Towards a Tractable Appraisal-Based Architecture for Situated Cognizers

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Abstract

This paper introduces TABASCO[1], an architecture for software agents aimed at integrating results from functional theories in emotion research and insights on the impact of the capacities and limitations of perception in a framework orientated along the situated "New AI"/ALife approach. This expository paper first briefly summarizes current views on the adaptive nature and function of emotion, discussing related current appraisal theories in more detail. A survey of research on agent architectures and emotion synthesis is followed by a first outline of the TABASCO architecture, relating it to the areas of research in psychology and ALife.

Introduction

After having long been dismissed as irrational and of no utility, the Emotional is being rehabilitated as the system that continuously monitors the relationship of the individual to its world and instigates tendencies to act. Emotions are seen as a key element for successful coping with nondeterministic, highly dynamic environments, providing a flexible and adaptive mechanism. At the same time, "New AI" aims at modelling adaptive behaviour in autonomous agents situated in complex, dynamic environments. It is therefore a reasonable goal to integrate a computational model of the emotion process within the architecture of a situated agent. This paper reports the first steps towards this end.

The Adaptive Nature and Function of Emotion

Emotion and Adaptation

Emotion can be viewed as a flexible adaptation mechanism that has evolved from more rigid adaptational systems such as reflexes and physiological drives (Lazarus 1991; Scherer 1984; Smith and Lazarus 1990). The flexibility of emotion is obtained by decoupling the behavioural reaction from the stimulus event. The heart of the emotion process thus is not a reflex-like stimulus-response pattern, but rather the *appraisal* of an event with respect to its adaptational significance for the individual, followed by the generation of an *action tendency* aimed at changing the relationship between the individual and the environment (Frijda 1986). Lazarus (1991) subsumes adaptive activitites under the term *coping.* In the following, appraisal, action tendencies, and coping are discussed in more detail.

Appraisal Theories of Emotion

Appraisal theories of emotion emphasize the role of *appraisal*, i.e., a hypothesized continuous evaluation of the environment according to dimensions regarding the individual. Appraisal is conceived of as constituting element in emotion generation, mediating between events and emotions, explaining why the same event can give rise to different emotions in different individuals, or even in one and the same individual at different times. Conversely, appraisal offers a framework for the identification of the conditions for the elicitation of different emotions, as well as for understanding what differentiates emotions from each other.

Many theories have been developed in order to specify how many and which appraisal criteria are minimally needed for emotion differentiation (e.g. Frijda 1986; Lazarus 1991; Ortony, Clore, and Collins 1988; Scherer 1984). There is a high degree of consensus with respect to these appraisal criteria (e.g. Scherer 1988). According to Reekum and Scherer (1997, pp.259-260), these include "the perception of a change in the environment that captures the subject's attention (novelty and expectancy), the perceived pleasantness or unpleasantness of the stimulus or event (valence), the importance of the stimulus or event to one's goals or concerns (relevance and goal conduciveness or motive consistency), the notion of who or what caused the event (agency or responsibility), the estimated ability to deal with the event and its consequences (perceived control, power or coping potential), and the evaluation of one's own actions in relation to moral standards or social norms (legitimacy), and one's self-ideal."

[1]The name TABASCO is derived from the project's name "A **T**ractable **A**ppraisal-**B**ased **A**rchitecture for **S**ituated **Co**gnizers."

Modelling the Appraisal Process

The main application of the appraisal theories cited above is the structural analysis of the semantics of emotion words. However, these structural theories do not specify the nature of the appraisal process. In response to Zajonc (1980), who criticized the "exaggerated cognitivism" of appraisal theories, several appraisal theorists pointed out that the appraisal process is not necessarily conscious or voluntary (Frijda 1993; Scherer 1984; Smith and Lazarus 1990).

Leventhal and Scherer (1987) attempt a more precise specification of the nature of the appraisal process. They suggest a hierarchical processing system consisting of three levels: *sensory-motor*, *schematic*, and *conceptual*. The sensory-motor level is based on innate hard-wired feature detectors giving rise to reflex-like reactions. The schematic level is based on schema matching. The conceptual level involves reasoning and inference processes that are abstract, active, and reflective.

Smith et al. (1996) suggest a model of the appraisal process that builds on the distinction between schematic and conceptual processing suggested by Leventhal and Scherer (1987). Schematic processing is fast, automatic, parallel, inflexible, and concrete. It can be thought of in terms of priming and spreading activation. In contrast, conceptual processing is slow, voluntary, serial, flexible, and relying on semantically accessible information. A novel feature of the model proposed by Smith et al. (1996) is the so-called appraisal register. It monitors appraisal information generated through schematic and conceptual processing, in addition to perceptual information, and generates an emotional reaction. The appraisal register is supposed to model the presumably important function of the amygdala in the elicitation of emotion (LeDoux 1996).

