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LOOPS AND RECURSIONS IN COGNITIVE SCIENCE: CROSS-ROADS BETWEEN METHODOLOGY AND EPISTEMOLOGY

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ABSTRACT

This article addresses the need for cognitive science to loop back and examine its roots and presuppositions, pointing out the three recursive issues: 1.) The observer effect or how observing a phenomenon affects the phenomenon that is being observed, an issue that has been acknowledged by natural science, which cognitive science attempts to emulate, and empirical phenomenology, but not cognitive science itself; 2.) Human kinds or how our research affects us, the researchers, and society (people's self-understandings), an issue which forms a loop with the observer effect – observation thus changing the observed, the observer, as well as itself, and 3.) The dangers of over-eager extrapolation or how complexity is lost during shifts in explanatory level, issues pertaining to using findings from studies of one explanatory level (e.g. experiments with rats) to inform a different explanatory level (issues within human society). Finally, the article presents a fourth recursive loop which presents a potential solution to the above: a self-correcting mechanism that allows science to recursively correct its mistakes and improve on its own work.

KEY WORDS

observer effect, human kinds, recursion, looping effects, philosophy of science

CLASSIFICATION

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INTRODUCTION

Upon reaching a dead end, the only way forward is back. One has to retrace one's steps and investigate the path that has led up to that point, so that a more viable way may be found. This is also true in science, and doubly so in cognitive science, where its constituting disciplines present a myriad of branching, joining and again diverging paths. So let us loop back (a phrase that shall become the leitmotif of this article) to the roots of these paths in order to see where we came from and whether there is perhaps a dead end ahead.

The cognitive revolution [1] that gave rise to cognitive science traces its roots to cybernetics – one of the first modern interdisciplinary fields that attempted to study the mind with the computational methods of the rapidly developing fields of computer science and artificial intelligence. It was then that the idea took root to liken the mind to a computer [2], processing information from an input (stimuli) into an appropriate output (behaviour). Some 25 years after the birth of the information-processing (IP) analogy, the young and upcoming field of neuroscience came to fore, uncovering the hardware behind the software that has been (and still is) laid out by psychology, linguistics and anthropology.

There were (and still are), however, problems that provide quite an explanatory challenge if they are to be phrased in an IP framework (but one of many prominent examples of these problems being illustrated by [3], see also [4-6]). While these problems are not exactly dead ends, they are sufficient to evoke doubt in the explanatory power of the IP metaphor – a metaphor that while providing a relatively simple and vivid illustration of some issues, it obfuscates others. Increased awareness of the IP metaphor's (and through it, cognitive science's) limitations and problems gave birth to new explanatory frameworks such as embodied, embedded, extended, enactive or affective cognition (see e.g. [7, 8]).

However, not all issues have been resolved. The emergence of competing theories does not mean a complete transition away from the IP metaphor. Even if it did, these theories do not address all the problems that cognitive science struggles with. Some of these issues shall be the topic of this special issue of INDECS, wherein we shall focus on select methodological and epistemological challenges, such as those of the recursive character of cognitive systems – started by this article and continued by T. Strle [9] – of different ways of modelling and their validity, from computer modelling – see T. Kolenik [10] – to thought experiment – M. Malec [11] – and the challenges the notion of probability poses for metaphysics – P. Lukan [12].

This particular article shall attempt to serve as connecting tissue between these topics, though its main two focuses shall mainly be: the recursive nature of research in cognitive science, and the importance of being mindful of how the paths we take and investigations we perform loop back towards us (the meaning of this shall, hopefully, become clearer throughout this article). Four recursions or loops shall be addressed, the first three representing challenges in research of complex phenomena (i.e., the mind), the last representing a potential solution – or at least the promise of one – to all challenges:

1) The observer effect – how observing a phenomenon affects the phenomenon that is being observed.
2) Human kinds – how our research affects us, the researchers, and society – in the sense of people's self-understandings.
3) From simplification to extrapolation – how complexity is lost during shifts in explanatory level.
4) The self-correcting mechanism: how science recursively corrects its mistakes and improves on its own work.

THE OBSERVER EFFECT

Natural science holds the prestigious position of the human endeavour that uncovers the secrets of the universe 'as it is'. Aspiring to likewise uncover the secrets of the mind 'as it is', cognitive science aims to emulate natural science by imitating its methods. Thus, cognitive science's methods (in general) tend towards an experimental design, isolating a single (quantifiable) variable and controlling all other parameters, until finally, through rigorous statistical analysis, relationships between variables can be determined. The quantities that constitute the explanatory apparatus of science must be as few and as well defined as possible to still describe the whole system, while the measurement must be such that it disturbs the system in the least possible amount, thus producing a clean, pristine quantity, without disturbing other important parameters. These are (some of the) ideals of psychological and neuroscientific research.

