How does psychology progress as a science? The case of the face inversion effect

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**Abstract**

 Unlike developments in physics, psychology has so far been unable to produce a unified general theory in any of its fields of research. The present article suggests a relatively new methodology by which psychology could develop, not a general theory as in physics, but a Limited General Theory, in a certain domain of psychological research. The proposed methodology is based on the well-known method of empirical hypothesis testing with the addition of two comparatively new methodological rules. The present article shows that the proposed methodology facilitates the development of a Limited General Theory concerning the Face Inversion Effect (henceforth, FIE), which is a topic of research in face perception and recognition. This illustrates that psychology made genuine scientific progress in a certain research field, namely, FIE.

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**Introduction**

An overview of psychology shows that no field in psychology has yet developed a successful unified theory (e.g., Leahey, 2004; Rakover, 1990). In contrast, in physics, the three unified theories of Newton, Einstein, and quantum theory offer satisfactory explanations for a variety of empirical observations. These three theories constitute the foundations for three scientific paradigms in physics. Unlike physics, psychology is still in the pre-paradigm stage, since a unified theory in psychology has not yet been developed (e.g., Kuhn, 1970).

Other researchers have reached similar conclusions. For example, Allen Newell (1973), a cognitive psychologist and computer scientist, summarized several articles presented at a conference on visual information processing and found that every empirical paper presented had the same following structure. An interesting new phenom­enon had been discovered and two contradictory explanatory hypotheses were offered: single vs. dual memory systems; serial vs. parallel processing; single vs. multiple coding; decay of memory vs. interference; innate vs. learned processes; conscious vs. unconscious processes; and gradual vs. one-trial learning. The emerging problem is that these opposing hypotheses do not combine and a unified theory has not been developed. Newell predicted that, in another 30 years, all we would have is a new collection of articles, describing two opposing hypotheses to explain new empirical and cognitive discoveries. Based on the current state of psychology, it appears that Newell’s prediction was correct — despite several unsuccessful attempts to develop general theories.

Newell (1992) proposed the “Soar” model on the basis of research in artificial intelligence. However, Soar seems not to have been accepted as a unified theory for psychology, in contrast with how Newtonian theory has been accepted in the field of physics (e.g., Cooper & Shallice, 1995; Garcia– Marques & Ferreira, 2011; Lewis, 2001). Other attempts to propose unified theories such as Freud’s psychoan­alytic theory, Hull’s theory of learning, or Estes’s stimulus sampling theory, were also unsuccessful (e.g., Estes, 1950; Hilgard & Bower, 1966; Marx & Cronan–Hillix, 1987). While these theories were initially well-received, within approximately two decades, each had been disconfirmed empirically and theoretically.

On the basis of these historical observations, i.e., that psychology encountered difficulties in developing a successful unified theory, two important questions arise. The first question is how we might explain the difference between psychology and physics. In response, Rakover (2020), who reviewed and rejected several proposals, suggested that psychology did not develop like physics, because, unlike physics, it did not manage to dis­cover empirical units of measurement for its theoretical concepts. For example, in physics, the mathematical properties of the theoretical concept ‘distance’ were found exactly in the empirical measurement of ‘distance,’ so that if the theory predicted that a car will drive 75 kilometers in a given time, then the empirical measurement would confirm this prediction by measuring the distance in exactly the same units of measurement.

The second question, which is the main topic of the current article, is this: Does the research methods of psychology necessarily preclude the development of a unified general theory? This methodology is primarily characterized as the procedure of ‘empirical hypotheses testing’ (see Neal & Liebert, 1986; Rakover, 1990). Relying on Newell (1973), we can suggest that all that this method can discover in psychology (visual perception) is a collection of very interesting phenomena explained by two opposing hypotheses that do not lead to a unified general theory.