Reekum and Scherer (1997) provide a review of research in the areas of social cognition, clinical psychology, and neuropsychology that strengthens the evidence for a multi-level appraisal process.

Action Tendencies and Coping

For successful adaptation, emotion must have an effect on the actions of the individual. According to Frijda (1986), a "change in action readiness" is the essence of an emotion. Emotion does not lead to a fixed action, but to the generation of an *action tendency*. Action tendencies "are states of readiness to achieve or maintain a given kind of relationship with the environment. They can be conceived of as plans or programs to achieve such ends, which are put in a state of readiness" (Frijda 1986, p.75).

Lazarus (1991) stresses that especially in humans action tendencies do not automatically lead to action. He emphasizes the importance of *coping*, which "consists of cognitive and behavioral efforts to manage specific external or internal demands (and conflicts between them) that are appraised as taxing or exceeding the resources of the person" (Lazarus 1991, p.112). Action tendencies are innate biological impulses, while "coping is a much more complex, deliberate, and often planful psychological process" (*ibid.*, p.114), which can augment or inhibit the innate action tendencies. Thus, Lazarus argues that plans are involved in coping, not in the generation of action tendencies (in contrast to Frijda's definition of action tendencies cited above).

Agent Architectures and Emotion Synthesis

Agent Architectures

Wooldridge and Jennings (1995) as well as Jennings, Sycara, and Wooldridge (1998) provide a thorough review of existing agent architectures. Here only the distinction between *deliberative*, *reactive*, and *hybrid* architectures is briefly highlighted.

Wooldridge and Jennings (1995, p.24) define a *deliberative* agent architecture "to be one that contains an explicitly represented, symbolic model of the world, and in which decisions (for example about what actions to perform) are made via logical (or at least pseudo-logical) reasoning, based on pattern matching and symbolic manipulation."

The well-known problems of the symbol-processing approach, such as the symbol grounding problem and the frame problem, led to the emergence of "New AI" ("behaviour-based AI," "situated AI"). Brooks (1986) argues that intelligence is not a property of disembodied systems, but a result of the interaction of an embodied agent with its environment. Further, his subsumption architecture does not make use of symbolic representations or reasoning at all. It is a collection of task-accomplishing behaviours that are implemented as augmented finite state machines arranged in a hierarchy. The subsumption architecture is the prototypical example of a *reactive* agent architecture.

Despite the merits of reactive architectures, Jennings, Sycara, and Wooldridge (1998) enumerate a number of disadvantages. For example, the fact that overall behaviour emerges from the interaction of simple behaviours, implies that there is no principled methodology for engineering agents to fulfill specific tasks. As a result, so-called *hybrid* architectures have been developed that combine aspects of both deliberative and reactive architectures. Typically, a hybrid architecture consists of a number of hierarchically arranged layers. Very common is a hierarchy of three layers. Examples of hybrid three-layer architectures are 3T (Bonasso et al. 1997) and TouringMachines (Ferguson 1992).

Artificial Life: Situated Emotions

In a survey of earlier artificial intelligence research on models of emotion, Pfeifer (1988) found the majority of efforts to be fundamentally hampered by the attempt to isolate the object of study according to what has been termed "the traditional research methodology." Pfeifer's review has had a seminal effect insofar as it substantially contributed to setting off a whole avalanche of related work in the Artificial Life community. The basic tenet of the Animat/Artificial Life approach is to thoroughly explore the space of opportunities offered by the most simple designs by virtue of their situatedness and physical embodiment, before moving up towards the incorporation of more "complex" components, such as declarative representations and related manipulation capabilities. Pfeifer (1996) provides a succinct compilation of design principles.

Nowadays, it is commonly recognized that research on functional process models of emotion synthesis requires *whole agent designs* (Picard 1997; Sloman 1997).

A Typical Appraisal-Based Architecture

The Affective Reasoner (Elliott 1992) is a typical example of an existing appraisal-based architecture. It is an architecture for agents in a multi-agent world with the capability of abstract, domain-independent reasoning about emotion episodes. It includes representations of twenty-four emotion types, based on a structural appraisal theory specifying the cognitive structure of emotion eliciting conditions (Ortony, Clore, and Collins 1988).

