Routledge
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Commentary

Coherence, causation, and the future of cognitive neuroscience research

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http://dx.doi.org/10.1080/17588928.2014.950213

Abstract: Nachev and Hacker's conceptual analysis of the neural antecedents of voluntary action underscores the real danger of ignoring the meta-theoretical apparatus of cognitive neuroscience research. In this response, we temper certain claims (e.g., whether or not certain research questions are incoherent), consider a more extreme consequence of their argument against cognitive neuroscience (i.e., whether or not one can speak about causation with neural antecedents at all), and, finally, highlight recent methodological developments that exemplify cognitive neuroscientists' focus on studying the brain as a parallel, dynamic, and highly complex biological system.

We welcome Nachev and Hacker's increased attention to the meta-theoretical apparatus of cognitive neuroscience and hypothesis testing. In this response, we temper certain claims and consider cognitive neuroscience's viability given a more extreme interpretation of their conceptual analysis.

Scientific hypotheses state relations between variables in a double sense: A relation between operationalized variables given one's data and a relation between loftier "conceptual" variables. Researchers would prefer to settle disputes about relations between conceptual variables like *empathy* and *theory of mind*, but these concepts must be translated first into more humble terms (scores on questionnaires, response times to stimuli, etc.) which, more frequently than not, are far from settled in a literature. For Nachev and Hacker, empirical data from cognitive neuroscience often do not speak coherently to any question's resolution precisely because the conceptual variables at issue (and so their hypothetical relations) have been ignored in favor of a subtly different examination of operationalized variables. The problem is that when one supports a scientific hypothesis, it's simply stating an incoherent set of empty terms, and so any data interpretation is unclear. This conclusion, however, might be too strong. Data are never "irrelevant to the question they are collected to answer," even if the conceptual variables that spurred some specific operationalization are unclear. Data are what they are; they are never wrong. At worst, they are rendered with an asterisk under the condition of future research. No empirical data settle a conceptual matter. As Nachev and Hacker would no doubt agree, conceptual matters are settled by coherence and likely a certain aesthetic, so conceptual analysis would not render the empirical work of cognitive neuroscience impotent, even if parts were misguided. With careful attention to how variables have been operationalized in the literature (instead of how they've been conceptually interpreted), empirical work may yet be reinterpreted in light of future conceptual (and empirical) analysis.

The promise of future research may alleviate another concern of Nachev and Hacker. That there can be a dissociation between urges and action does not mean that "a causal link between them [is] implausible." Even in straightforward drug trials, there are individual differences (e.g., some who receive the drug don't respond favorably); this does not negate or jeopardize causal claims. There may simply be unknown interactions (e.g., certain *kinds* of people don't respond under certain circumstances) or errors (e.g., certain *individuals* don't follow task instructions). Likewise, a cause (e.g., an urge) can lead to multiple effects (e.g., a subsequent movement in some or an inhibition to move in others) without negating it as a causal force. What would unproblematically account for the variability in a study would be some particular, though unknown,

set of moderating or mediating conditions that future research would specify.

Nachev and Hacker's concern about incoherency may be even more strongly applied to discussions of causation (viz. that cognitive neuroscientists are ill-equipped conceptually from the start). The "neuroscience" element is engaged in a micro-analysis of what is essentially physics, whereas the "cognitive" element examines function (see Fodor, 1968). Neural activity that is, or that precedes, a human being's button-pressing and a rat's lever-pressing are quite different, though in a real functional sense these *different physical descriptions* may be readily identifiable as both *equivalent responses*. Behavior may be operationalized differently from species to species and even from lab to lab. Thus, one can't address what a neural antecedent would be to a voluntary action (or anything psychological) because conceptually the accounts of causation from cognitive and neuroscientific perspectives are at cross-purposes.

At any moment, a goal or circumstance may change and an organism must be ready to change the type, timing, or, even, the implementation of an action. Hence, a key cognitive neuroscience question is not so much antecedence, but how the brain's dynamic flexibility and efficiency helps identify which, among an infinite number of possible motor solutions, is the one that will satisfy a goal (see Haggard, 2001). The reality is that cognitive neuroscientists acknowledge that the brain is a highly parallel, largely non-linear system. Recent methodological developments signal this perspective, for example, the shift in the analysis of functional neuroimaging data from conventional activation-based methods that simply show a region's involvement in a task, to multi-voxel pattern analysis methods that can reveal fine-grained patterns of activity corresponding to representational content within a brain region (Norman, Polyn, Detre, & Haxby, 2006). Such methods hold promise for differentiating among competing hypotheses pertaining to complex biological systems and do not require the problematic where and when of a homuncular decision-maker.

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