How Cognitive Science Can Contribute to Helping Psychology Out of the Crisis

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In science, forging results is the biggest of sins; and inexcusable sin. The field of psychology has therefore been thrown into quite an uproar after the commencement of the so-called replication crisis. A 2015 study known as the Reproducibility Project attempted to replicate 100 published experimental and correlation psychological studies. Little luck did they have, as the effect size of the repeated studies was only half the magnitude of the effects that the original studies reported. This raises serious questions about the extend to which we can trust the scientific findings from psychology. In human beings, truth is necessary for a consistent and meaningful approach to life. If we cannot trust what we think we know, we will have a hard time making reasonable decisions in our lives and predictions about the future. As the philosopher David Hume once put it: "A wise man proportions his belief to the evidence". But how can we do so, if we cannot trust the evidence? Truth has its own virtue, and we must strive towards a more sustainable foundation of psychology, so that we once again can make use of the knowledge from the field of psychology.

In this paper I will argue that cognitive science can make important and unique contributions to improving the methodological and theoretical foundations of psychology. But before dwelling into a discussion of the ways in which cognitive science can contribute with new perspectives to this methodological crisis, I will start out with an assessment of the fundamental methodological and theoretical perspectives in psychology today and the impacts of the non-reproducibility on the scientific process.

Psychology embraces the study of human behavior and mental processes for use in academic settings, including areas as developmental psychology, personality psychology, cognitive psychology and social psychology. Research in psychology is conducted according to the standard of the scientific method, including both qualitative ethological and quantitative statistical modalities, in order of generating explanatory hypotheses regarding psychological phenomena. Psychology tends to be very wide-ranging, drawing on scientific knowledge from various schools of thoughts when seeking to understand and explain psychological phenomena.

Psychological research is typically divided into three main types: correlation research, descriptive research and experimental research. The methods used in each field then vary by whether they collect qualitative or quantitative data, or maybe both. The qualitative approaches utilize an expansive spectrum of observational methods, including interviews, first-hand observation and participant observation. Quantitative approaches, on the other hand, lend themselves to the statistical testing of hypotheses. Even though this field has a sufficient use of controlled and randomized experiments in the laboratory, these approaches can only assess a quite limited spectrum of short-term phenomena (Schinka & Veliver, 2003).

There are different theories in psychology that govern how different psychologists approach research into the behavior and mental processes of humans. The major of these include: biological-, behavioristic-, psychoanalytic-, cognitive-, sociocultural- and postmodernist theories.

Each of the above theories provides an overall framework within which most research in psychology is conducted. They each have different point of emphasis in their approach to the core psychological questions of what, how and why.

However, there seem to be some contemporary issues in the the methodology and practice of psychology, since it appears in the center of the aforementioned replication crisis. It is a methodological crisis, in which scientists find it difficult or even impossible to replicate the results of various scientific studies, either by the original researchers themselves or by other independent researchers (Schooler, 2014). Since reproducibility of experiments is a very essential part of the scientific method, which psychology claims to rely on, the psychological field lands right in the soup, as most of their theories are grounded on experimental work which has now been found to be resistant to replication.

The crisis is particularly present in the field of psychology, but is also existing in fields as medicine; a 2012 study was only able to replicate eleven percent of a group of pre-clinical cancer studies (Begley & Lee, 2012). But even though psychology is not the only field that ended in this crisis, several factors combined put psychology in the center of the controversy. First of all, questionable research practices (QRPs) have become a common part of psychology. QRP are not directly fraud, but are moving around in a gray area of acceptable scientific practices, and exploit the flexibility of comprehending and reporting data. Incidents of QRP could include optional stopping, p-value rounding, selective reporting and manipulation of outliers. A survey conducted on more than 2000 psychologists showed that nothing less that 91.5 percent of psychologists have engaged in questionable research practice at some point in their career (John, Loewenstein & Prelec, 2012). The QRPs often result in a false positive outcome, and are usually made in order of obtaining desired conclusions that fits the researcher's hypotheses, but usually lead to biased results. This is known as the confirmation bias, and is a systematic error of inductive reasoning and a type of cognitive bias (Plous, 1993). Besides this, there is also a great pressure on the researchers to publish their academic work continually and briskly, in order of preserving their further career (Fanelli, 2010), which also incites this conflict of interests that is going on in psychology.

