Commentary on *Semantic Cognition*, by Rogers and McClelland

Abstract: *65* words
Main Text: *1355* words
References: *385* words
Total Text: *1805* words

Semantic Redintegration: Ecological Invariance

(2008) *Behavioral and Brain Sciences, 31*, 726-727.

Stephen E. Robbins
Center for Advanced Product Engineering,
Metavante Corporation,
Milwaukee, WI, 53224

Home: 262-628-3502
Homepage: stephenerobbins.com

mailto:Stephen.Robbins@metavante.com

Abstract

In proposing that their model can operate in the concrete, perceptual world, the authors have not done justice to the complexities of the ecological sphere and its invariance laws. The structure of concrete events forces a different framework, both for retrieval of events and concepts defined across events, than that upon which the proposed model, rooted in essence in the verbal learning tradition, implicitly rests.

There is no cognition without memory, that is, without the redintegration of events. The depth and breadth of thought by Rogers and McClelland on semantics is impressive, but I fear the claim that their model dwells in the perceptual/ecological sphere ignores the realities of this sphere, in the end resulting in an inadequate theory of redintegration.

Consider an event: stirring coffee in a cup, using a spoon. The event has a time-extended invariance structure, here defined as the transformations and invariants specifying an event and rendering it a virtual action. The swirling coffee surface is a radial flow field. The constant size of the cup, should it move forward or backward, is specified, over time, by a constant ratio of height to the occluded texture units of the table surface gradient. The tau ratio defined over this flow field supports modulating the hand for grasping the cup (Savelsburgh et. al, 1991). Were the cup cubical, its edges and vertices are sharp discontinuities in the velocity flows of its sides as the eyes saccade, where these flows specify the form of the cup (cf. Robbins, 2004, 2007). The periodic motion of the spoon is a haptic flow field that carries an adiabatic invariance – a constant

ratio of energy of oscillation to frequency of oscillation (Kugler and Turvey, 1987). The action of wielding the spoon is defined by an inertial tensor describing the moments of force (Turvey and Carello, 1995). This entire informational structure and far more must be supported, globally, over time, by the resonant feedback among visual, motor, auditory, even prefrontal areas. To store such a dynamic, ever changing, global pattern entirely in the hippocampus for future feeding to the cortex, as suggested (McClelland et al., 1995), is an impossibility.

In the authors' formulation, I present an occurrence, SPOON, in the context of CAN, and the network must be trained, via weight adjustments, to respond with STIR. Or equivalently, in the causal version, the network is trained to predict the sequelae, e.g., the "circular motion of the coffee liquid," or the clinking sound, etc. What sense does this make? This is a remnant of the supremely non-ecological verbal learning tradition, its roots in the semantics-eradication program of Ebbinghaus, which ultimately bifurcated events arbitrarily into components, e.g., SPOON and COFFEE, then asked: how do we learn these components as a paired-associate pair? This is the PA-learning framework of the older cousin-model (McClelland et al., 1995). Paivio's (1971) introduction of imagery, and later the elaboration techniques, where SPOON and COFFEE are imagined in a dynamic event, were the first somewhat ecological cracks in this brute force, syntactic learning framework.

In reality, we are perceiving the spoon as an integral part of a stirring event, with all the event's ongoing invariance structure. Where is the "error?" We need no weight adjustments to "link" the event "components." This is precisely why the mechanism of back propagation or its equivalent will never be found. A spoon scooping and lifting oatmeal is yet another event with an integral and complex set of forces and auditory/visual patterning. A spoon stirring pancake batter is yet a different complex invariance structure. A spoon digging into and cutting and lifting grapefruit is yet another. A spoon balancing on the edge of the coffee cup another. Now we have the set: SPOON CAN: [stir, balance, scoop, cut]. If I re-present SPOON, which event will it redintegrate? Presenting SPOON is roughly equivalent to a static event, a resting spoon. There is little structure to this event as a cue; it is underspecified, and yet is common to all. It is like sending an imprecise reconstructive wave with little coherence through a hologram – we reconstruct a composite image of multiple recorded wave fronts, or in this case, stirring events. It is the classic interference of McGeoch (1942). A network does not have to be error-trained to specify this set.

But equally, we can retrieve a specific event. The cue must bear the same invariance structure or a sufficient subset. For the coffee stirring, we re-present an abstract rendering of the coffee's radial flow field, or simulate the inertial tensor of the wielding. We are creating, globally throughout the brain, a more constrained, more coherent "reconstructive wave." To reconstruct the batter-stirring event as opposed to the coffee-stirring, we must constrain our wielding cue differently to capture the larger amplitude of the stirring motion and/or the greater resistance of the medium. In essence, we are discussing a "paired associate" paradigm, call it A-B_i, that is impossible in the verbal learning realm, for every cue is in effect SPOON, yet with the appropriate ecological, dynamic constraints on the cue event involving a spoon, we can reconstruct each separate event (Robbins, 2006a, 2006b). But we also understand, "A SPOON can CATAPULT (a pea)," for the spoon, we know, can be inserted in, and supports the forces/invariance structure of, catapulting. This is precisely the realm of French's (1990, 1999; cf. Robbins, 2002) devastating critique re the Turing Test, and the network proposed is no better equipped for these emergent analogies.

