefully argued from a phenomenological perspective, this metaphor is fundamentally inadequate. Similarly, the work on ER rejects the assumption that the mind is like a computer, and operates more according to what might be called 'Heideggerian' principles (Wheeler 2005). In other words, whereas AI conceives of the computer as

[3] These differences in the choice of medium typically have a lot to do with the goal of the Alife project (e.g. scientific, engineering, commercial, artistic, etc.), but even within scientific circles there are pros and cons associated with software, hardware and chemical implementations Cf. Webb (2009), and the commentaries in that same journal issue for an extensive discussion. This is an area where phenomenologists could help to determine the essential similarities and differences of these ontological regions. However, we will not go into this analysis here because the arguments that we wish to convey in this paper have to do precisely with a general style of research that is not limited to any of those regions.

the *target of* its scientific investigation, ER uses the computer only as a *tool for* its scientific investigation, namely as a platform that allows researchers to simulate other non-computational phenomena that are of interest. With this clarification in place let us take a closer look at the ER methodology.

First, ER takes a *holistic* approach to behavior. This is in contrast to much traditional AI, which largely studied the internal operations of abstract software systems and isolated computational modules (Dennett 1978). In contrast, ER is concerned with how adaptive behavior emerges out of the non-linear interactions of a whole embodied agent within its environment (Beer 1997). One popular way to achieve this goal is to embed an artificial nervous system within a simulated robot and place it within a simulated environment such that the behavior consists of a stable sensory-motor loop. The aim of this "synthetic ethology" (MacLennan 1992) is to combine the simplicity and control of behaviorist psychology methods, i.e. the precise definition and incorporation of only the essential environmental conditions, with the ecological and contextual validity of empirical ethology, i.e. that the robotic agent is also fully integrated and adapted to its 'habitat'. Moreover, because the artificial neural network, the robotic body and the environment are being simulated on a computer, it is possible to study the unfolding 'brain' dynamics while the artificial agent is actively engaged with its task. This makes it possible to demonstrate that behavior is an emergent phenomenon resulting from the non-linear interactions of a brain–body–world systemic whole (Beer 2003).

This holistic approach to behavior is complemented by an *evolutionary* approach to its optimization. This ensures that the robotic agent is adapted to its task environment. In addition, and in contrast to traditional AI which for the most part specifies a system's cognitive functions directly in software code, this evolutionary optimization is one way in which ER tries to take the human designer out of the loop as much as possible. To be sure, it is still necessary to specify what defines an agent, its environment, and the desired type of behavior, but the particular way in which this behavior is realized depends on the historical contingencies of an evolutionary process. This allows for a minimal and controllable impact of our preconceptions and scientific assumptions, and it is easier to investigate the minimal conditions for a behavioral capacity (Harvey et al. 2005). One still must specify a task environment against which the performance of the robotic agent will be measured—e.g. active categorical perception (Beer 2003)—but in contrast to AI it is no longer necessary for the program designer to specify *how* this goal will have to be achieved. As we will show with the examples later, often the evolutionary process leads to novel and surprising mechanisms that undermine our preconceptions about the necessary conditions for a certain behavior to emerge.

Finally, the holistic approach to behavior and the evolutionary approach to its goal optimization are complemented by a *dynamical* approach to its realization and its understanding (Beer 1997). Whereas the control architectures for AI systems are typically implemented in terms of symbolic representations that are pre-specified by the designer (a type of higher-level programming code), the ER methodology always tries to minimize the impact of prior assumptions about what kind of internal operations might be necessary. The aim is therefore to provide a more generic substrate for the controller, e.g. a malleable artificial 'brain', which can then be shaped by the selective pressures of the evolutionary algorithm. One popular way of implementing this generic substrate is in terms of continuous-time dynamical systems (Beer 1995). An advantage of using such a mathematical formalism (in contrast to doing actual empirical psychological research) is that the robotic system is no 'black box'; it is possible to use dynamical systems theory to understand and formalize the system's behavior. Moreover, this theory is especially attractive in relation to a holistic approach to behavior because it can deal with changes in behavior in a unified mathematical manner that spans brain, body and world (Kelso 1995) as well as various temporal scales (Thelen and Smith 1994).