Processing flows from some initiating event in a simulated world through emotion and action generation to the final stages simulating observation by other agents. Initiating situations are "construed" to fall into one of a number of eliciting condition classes. In this way, each successful construal instantiates an Emotion Eliciting Condition relation structure (EEC). As the Affective Reasoner covers only a finite set of discrete emotions, the mapping of EECs to emotions involves some ad-hoc solutions to cope with a number of problems caused by the fact that often this mapping would not be unique but may reference multiple, and at times conflicting emotions.

Instantiated emotions are mapped to actions by means of an emotion manifestation lexicon. For each of the twenty-four emotion classes, seventeen action response categories are defined. For deployment in a given domain, a few actual response actions (ranked by "intensity") are to be defined for each action response category. The lexicon thus comprises over a thousand individual actions to be defined for each application domain.

The Affective Reasoner also includes support for social emotions, by virtue of a "Concerns of Other" database.

Discussion

The following is a summary of some noteworthy points:

- There exist robust, widely adopted solutions to fundamental aspects of the realization of situated software agents in virtual environments, in terms of hybrid layered architectures, substantially facilitating the overall task of implementing such systems.
- Domain-independent architectures such as the Affective Reasoner run into serious problems when deployed in interactive virtual scenarios, as also openly recognized by Elliott (1994): To be effective in such applications, affective reasoning has to have appropriate access to pertinent information about and from the world, and has to be able to influence the overt external behaviour as well as the internal information processing of an agent. The only means to achieve this is to fully integrate emotional competence into an architecture that in turn has to be adapted to the environment in which the agent is situated.
- Shallow approaches with a reified representation of a finite number of discrete emotional states, such as the Affective Reasoner, demonstrate the problems of brittleness and consistency well known from the traditional research area of expert systems.
- Reification of emotions as identifiable system components and routing of all processing through these entities engenders the problem of how to proceed from these emotions for further system processing, leading to the adoption of ad-hoc constructions of dubious validity.
- Discretizing emotions all but rules out smooth and fine-grained system behaviour; it is precisely this kind of capability that is becoming of increasing importance, as the information infrastructure in general, and virtual environments in particular increasingly assume the characteristics of persistent social places, in which long-term relationships develop.
- Applications of functional emotion theory can provide an alternative approach for tackling at least some of the problems mentioned, in good part by virtue of seeing emotions as processes, as characteristics of a whole architecture, which pervasively influence the overall behaviour of the agent.

The TABASCO Architecture

Outline

TABASCO is an architecture for software agents situated in virtual environments that takes the above points into account. We model emotions not as reified entities, but as adaptive processes related to the agent-environment interaction. In particular, TABASCO models the appraisal process, the generation of action tendencies, and coping. The aim of this section is to provide a rough first outline of TABASCO. The architecture is shown in Figure 1.

The basic idea behind TABASCO is that the distinction between sensory-motor, schematic, and conceptual processing does not only apply to appraisal, but also to the generation of action, as proposed originally by Leventhal in his "perceptual-motor theory of emotion" (e.g. Leventhal 1984). So the two main components of the agent architecture, **Perception and Appraisal** as well as **Action**, are three-level hierarchies.

In the following, the components of TABASCO are described in more detail.

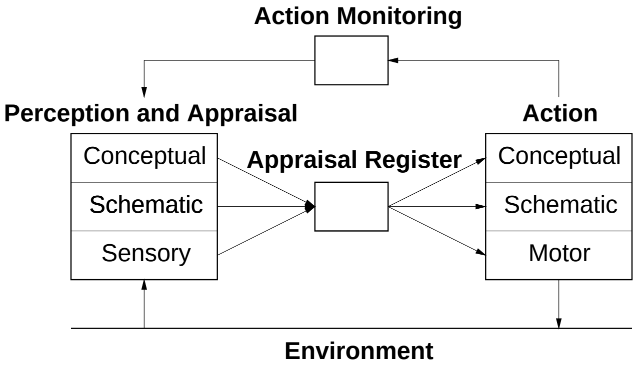

Figure 1: The TABASCO Architecture

- **Perception and Appraisal**
  This component processes environmental stimuli and models the appraisal process.

  Frijda (1993) argues that it is not necessary to model all appraisal checks explicitly. Rather, most of the appraisals "can be seen as implied by the very perceptual processes by which stimulus events are taken in" (Frijda 1993, p.380). For example, it is not necessary to model a "novelty check" explicitly. Instead, the appraisal of novelty is implied by the fact that the input does not match any existing knowledge structure.