A 2011 study showed another systematic error in psychological studies towards WEIRD subjects (*western, educated, industrialized, rich and democratic)* (Henrich, Heine & Norenzayan, 2011). This category of people only constitutes 12.5 percent of the population on this earth, and according to the study, 60-90 percent of all psychology studies are conducted on this category of people.

These factors, combined with the discouraging results from the Reproducibility Project, leave quite some explaining to do for the psychologists, but it does not necessarily mean that the field of psychology is directly unscientific. The process that psychology now goes through can in some ways be a healthy part of the scientific process, where the ideas that cannot withstand thorough scrutiny or that are not current any longer can be pruned. However, this process of pruning may in some cases be rather ineffective. According to the results of the Reproducibility Project, much of the research in psychology that is published today is just "psycho-babble" (Connor, 2015). Following this, areas as social priming, which was previously considered solidly grounded in science, would fail the test of being real science, as the Reproducibility Project did not have any luck in replicating studies in this area.

To this controversy, Kahneman argues that the original authors should have had the right to participate in the replication of their work, as it is their work and reputation that is on stake, and because the method sections published by the psychological journals generally are to vague to provide a practice that can be repeated by other independent researchers (Kahneman, 2015).
In continuation hereof, a 2012 study showed that replication studies where the original author was involved in the replication were more successful in their replication (91.7 percent) compared to replication studies without the participation of the original author (64.6 percent) (Makel, Plucker & Hegarty, 2012).

On this background it might be worth taking a look at the foundation stones of the Reproducibility Project. According to psychologist Daniel Gilbert, the project contains some key errors that need to be corrected for. For example, a lot of the replication studies used a different population; in a study concerning Americans' attitude towards Afro-Americans, the American population was substituted with Italians. Another study, concerning how college students feel when being called on by a professor, was replicated with participants who had never gone to college. Besides, all the studies were only replicated one time each, so in principle, the results found in these replications could be a coincidence just as much as the original studies are claimed to be. Gilbert rounds off saying "There's no evidence for a replication crisis in psychology" (Gilbert, King, Pettigrew & Wilson, 2016). In a response to this, the group behind the Reproducibility Project rejects Gilbert's analysis. They call it a very optimistic assessment, and argues that it is limited by statistical misconceptions and by causal inferences from selectively interpreted, correlational data. They end up concluding that both pessimistic and optimistic conclusion about reproducibility are possible and that neither are yet warranted (Anderson et *al.*, 2016). The conclusion of this must then be that however strong and clear any results are, the assumptions and expectations of the researcher will always in some way influence his take on the results.

But where does this then leave the scientific enterprise in psychology? Science is typically defined as the effort to understand how the universe works through the scientific method. An essential part of the scientific method is reproducibility, and the irreproducibility in psychology therefore raises important questions about its belonging in the scientific realm.

When looking deeper into the Reproducibility Project it turns out that the replication rate for studies in cognitive psychology is twice as high as the rate for social psychology studies. This could

indicate that psychology has a thing or two to learn from the domain of cognitive science, if it seeks to preserve the quality of the knowledge that is gained through the scientific method.

Cognitive science is the interdisciplinary study of the mind and its processes, among these intelligence and behavior, and embraces the disciplines of philosophy, linguistics, psychology, neuroscience, anthropology and artificial intelligence. In its weakest from, cognitive science is just the sum of those fields, but the interdisciplinary work gets a lot more interesting when there is theoretical and experimental convergence on conclusions made about the nature of the human mind. Using the various methods from these disciplines constitutes the best way to grasp the complexity of the mental processes in humans. For instance, psychology can be combined with artificial intelligence through computational models of how participants behave in experiments. Theoretically, the most fertile approach to understanding the mind has been in terms of representational structures and computational procedures that operate on those structures

The superior paradigm in cognitive science today is computationalism. In the view of computationalism, the mind is seen as a computation that arises when the brain acts as a computing machine, and holds that intelligent behavior causally is explained by computations performed by the agent's cognitive system (or brain) (Piccinini, 2009). A common analog in computationalism is that the brain is a computer and the mind is then the program that the brain runs. A program can be viewed as the finite description of an algorithm, which defines a sequence of discrete states that produces an output based on the inputs and internal states of the computing machine only. That is, according to computationalism, the mind is a computation of a machine (could be the brain) that derives output representations from input representations of the external world combined with internal memory.