Note, however, that the ER method presupposes the external specification of individual agents that can be 'evolved' by the evolutionary algorithm. The experiment designer must decide in advance what part of the simulation will count as an 'agent' and what will not. Accordingly, the metabolic self-constitution of a living being, which in nature is a way for an organism to autonomously specify its own boundaries, must unfortunately be abstracted away in favor of exploring their behavioral dynamics alone. As such, this methodology is unsuitable for inquiring into the essential elements in the autonomous constitution of biological individuality (Froese et al. 2007). ER addresses the problem of the emergence of behavior, but not the problem of 'second-order emergence', i.e. the problem of how it is possible to set the conditions such that an individual emerges which, when interacting with its environment, gives rise to a specific behavior (Froese and Ziemke 2009). For this a different kind of approach is needed, for instance one that is based on artificial chemistries (e.g. Egbert and Di Paolo 2009). The use of such artificial chemistries is another popular methodology of artificial life research that shares many affinities with the ER methodology (e.g. Ikegami and Suzuki 2008). Future work in that area could help phenomenologists in clarifying the defining characteristics of living beings in contrast to mere material objects, and thereby contribute to a scientifically informed assessment of Husserl's observations on the biological body (e.g. Hua IV). Here we will specifically focus on the ER approach alone for reasons of limited space, and because it has already been shown that the results of ER modeling experiments can be fruitfully interrelated with phenomenological considerations in a mutually informative manner (Froese 2009).

4.2 What is Artificial Life Used For?

We can identify three broad contexts in which the ER methodology (and Alife more generally) is used. First, it is by and large the case that the sciences of the artificial are part of *theoretical science*. To be sure, many researchers have unfortunately succumbed to the functionalist temptation to view their artificial systems as actual empirical instances of the phenomena they are investigating, especially during the early years of the field (e.g. Langton 1989). However, there is a growing consensus that this confuses the model with the phenomenon that is being modeled. Note that this clarification does not diminish the scientific value of the synthetic approach, but shifts its emphasis toward creating "opaque thought experiments" by which it is possible to systematically explore the consequences of a theoretical position (Di Paolo et al. 2000).

This notion of an opaque thought experiment denotes that Alife gives us tools with which to explore the consequences of a theoretical position, but also emphasizes the *in principle* impossibility of predicting in advance the emergent behavior of a non-linear dynamic system. In other words, just as when we devise a normal philosophical thought experiment, the design of a simulation model will always incorporate our explicit and implicit premises from which the consequences will follow. The simulation model, however, is an opaque thought experiment because the consequences of its design are not self-evident. Of course, we can produce some behavior by running the model, but we will not immediately understand how that behavior follows from our premises. Thus, akin to research in the empirical sciences, the meaning of the results must be revealed through further systematic enquiry. Once the consequences of a theoretical position have been better understood, these insights can then be related back to factual research. The idea is that we use theories about the empirical world to inform the design of Alife models, and in turn these models constrain the interpretation of the theories (Moreno 2002). This can happen negatively, as when the Alife methodology is used as a subversive tool to undermine theoretical claims for necessity, but also positively, as when it is used to synthesize a model that serves as a proof of concept (Harvey et al. 2005).

What makes ER attractive to science, namely its capacity for the synthesis of systematic thought experiments of indefinite complexity, also aligns it with the aims of analytic philosophy (Dennett 1994). Broadly speaking, we can capture this aspect of ER with the slogan “philosophy of mind with a screwdriver” (Harvey 2000). To be sure, it is not always the aim to explicitly model one’s philosophical assumptions in the process of synthesizing an artificial system, but in practice it is difficult—if not impossible—to avoid doing so at least implicitly.[4] In general, the advantage of probing philosophical positions with ER and other Alife methods, rather than by means of traditional thought experiments or Husserl’s eidetic variation alone, is the increased capacity to deal with emergent phenomena of complex systems, as well as to test them in more realistic, but still fully controllable settings.

Finally, an important but often underappreciated aspect of artificial life is the synthetic methodology’s *pedagogical* value. It is quite a formative experience to spend countless hours in front of the computer trying to design and implement an artificial agent that can solve what intuitively appears to be a simple task, but repeatedly getting nothing but senseless behavior (cf. Dennett 1984). It quickly becomes clear that these systems do not know what they are doing; they have no *understanding* of their situation (Haugeland 1997), nor do they *care* about the fact

[4] The fact that the systems we create embody our presuppositions has been exploited to great effect by Dreyfus, who traces the limited success of traditional AI to its underlying Cartesian philosophy (Dreyfus and Dreyfus 1988). More recently it has been argued by Wheeler (2005) that the field’s subsequent turn toward embodied-embedded AI coincides with an underlying shift to a more Heideggerian philosophy. For example, the focus on designing robotic systems that can robustly adapt to dynamic environments in real-time, Wheeler suggests, can possibly be viewed as a scientific investigation into *Dasein*’s mode of ongoing coping (cf. Heidegger 1927). In on-going debates, Dreyfus (2007b) has raised additional phenomenologically informed criticisms against this notion of ‘Heideggerian AI’, and Froese and Ziemke (2009) have proposed a biologically informed response toward more appropriate forms of AI.

