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Building up Hypotheses in Clinical Psychology and Neuroscience: Similarities and Differences

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Abstract Hypotheses are the first step in scientific and clinical enquiry. They guide all of the subsequent steps in an investigation, and influence data collection, analysis, and interpretation. But how do we build scientific and clinical hypotheses? In both research and clinical contexts, a professional's idiosyncratic way of perceiving reality, her prejudices and biases will influence the process of hypothesis formulation. We compare the process of formulating a scientific hypothesis in the field of neuroscience with the process of building a clinical hypothesis in the systemic therapeutic approach. This comparison is intended to highlight the biases that influence researchers and clinicians when formulating hypotheses. Our aim is to raise awareness of the most common biases, and to point out how the tools developed by clinicians could be useful to researchers, and *vice versa*.
KEYWORDS: Hypotheses; Clinical Psychology; Neuroscience; Bias; Interdisciplinary Approach

Riassunto *La costruzione di ipotesi nella psicologia clinica e nella neuroscienza: similitudini e differenze* – Le ipotesi sono il primo passo della ricerca scientifica e clinica. Sono la guida di tutti i passi successivi e influenzano la racconta dei dati, la loro analisi e l'interpretazione. Come si costruiscono le ipotesi scientifiche e quelle cliniche? Sia nell'ambito della ricerca che nei contesti clinici le idiosincrasie con cui un professionista percepisce la realtà, i suoi *bias* e pregiudizi influenzeranno il processo di formulazione dell'ipotesi. In questa sede intendiamo confrontare il processo di formulazione di un'ipotesi scientifica nel campo della neuroscienza e il processo di costruzione dell'ipotesi clinica nell'approccio della terapia sistemica. Questo confronto vuole mettere in luce i *bias* che influenzano ricercatori e terapeuti nella formulazione delle ipotesi. Il nostro scopo è mettere in luce gli errori sistematici più comuni, mostrando come gli strumenti sviluppati dai terapeuti possano essere utili per i ricercatori e viceversa.
PAROLE CHIAVE: Ipotesi; Psicologia clinica; Neuroscienza; Bias; Approccio interdisciplinare

IN THIS PAPER, WE DISCUSS how hypotheses are formulated in psychotherapy and in neuroscience. In particular, we analyze some similarities and differences between the ways in which hypotheses shape clinical investigations on the one hand, and neuroscientific

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practice on the other. With respect to clinical investigations, we restrict our attention to the interactional-systemic psychotherapeutic approach – as originally formulated by Gregory Bateson and Paul Watzlawick[1] – since this approach focuses specifically on constructing hypotheses, and devotes special attention to the influence of the therapist on the treatment.

We usually think of clinical and scientific observations in terms of an objective, passive registration of the data; however, as Ramón y Cajal suggested,[2] even observation cannot be accomplished without the guidance of a hypothesis. Thus, we share the view that hypotheses have a considerable impact on data collection, and therefore on research results.

For these reasons, it is important to understand how clinical and scientific hypotheses are formulated, and to examine the similarities and differences between them.

How to build a systemic clinical hypothesis

Building hypotheses is a central and fundamental step in family treatment within the interactional-systemic psychotherapy framework for they guide the systemic therapist in investigating the relational interplay within families.[3] A systemic hypothesis consists of a supposition, formulated by the therapist, as to why an individual or a family acts the way they do, even after such behaviors have proven to elicit unhappiness.[4] One of the grounding ideas of the systemic approach is that psychological symptoms, even though they generate discomfort, are not dysfunctional behaviors.

More specifically, the behavior exhibited by an individual or her family represents an adaptive response that emerged at a given point in that individual or family's history. The fact that a particular symptom causes discomfort at the current moment suggests that these responses were generated when they were appropriate to a particular condition that has changed in the meantime. It might be that an originally useful coping mechanism ended up being more disruptive than protective or that, by discussing the situation more explicitly in the therapy, the participants can find the necessary resources to enact a better solution.