Cognitive science, like most other experimental sciences, progresses through a *theorize* → *predict* → *experiment* → *theorize* cycle. This is the cycle of building theories, where predictions made from the theory is tested experimentally, and the theory is amended in the light of empirical findings, then retested etc. (D'Mello & Franklin, 2011). To some extent, all scientific theories are both mechanistic and functional in nature. Functional theories are concerning *what* occurs in a given situation, whereas mechanistic theories concern *how* the occurrence happened; that is, the mechanism behind the occurrence (Block, 1980). Most psychological theories are usually functional in nature. From these theories, they make functional models which are intended to explain both mental processes and predict the functionality of them. According to Logan, these functional models are without doubt useful in the understanding of human cognition, but they do not yield reliably insight into the mechanisms that underlie the cognitive processes (Logan, 2002).

Cognitive science might have a solution for this. It offers a theoretical framework in which computational models that are intended to be analogous to mental operations can be formed and tested. These models that simulate diverse aspects of human performance can complement psychological experimentation on e.g. deductive reasoning, mental imagery and analogical problem solving. For instance, the development of theories in cognitive neuroscience is supported by the development of computational models upon the behavior of different groups of neurons, so using computational modeling, we get to an understanding of the functional organization of a given cognitive phenomenon.

In cognitive science, there are two basic approaches to computational cognitive modeling. The first one is a symbolic approach, which focuses on the mental functions of an intelligent mind and it operates by using symbols. The second approach is subsymbolic, and follows the neural and associative

properties of the human brain. Whatever approach, computational cognitive modeling deals with componential processes of cognition in a structurally and mechanistically well defined way (Sun, 2001). This way, we can get to a better understanding of the cognitive mechanisms that underlie our behavior, which is crucial for understanding the human mind in general. Likewise, it would be awfully difficult to understand a complex computer system solely based on the tests that we can perform on its behavior, without having any a priori ideas of the nature, inner working and theoretical foundation of tat system.

A good example of a field in psychology where cognitive models successfully have been implemented is developmental psychology, where models of child development have had success in explaining subtle developmental processes. For centuries, nativism and empiricism has argued whether children are born with innate knowledge or acquire knowledge through interaction with the environment; the nature-nurture debate. It has been argued that mechanisms of brain development and gene expression do not allow for the detailed specification of neural networks in the brain, which is required if the nativist position should be true. Instead, a more plausible role for innate knowledge is at the level of architectures and timing of development (Westermann, Sirois, Shultz & Mareschal, 2006). To this issue, neural network models have provided new ways to think about innateness, saying that instead of asking whether something is innate or not, one should ask how evolution constrains the emergence of a brain function during development of the child.

Another example of computational models used in developmental psychology concerns children's acquisition of past tense in English. The main issue in this domain is the account for children's characteristic error patterns with over-regularizations of irregular verbs (such as eated and goed), before all forms are learned. Here, a constructivist model can be able to capture the developmental trajectory that is observed in children as well as the level of adults (Plunkett & Juola, (1999). This way, the model provides a mechanism for the transition from development to adult competence.

Overall, models of cognition that are mechanistic embodiments of functional psychological theories can be useful tools to guide the research of psychologists by generating testable hypotheses empirically. So if a methodological change in the field of psychology could be inspired by the theoretical and methodological building blocks of cognitive science, it would most certainly make a significant impact in theoretical and experimental psychology, and probably allow psychology to deal with psychological concepts and phenomena at a different level of abstraction.

