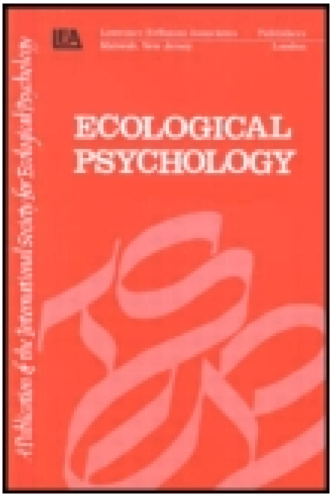

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Dealing With Complexity Differently: From Interaction-Dominant Dynamics to Theoretical Plurality

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Dealing With Complexity Differently: From Interaction-Dominant Dynamics to Theoretical Plurality

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We describe how the work of Guy Van Orden has been deeply influential in a variety of ways and focus on 2 important features: measurement and context. The centrality of these variables in understanding how psychological regularities emerge in our investigative contexts, and evolve into theories, recommends a different way of dealing with complexity. We argue that the Van Orden approach has, as one possible consequence, a plural approach to psychological phenomena. We end by describing what this means for cognitive science.

> The philosophy itself recommends endless looping self-questioning and recapitulation, and insinuates subtle unspoken differences of opinion even as we concur. You will always in some way disagree with me, even as we shake hands in agreement or co-author a scientific paper. That we may always disagree is the fuel of creative and productive collaborations, the grist of the grinder for change and discovery. (Van Orden, 2008, p. 219, commenting on pragmatism)

Guy Van Orden (2008) relished disagreement and discussion, even among like-minded colleagues. Two people can be simpatico with respect to the overall theoretical landscape, but the details leave much to discussion and dispute. These disputes are where new theoretical ideas can be conceived, and over many hours of chatting with Guy, these ideas can even gestate substantially. We always wanted to have a pen and paper in Guy's presence and unabashedly ask, "Mind

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if we take notes while we talk?" Accordingly, the published work of Guy and his collaborators influenced many, from the youngest to among our most senior and established colleagues (see review in Kello et al., 2010). This influence sometimes took the form of heated dispute, too (see collection in Stephen & Van Orden, 2012; Van Orden & Stephen, 2012).

In this article, we describe one way that Guy influenced us. Guy's exhortations to the field to deal with complexity had impact on us. But akin to disagreement among like-minded colleagues, the details end up looking different. We first summarize how Guy's work influenced us radically. The overall theoretical landscape is a vision that Guy taught us and inspired in us. But the upshot for cognitive science is to reframe the ongoing theoretical disputes that seem to be continuing without end. In fact Guy's work suggests to us *why* these theoretical disputes appear to continue without resolution and in some cases even without abatement. The result, for us, is to consider the possibility of theoretical plurality. In fact, Guy's perspectives, and those of his collaborators, on interaction-dominant dynamics, measurement, complexity, self-organization, and so on, offer the seeds of a potential solution. The solution may come from asking how different theories emerge in different measurement contexts; relate to one another; and perhaps in the rarest cases, dissolve into one another.

MEASUREMENT AND CONTEXT

The work of Guy Van Orden and his collaborators challenges cognitive science to question many of its assumptions (e.g., Van Orden & Holden, 2002; Van Orden, Holden, & Turvey, 2003; Van Orden, Jansen op de Haar, & Bosman, 1997; Van Orden, Kello, & Holden, 2010; Van Orden, Pennington, & Stone, 2001). The challenge is based on the fundamental interactivity of nested scales that compose the cognitive system. As a consequence, we cannot fully understand a cognitive performance by decomposition into a small set of linearly combined mechanisms or processes. The articles in this special issue summarize some of these issues more effectively than we could. However, we highlight two concepts that become central under this approach: *measurement and context*.

First, measurement schemes inherently shape the regularities that can be inferred from a program of research (Holden, Choi, Amazeen, & Van Orden, 2011). Psychological regularities found at one level of analysis should not by default be assumed to hold at other levels. Even worse, they should not be forced onto those levels (Van Orden et al., 2001). The proposed constructs and processes of behavioral laboratory memory research, for example, may not hold in "higher level" ecological memory (Neisser, 1991) or at the "lower" neurophysiological level (Moscovitch, 2007). This is not to say that different accounts of memory cannot guide and constrain one another; they are not independent. They are regularities identified with different sets of theoretical: methodological; and it is important to note, *measurement* assumptions (Van Orden et al., 2010).