that they don't (Di Paolo 2003). Why is that the case? What necessary conditions for adaptive behavior are not yet in place? What is missing from these robotic agents that would allow them to generate meaning about their situation (Froese and Ziemke 2009)? How can we tell? There are advantages to engaging in Alife as a practice, because it forces one to test one's intuitions in terms of the actual operation of an implementation. As is the case in the history of ideas as such, perhaps certain notions about what is being modeled "cannot be attained except by a series of successive steps and by a sedimentation of meaning which makes it impossible for the new sense to appear before its time and apart from certain factual conditions" (Merleau-Ponty 1961, p. 89). Similarly, it is a humbling experience to consistently have your own and others' cherished presuppositions and expectations undermined by an opportunistic evolutionary algorithm. Over time this subversive process starts to affect the way in which you approach problems, expanding the range of possible explanations that you want to be considered, while at the same time teaching you to be careful about positing necessary and sufficient conditions.

4.3 Examples of Evolutionary Robotics

In order to illustrate the effectiveness of the ER methodology it is helpful to mention a few concrete examples. For instance, while ER has been successful at synthesizing models of agents that are capable of engaging their environment in a robust, timely and adaptive manner, there has been some debate about the internal mechanisms that are necessary for these agents to switch between qualitatively different behaviors depending on situational changes. In other words, it has been practically demonstrated that the '*intra*-context frame problem' (e.g. adaptive behavior) can be resolved, but a solution to the '*inter*-context frame problem' (e.g. meta-cognition) arguably requires a different kind of mechanism (Wheeler 2008). In response to this debate it is possible to cite a recent ER study conducted by Izquierdo and Buhrmann (2008), where a single dynamical artificial neural network was evolutionarily optimized so as to perform two qualitatively different behaviors, viz., bacterial chemotaxis and legged locomotion, in two different bodies and environments. They demonstrated that the ability to switch between these two behaviors was indeed possible without providing the 'agent' with a priori structural modules, explicit learning mechanisms, or an explicit external signal that would indicate when to switch between them. How then does this artificial agent 'know' when to switch its mode of operation from bacterial chemotaxis to legged locomotion?

Interestingly, the agent's ability to switch its behavior appropriately when moved from one situation into another can be explained in terms of the *interactions* between the artificial neural network's dynamics, its body and environment, thereby calling into question the internalist assumption that the necessary and sufficient conditions for context-switching behavior must reside in the individual alone. Here we might thus have a suitable simulation model for investigating Merleau-Ponty's (1945) notion of 'motor intentionality', as proposed by Dreyfus (2002). In particular, the fact that we have access to all elements of the whole 'brain-body-world' model means that we can understand precisely how it is possible that changing situations solicit different behavioral dispositions.

It might be argued in response to this ER study that, while it supports the notion of motor intentionality and points to the importance of environmental affordances, in the end our account must still have recourse to the 'inner' mental states of a subject whose behavior is being solicited. And, indeed, the model agent presented in the work by Izquierdo and Buhrmann (2008) is defined by internal states which, in combination with the incoming stimuli, determine the agent's behavior. However, does the emergence of motor intentionality necessarily depend on this internal configuration? Let us imagine an extreme case in order to probe our intuitions: an embodied agent that has no internal state, that is, a sensory-motor system that is purely reactive such that its behavior is always directly determined by its current perturbations. According to Husserl such an embodied system epitomizes the very essence of a material thing which, as a purely externally determined entity, is *not* historical, and therefore fundamentally distinct from living (and human) beings which, in virtue of their continuous 'inner' mental existence, are intrinsically historical.[5] In other words, it would seem that the reactive embodied agent is *in principle* unable to behave differently when presented with the same stimuli but within a different context. For that differentiation, Husserl would argue, we need to posit some kind of internal mental continuity that can track the historical development of contextual change. Is this assumption valid?