But apparently unbeknownst to the core of scientific community within cognitive science, some odd 100 years ago, physics (the non plus ultra of natural science) has come to the realisation that the idea of measurement as extracting a quantity out of reality is not always viable. Within the realm of quantum physics, when measuring a phenomenon, it does not behave the same way as it would when it is not being measured (see e.g. [13]) – this has been dubbed the observer effect. Moreover, the very physicist who first articulated this realisation, Niels Bohr [14], postulates that the observer effect also applies to measurement within psychology, all the while psychologists cling to assumptions about the nature of measurement that physicists have long let go.

It needs to be conceded that the basic idea of the observer effect is not completely alien to the field of psychology: a similar effect has been noticed and dubbed "demand characteristics" [15]. A participant in a study is aware that they are in an experimental situation and act accordingly: they try to be a 'good participant' in that they willingly perform the tasks as they think it is expected of them. These perceived expectations and the behaviour they elicit differs from participant to participant [15]. Perhaps the most illustrative and recent study showing the consequences of demand characteristics is the one by R. Hurlburt et al. [16], where fMRI images were taken of people during inner speech, with there being difference in brain activations between spontaneous occurrences of inner speech and on-demand performances. Yet studies such as this one are an exception. Demand characteristics are not often acknowledged in psychological or neuroscientific research, and if they are, they are a thing to be minimized [17].

There is, however, a field of research within cognitive science that pays greater attention to the difference between measured and unmeasured phenomena, the young and burgeoning field of experience research, also known as empirical phenomenology. Besides collaborating with other fields to reveal the effects of demand characteristics (as it did in the previous illustration thereof, Hurlburt et al., 2016), it also acknowledges the observer effect within its own field of experience research, speaking of an "excavation fallacy" [18], which describes the issue that exploring experience deforms, distorts or even wholly creates the experience one purports to examine.

How, then, do we deal with the observer effect and the various forms it takes throughout cognitive science? It is yet unclear how (or even whether) it would be possible to be rid of the effect altogether, but ignoring it or trying to minimise the effect are both approaches of questionable potency. Empirical phenomenology seems so far to be the only field (besides quantum mechanics itself) to have properly acknowledged the seriousness of this issue and formulated a response (cf. [19]). U. Kordeš and E. Demšar [20] suggest that the excavation fallacy should be rephrased as an excavation characteristic – meaning that the effect becomes itself something to be studied. We have to leave it to our fourth loop to apply this same approach to the other fields within cognitive science, but as the example of Hurlburt et al. [16] indicates, baby steps are being made.

HUMAN KINDS

An effect similar to the observer effect can be detected between science and society – a relationship that can be caricaturised as, again, between observer and the observed, but this time focused on how observation changes the observer themselves. To better understand this interplay Ian Hacking [21] provides the terms natural and human kinds.

Natural kinds are the typically well defined, context independent, and not (too) interconnected concepts or kinds usually found in the natural sciences – such as gravity, force, electric charge, etc. Human kinds, on the other hand, tend to be understood only within a specific context, appear in groups with interwoven meanings, with shifting or flexible definitions – e.g. virtue, morality, love, decision-making, etc. Our definitions and descriptions of human kinds are influenced by how we experience them, which is reciprocally affected by the definitions and descriptions of the greater societal discourse we are contributing to. Human kinds are found in every-day discourse and the humanities, as well as, despite its efforts, in psychology and cognitive science.

To reiterate: many of the phenomena researched by cognitive science are intrinsically dependent on our intuitions[1], all the while our use of those terms shapes the very intuitions the definitions of those phenomena depend on. The relationship between research, resulting constructs, those constructs' effect on social sense-making, and, in turn, social sense-making's effect on research, is not yet sufficiently understood (though attempts have been made, see e.g. [9, 22]).

The previously described issues concerning the observer effect and human kinds come full circle: measurement (or observation) is not a simple extraction of data, but an act that itself changes the phenomenon being observed. Similarly, the observation's results shape how the phenomenon is understood in the greater societal discourse, which loops back, affecting the observer's intuitions, which shape their observation. To simplify these two loops into one: observation (measurement, research) changes both the observed and the observer (Figure 1).