  Research in the field of social cognition (e.g. Fiske and Taylor 1991) may help with modelling the evaluations made during appraisal. For example, findings on causal attribution are relevant for the appraisal of agency or responsibility. Another relevant research topic is the influence of social and self schemata on encoding, memory, and inference in social situations.

  The processes at each level can be summarized as follows:

  The sensory level consists of feature detectors for the detection of e.g. sudden, intense stimulation or the pleasantness of a stimulus.

  At the schematic level, the input is matched with schemata, especially with social and self schemata. Smith et al. (1996) propose the implementation of the schematic level as an associative network with a spreading activation mechanism.

  The conceptual level involves abstract reasoning and inference based on propositional knowledge and beliefs. Models of self and others will be placed at this level. Ferguson's (1992) use of Belief-Desire-Intention (BDI) models at the "Modelling Layer" of his hybrid TouringMachines architecture as well as Elliott's (1992) "Concerns of Other" database are relevant for the design of the conceptual level.

- **Action**
  We plan to design and implement this component by using an already existing hybrid agent architecture. A suitable candidate is the 3T architecture (Bonasso et al. 1997) consisting of the three layers *deliberation*, *sequencing*, and *reactive skills*.

  The 3T deliberation layer consists of a planner and corresponds to the conceptual level of the **Action** component. Following the characterization of coping as a planful process (Lazarus 1991), coping can be implemented at the conceptual level.

  The 3T sequencing layer based on the Reactive Action Packages (RAPs) system (Firby 1989) corresponds to schematic processing. Action tendencies may be implemented using the RAPs system. Although Frijda (1986) uses the term "plan" to characterize an action tendency, he also uses the term "flexible program" and states: "Flexible programs are those that are composed of alternative courses of action, that allow for variations in circumstances and for feedback from actions executed" (Frijda 1986, p.83). This notion of a flexible program is very close to the functionality of a RAP.

  The reactive skills of the 3T architecture correspond to sensory-motor processing. In Figure 1 the lowest level of the **Action** component actually contains only the motor commands of the reactive skills, while the sensory input is processed at the lowest level of the **Perception and Appraisal** component. One important class of motor mechanisms relevant for modelling the emotion process are "expressive" motor mechanisms, such as facial and body expressions. This expressive behaviour can be implemented at the motor level of the **Action** component.

- **Appraisal Register**
  This component mediates between the **Perception and Appraisal** and the **Action** components. The notion of an appraisal register is taken from Smith et al. (1996). It detects and combines the appraisal outcomes from the sensory, schematic, and conceptual levels of the **Perception and Action** component and influences the **Action** component based on the appraised state of the world. This influence can extend across all three levels: First, a motor program, such as a startle or orienting response, may be executed. Second, an action tendency may be generated by putting a RAP in a state of readiness. Third, a long-term planning process may be initiated in order to cope with the appraised event.

  It should be noted that it is not necessary to wait for the appraisal outcomes of all levels of processing in order to influence the **Action** component. A startle response occurs immediately after fast sensory processing, not after slow conceptual processing. It is therefore a matter of discussion, whether the appraisal register is actually necessary. It may be possible to design a three-level architecture in which at each level of processing appraisal and the influence on action are directly coupled. On the other hand, the appraisal register has the advantage of a better coordination between coping, action tendencies, and expressive behaviour.

- **Action Monitoring**
Frijda (1993, p.381) notes that a "major source of appraisals is the monitoring of action planning and action execution." For example, the exhaustion of the whole repertoire of plans and actions without success leads to the appraisal that no coping potential is available. Therefore, TABASCO contains an **Action Monitoring** component that monitors the planning and execution processes in the **Action** component and sends the results of the monitoring process to the **Perception and Appraisal** component, where it is integrated within the appraisal process.

Situated Cognizers

The view of emotion as a flexible adaptation mechanism is fully compatible with the concept of a situated agent. Agre (1995) argues that the interaction between an agent and its environment should guide the analysis of living agents and the design of artificial ones. In accordance with this view, Lazarus (1991, p.29) identifies the "person-environment relationship" as the "basic arena of analysis for the study of the emotion process." Appraisal is the evaluation of this relationship, while action tendencies and coping are aimed at changing it. Frijda (1986) also uses the term "relational action tendencies."