What now is an end element of the "hierarchy," e.g., the concept STIR? For coffee-stirring, it is a higher order invariance existing or taken across many instances of the dynamic invariance structure described above. Similar to Goldinger's (1998) "exemplar" suggestion, it would be the

firing of the family of all "traces" or pattern/paths ever supporting a coffee-stirring event. The result is a context free COFFEE-STIRRING, while STIRRING in general is a higher order invariance over a yet larger number of event patterns, to include stirring cake batters, soups, coffee and cement. This is the meaning of the abstract, general, context-free STIRRING, but this meaning is intrinsically based in a system that can equally reconstruct the specific, e.g., the precise event of the cake-batter stirring versus the coffee stirring, via cueing by any appropriately constrained, sufficient subset of the invariance structure of these events.

Such a view questions the book's model of memory at its base. For relating arbitrary, unrelated events, we perhaps need a syntactic association mechanism of some form. For ecological events with their invariance structures, the principle of retrieval, for both individual events and abstract classes defined across events, is quite different.

Balancing a scale is an event. To derive the full semantics of the principle of torque in and across such events, there is again the perception of invariance over transformation. We specify the successive balancing transformations re the two sides: 2 lbs placed at 10 inches (from center) or 2 lbs x 10 inches = 5 lbs x 4 inches; 3 lbs x 6.66 inches = 5 lbs x 4 inches; 4 lbs x 5 inches = 5 lbs x 4 inches; 6 lbs x 3.33 inches = 5 lbs x 4 inches. Over this transformation set, the invariance law emerges. This invariance is the semantics of torque. Quinlan et al. (2007) have shown that in balance scale simulations, connectionist networks never learn the principle of torque, nor do many internal representations of approximate rules correspond to the human. There is a significance to this, deeply related to the subject – semantic cognition – and it is that connectionist models are insensitive to the transformations and invariants defining events. It would be an easy exercise to show that this will be true for nearly all Piagetian tasks. What else is the tunnel-bead experiment (Piaget, 1946), which demands the child predict the oscillation of order in three colored beads moved into a cylinder/tunnel, given any n semi-rotations of the tunnel?

Discovering invariance laws, it has been heavily argued (Kugler and Turvey, 1987; Wigner, 1970; Woit, 2006; Woodward, 2000; 2001), *is* scientific explanation. This subsumes the "causal" explanations of theory-theory. In this, science models itself after the brain in perception, and in this sense the authors, in holding, contra theory-theory, that there is no special mechanism, are perceptively right. But coherent covariation is a low order, syntactic form of invariance. The neural dynamics required for the transformations and invariance noted above, I believe, is beyond the coherent covariation detection of the model; the lesson of invariance in the ecological sphere has yet to be engaged by either side.

References

French, R. M. (1990). Sub-cognition and the limits of the Turing Test. *Mind, 99*, 53-65.

French, R. M. (1999). When coffee cups are like old elephants, or why representation modules don't make sense. In *Understanding Representation in the Cognitive Sciences*, eds., A. Riegler, M. Peshl, & A. von Stein. Plenum.

Goldinger, S. (1998). Echoes of echoes? An episodic theory of lexical access. *Psychological Review, 105*, 251-279.

Kugler, P., & Turvey, M. (1987). *Information, Natural Law, and the Self-assembly of Rhythmic Movement*. Erlbaum.

McClelland, J. L., McNaughton, B. L., & O'Reilly, R. C. (1995). Why there are complementary learning systems in the hippocampus and neocortex: Insights from the successes and

failures of connectionist models of learning and memory. *Psychological Review, 103*, 419-457.
McGeoch, J. A. (1942). *The Psychology of Human Learning*. Longmans, Greene.
Paivio, A. (1971). *Imagery and Verbal Processes*. Holt, Rinehart, and Winston.
Piaget, J. (1946). *The Child's Conception of Movement and Speed.* Ballentine.
Quinlan, P., van der Maas, H., Jansen, B., Booij, O., Rendell, M. (2007). Re-thinking stages of cognitive development: An appraisal of connectionist models of the balance scale task. *Cognition, 103*, 413-459.
Robbins, S. E. (2002). Semantics, experience and time. *Cognitive Systems Research, 3*, 301-335.
Robbins, S. E. (2004). On time, memory and dynamic form. *Consciousness and Cognition, 13*, 762-788.
Robbins, S. E. (2006a). On the possibility of direct memory. In *New Developments in Consciousness Research*, ed.,V. W. Fallio. Nova Science, 1-64.
Robbins, S. E. (2006b). Bergson and the holographic theory of mind. *Phenomenology and the Cognitive Sciences, 5*, 365-394.
Robbins, S. E. (2007). Time, form and the limits of qualia. *Journal of Mind and Behavior, 28*, 19-43.
Savelsbergh, G. J. P., Whiting, H.T., & Bootsma, R. J. (1991). Grasping tau. *Journal of Experimental Psychology: Human Perception and Performanc*e, *17*, 315-322.
Turvey, M., & Carello, C. (1995). Dynamic touch. In *Perception of Space and Motion*, eds., W. Epstein & S. Rogers. Academic Press.
Wigner, E. P. (1970). *Symmetries and Reflections*. MIT Press.
Woit, P. (2006). *Not Even Wrong: The Failure of String Theory and the Search for Unity in Physical Law*. Basic Books.
Woodward, J. (2000). Explanation and invariance in the special sciences. *British Journal for the Philosophy of Science, 51*, 197-214.
Woodward, J. (2001). Law and explanation in biology: Invariance is the kind of stability that matters. *Philosophy of Science, 68*, 1-20.