Despite the above difficulties, standing in the way of developing a general theory, in the present article I propose that, based on the customary ‘empirical hypotheses testing,’ an additional new methodology may lead to the development of a “limited general theory” in several psychological research-domains. This theory’s scope is limited; it is much narrower than the scope of the general theories of physics. The proposed methodology, which I will call “two additional research-rules” (2ARR) methodology, is based on two research rules that describe how researchers in cognitive psychology carry out experiments. These rules are: (a) the behavioral phenomenon being studied has an unknown cognitive process that produces and explains it [called the “unknown cognitive process” (UCP)] and (b) the domain of application of the hypothesis (model or theory) that explains the main phenomenon under investigation and other phenomena similar and related to it [called the “application-domain”].

In the present article I first introduce and explain the 2ARR methodology and then illustrate it with a description of research in perception and face recognition, the Face Inversion Effect (FIE). This will show that it is indeed possible to arrive at a “limited general theory” in several research domains in psychology.

**Two additional research-rules (2ARR) methodology**

The two additional research-rules (2ARR) methodology is based on two fundamental research-rules. First, I will briefly describe these two rules and then I will discuss their properties and certain of their important consequences.

1. **Unknown Cognitive Process (UCP)**: All behavioral phenomena are based on the UCP that is responsible for their occurrences. The concept of responsibility here at play has the status of generating and explaining the studied phenomena. For example, the investigated phenomenon may be a particular instance of a general law or it may be produced by a certain process/mechanism. That is, the concept of responsibility aims to answer the questions of ‘why’ and ‘how’ some phenomenon occurred.
2. **Application-domain**: Because the range of possible behavioral observations is enormous, it is highly plausible that every cognitive theory limits its explanations to a certain range of observations, an application-domain. It is, therefore, more efficient to produce a series of different theories each of which deals with its own application-domain. For example, it would be difficult to explain behavior related to economic decisions with the help of a theory of face perception.

It should be emphasized that 2ARR is not a theory that, under certain conditions, offers empirically testable predictions. It is a research methodology that describes how psychologists conduct research. As mentioned above, this methodology is additional to the accepted procedure for testing hypotheses.

**The UCP’s properties**: The first question we have to discuss is this: Why should cognitive researchers assume the existence of the UCP? Is it not possible to be satisfied with the empirical examination of certain hypotheses put forward to explain the phenomenon under study? The answer to these questions rests on two arguments. First, since psychology's methodology was largely imported from the sciences (e.g., Rakover, 1990), this import also involved the idea of a unified theory that would explain a large collection of observations. Furthermore, in the philosophy of science literature we find the idea that the world operates according to certain universal laws (processes, mechanisms, structures) that offer complete explanations for the phenomena being studied. For example, Salmon (1984) suggests that physical phenomena can be explained by assuming that the world is founded on a causal structure. Secondly, it seems that the relation ‘one theory/many observations,’ according to which one theory offers successful explanations to many observations, is to be preferred over other possibilities from the viewpoint of rationality: ‘one theory/one observation,’ ‘many theories/one observation,’ and ‘many theories/many observations.’

The second question to be discussed is whether to conceive of the UCP as merely a theoretical concept? Given the information-processing approach, Marr (1982) suggested that we may consider visual information processing at three levels of analysis. At the first level, the level of computational theory, one specifies the goal of the process. For example, one might try to provide an answer to the question: what is the goal of face recognition?. At the second level, the algorithmic representation, an attempt is made to develop an algorithm that will represent the process identified at the first level, a mathematical procedure that connects the inputs to the outputs. At the third level, the implementational level, one realizes the second level materially, as is the case when some software is carried out by some hardware or when a cognitive process is realized by the neurophysiology of the brain. For the sake of simplicity, I will distinguish here between two viewpoints, the theoretical (computational and algorithmic) and the actual. In view of this distinction, the concept of the UCP can be thought of either as pertaining to the theoretical level or to the actual, real, level. As a theoretical concept, we expect that UCP will offer the correct explanations for the phenomena under study. As an actual, real concept, we assume that UCP will be an actual cause or mechanism (physical, chemical, neural) that brings about the behavioral phenomenon under study and offers the correct explanation for it. It should be emphasized that this conceptualization differs from the routine research practice wherein a researcher proposes hypotheses (models or theories) to explain behaviors. While the assumption of the UCP is an assumption about one true process that generates and explains behavior, the researchers test many hypotheses that attempt to explain that behavior. Despite this sharp difference, it should be noted that the UCP and the various research hypotheses stem from the same source: the theoretical framework that has been developed on the basis of the analogy between mind/brain processes and computer software/hardware processes. In light of these clarifications, I would like to present several arguments in favor of conceiving of the UCP as a real concept.