Another strength in cognitive science is its interdisciplinary approach to gaining knowledge. A good example of this interdisciplinarity is the old fable about the five blind men who stumble upon an elephant. Not knowing what it is, they start to feel the animal. The first man feels only the tusk of the elephant and believes that he is touching a big carrot. The second man feels only the ears and believes that he is touching a huge fan. The third man feels only the trunk and proclaims that the object is a pestle. The fourth man feels only a leg and believes that it is a mortar, and the fifth man feels only the tail and believes it to be a rope. Obviously all men are wrong in their beliefs, as each of them only examined one aspect of the elephant. If the five men had instead gotten together and shared their findings, they may have figured out what they were dealing with very easily (Friedenberg & Silverman, 2012). We can use this story as a metaphor for cognitive science, with the elephant being the

mind and the blind men being researchers from the different disciplines in cognitive science. Each discipline makes a great contribution to understanding the mind and its processes, and when utilizing the interaction between the different disciplines, we get a strengthened discipline, which would be very applicable to psychology as well. Through this exchanging of ideas from each field, we get a fruitful synergy between all the fields, which accelerates a progress of finding solutions to problems and yielding insights into other research questions within the field of cognitive science (or psychology for that matter).

The methodology and paradigms of cognitive science are definitely able to influence the psychological field positively. But is the computationalism paradigm in cognitive science as a solution to the crisis purely indisputable? You can find a quite fundamental flaw with the computational theory just by 'taking a feel' and looking into your own mind. You probably feel very proud of your dear students, when reading their exam papers. Or maybe the feelings inside of you are inconsistent because of a contradiction between the way you think of yourself as being as a good teacher (and therefore have great expectations to your students' exam papers) and the lousy way you actually taught your students during the semester, leading you to experience cognitive dissonance[1]. Both are common feelings that most people can relate to. However, it appears to be rather inconceivable that a computational model would be able to relate to these feelings as well. As the physicist Emerson Pugh once put it: "*If the human brain were so simple that we could understand it, we would be so simple that we couldn't*".

An early and very noticeable argument against a computational theory of mind was proposed by the philosopher John Searle: The Chinese Room Argument. He lined up a thought experiment where he opposes the allegation that artificially intelligent systems can be said to have intensions and understanding, and disputes that these systems are sufficient for the study of the human mind, which is what computationalism claims them to be (Searle, 1980). In the thought experiment, he asks us to imagine a man sitting in a room alone without being able to communicate with anyone (or anything for that matter) outside of the room except for a piece of paper with symbols written on it that can be passed under the door. The paper enables the man to use a series of provided rule books to return the paper containing different symbols. These symbols turn out to be of a Chinese language (unknown to the man in the room), which generates a conversation that a Chinese speaker outside of the room can understand. It is contended that the man in the room not is able to understand the conversation in Chinese.

The intent with this thought experiment is to show us what computationalism de facto presents us; nothing but a model of the mind that simply decodes symbols and outputs more symbols. There is therefore no case of intentionality or understanding in the 'mind', which was what computationalism claimed to be the case.

Although the Chinese Room Argument was originally written as an abrogation of the idea that computers do not work like minds, it cannot be derived from this position that minds do not work like computers. Therefore, we should not throw in the towel already, in regard to using some of the cornerstones of the computational paradigm in cognitive science in the psychological discipline; we just

[1] To Josh: In case of a misconception, you are a very well-liked teacher among your students, so don't worry!

need to be very aware of the way in which the methodology is used. I still believe that psychology can strengthen its position by implicating some of the computational cognitive models from cognitive science into their methodology, and when using some elements from computationalism reconciled with some of the more subjective methods from the psychological discipline, psychology might be able steer clear of the feasible fallacies in computationalism.
So by implementing some of the theoretical and methodological foundations of cognitive science, psychology will probably get out of the crisis in an even stronger position.

The only questions that is still leaved unanswered is whether we should remain questioning psychology's belonging in the scientific realm. It clearly has some questionable issues concerning its replicability and thereby validity. But by implementing some of the cornerstones from the methodology and interdisciplinarity in cognitive science, these should be possible to account for (if not even solvable!). This way, psychology can succeed in escaping from the sinful box marked with the word 'fraud', and we can keep proportioning our beliefs to evidence derived from fields as psychology, as Hume wants us to do.