Second, the regularities we can infer in a program of research depend intrinsically on the contexts that are established for cognitive system performance. One piece of advice Guy gave, about starting a new empirical project, is to start where a phenomenon is unstable; this is one way we could reinterpret his famous findings in “A ROWS is a ROSE” (Van Orden, 1987). At these junctures, we find great system adaptivity, where small task parameters can lead to nonlinear changes in system performance. Through this lens, we could redescribe some theoretical disputes in cognitive science as being based on points of instability. Parameters that sharply shape cognitive performance such as linguistic recursion (Christiansen & Chater, 1999) provide key hints about human language. And the powerful role of context in transforming performance seems pervasive, from perception (Rensink, O’Regan, & Clark, 1997) to reasoning (Cosmides, 1989). Points of instability are hints that a current theory may have important boundary conditions and that system behavior is considerably more fluid and adaptive than one may suspect.

Both of these tenets, one about the importance of measurement and the other about the important role of context, derive from the intrinsic interactivity among nested scales underlying a cognitive performance and how we go about studying it. In fact, both can be seen to derive from the same inspiration:

> Context dependence is consistent with the idea that behavioral dualities of fractal wave and datum are emergent. They depend for their existence on the dynamic linkage among component systems, including measurement protocol. They are exclusively soft-assembled dynamical phenomena, which is a term meaning they don’t have a separate, hard-assembled, off-line existence in physiological or physical components, and they cannot be predicted from the individual behaviors of such components. Human behavior originates in temporary dynamical mechanisms of participant-history-context systems. (Van Orden et al., 2010, p. 34)

From this perspective, there is no privileged level of analysis in the study of cognition. Despite the apparent hegemony of the neurosciences, the wide array of modeling approaches in cognitive science, the plethora of theoretical frameworks on offer, and so on—none of these dictates a single true answer to *what the system is* or even *what it is like*. Theoretical radicalism is too far reaching because it underestimates the boundary conditions imposed by the adaptive cognitive system (see also Chater & Brown, 2008). And yet, in another sense, theoretical radicalism is simply too specific in that it is an explanatory induction from an unavoidably limited range of measurement and contextual variables.

This feature from Van Orden’s approach, the centrality of measurement and context, suggests that our empirical inductions can reveal *real but different* psychological regularities. Indeed this is what we should expect to see in so multileveled and multifarious a domain of inquiry as cognitive science. The upshot, to us and many others, is to embrace theoretical diversity (Chemero, 2009; Chemero & Silberstein, 2008; Dale, 2008; Dale, Dietrich, & Chemero, 2009), although this is something that Van Orden acknowledged but saw as a worrisome portending (see Van Orden, 2008, for discussion).

Theoretical diversity should not come as a surprising outcome of studying a ridiculously complex system. Writ large, the human scientific enterprise is highly heterogeneous (Suppes, 1978). If we could stand back and look at the whole of science in a beaker, its appearance would reflect a mechanical mixture—clumps of diverse subjects of study and methodologies (Cartwright, 1999). These subjects of study and methodologies interweave in a variety of ways, but it is partial, a mosaic. Despite the century or more of philosophy of science from Ernst Mach to logical positivism to Karl Popper to more recently, science has resisted anything remotely approaching a consensus systematization (although proposals abound). Perhaps it should not be surprising that our study of psychology would face the same limitations.

COMPLEMENTARY TENSIONS IN THE MARCH OF SCIENCE: UNITY VERSUS PLURALITY

Some readers may be furrowing their brows, as the intuition of the unity of science is powerful and taken for granted; sadly it's a fiction. In the words of Suppes (1978), "We are continually confronted with new situations and new problems, and we bring to these problems and situations a potpourri of scientific methods, techniques, and concepts, which in many cases we have learned to use with great facility" (p. 14). This is not to say that pursuing unification is not a useful agenda. Yet, Suppes also argues that seeking diversity and new ideas and extending the domain of science seems to have been useful, too. Both reflect the march of scientific progress, although the former has been more glorified through the textbook's lens (Brush, 1974). One reason for this diversity has been expressed in a simple mantra: More is different (Anderson, 1972). The regularities at one level of analysis may not translate readily to domains in which many constituents at that level combine and interact. An interacting assemblage of such constituents may lead to novel patterns, novel collective properties, new levels of analysis. In the words of Anderson,

> The constructionist hypothesis breaks down when confronted with the twin difficulties of scale and complexity. The behavior of large and complex aggregates of elementary particles, it turns out, is not to be understood in terms of a simple extrapolation of the properties of a few particles. Instead, at each level of complexity entirely new properties appear, and the understanding of the new behaviors requires research which I think is as fundamental in its nature as any other. (1972, p. 393)

This diversity of theoretical and methodological agendas across the sciences, in general, is a perfectly viable metatheoretical stance for the cognitive sciences, in particular. We see no reason to suppose otherwise.