Given that the purpose of a scientific theory is to seek the truth, we may suggest that seeking the truth motivates researchers in psychology to discover the actual causes and processes that describe, explain, and induce understanding of the behavior being studied (e.g., Hempel, 1965; Keas, 2018; Popper, 1972; Rakover, 1990, 2018). They accomplish this goal by proposing a hypothesis, a model, or a theory that they believe approaches the real factor/process, that is the UCP. Considering that one of the central purposes of psychological research is to understand behavior, where such understanding is grounded in scientific explanation (see Rakover, 2018, 2021; Salmon, 1990), we may suggest that the purpose of psychological theories is to describe the UCP as accurately as possible. Apparently, each field of scientific research has its own explanatory procedure (model) that is appropriate to it (see Rakover, 2018, 2021; Salmon, 1990). For example, Hempel’s (1965, 1966) model is appropriate to classical physics. To explain the empirical observation that a steel ball (B) at free-fall descends 4.9 meters in the first second, we utilize the Deductive-Nomological (D-N) model according to which from two pieces of information, Galileo’s law and time being equal to 1 second, we mathematically derive the distance of the fall, namely 4.9 meters. Given these pieces of information we can argue that the explanation of that specific observation of (B) shows that its behavior is but a particular instance of Galileo’s law (which can be inferred from Newton’s laws), and that, in fact, all bodies under the same conditions can be expected to behave in the same way as (B).

In the biological sciences and in psychology, the most appropriate approach is that of the New Mechanists (e.g., Bechtel, 2009; Craver & James, 2019; Machamer, Darden & Craver, 2000; Rakover, 2018). According to this approach, an empirical phenomenon is explained by describing a particular mechanism, which is composed of certain components with certain activities that engage in certain causal interactions, such that the mechanism as a whole produces the observed phenomenon. For example, the prevalent explanation of cases in which a person forgets a seven-digit-long number (within around 20 seconds) is provided by describing an information processing mechanism, analogous to the operation of a computer, which is based on a distinction between short-term memory (STM) and long-term memory (LTM). While STM stores very limited pieces of information for a short time, LTM stores a great deal of information for the duration of a person’s lifetime.

We can see that both of these explanatory approaches are rooted in the conception that an actual system is responsible for the occurrence of the investigated phenomenon. The D-N model is based on a law or general theory that addresses the investigated phenomena. Without the assumption of such a law or theory, it would be hard to explain the studied phenomenon as a particular instance of a general law, as a phenomenon that is to be expected to occur under the given conditions. The New Mechanists’ approach relies on the existence of a mechanism that actually produces the investigated phenomena. Without proposing such a mechanism, it would be hard to provide a description of how the investigated phenomenon was generated. Based on these two examples, we may suggest that an explanation of the investigated phenomenon is grounded in an attempt to describe the real law, the actual factor/process/mechanism, that is, to describe the UCP that is responsible for the generation and true explanation of the phenomenon in question.

