Affect Control Theory as a Foundation for Socially Intelligent Systems

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Social models of interaction may provide insight on the dynamics of human-computer interaction (HCI) (e.g., Heise in press, Lee and Nass 2003, Nass et al. 1994; Reeves and Nass 1996). Here, I discuss how affect control theory (ACT), a social theory of interaction, might inform HCI research.

Affect Control Theory[1]

ACT (Heise 1987) portrays individuals as continually assessing meaning in interaction and seeking consistency across interactions. At the onset of interaction, we assign elements of interaction to categories. For instance, humans are categorized into roles (e.g., teacher, student), with shared expectations regarding actions appropriate for the role. Actions that we take towards and in response to one another are the defining markers of "social events."

ACT conceptualizes social events in terms of their constituent elements: (1) Actors who assume identities (e.g., teacher), (2) Behaviors of actors (e.g., help), (3) Objects to whom the actions are directed (e.g., student).[2] These elements capture the linguistic structure of events, e.g., "Teacher Helps Student." (ABO). Each ABO element has meaning outside specific events defined in three dimensions (operationalized on scales from -4.5 to +4.5): Evaluation (goodness), Potency (powerfulness), Activity (liveliness) (EPA; e.g. Osgood et al. 1957). EPA ratings of each element are "fundamental sentiments." ACT recognizes that humans have culturally shared fundamental sentiments and expectations for how ABO elements *should* combine in events. For instance, we expect good actors to behave in good ways. When ABO elements combine in an event, emotion signals the correspondence between the meanings we expect to be evoked and ones that are actually evoked (i.e., "transient impressions"). Smith-Lovin (1987) formulated impression-formation equations combining EPA ratings of elements to estimate new ratings for elements combined in events. This exemplary impression-formation equation predicts a new evaluation (i.e., goodness) of an actor (A_e) in an event:

$$A_e' = c_1A_e + c_2A_p + c_3A_a + c_4B_e + c_5B_p + c_6B_a + c_7O_e + c_8O_p +$$
$$c_9O_a + c_{10}A_aB_e + c_{11}B_aO_e + c_{12}A_pB_p + c_{13}B_pO_p + c_{14}A_aB_a + c_{15}A_eB_p +$$
$$c_{16}A_eB_a + c_{17}A_pB_e + c_{18}A_pO_a + c_{19}B_eO_p + c_{20}B_pO_e + c_{21}B_pO_a + c_{22}B_aO_e +$$
$$c_{23}B_aO_p + c_{24}A_eB_eO_e + c_{25}A_pB_pO_p + c_{26}A_aB_aO_a + c_{27}A_eB_pO_p + c_{28}A_pB_pO_a + e_e$$

There are nine equations (predicting each E, P, A rating for each A, B, O element). The equations predict how meanings shift as interaction evolves. The sum of the squared differences between fundamental sentiments of the ABO elements and transient impressions from the event operationalize "deflection," which corresponds to the perceived likelihood of an event (Heise and MacKinnon 1987). The greater the deflection, the more arousal actors experience and the more likely they are to redefine the actors, objects, behaviors, so meanings correspond to expectations. ACT includes a database of EPA ratings for thousands of ABO elements and modifiers, which are emotion labels for roles (e.g., "angry teacher"). Using the impression-formation equations and database, ACT predicts the redefinitions (including modifying emotion labels) that most reduce deflection. The redefinitions form the basis for expectations in subsequent interaction. The models and database are combined in software, Interact (Heise 2001). With Interact, researchers simulate events and generate testable predictions regarding sequences of events and (re)definitions. ACT has focused on human-human interaction. If objects have meaning that can be defined and categorized in three-dimensional EPA space, ACT may also be used to model HCI. Before presenting a pilot study demonstrating this application, I briefly address how ACT relates to existing models of emotion.