A guideline for modelling appraisal in a situated agent may be the concept of *affordances*. An affordance is defined by Gibson, the founder of "ecological psychology," as "what it offers the animal, what it provides or furnishes, either for good or ill"(Gibson 1979, p.127). The general idea is that a perceptually attuned animal actively perceives meaning in the environment without further interpretative cognitive processing. Both Frijda (1993) and Lazarus (1991) emphasize that appraisal may be based on the perception of affordances.

Baron (1988) applies the affordance concept to social perception and establishes a "dual-mode theory of social knowing." He treats the ecological view and the traditional cognitive view not as contradictory, but as complementary.

We apply this dual-mode view to the nature of appraisal: Although appraisal may be based on the direct perception of affordances, it nevertheless involves *cognizing*. According to Chomsky (1980), who introduced this term, cognizing means having access to knowledge that is not necessarily accessible to consciousness. A typical example of cognized knowledge is a speaker's knowledge of grammar. As described earlier, the appraisal process is not necessarily conscious or voluntary, but nevertheless based on knowledge, e.g. represented in form of schemata. So cognizing is a central part of the appraisal process.

We chose the term *situated cognizers* to emphasize the importance of both situatedness and cognizing for the view of emotion as a flexible adaptation mechanism adopted in this paper.

Tractability

An interesting and important aspect regards the *tractability* of the architecture for situated cognizers, particularly with respect to the design of flexible representation schemes that are perceptually tractable in the sense exposed by Horswill (1997). Horswill specifically addresses the problem of the maintenance of complex world models with limited resources, i.e., "the perception system's problem of knowing how and when to allocate its internal resources to updating different components of the world model" (Horswill 1997, p.290). While Horswill envisages solutions based on mixed reaction and deliberation, he does not hesitate to express reservations with respect to simple layering approaches. Instead, he states: "In practice, hybrid systems work well when they are given problems in which the deliberative components (1) are given little to do and (2) work only on problems, such as topological path planning, in which the relevant portions of the world model are updated slowly or not at all. ... I believe that the solution to perceptual and combinatoric problems lies not in adjoining traditional and reactive systems but in finding useful intermediate points in between" (*ibid.*, p.290).

Horswill cites instantiations of the 3T architecture among the examples of such "useful intermediate points." It is our intention to devise TABASCO as another derivative of this architecture: smart and programmable reactive systems (e.g. sensory-motor mechanisms) that are allowed to spawn off graph search algorithms or resource allocators (in our case e.g. action tendency generators or coping strategies) as primitive operations when necessary. This bottom-up design methodology is also in accordance with the Animat/Artificial Life approach advocated by Pfeifer.

Summary and Future Work

In this expository paper, we have sketched some of the background that we are drawing upon in the attempt to design TABASCO, a tractable appraisal-based architecture for situated cognizers. We have tried to cast some light on the relevance of each of the aspects identified in the project's name. In the best of the ALife tradition, we do expect the strong links we tied between (psychological) emotion research and work on situated autonomous agents to bring forward interesting insights and further research in both areas.

Clearly, a challenging part of the detailing of the encompassing abstract design will be the identification of a limited set of functionalities allowing to proceed to concrete implementations putting our architecture to the test: To this end, two different—if related—variants of the architecture are being worked on, necessarily hand in hand with respective virtual environments, one text-based and one graphical/3D.

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References

Agre, P.E. 1995. Computational Research on Interaction and Agency. *Artificial Intelligence* 72(1/2):1–52.

Baron, R.M. 1988. An Ecological Framework for Establishing a Dual-Mode Theory for Social Knowing. In Bar-Tal, D., and Kruglanski, A.W. eds., *The Social Psychology of Knowledge*, 48–82. Cambridge, UK: Cambridge University Press.

Bonasso, R.P.; Firby, R.J.; Gat, E.; Kortenkamp, D.; Miller, D.P.; and Slack, M. 1997. Experiences with an Architecture for Intelligent, Reactive Agents. In Hexmoor H. ed., Software Architectures for Hardware Agents, Special Issue, *Journal of Theoretical and Experimental Artificial Intelligence* 9(2/3):237–256.

Brooks, R.A. 1986. A Robust Layered Control System for a Mobile Robot. *IEEE Journal of Robotics and Automation* 2(1):14–23.

Chomsky, N. 1980. *Rules and Representations*. New York: Columbia University Press.

Elliott, C.D. 1992. The Affective Reasoner: A Process Model of Emotions in a Multi-Agent System. Ph.D. diss., Northwestern University.

Elliott, C.D. 1994. Research Problems in the Use of a Shallow Artificial Intelligence Model of Personality and Emotion. In *Proceedings of the Twelfth National Conference on Artificial Intelligence*, 9–15. Cambridge, MA: AAAI Press/MIT Press.