Let us consider a practical example of a young boy displaying dramatic obsessive-compulsive behavior. At first glance, it would be difficult to explain why he is unable to leave his room until the whole house has been disinfected. After scrutiny, however, the therapist may hypothesize that such behavior is holding the family together, effectively reorganizing the parents' life around the son's, and thus maintaining the status quo of the family as a united nucleus during a phase when the child and parents might otherwise have grown apart. In order to be systemic, a hypothesis should:

1. Include the individual displaying the dysfunctional behaviors together with her family or important relationships. A principle of the systemic approach is that no individual behavior can be understood in isolation from its context, and that relationships are the context of psychological wellbeing. When treating a family, therefore, the therapist will have to include all family members in the hypothesis of how the family functions, and not only the one (or ones) displaying the dysfunctional symptoms. A psychological symptom can only be understood in the context of the network of relationships where it has emerged.[5] In the example above, had the adolescent enjoyed a secure attachment to his parents, and had he perceived that their union was based on solid ground that would not have been shaken by his becoming more adult and independent, he would probably not have found it necessary to display a symptom in order to hold the family together.

2. Be formulated as a working supposition, that the therapist can use to investigate the relationships of a patient, rather than

as esoteric truths to be proven. Selvini argues that the functional value of a hypothesis in family therapy is to warrant the activity of the therapist in tracking relational patterns.[6]

3. Include the therapist in the system. By interacting with the family, and pursuing evidence that will help build and delve deeper into the hypothesis, the therapist gains information on how each part of the family system works in relation to the others (and to the therapist). The systemic approach refers to this stream of information from the family to the therapist, and back, as circularity.[7]

4. Assume that relationships and interactions cannot be understood in a linear framework of cause and effect. Individuals are immersed in complex relational systems that evolve through time, and attempting to find a single cause for complex behaviors would mean ignoring the very nature of relationships. No single event or behavior observed at a certain moment of time can be mistaken as the individual cause of a symptom or of a repeated pattern, especially when considering the symptom of the individual in the wider framework of the individual's significant relationships.[8]

5. Be considered as one of the many possible ways to give structure to the information about a system. In the systemic perspective, it is important to keep in mind that our ideas are never faithful representations of an immutable truth, but possible perspectives that organize thoughts. Cecchin argued that the filter through which we perceive reality has been constructed over years of interactional experience with others, making it impossible for us to be free of biases or prejudices.[9]

6. Be useful. Since there is no truth to discover, it is important to remember that the most sophisticated hypothesis formulated by the therapist will be useless if it does not help the family by providing a novel point of view on the situation. From this point of view, even hypotheses that prove to be wrong provide useful information, by eliminating some variables.[10]

How to build a scientific hypothesis

«Three successive operations are necessary in all scientific research: observation and experimentation, hypothesis or supposition, and proof».[11] Scientific hypotheses are inspired by the desire to find an explanation for a natural phenomenon. In order to formulate a hypothesis, then, a researcher would have to observe a phenomenon of interest and be dissatisfied with existing explanations. Indeed explanations for natural phenomena have been proposed since the dawn of time and, however extravagant ancient explanations may seem to us now, they were once widely believed.

Consider the case of what was thought to hold up the Earth: for the ancient Greeks it was the giant Titan named Atlas, and for the native Americans and Chinese a giant turtle. Neuroscience has also had its share of flawed/erroneous explanations. One of the most popular theories about the mind/brain was the cell doctrine, formulated by Galen around 200 BC, a theory that held sway for a thousand years. According to this view, brain ventricles were the seat of all mental functions, and the liquid that they contained, called pneuma, flowed through the body in small tubes, the nerves, to control body functions. Attempts were even made to correlate specific ventricles with specific functions. This theory had a strong and lasting influence on our understanding of how the central nervous system worked, while differences between the gray and white matter in the brain were ignored for centuries.

Formulating a hypothesis therefore means looking for an alternative explanation, rather than offering an explanation for a phenomenon not yet understood. As Ramón y Cajal himself pointed out, dissatisfaction with a current explanation itself bears the mark of subjectivity:

an a priori dislike for a rather widely held tenet, or interest in finding an alternative explanation for a natural phenomenon can stimulate a researcher's subjectivity, and her idiosyncratic ways of perceiving reality.[12]

Once a researcher formulates a general hypothesis, she must then operationalize it in order to test it. To be testable, hypotheses have to be falsifiable. An established scientific hypothesis will be considered to stand until new data disproves it.

