A Robot Model of Dynamic Appraisal and Response[1]

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INTRODUCTION

A general goal of biologically inspired robotics is to learn lessons from actual biological systems and to find applications in robot design. Neural controllers and adaptive algorithms are major tools to model, at some level of abstraction, functions, structures, and behaviors present in biological systems. This involves, of course, identifying in virtue of what biological systems exhibit the behavioral characteristics we want to explore. One of the biological phenomena of great interest is *emotion*. Despite the effort of leading researchers to raise the question "whether machines can be intelligent without any emotions" (Minsky., 1988), AI interest in emotional phenomena has increased only in the last decade. An underlying assumption is that many cognitive functions, such as memory, attention, learning, decision making and planning, are at least partly based on emotional mechanisms in biological systems (Damasio, 1995).

One of the qualities of emotional behavior is its flexibility (Frijda, 1986), which contrasts with the rigidity of stereotyped behaviors such as reflexes or habits. Hence, it is relevant to investigate what it is that makes emotional behavior flexible. The body, through mostly chemical channels, produces diffuse effects on the neural system, processes at the root of emotional phenomena. Parisi has recently argued that in order "to understand the behavior of organisms more adequately we also need to reproduce in robots the inside of the body of organisms and to study the interactions of the robot's control system with what is inside the body"

(Parisi, 2004), using the term *internal robotics* to denote the study of the interactions between the (neural) control system and the rest of the body.

Mechanisms that control homeostasis, based on hormonal modulation, can motivate appropriate behaviors (Avila-García & Cañamero, 2004; Gadanho & Hallam, 2001). Emergent behaviors from the interaction of a motivational system with the environment may be called emotional. Cañamero's architecture, for example, consists of "a set of motivations; a repertoire of behaviors that can satisfy those internal needs or motivations as their execution carries a modification in the levels of specific variables; and a set of 'basic' emotions."(Cañamero, 2005).

We consider emotional phenomena to emerge from a dynamic interaction between internal states, current perceptions and environmental relations, such that certain neural/physiological states have a close causal link with relational situations. This is, in a nutshell, the *embodied appraisal* hypothesis (Carlos Herrera, 2002; Prinz, 2004). We use two major concepts from the dynamical systems (DS) approach to cognition (Clark, 1997; Kelso, 1995): *collective variables* and *control parameters*. In (Carlos Herrera, 2002) we argue that internal states can be interpreted as collective variables of agent/ environment interaction that allow tracing concern-relevant situations. These variables are "non-specific: they do not prescribe or contain a code for the emerging structure" (Kelso, 1995). They also can be considered control parameters, as activation in the agent's physiological substrate affects overall

action readiness (response, including perceptual and cognitive readiness).

BACKGROUND

An architecture for the design of emotional appraisal and response in artificial agents must take into account that emotions bear an intrinsic dynamic relationship between internal mechanisms, embodiment and situation (Frijda, 1993; Lazarus, 1991; Lewis, 2005). Emotions are emergent patterns that involve relational behavior as well physiological and psychological processes. In this section we argue that physiological states are essential for understanding emotion appraisal and response: they allow to trace agent-environment relations, and their modification is a mechanism for control of dynamics.

Appraisal is the process by which an agent is capable of recognizing that a situation is relevant to some of its concerns. From an information-processing perspective, an agent requires the capacity to differentiate situations which anticipate that a concern may be at stake if no proper response is carried out. Cognitive models consider appraisal the product of a reasoning engine (Zajonc, 1980), and robotic models often simplify this problem by manipulating the environment so that the concern-relevance of specific objects/stimuli is particularly salient (e.g. red color for dangerous objects).

Appraisal involves categorization, or hot cognition (Zajonc, 1980). The theory of embodied appraisal argues that the body plays an essential role in structuring sensory-motor patterns that, once processed by the brain, result in appraisal (Damasio, 2000). In the case of emotion certain physiological states are indicative of concern-relevant situations (Prinz, 2004). A high level of adrenaline, for instance, correlates with a wide class of emotional situations. The fact that the correlation is not one-to-one (physiological states are not sufficient to determine emotions) does not imply that they have no relationship to interactive relations. We understand embodied appraisal as dynamical coupling (attunement) in which some internal states are representative (collective variables) of agent/environmental interactions.

But emotion is not only about appraisal, but also response. Emotion theorists have proposed the notion of *action tendency* to explain the inherent relational purpose of emotional behavior: it establishes or modifies a relationship between the agent and the world "at large" (Frijda, 1986). That means, "[a]ction tendencies are hypothesized … for theoretical reasons: to account for latent readiness and to account for behavior flexibility" (Frijda, 1986). Tendencies imply a direction, although they are "not usually guided by a prior goal representation" (Frijda, 1986). It is also important to distinguish between action tendency and the function of emotional behavior. For example, the tendency in fear is withdrawal. The function, on the other hand, is protection. Similarly, the tendency in shock or surprise is interruption of ongoing activity, whilst the function is reorientation (Frijda, 1986). Withdrawal can come as, for example, freeze, flight, or faint; responses with very different functional roles. Hence, emotions are far from reflex-like responses. Even though emotion responses are often stereotyped and the product of evolution, we "should not conceive affect programs as fixed and peremptory" (Lazarus, 1991), i.e. "[t]o the extent that action programs are fixed and rigid, action tendency loses much of its meaning" (Frijda, 1986). On the contrary, emotional responses are dynamically situated, that is, outward behavior is configured in dynamic interaction with the environment.

For modeling the mechanisms underlying action tendencies in biological agents, it should be noted how different physiological subsystems are dynamically interrelated. In particular, certain hormones (e.g. adrenaline), can affect, on the one hand, the autonomic system, whose activation involves a process of energy mobilization, and thus action readiness (Frijda, 1986). Hormones also act as neuromodulators, affecting the general processing of the nervous system, thus producing forms of cognitive or attention readiness.

MAIN FOCUS OF THE CHAPTER

This article presents a robotic approach for the emergence of a coupled agent-environment interaction with the ability to: (a) to appraise the concern-relevance of the situation, and (b) to control through activation of action readiness. The specific mechanisms that allow the emergence of such phenomena are based on sensitivity to overall patterns of interaction through the production of hormonal regulation.

The model illustrated in Figure 1 (Carlos. Herrera, 2006) is intended to illustrate the relationships between nervous system, body and world. The basic feature is that a number of internal variables in the body (such as

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