The above explication of the UCP clarifies the difference between this concept and Kant’s notion of the *Noumena* (see Stang, 2021). (Note that there are different views and interpretations of the latter term, which are clearly beyond the scope of this paper.) Briefly, while Kant made a distinction between phenomena and noumena, the things as we perceive them and the things in themselves that are unknown to us, the concept of the UCP is not based on such an encompassing distinction. It is restricted to the domain of explanation/understanding of behavior: it assumes that the goal of cognitive science is to provide explanation of the phenomenon under investigation and that this will be done by proposing hypotheses that get closer and closer to the actual unknown process responsible for the behavior, i.e., the UCP.

**The application-domain’s properties:** Every cognitive theory, T, must offer adequate explanations and an understanding of all the behavioral phenomena included in its application-domain (e.g., Keas, 2018; Rakover, 2018, 2021). The question that arises here is how to define this domain. It is difficult to outline the application-domain in advance, because the domain changes with the advancement of research. Nonetheless, we may suggest that the application-domain can be anchored to the following two important factors: (a) the range of values of T’s dependent and independent variables; and (b) the similar behavioral phenomena that share the same fundamental experimental manipulation. For example, in studies on the facial inversion effect, the main manipulation is the rotation of an image of a face (or of another object) by 180° (e.g., Rakover & Cahlon, 2001). Therefore, we can suggest that all the studies included in this application-domain are characterized by the inversion manipulation. The second factor (b) is of utmost importance, because the relevant hypotheses (models, theories) are developed as a result of the interaction between the studies that are anchored in the fundamental experimental manipulation and the attempt to explain these findings. Out of this process emerges one theory that manages to explain most of the experimental findings. This is the limited general theory, and though it is usually criticized theoretically and empirically, it need not be discounted until a competing theory has emerged that is better able to explain all the relevant findings (e.g., Kuhn, 1970; Niiniluoto, 2019; Rakover, 1990, 2018).

The present concept, ‘application-domain,’ is similar in certain respects to the concept of ‘scope’ or ‘unification,’ which marks a theoretical virtue of scientific theories. For example, Keas (2018), whose paper summarizes and discusses the rich literature on the subject writes:

“A unified theory, however, is one that explains *more kinds of facts* than rival theories with the *same* amount of theoretical content. … Simplicity is increased informativeness by means of a comparative *reduction* (relative to rival theories) of theoretical content. Unification is increased informativeness by means of comparative *increase* in the different kinds of data that get explained.” (2775).

The central differences between the present account and the appeal to these theoretical virtues are as follows. While the 2ARR methodology considers a theory’s success to be an expression of the realization of the aim of scientific research, i.e., to understand behavior by providing a scientific explanation, Keas (2018) thinks of the notion of scope/unification as an aesthetic quality of a scientific theory – a quality that complements that of simplicity. Furthermore, according to the present account, the application-domain results from the difficulty to explain all possible behavioral observations (an infinite number of them, in fact), so that T must be limited to the explanation of only a certain set of phenomena, which are defined by its application-domain. To illustrate this point, consider how unlikely it is that Freud’s theory of personality could explain the face inversion effect or Pavlovian learning, for example.

**Consequences of the Two Additional Research-Rules (2ARR) methodology:** The first important consequence concerns the development of behavioral understanding. Given that the goal of cognitive science is to increase our understanding of behavior, the 2ARR methodology proposes an intuitive theoretical index that estimates the degree of understanding as a function of scientific progress: the more a cognitive theory T approaches the UCP, the greater is such understanding (for other indexes of scientific advancement see Niinilouto, 2019):

Understanding-Distance (UD) index = *f*(T – UCP)