In the frequentist approach, hypotheses are tested against the null hypothesis that any kind of variance present in a set of data is due to chance. Frequentist statistical analyses provide p-values and confidence intervals that are used to interpret whether the null hypothesis is true or not. Frequentist hypothesis testing consists in asking the question: given this data, can I say, with a likelihood of being wrong less than a fixed threshold (usually 5%), that this difference is random? Deciding to either reject the null hypothesis (that the difference is not greater than what could be expected from random variation) in favor of the alternative, or to not reject it, is called hypothesis testing.[13]

For example, to test the hypothesis that the visual processing of faces recruits specific brain areas that are not as active in processing any other object,[14] researchers would need to compare brain activation in response to faces to activation in response to other similar objects that while sharing as many properties as possible with faces, are still not faces. In this case, the null hypothesis would be that the difference in brain activation associated with these object and actual face processing is what might be expected due to random variation, and no more; the experimental hypothesis will be that these two types of stimuli elicit different activation patterns. In order to decide whether to accept the null hypothesis or the alternative, researchers have to compare the activation patterns in response to faces with the activation patterns in response to other objects. In order make sure that any difference found in these patterns is due to faces being processed in a unique way, researchers will have to compare faces with objects that are matched for as many qualities as possible (e.g., they have the same low-level features in terms of luminance, spatial frequency etc., the same familiarity and emotional valence, and so on). If these conditions are not met, the experiment is flawed, as the difference in the activation patterns could be due to one or more of these other qualities that differed for faces and objects, and it will be impossible to ascribe the activation pattern as being unique for faces. Once all other variables have been controlled for, if the difference in the patterns for faces and other objects is larger than what can be explained by random variation, the null hypothesis can be rejected, and the experimental hypothesis that face visual processing recruits specific brain areas that are not involved in the processing of any other object can be accepted.

In recent years, Bayesian statistics has become increasingly popular in neuroscience as it offers an approach to hypothesis testing that is not as binary as that of classical inferential statistics. Rather than asking if it is possible to accept or reject a hypothesis with a fixed amount of probability of being wrong, Bayesian models compare reality (i.e., empirical data) with the predictions derived from two competing scientific theories[15], and test which theory explains the data better. The output of a Bayesian analysis represents the probability that the data under study could have been produced by assuming a given model to be accurate. Therefore, if in the frequentist approach the probability of an event is measured as the frequency of this event under the same repeatable conditions, in the Bayesian approach the probability of an event is measured as a degree of belief.[16]

From a gnoseological point of view, the distance between classical hypothesis testing and Bayesian statistics is somewhat similar to the distance between the truth-seeking psychologists of the Freudian era and the constructivism of the systemic approach.

How do hypotheses shape clinical and scientific investigation?

Both the scientific community and the clinical group of the Milan Approach have often debated several issues concerning the influence that researchers or clinicians may have in a scientific or clinical setting, respectively.

First, it has been proposed that putting a system under observation already changes that system, an effect known even in the realm of particle physics under the name of the "observer effect".[17] In physics, this refers to the fact that including an instrument for data collection in the experimental environment will, by necessity, alter the state of what is measured in some manner. Likewise, the presence of a clinician in the clinical setting is expected to alter the behavior of the people under scrutiny. In addressing these issues the scientific and clinical community have adopted solutions that share this recommendation: if it is not possible to exclude the influence of the measuring tool, consider that the system you are observing includes it, and that you are effectively studying the larger system composed of the original experimental environment plus the measuring tool in a complex interaction. In clinical settings, the observed system will consist in the interaction between patients and therapists. Understanding how a particular tool works will help the experimenter evaluate what part of the variance can be ascribed to its presence, just as a good knowledge of the therapist's own biases and prejudices will help her to be aware that what she perceives is just a perception, and to recognize that it is not possible to objectively observe reality. As Bateson puts it, «the map is not the territory».[18]

Second, another effect related to the presence of the experimenter/observer, is the observer-expectancy effect:[19] having a prediction about how a system will work necessarily affects the interpretation of the data. In addition, human participants tend to comply with social expectations. In scientific experiments this bias is usually corrected by using blind designs.[20] In a blind design, neither the person carrying out the experiment nor the participants performing it are aware of the experimental hypothesis, nor of the experimental manipulations. However, even when the hypotheses are hidden from both participants and experimenters, their knowledge that they are taking part in an experiment can still influence outcomes. Participants will expect to be subjected to some kind of manipulation, and even if they are unaware of the nature of this manipulation, this knowledge can still alter their observed behavior.