ACT & Existing Models of Emotion

Similar to current neurological and psychological theories, in ACT emotion facilitates rationality (e.g., Damasio 1994) and cognitions underlie emotion (e.g., Ortony et al. 1988). Like Lewis and Granic's (1999) emotional interpretation model, ACT emphasizes how social events are construed and posits a recursive relation between emotion and cognition, capturing the dynamic, iterative nature of events. And like Lewis and Granic, ACT posits an equilibrium principle involving minimization of discrepancies between meanings over iterations of events. Equilibrium tendencies drive (re)assignment of meaning to situational elements.

In contrast to psychological theories, ACT does not rely on a self-relevance principle positing that emotions are triggered (or intensified) by the self-relevance of others' actions, as for example, in Frijda (1993) or Stein and Trabasso (1992). (Yet, this may be a fruitful consideration for ACT.) Instead, ACT emphasizes that meanings are culturally shared and deviations from meanings generate

[1] This section draws on Troyer and Robinson (forthcoming).

[2] Since ACT only models human-human interaction, objects are humans; however here, I extend ACT to non-human interactions.

arousal that triggers re-appraisals. ACT is also unique in its reliance on mathematical formalization and a database of meanings (EPA ratings) for thousands of roles, emotions, and behaviors. Now, I turn to a pilot study demonstrating how ACT might be used to model HCI. As the study suggests, ACT does not require that computers feel or exhibit emotions, but only that they be able to reason about them (e.g., Ortony et al. 1988; Picard 1997).

Pilot Study

15 subjects provided independent EPA ratings for elements of human-computer interaction: "Computer," "Run Analysis," "Provide Output," "Freezes," "Runtime Error 00xbs." The mean EPA ratings are in Table 1. Column 5 shows the identity/behavior from Interact corresponding most closely to the EPA rating for items in Column 1.

Table 1. Mean EPA & Social Category for HCI Terms

ABO Element	E	P	A	Correspondent Social Concept
Computer	+0.87 (1.73)	+0.67 (1.97)	-0.45 (3.41)	Academic (0.84,0.76,-0.50)
Run Analysis	+0.77 (0.75)	+0.43 (0.28)	+0.17 (0.20)	Ask__About Something (0.73,0.48,0.18)
Provide Output	+1.97 (0.80)	+1.87 (0.87)	+0.42 (0.24)	Educate (2.07,1.95,0.24)
Freeze	-1.13 (0.77)	-1.0 (0.82)	-0.2 (0.35)	Beg (-1.17,-0.93,-0.36)
Runtime Error 00xbs	-1.63 (0.52)	-0.10 (0.54)	+1.87 (0.98)	Laughs At (-1.64,-0.56,1.72)

Note: Correspondent Social Concepts are from Interact (Heise 2001). Values in parens. for E, P, A are variances; for Correspondent Social Concept they are EPA values.

Next, I substituted the correspondent social concepts (Column 5) for HCI terms in Column 1 to simulate ABO events representing human-human interaction analogs of HCIs. The simulations explore how meanings shift when a computer initially behaves as expected, then produces unexpected behavior. Table 2 shows the results.

Table 2. Simulation of Events & Redefinitions

Events in Simulation 1	Deflection	Redef./Respons
I Ask Acad. About Something	2.0	---
Academic Educations Me	5.0	---
I Ask Acad. About Something	7.0	---
Academic Begs Me	12.0	Grouch/Scold
Events in Simulation 2		
I Ask Acad. About Something	2.0	---
Academic Educates Me	5.0	---
I Ask Acad. About Something	7.0	---
Academic Laughs At Me	14.0	Delinquent/Avoid

The simulations demonstrate how different events lead to different definitions of the actor eliciting the behavior (grouch/delinquent) and subsequent responses to that actor (scold/avoid). Also, ACT predicts the emotions of the object receiving the behavior -- the "I' in Table 2 (Sim 1: anger, Sim 2: embarrassment). ACT portrays interaction as a dynamic series of events, with emotion playing a key role in the evolution of meaning and behavior. If EPA meanings of HCI objects and behaviors are obtained, ACT's theoretical tools (EPA database, equations) may provide an architecture for systems, allowing them to intelligently reason about the emotions and meanings interactants experience. This, in turn, may lead to "*socially* intelligent" systems that optimize user experiences and outcomes.

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