The main method for evaluating *f* in the UD index is by experimentation and observation. The index relies on a fundamental decision rule, the ‘theory-success’ rule, which is based on the confirmation/refutation of the predictions of T in relation to other theories: the successful theory TS is to be preferred over the unsuccessful TUS when observations confirm TS and refute TUS or when TS is able to explain certain phenomena that TUS cannot. Utilizing the theory-success rule brings TS closer to the UCP in the following sense: the preference of TS over less successful theories removes from scientific consideration un-useful theories and inefficient research avenues. This kind of progress can be characterized as minimizing errors. If UD index ≠ 0, it follows that TS is distinct from the UCP; however, even if within the application-domain of T­S the UD index = 0, i.e., the phenomena predicted by TS are those generated/explained by the UCP, it does not follow that TS is identical to the UCP, because such identity holds only within the application-domain (see Figure 1, which illustrates this point). Similar ideas have been suggested by other researchers. For example, Popper (1972) says:

"And if we fail to refute the new theory, especially in the fields in which its predecessor has been refuted, then we can claim this as one of the objective reasons for *the conjecture that the new theory is a better approximation to the truth than the old theory*" (p. 81; emphasis in the original).

Another example comes from Godfrey-Smith (2008):

“The strategy employed by science would be, at any point, to use data to show that T1 is better than T2, where the hope is that this fallibly indicates that T1 is closer to the truth than T2. (p. 146).

The central difference between the present account and these earlier ideas can be summarized as follows: The 2ARR methodology suggests that we should prefer the successful TS over the refuted theory, the unsuccessful TUS, because the greater the number of successful predictions within the application-domain of TS the greater is the overlap between TS and the occurrences/predictions generated by the UCP. However, it is impossible to know the extent to which TS has approached the UCP, as the UCP is unknown. Therefore, the proximity of TS to the UCP is estimated only in relation to other competing unsuccessful alternative theories TUS, i.e., TS is better than other TUS.

The second important consequence concerns the relations between the research hypotheses and the UCP. According to the 2ARR methodology, the purpose of scientific research is to understand behavior by uncovering the UCP that provides the ultimate explanation of the investigated phenomena. This is achieved by suggesting hypotheses (models, theories) that attempt to explain these phenomena within the application-domain. The immediate question that arises is: Does the process of scientific research actually lead to the eventual discovery of the UCP, that is, to a theory T that is an accurate representation of the UCP? My answer is based on the following arguments.

It is clear that even if T under condition S predicts P, and that the UCP under the same condition S generates phenomenon O, when O=P, it does not follow that T is indeed an accurate description of the UCP. This conclusion remains true even if we find that a great number of T’s predictions are identical to the phenomena generated by the UCP. This is because for any series of outcomes it is possible to match infinitely many functions, that is, theories that under the same conditions will produce the same predictions (e.g., Laudan & Lepin, 1991; Nola & Sankey, 2007). But then in what sense does this methodological rule, the theory-success rule, advance us toward the discovery of the UCP? In answering this question, we must consider the immense number of possible observations and the application-domain of T.

Considering the huge number of possible observations, we can safely say that the process of scientific research will never reach the UCP, that is, a complete understanding such that UD index = 0. After all, the range of possible behavioral observations is infinite and, as such, it is always possible that some future observation will be inconsistent with the predictions of the theory in question. Similar ideas can be found in the literature. For example, Godfrey-Smith (2008, p. 145) claims that: “…we can never believe, at any specific time, that we have found a theory that is *true*”. Popper (1972) believes that scientific research is a never-ending process, and that anyone who thinks that s/he has reached the true theory, has in fact abandoned the game of science.

For these reasons, not only will we never discover the truth, that is, the UCP, but even if, by some chance, we happen upon a theory that is identical to the UCP we will have no way of determining that the purpose of scientific research has been realized – that the UCP has been discovered. All we could do is to continue to hold the theory and test it over and over again; tests that the theory will successfully pass.

Considering all that was said above, the 2ARR methodology suggests that a unified theory T may be developed in psychology, but only within the limitations of its application-domain. Successful scientific theories provide explanations to a range of empirical phenomena within their application-domains. Thus, as can be seen in Figure 1, in the good case, we can suggest the existence of a partial overlap between the predictions of the UCP and the predictions of T within its application-domain (see in Figure 1 the range of X’s in which the functions overlap). However, beyond this domain, T fails and no longer matches the predictions of the UCP that is responsible for the occurrence of the investigated phenomenon.