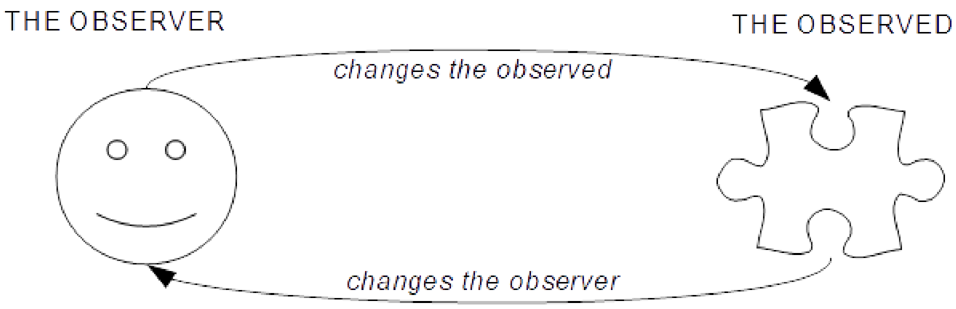

Figure 1. The recursive nature of observation.

The recursive and self-referential nature of research makes a simple transfer of methodologies found in natural science to the fields of research on the mind exceptionally difficult. Even more so as different fields deal in different levels of explanation, such as molecules, cells, individuals, societies and cultures. Methodologies employed to study molecules are questionably effective for studying individuals thus the findings from, for example thermodynamics cannot easily be translated into how the mind works (though respectable attempts have been made, cf. [23]).

FROM SIMPLIFICATION TO EXTRAPOLATION

In trying to study the mind by means of natural science means to transfer information between different levels of explanation and complexity, distorting information along the way. The transfer goes two ways, which shall here be described as 'simplification'[2] (from a 'higher' level to a 'lower' one) and 'extrapolation' (vice versa). Studying the mind usually involves shifts in both directions: first simplification, then extrapolation.

As mentioned before, the most 'prestigious' way of research, which cognitive science is striving towards, is that of natural science. So the first step of researching a given phenomenon is to 'simplify' it, distilling it into few, easy to measure (quantifiable) variables. However, while, for example, simplifying water temperature into degrees Celsius is rather straight forward, the same cannot be said for complex cognitive phenomena such as decision making, empathy or morality.

Similar concerns have already been raised in biology under the name of epistemological reduction [24], questioning whether, for example, all of evolution can be explained solely by genes. Our concerns regarding simplification take a similar direction, perhaps going even a bit further. We do not only question whether phenomena such as empathy can be sufficiently explained by, for example, activations of certain neurons, but what (information) is lost when one distils or simplifies empathy into neuronal activity? The question is thus: how does one even go about transforming complex and ambiguous phenomena into simple, well-defined variables? We would argue that it is impossible to do so without losing a significant amount of nuance and complexity – which in turn makes the transfer back from the lower level of explanation onto a higher one (extrapolation) problematic, as one might have lost something integral in the process (an idea not dissimilar to incommensurability [25]). Yet the extrapolative jump to conclusions is well employed in the social system of science: results from studies are framed as relevant in the broader societal context, which changes how society understands itself, how individuals understand themselves, and how some of those individuals – the scientists – understand the phenomena they are researching. From observing how neurons that fire when a monkey eats a banana also fire when the monkey sees another monkey eat a banana [26], we (humanity as a whole) are quick to posit 'answers' to 'big' questions of cognition such as empathy or even love.

An illustrative example of the dangers of over-eager extrapolation is the now famous experiment with rats whose brains had been wired to a lever so that, upon pressing the lever, their reward centres were stimulated [27]. Once the rig had been figured out, the rats would press the lever continuously, thousands of times per hour, day after day. In similar studies, it has been shown that these more direct forms of stimulation (intravenous cocaine or direct electrical brain stimulation) were preferred even over food, resulting in the rats' eventual starvation [28].

These findings were kindling for the fires of reckless explanation. Their conclusions were immediately applied to humans: that our other survival instincts bow to the tyrannical rule of our rewards system. There is no hope for wholesome living – for as long as drugs are available, addiction and ruin are inevitable. Such have we divined from rats.

However, the cogs of science ground on. A subsequent study [29] introduced a control group. While one group of rats was kept, just like in the previous studies, in a small cage, the other group had a pen with numerous toys, ample food and lots of room for playing and mating – a so-called 'rat park'. Both groups started off addicted to morphine and given a free choice of regular water or morphine solution. As by then expected, the caged rats gorged themselves on the drug. But, surprisingly, the park rats seemed to prefer regular water [29], indicating that addiction might be stymied by a sufficiently stimulating environment. The previous extrapolation that the rewards system subjugates all other instincts was thus challenged, thus also pointing out how problematic it is to infer complex environmentally dependent cognitive dynamics from studies accommodating necessarily reductive and 'simplifying' methodology (which tries to negate environmental impact as much as possible).