Ferguson, I.A. 1992. TouringMachines: An Architecture for Dynamic, Rational, Mobile Agents. Ph.D. diss., University of Cambridge, UK.

Firby, R.J. 1989. Adaptive Execution in Complex Dynamic Worlds. Ph.D. diss., Yale University.

Fiske, S.T., and Taylor, S.E. 1991. *Social Cognition* (2nd edition). New York: McGraw-Hill.

Frijda, N.H. 1986. *The Emotions*. Cambridge, UK: Cambridge University Press.

Frijda, N.H. 1993. The Place of Appraisal in Emotion. In Frijda, N.H. ed., Appraisal and Beyond: The Issue of Cognitive Determinants of Emotion, Special Issue, *Cognition and Emotion* 7(3/4):357–388.

Gibson, J.J. 1979. *The Ecological Approach to Visual Perception*. Boston: Houghton Mifflin.

Horswill, I. 1997. Visual Architecture and Cognitive Architecture. In Hexmoor, H. ed., Software Architectures for Hardware Agents, Special Issue, *Journal of Experimental and Theoretical Artificial Intelligence* 9(2/3):277–292.

Jennings, N.R.; Sycara, K.; and Wooldridge, M. 1998. A Roadmap of Agent Research and Development. *International Journal of Autonomous Agents and Multi-Agent Systems* 1(1):275–306.

Lazarus, R.S. 1991. *Emotion and Adaptation*. New York: Oxford University Press.

LeDoux, J.E. 1996. *The Emotional Brain*. New York: Simon & Schuster.

Leventhal, H. 1984. A Perceptual-Motor Theory of Emotion. *Advances in Experimental Social Psychology* 17:117–182.

Leventhal, H., and Scherer, K.R. 1987. The Relationship of Emotion to Cognition: A Functional Approach to a Semantic Controversy. *Cognition and Emotion* 1(1):3–28.

Ortony, A.; Clore, G.L.; and Collins, A. 1988. *The Cognitive Structure of Emotions*. Cambridge, UK: Cambridge University Press.

Pfeifer, R. 1988. Artificial Intelligence Models of Emotion. In Hamilton, V.; Bower, G.H.; and Frijda, N.H. eds., *Cognitive Perspectives on Emotion and Motivation*, 287–319. Dordrecht: Kluwer.

Pfeifer, R. 1996. Building "Fungus Eaters": Design Principles of Autonomous Agents. In *Proceedings of the Fourth International Conference of the Society for Adaptive Behavior*, 3–12. Cambridge, MA: MIT Press.

Picard, R.W. 1997. *Affective Computing*. Cambridge, MA: MIT Press.

Reekum, C.M. van, and Scherer, K.R. 1997. Levels of Processing in Emotion-Antecedent Appraisal. In Matthews, G. ed., *Cognitive Science Perspectives on Personality and Emotion*, 259–300. Amsterdam: Elsevier.

Scherer, K.R. 1984. On the Nature and Function of Emotion: A Component Process Approach. In Scherer, K.R., and Ekman, P. eds., *Approaches to Emotion*, 293–318. Hillsdale, NJ: Erlbaum.

Scherer, K.R. 1988. Criteria for Emotion-Antecedent Appraisal: A Review. In Hamilton, V.; Bower, G.H.; and Frijda, N.H. eds., *Cognitive Perspectives on Emotion and Motivation*, 89–126. Dordrecht: Kluwer.

Sloman, A. 1997. What Sort of Control System Is Able to Have a Personality? In Trappl, R., and Petta, P. eds., *Creating Personalities for Synthetic Actors*, 166–208. Heidelberg/New York: Springer.

Smith, C.A.; Griner, L.A.; Kirby, L.D.; and Scott, H.S. 1996. Toward a Process Model of Appraisal in Emotion. In Proceedings of the Ninth Conference of the International Society for Research on Emotions, 101–105. Toronto, Canada: International Society for Research on Emotions.

Smith, C.A., and Lazarus, R.S. 1990. Emotion and Adaptation. In Pervin, L.A. ed., *Handbook of Personality: Theory and Research*, 609–637. New York: Guilford.

Wooldridge, M., and Jennings, N.R. 1995. Intelligent Agents: Theory and Practice. *The Knowledge Engineering Review* 10(2):115–152.

Zajonc, R.B. 1980. Feeling and Thinking: Preferences Need No Inferences. *American Psychologist* 2:151–176.