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**An empirical example of the 2ARR methodology: The face inversion effect**

For the last 50 years or so, research on face perception and recognition has centered on the Face Inversion Effect (FIE). Accordingly to FIE, an upright face (hair on top and chin below) is recognized much better than an inverted face (chin on top, hair below, at a rotation of 180°) (Maurer et al., 2002; Rakover, 2002, 2013; Rakover & Cahlon, 2001; Rossion, 2008, 2009; Valentine, 1988; Yin, 1969). The rotation of the face (and of other objects) by 180° is the manipulation that largely defines the application-domain of the theory that explains the set of observations that belong to this domain. Extant research has focused on four types of facial information: (1) featural (eyes, nose, and mouth), (2) relational (eyes above nose, nose above mouth), (3) configural (space between eyes, space between nose and mouth), and (4) holistic perception of the whole face as a unity. Two similar hypotheses emerge from this research that provide satisfactory explanations to many of the experimental findings in FIE research—the configural processing hypothesis and the holistic hypothesis. Both hypotheses suggest that all four types of informa­tion undergo appropriate processing when a face is presented upright. However, when the face is presented upside down, the featural information processing remains intact, whereas the configural and holistic information are greatly impaired (Maurer et al., & Mondloch, 2002; Rakover, 2002, 2013; Rakover & Cahlon, 2001; Rossion, 2008, 2009; Tanaka & Farah, 1993; Valentine, 1988; Yin, 1969). Hence, while in­verted face processing is part-based (featural), upright face processing is principally configurally and holis­tically based (Maurer et al., 2002; McKone, 2010; Piepers & Robbins, 2012; Rakover, 2013; Rossion, 2008, 2009). I will call these two hypotheses the “holistic/configural” (HC) theory, because (a) inversion impairs these two types of information (the configural and the holistic), (b) holistic perception of a face is based on the above three other forms of facial information, and (c) configural information is an essential part of the holistic perception of a face as one whole unit (e.g., McKone, 2010; McKone & Yovel, 2009; Piepers & Robbins, 2012. However, for a number of subtle differences between these two hypotheses see Rakover, 2013). McKone (2010, p 275) writes: “… a general consenus by face-recognition researchers [is] that faces are processed holistically/configurally…”. As we will see below, the HC theory manages to explain a considerable collection of empirical findings, which are included in its application-domain. For these reasons, the HC theory can be seen as a “limited unified theory” that is adequate for its specific application-domain, which I will call the “face inversion application-domain.”

 Here I present a partial list (see also the above references) of some of the relevant research topics and their findings that the HC theory manages to explain. 1. Inversion affects face recognition more than recognition of non-faical objects (e.g., McKone, 2010; Piepers & Robbins, 2012; Rakover & Lurie, 2020; Yin, 1969). 2. Face inversion is associated with the activation of different brain regions than those associated with upright face perception (e.g., Gilaie-Dotan et al., 2010; Pitcher et al., 2011; Yovel & Kanwisher, 2005). 3. FIE is not obtained in individuals with prosopagnosia (e.g. Avidan et al., 2011; Busigny & Rossion, 2010). 4. Given inversion of individual facial-features, inversion of the whole face reduces the strangeness of its perception (e.g., Thompson’s illusion) (e.g., Civile et al., 2014, 2016; Rakover & Cahlon, 2001 for review; Thompson, 1980). 5. Inversion impairs recognition of emotions (e.g., Fallshore & Bartholow, 2003; McKelvie, 1995; Pallett & Meng, 2015; Sato et al., 2011).