In order to answer this question it is difficult—if not practically impossible—to make use of free imaginative variation so as to distill the essential conditions and their necessary consequences. Fortunately, it is nevertheless possible to externalize the whole situation by means of a simulation model, such as the one designed by Izquierdo-Torres and Di Paolo (2005). They used ER to synthesize a model which demonstrated that even a purely reactive (stateless) system, i.e. a system whose outputs are at each moment only determined by its current inputs, can engage in non-reactive behavior due to the ongoing history of interaction resulting from its situatedness. More specifically, they designed a simulation model of a simple 'agent' which can move left and right and which has an array of distal sensors that are perturbed by falling objects. The agent is a purely reactive system such that its ongoing movement is directly determined by the current input of the sensors and does not depend on any internal state, representation, or other internal registration of its history. The goal of this agent is to catch the falling objects by moving underneath them. The decisive point of this modeling experiment: the agent must accomplish its task under two different scenarios: (i) with normal sensor-to-motor determination, and (ii) with *inverted* sensor-to-motor determination, whereby objects that are falling on the left side of the agent appear to be falling on the right and vice versa. In order to catch the falling objects in both of these scenarios the agent must therefore be able to react differently to the same type of stimuli depending on the type of scenario that it happens to find itself in.

[5] "Da zeigt sich nun das Merkwürdige, daß materielle Dinge ausschließlich von außen her bedingt sind und nicht bedingt sind durch ihre eigene Vergangenheit; sie sind geschichtslose Realitäten. […] Demgegenüber gehört es zum Wesen seelischer Realität, daß sie prinzipiell in denselben Gesamtzustand nicht zurrückkehren kann: seelische Realitäten haben eben eine Geschichte. […], weil der frühere Zustand den späteren funktionell bestimmt." (Hua IV, Sect. 33)

Of course, a standard solution to this problem would be to use sensory-motor correlation rules to arbitrate between these two scenarios, i.e. if I actively move toward the object and it appears to recedes further away proportionally, then I know that I am in the inverted scenario and must change my future behavior appropriately (moving away will bring me closer). This kind of associative learning, however, is impossible for a purely reactive system, because it does not have any internal state configuration that could be adjusted accordingly. Nevertheless, Izquierdo-Torres and Di Paolo showed that their reactive agent is able to catch the objects in both of these scenarios. How is this possible? Although the current relation of the agent to its environment certainly determines its current behavior, it turns out that: (i) this current relationship is itself the result of a historical sequence of agent–environment interactions, and (ii) this historical trajectory is sufficiently different for the two types of scenarios such that the agent ends up in regions of its environment where appropriate catching behavior becomes possible. In a sense, the agent's embodiment and situatedness acts as a surrogate for internal complexity.

This model thus presents us with a basic existence proof. It makes it conceivable that an agent's behavior, which at first sight might appear to depend on some form of historical trace (or internal representation), may actually depend on a *relational* rather than an *internal* form of state. In other words, this modeling experiment supports the phenomenological notion, developed by Heidegger and Merleau-Ponty among others, that it is our ongoing involvement in the world which is decisive for understanding the essence of behavior. Indeed, it provides this support in a manner that is highly unusual for phenomenology, namely in a form that is amenable to precise mathematical analysis. Moreover, this work reinforces the idea that embodied behavior can exhibit properties that cannot be deduced directly from those of the individual's internal milieu itself. It therefore challenges those phenomenologists who wish to determine the necessary and sufficient conditions for intentional behavior from the perspective of transcendental subjectivity alone. It is important to emphasize, however, that this is *not* to say that human subjects are like reactive systems or that our lived embodiment or intentional consciousness is negligible. On the contrary, any emphasis of the role of our worldly involvement must certainly be balanced by a consideration of the impact of our biological and conscious existence (Barbaras 1999). All that the model intended to achieve was to raise awareness of the rich possibilities that are already inherent even in relatively simple interaction dynamics.

4.4 Computer Simulation as Externalized Imaginative Variation

Now that we have a better understanding of what Alife is about, we can ask: What do the results of this 'artificial' science entail, given their ideal and abstract nature? Of course, like any thought experiment, a simulation model cannot say what is in fact the case. After all, it is only a model. But it nevertheless helps us to expose assumptions as unfounded, extend our imagination so as to include previously inconceivable situations, and inform the direction of our phenomenological and scientific research. And what does it mean to understand Alife as a form of eidetic method in Husserl's sense? We propose that simulation models considered as opaque thought experiments are indeed a kind of imaginative variation. For instance, they can help us to understand the essence of biological phenomena by enabling us to consider “life as it could be” (Langton 1989). As was already noted, this can occur both in a negative and positive manner: a working simulation model is an undeniable existence proof of an *in principle* possibility, which can therefore (i) effectively undermine established necessity claims as prejudices, as well as (ii) establish new claims of sufficiency.