References

Anderson, C. J., Bahník, S., Barnett-Cowan, M., Bosco, F. A., Chandler J., Chartier, C. R., Cheung, F., Christopherson, C. D., Cordes, A., Cremata, E. J., Penna, N. D., Estel, V., Fedor, A., Fitneva, S. A., Frank, M. C., Grange, J. A., Hartshorne, J. K., Hasselman, F., Henninger, F., van der Hulst, M., Jonas K. J., Lai, C. K., Levitan, C. A., Miller, J. K., Moore, K. S., Meixner, J. M., Munafò, M. R., Neijenhuijs, K. I., Nilsonne, G., Nosek, B. A., Plessow. F., Prenoveau J. M., Ricker A. A., Schmidt, K., Spies, J. R., Stieger, S., Strohminger, N., Sullivan, G. B., van Aert, R. C. M., van Assen, M. A. L. M., Vanpaemel, W., Vianello, M., Voracek, M., Zuni, K. (2016) Response to Comment on "Estimating the reproducibility of psychological science". *American Association for the Advancement of Science*

Begley, C. G. & Lee M. E (2012) Drug Development: Raise Standards for Preclinical Cancer Research, *Nature*, p. 483

Block, N. (1980) Readings in the philosophy of psychology. *Harvard University Press. Vols. 1 and 2*. Cambridge. MA

Connor, S. (2015). Study reveals that a lot of psychology research really is just 'psycho-babble'. *The Independent.* London

D'Mello, S. & Franklin, S (2011) Computational modeling/cognitive robotics complements functional modeling/experimental psychology. *New Ideas in Psychology. Volume 29.* Special Issue: Cognitive Robotics and Reevaluation of Piaget Concept of Egocentrism

Friedenberg, J. & Silverman, G. (2012) *Cognitive Science: An introduction to the study of mind*. SAGE Publications Inc. 2nd Edition.

Gilbert, D. T., King, G., Pettigrew, S. & Wilson, T. D. (2016) Comments on "Estimating the reproducibility of psychological science". *American Association for the Advancement of Science*. Harvard University. Cambride. MA.

Henrich, J., Heine, S. & Norenzayan, A. (2011) The WEIRDest people in the world? *Behavioral and Brain Sciences. 33.*

John, L. K. & Loewenstein, F. V. (2012) Measuring the Prevalence of Questionable Research Practices with Incentives for Truth Telling. *Psychological Science. 23(5).*

Kahneman, D. (2015) A new etiquette for replication. *Social Psychology, Vol 45(4).*

Logan, G. D. (2002) An instance theory of attention and memory. *Psychological Review, 109.*

Makel, M. C., Plucker, J. A. & Hegarty, B. (2012) Replications in Psychology Research – How Often Do They Really Occur? *Perspectives on Psychological Science*, *7*(6)

Piccinini, G. (2009) Computationalism in the Philosophy of Mind. *Philosophy Compass. 4.* University of Missouri – St. Louis.

Plous, S. (1993). *The psychology of judgment and decision making*. Mcgraw-Hill Book Company.

Plunkett, K. & Juola, P. (1999) A connectionist model of English past tense and plural morphology. *Cognitive Science. 23.*

Schinka, J. A. & Velicer, W. F. (2003) "Volume Preface" in Weiner (ed.). *Handbook of Psychology* Volume 2: *Research Methods in Psychology*.)

Schooler, J. W. (2014). Metascience could rescue the 'replication crisis. *Nature*. P. 515

Searle, J. R. (1980) Minds, brains and programs. *The Behavioral and Brain Sciences, 3(3)*.

Sun, R. (2001). Cognitive science meets multi-agent systems: A prolegomenon. *Philosophical Psychology.* 14 (1)

Westermann, G., Sirois, S., Shultz, T. R., & Mareschal, D. (2006). Modeling developmental cognitive neuroscience. *Trends in cognitive sciences*, *10*(5)