I believe that this list of experimental results, though it does not exhaust the relevant literature, demonstrates that the HC theory does, indeed, offer satifactory explanations for a wide variety of findings and can, therefore, be considered a limited general theory. However, it must be noted that this theory has also been criticized. For example, using the dynamic-apertures technique, Murphy & Cook (2017) found that the FIE results from damage to local facial regions and not from impairment to the holistic perception of the face. Furthermore, Rakover (2013) reviewed several findings that do not cohere with the HC theory (for a discussion of other criticisms see McKone, 2010). For example, Rakover and Teucher (1997) and Rakover (2012) found that some isolated and inverted facial features produced effects that are similar to the FIE. Thus, the spatial relations between facial features are not necessary conditions of the FIE. Furthermore, Rakover (2011), who discovered the novel “eye-size illusion,” reported that rotation of a face with this illusion did not generate the FIE. (The eye-size illusion is generated when the whole face is increased or decreased except for the eyes, which are percevied as smaller than the eyes in the regular face.) This finding ilustrates that changing the configural-holistic information of the face is not suffecient to produce the FIE. However, Fu et al. (2015) and Xiao et al. (2014) did find an inversion effect. In response, Rakover (2017) found that the inversion effect ocurres in an eye-size illusion face when one uses a between-subject design but not when using a within-subject design.

As an alternative to the HC theory, Rakover (2013) proposed the Face-Scheme Incompatability (FSI) model. It is based on the fundamental idea that one perceives a face and its parts (presented upright or inverted) by employing the appropriate upright schemes which are in the cognitive system. This model also offers an interpretation of the idea that inversion impairs configural and holistic facial information. According to the FSI model, the inversion does not erase, partially eliminate, or distort this information, but processes it according to the upright schemes of the face and its parts, which exist in athe cognitive system.

**Discussion**

The 2ARR methodology includes two important concepts: the UCP and the Application-Domain. I will begin with a few comments related to these concepts and will then summerize several important implications of the current approach to the question of how psychology progresses.

*UCP and Application-Domain*: In the preceeding, I have suggested several arguments in favor of conceiving of the UCP as a concept that refers to an actual process/mechanism. Here it should be noted that this conception is consistent with a realist approach to science. There seems to be little agreement about what scientific realism amounts to (e.g., Chakravartty, 2017; Psillos, 1999; van Fraassen, 1980). However, putting these differences to the side, as they are beyond the scope of this paper, I believe that Nola and Sankey (2007) have aptly described the core of scientific realism in the following passages:

“Scientific realists maintain not only that the aim of science is truth, but pursuit of science does in fact give rise to truth about observable and unobservable dimensions of reality. Such a realist view has evident implications for the methodology of science. For if the pursuit of science gives rise to truth, it is presumably the methods employed by the scientists that are responsible for this achievement. But in this case the use of scientific methods must lead to truth, that is, they are truth-conductive.” (337)

“The core idea of realism is that there is a mind-independent world made up of items that have properties, enter into processes and stand in structural relations.” (339)

Personally, when I try to explain a behavioral phenomenon, I find myself in a situation where I attempt to guess the real UCP and its actual application-domain. For me, then, the assumption of a real UCP is very natural indeed. Despite this, as previously discussed , researchers may methodologically claim that they are merely interested in proposing an explanatory-hypothesis for a new behavioral phenomenon and that they are not bothered by the idea of the UCP. My answer is that this methodological claim is inefficient for the following reasons. Given that one of the goals of science is to discover a general unified theory that will explain as many experimental findings as possible (e.g., as in physics), the above explanatory-hypothesis methodology fails to promote scientific progress. This method encourages the proposal of a different hypothesis for each new empirical observation (one hypothesis/one observation), whereas the currently accepted methodology, which encourages the proposal of a single theory to explain a multitude of findings (one theory/many observations), leads to scientific development. Furthermore, the latter methodology, one theory/many observations, naturally directs us to the idea that the observed behavioral phenomena are generated and explained by an actual UCP.

 I shall now summarize several properties of the assumptions concerning the actual UCP and the Application-Domain.