In addition to all of these biases that can arise when planning and carrying out an experiment, each researcher can add variance to the experimental results by analyzing the data in a given way, as there is no single way to understand and analyze the data. This phenomenon is known as the "secondary observer effect" and has been described as an idiosyncratic variation, directly or indirectly produced by the researcher(s) that can lead to significant changes in the findings.[21]

Alongside these biases, we should also keep in mind that, both in experimental settings and in everyday life, people tend to seek confirmatory evidence, and rarely try to falsify their own hypotheses or viewpoints. This tendency to seek only information that will confirm previous beliefs, rather than information that could overturn them, was first explored by Wason[22] in the sixties with a series of thought experiments, and has implications for both experimental and clinical settings.

In clinical settings, it is of course impossible to keep the clinician and the patient in the dark as to the reason for their meeting. When psychology was first established as a practice the mainstream idea was that the therapist should be as neutral as possible, striving to be a "blank screen", to serve as the reflecting mirror of the patient's thoughts and emotions. Freud, in his *Further recommendations in the technique of psychoanalysis*,[23] insisted that therapists should remain neutral, saying only as much as was absolutely necessary to keep the patient talking. In order to achieve such neutrality, therapists went through long therapies that also served as part of their training to become therapists. In the relationship with a perfectly neutral therapist, a patient could enact her own needs, feelings and ways of interactions outside of the therapy setting, in a phenomenon referred to as "transference".

Transference was seen as both an impediment to the therapy, and as a tool to identify the work that needed to be done: «the transference, which, whether affectionate or hostile, seemed in every case to constitute the greatest threat to the treatment, becomes its best tool».[24] Of no use, on the other hand, were the therapist's reactions to her patient, the «result of the patient's influence on [the physician's] unconscious feelings», often referred to as "countertransference":[25] these were considered to be purely a personal problem of the analyst, who should not let such feelings interfere with the therapy.

It is now widely acknowledged that perfect neutrality on the part of the therapist is not realistic.[26] Therapists in training are rather encouraged to understand their personal biases as deeply as possible, in order to take their influence into consideration when treating a patient, rather than struggle to achieve neutrality. From a constructivist point of view, the observer is recursively connected to the observed system; it is therefore crucial that therapists reflect on themselves.[27]

In the systemic approach the idea that the therapist has an influence on the patient takes a step forward and is considered to be a useful instrument in her work rather than an obstacle. In the systemic view, no person exists outside of relationships, and observing the patients immersed in their relationships, including the relationship with the therapist herself, is the most fruitful path towards understanding how pathological dynamics have formed and are maintained across time. Cecchin suggests that observing the interactions between the therapist's and the patient's biases can be very informative, and argues that striving to achieve neutrality would mean giving up a most useful therapeutic tool.[28]

Discussion: What can these two methods of building hypotheses teach each other?

When considering the scientific and the clinical methods for building hypotheses, at first glance it seems that these processes are rather different, and that no benefit can be derived from analyzing them together. We believe, however, that this is not the case, and that both the scientific and clinical communities could gain from a better understanding of their respective assumptions and methods.

Among the basic assumptions of the scientific method which could be useful to clinicians, we would include the habit of always being open to an alternative hypothesis to test against the working hypothesis. As we have mentioned above, having a single hypothesis in mind can heavily bias both the observation phase and subsequent analyses. By contrast, keeping multiple hypotheses in mind can help clinicians reduce the influence of any single hypothesis. This is particularly relevant, as mentioned earlier, since we have the tendency to seek information that confirms our hypotheses;[29] keeping multiple hypotheses in mind would prompt clinicians to consider all data, and not just the bits that are useful for a single current hypothesis.

On the other hand, there are many lessons that scientists could learn from clinicians. The first one would surely be that our understanding of reality is always subject to the way we observe it and that objectivity does not exist, even when we rely on the scientific method. In our positivistic view of science, we tend to believe that the latest understanding of a phenomenon is the correct one (in fact, the *only* correct one).

Scientists could learn from clinicians to be mindful of their own biases, and the unavoidable existence of these biases, as objectivity does not exist. Understanding that a scientific theory can only ever be a representation of the truth, could furthermore help scientists remember that the hypothesis one accepts is only valid under the precise conditions in which the data supporting that hypothesis was observed, and does not have universal value; that the value of a hypothesis does not lie in how true it is, but in how useful it is in terms of leading to further exploration. Scientists tend to consider science as a collection of universal truths, and forget that all knowledge is merely a useful representation under the circumstances in which it has been acquired; being mindful of this could also help encourage the clinician to consider variables in the context other than the one under study.

As a final remark, clinicians can remind scientists that the force that propels all efforts to understand reality should be curiosity, rather than the desire to be right.

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Notes

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