The major drawback of this variation by artificial modeling, with regard to the eidetic intuition performed by a conscious subject, is that the results lack self-evidence. In this sense they are ‘opaque’. Further analytic work is always required to establish the conditions of emergence for a particular phenomenon and their essential structures. This puts their ontological status closer to that of a material rather than an imaginative phenomenon. Nevertheless, we need to remember with regard to empirical data that operational models are at best abstract possibilities, and their factual validity has to be verified by further empirical research. Alife therefore occupies an odd position between eidetic and empirical research in that it shares commonalities with both but is exhausted by neither. However, rather than being a disadvantage, in the sense that it cannot live up to the expectations of either phenomenology or science, it is actually a unique opportunity. Rather than focusing on what Alife lacks, what it is not and can never be, we should also consider what it is currently and what its further potentials are. From this perspective its methodology appears as an important, and perhaps essential, link between phenomenology and science.

5 Concluding Remarks

We have argued that the methodology underlying the sciences of the artificial, especially simulation in the field of artificial life, can be considered as a specific extension of Husserl’s method of *Wesensschau*. Both methods aim at grasping the essence of a particular phenomenon by creating hypothetical variations. Their main difference lies in the fact that the methodology of artificial life externalizes a crucial part of the imaginative process by means of what we have called ‘technological supplementation’: conscious imagination is extended by computer simulation.

In order to determine essences we need to ascertain those variations which turn the target phenomenon into something else. Otherwise our conceptions could be contingent on the selected facts or based on prejudice (Zahavi 2005). But what if, for whatever reasons, the appropriate empirical variations are unavailable? Here we would have to turn to an imaginative variation that is not based on empirical fact. While this is not a problem in principle, as it is in essence no different than the common practice of data interpolation, it quickly becomes unfeasible in practice. As discussed earlier, most scientific phenomena are so complex that we cannot imaginatively posit them in a unified intentional act. Does this mean that the methodology of eidetic intuition is in the end irrelevant for the advance of science? This would be a significant failure for the phenomenological tradition, with its aim of an enlightened science, namely a science that is aware of its own conditions of possibility. But all is not lost, as here the 'artificial' sciences come into their own. In the sense that they are technological extensions of our imaginative capacity, they provide the crucial supporting link between phenomenology and the increasingly complex (non-linear, dynamical, self-organizing) phenomena of the empirical sciences. On this view, such technological supplementation is indeed necessary for the future development of phenomenology, if it is to live up to its own ambitions.

Nevertheless, it is clear that Alife by itself is not strictly speaking a phenomenological methodology. A simulation model, as an opaque thought experiment, is essentially a type of imaginative variation whose meaning is not immediately self-given in consciousness. However, the effects of this drawback are mitigated because the computer provides a stable medium for repeated trial runs, systematic variations, and detailed analysis. In this sense Alife is an 'out-sourced' phenomenology, a type of eidetic method that exceeds the imaginative capacity of a human subject to perform it without the aid of technology, but whose results require further interpretation to be understood. Among the methodologies of the 'artificial' sciences some will be more appropriate for phenomenological purposes than others; the more dynamical in content, autonomous in their realization, and presuppositionless in their design, the better. The adoption of this kind of technological supplementation by the phenomenological tradition would mean that its methodology will have significantly less difficulty in dealing with the complex, non-linear dynamics of holistic system/environment interactions, a problem that will become particularly pressing with regard to gaining a better understanding of the essential aspects of our living (biological) embodiment.

Finally, we note that there is a considerable affinity between phenomenology and Alife in terms of there being a critical element involved in both. In the field of Alife there is a trend to undermine the necessity claims which can be found within the mainstream cognitive sciences. This has potentially important consequences for a variety of domains, such as the presupposed requirements for learning (Izquierdo and Harvey 2007), active categorical perception (Beer 2003), sensitivity to social contingency (Froese and Di Paolo 2008), and non-reactive behaviors (Izquierdo-Torres and Di Paolo 2005). Similarly, in his later writings Husserl presents phenomenology as a critical and rigorous science whose task is to disclose and examine the fundamental claims and assumptions which are presupposed by the positive (objective, dogmatic) sciences. Most phenomenologists will agree with the claim that: "Our investigation should be critical and undogmatic, shunning metaphysical and scientific prejudices. It should be guided by what is actually given, rather than by what we expect to find given our theoretical commitments" (Zahavi 2003, p. 44). We suggest that this critical goal can be productively supported by recognizing the compatibility between technological and imaginative methods of variation.

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