1. The UCP is a real process that we will never be able to discover, because the number of behaviors to be investigated is enormous, and in fact infinite.
2. We will never know if we are approaching the UCP, even if it so happens that our proposed theory is the UCP, because the UCP is an unknown process/mechanism.
3. The degree of proximity to the UCP is not measured by the distance of the proposed theory from the UCP, but by cutting down errors, that is, by eliminating unsuccessful theories that did not pass the empirical test and by continuing to hold the most successful theory.
4. Because in the application-domain the predictions of the accepted theory are equal to those of the UCP, one may suggest that in this domain the accepted theory comes as closest as possible to the UCP.
5. Because progress in psychology is made by minimizing errors, that is, by eliminating unsuccessful competing theories, an accepted theory would be accompanied by theoretical and empirical criticisms.
6. The application-domain is essentially defined by the central experimental operation, as in the case of the FIE (rotation of the face by 180°). However, the boundaries of this field are also determined by the theories proposed to explain the studied phenomena, as exemplified with the distinction between STM and LTM, a distinction that is anchored to the theory based on the computer metaphor.

*How does psychology progress?* According to Newell (1973) we can suggest that development in psychology ultimately stops at the discovery of a new interesting phenomenon accompanied by two opposing explanatory hypotheses. This situation prevents psychology from reaching a more advanced stage where researchers develop a unified general theory, similar to the developments found in the other sciences, particularly in physics. How does the current approach, the 2ARR method, cope with this situation?

The answer is not simple, for several important reasons. First, the assumption of an actual UCP stimulates researchers to search for more and more ways to reach the UCP, a search that may eventually break the stagnation of presenting two opposing hypotheses, as described by Newell (1973).

Second, the current methodological approach is not as broad as that which produces general and unified theories in the sciences. The accepted psychological theory is restricted to its application-domain, as in the case of the HC theory that addresses the FIE. As mentioned above, the accepted theory is accompanied by a number of theoretical and empirical criticisms (see property 5, in particular). Thus, the 2ARR methodology raises the accepted psychological theory to a level that stands between the one described by Newell (1973) and the level of the general and unified theory that is obtained in the sciences (in physics). In other words, it can be suggested that, on the one hand, the application-domain allows for the development of a theory that can explain a large number of findings, but that, on the other hand, this theory is not as broad as a general theory in the sciences.

Third, given the UCP and the application-domain, a broad psychological theory can be developed in the following two ways. According to the first way, empirical expansion, the accepted theory may expand its application-domain by explaining new findings in different sub-areas of research. For example, the HC theory was able to explain sub-areas such as the own-race effect, where invesion affects the participant’s own-race pictures more than other-race pictures (e.g., Rhodes et al., 1989; Gajewski et al., 2008), the expertise hypothesis, which suggests that holistic/configural processing operates in experts in any particular topic (e.g., Diamond & Carey, 1986; Gauthier & Bukach, 2007; McKone, 2010), and to explain certain important experimental paradigms, such as the Part-Whole and the Composite, which were developed for testing the effects of configural and holisitic information in upright and inverted faces (e.g., McKone, 2010; Tanaka & Farah, 1993; Young et al. 1987).

The second way, theoretical expansion, is based on the notion of theoretical reduction: one might suggest that it is possible to construct a broad theory from which several accepted limited theories with different application-domains would be reduced. However, to the best of my knowledge, I have not yet found an actual attempt to pursue this kind of reductionist program (see van Riel & Van Gulick, 2019).

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**Figure1**: Y-values as a function of X-values and of two hypothetical theories: the UCP and T. The UCP-curve represents the UCP’s predictions of the real occurrences created by the UCP; the T-curve represents T’s predictions. X1 …X4 represent four different experiments in the order in which they were performed. As can be seen, for X1 …X3 the two theories give very similar predictions (within the application-domain), while for X4 the predictions are very different.