The here elucidated issue with simplification and (reckless) extrapolation is concerning for the whole of cognitive science. Is the cognition that is researched in the lab the same one that occurs 'in the wild'? If (cognitive) science needs to distil every phenomenon into a measurable variable, can it still be said that it is researching that very phenomenon, or is it but studying a homeopathic solution of questionable potency and ecological validity[3]?

THE SELF-CORRECTING MECHANISM

The heretofore presented issues paint a grim and pessimistic picture. It seems that whatever step we take, however far we loop back, we are surrounded by dead ends and every time we try to move to a different road it turns out to be on a different (explanatory) level. Is there really no hope to someday find our way to the truth about the mind?

It would be only fair to concede at this point that the hitherto used metaphor of branching paths and stepping forward is, though illustrative, somewhat deceiving as far as the nature of scientific progress is concerned. Science is not in the business of discovering reality, but in negotiating with the environment, or as Bertrand Russell [30; p.15] puts it:

> "Science thus encourages the abandonment of the search for absolute truth, and the substitution of what may be called "technical" truth, which belongs to any theory that can be successfully employed in inventions or in predicting the future. "Technical" truth is a matter of degree: a theory from which more successful inventions and predictions spring is truer than one which gives rise to fewer. "Knowledge" ceases to be a mental mirror of the universe, and becomes merely a practical tool in the manipulation of matter."

If we subject the whole endeavour of science to this criterion of "technical" truth – that is, whether its theories can be successfully employed – we find ourselves before a staggering mass of evidence for its efficacy. How then do we console our analyses of its numerous flaws with its resounding success? How can it be riddled with mistakes and still grind on, spewing out better and better theories? The answer is exactly thus: it continues to spew out better and better theories, all the while looping back, correcting past mistakes and improving or discarding and substituting past theories that no longer appear to hold water.

This is science's self-correcting mechanism: a culture of falsification [31], replicability and peer-review – a culture of testing, retesting and gathering of new data to support or disprove. R. Feynman characterised science as "belief in the ignorance of experts" [32; p.315]. All this is done in an attempt to cover all the blind spots, account for biases and rectify past mistakes. The institutionalized self-correcting process was already evident in our previous example with rats: scientists put the work of their peers under close scrutiny, found shortcomings, and developed a better experiment. The new experiment in turn was put under close scrutiny that revealed shortcomings (cf. [33, 34]), and the cycle of re-examination continues.

Through this very same process, cognitive science – even from way before it was called that – evolved from a sole interest in the relationship between stimulus and behaviour (behaviourism), to an interest in the brain and how it processes information (information-processing metaphor) and now to tendencies towards embodied and social aspects of the mind. Finally, in the past few decades, the phenomenological or first-person perspective is being taken into account as well (for example, in the form of enactivism, see [7, 35]).

The self-correcting mechanism is perhaps science's strongest virtue. It allows science to constantly loop back and improve itself in the face of new data, to question perhaps out-dated metaphors, to re-evaluate the very nature of measurement and observation, to become aware of its own effect on society and society's effect on scientific work, and of the dangers of shifting between different levels of explanation. What is more, this mechanism built into the scientific process itself, so change need not be brought about by outside intervention. To overthrow a misruling despot within science – perhaps in the form of a common metaphor or a leading theory – there is no need for an armed militia to instigate a violent revolution. Science constantly revolutionises itself. The "governance" of a leading theory is thoroughly and ceaselessly being questioned by the very proponents of that theory and their peers. Thus, we invite the reader to do just that. Peruse this text (and this issue, this journal, other journals, …) and scrutinize the contents, be mindful of the problems described (t)herein in so far as they apply to your work, and do not hesitate to call us out on what we ourselves have missed. The descent into placid naivety can, after all, be ever so seductive.

REMARKS

[1]A prominent example of our intuitions shaping our research is found in computer modeling. The issue known as Pac-Man effect [36] brings to attention that, to simplify, it is always the one making the computer model that determines what is food that should be sought out and what are predators that should be avoided, not the agent itself (see also [10]).

[2]That is not to say that phenomena and their explanations are simple in the colloquial sense (anyone trying to wrap their head around quantum mechanics can attest to that), just that less "other factors" (such as the environment) need to be accounted for or ignored when researching them.

[3]See also Strle [37] for similar claims in the domain of decision-making.

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