This is where we might engage in "like-minded disagreement" with Guy and colleagues. When we look to the finer grained dynamics of the cognitive system and analyze these patterns of variability, we do not get a clean signal reflecting constructs and components—linear decomposability. Through Guy Van Orden and his colleagues, this has been demonstrated in many contexts (see Kello et al., 2010, for review) and confirmed by others despite raucous debate (Gilden, 2009). The implication is that whatever the favored level of a researcher, it is likely underlain by a complex system of many interdependent components. That system probably extends deeper into a range of nested spatial and temporal scales. No level of analysis relevant to the cognitive sciences—not one—is immune to this finding.

But this fractal finding alone cannot deny, nor is it inconsistent with, the identified higher order regularities. Put differently, unless the finer grained regularities can also predict and explain the regularities in the higher order measurement context, then they cannot account for it, or replace it, or even account for how the regularity emerges from the lower level. Here is where one might disagree with Guy and collaborators and engage in "differences of opinion even as we concur" (Van Orden, 2008, p. 219). In fact this way of thinking can be seen as a direct consequence of the work of Van Orden and colleagues. It is coming to theoretical grips with complexity in a way that is different—it embraces the multilevel, multiscale nature of the cognitive system, with its heterogeneous mix of regularities. The regularities that emerge from any agenda in cognitive science cannot be easily subjugated by observations at other levels.

Consider the case of choosing the best computational framework for exploring some phenomenon. At best, computational models of cognitive processes can only capture certain aspects of cognition within the boundaries of particular contexts. That is, models are only as good as the parameters of the problem space in which they are applied. This is not to say that a particular model is necessarily limited to particular contexts, as a model based on rule-based procedures can theoretically be translated into a distributed neural network and vice versa. But such transmutability does little to answer the question of what cognition is. As Gershenson (2004) notes, cognition is not found in model architecture or implementation but rather in the contexts in which the models (or theories) are examined. This is because cognition is not one thing; nor can it be understood in one way. It exists at multiple emergent levels. By taking many perspectives and incorporating a range of paradigms, only then can researchers begin to have a "less incomplete" understanding of cognition.

But this leaves us with many open questions. How can we determine what higher order regularities are valuable? How can we identify the collective variables themselves? These are exciting questions for ongoing research, which theorists in the interaction-dominant camp are ripe for offering substantial solutions. Some of this discussion has taken place in the artificial-life community in which the concepts of emergence and self-organization have great currency, such as in Ronald, Sipper, & Capcarrère's (1999) test of emergent behavior. In seeking a commonsense standard akin to Turing's test of artificial intelligence, Ronald argues that emergentism arises when a system-level design, known by an observer, gives way to a new behavior that requires the observer to adopt a new form of description.

A perhaps hackneyed example is the "Game of Life" cellular automaton; cells in a two-dimensional rectangular grid can be turned "on" (colored black) or "off" (colored white) given simple rules. These rules can be understood by an observer who knows that a cell will be activated based on the activation states of immediate neighbors. Nevertheless, an observer is surprised, a crucial criterion for Ronald's test of emergentism, by the complex, global patterns that can be seen across the cells. It is not obvious how the initial conditions and the known rules for interaction might readily produce such outcome behavior. To understand and describe the outcome, a new vocabulary is needed that is not contained in, or necessarily needs to reference, the more elementary lower level of operation. The new behavior can be studied on its own terms completely and is no less real than the dynamics by which it is produced and sustained (Dennett, 1991; see also Kubí, 2003).

So too with the nature of cognition. Underneath every mechanistic description of some high-level cognitive operation is a dynamical process of self-organization and nonlinear interaction. Although it has had prominence in some formal literatures (e.g., Wan, 1990), articulating these interrelationships, and exploring their *theoretical implications*, remains only a broad but still-budding agenda in cognitive science (e.g., Atmanspacher & beim Graben, 2007; Bechtel, 1990; Bechtel & Abrahamsen, 2006; Chemero & Silberstein, 2008; Dale et al., 2009; De Jong, 2002; Dove, 2009; Smolensky, 1990, 2012; Sun, Coward, & Zenzen, 2005; Tabor, 2002, 2009; Weiskopf, 2009).

A complex dynamical systems perspective should naturally support the notion that cognition is not one thing. It simultaneously exists for (external) symbolic manipulation, problem solving, and fast-acting adaptation to an environment. It may do all things at once, and even still, a grand unified theory of cognition, encapsulating or replacing all current theories, may never be realized. To us, Guy's work inspires not disengagement from broader theoretical enterprises but rather to seek generalizations in different ways. The complexity of cognition, its many contexts, and how we measure it, demand it.

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