

Endowing emotional agents with coping strategies: from emotions to emotional behaviour

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Key words: emotions, coping strategies, “intelligent” agent models, BDI logics.

Introduction. Emotion takes an increasingly important place in the design of intelligent virtual agents. Designers of emotional agents build on theories from cognitive psychology, that describe the cognitive functioning of emotions with two indivisible processes [1, 2]: the *appraisal* process triggers emotions, in particular intense negative emotions to point out threatening stimuli, and the *coping* process modifies the behaviour to manage these stimuli. Nevertheless, among the existing emotional agents, a lot express emotions triggered by an appraisal process [3] but few have a coping process allowing their emotions to impact their behaviour [4–6]. In previous work [7] we provided a formalization of Ortony *et al.*'s appraisal process [8] in a BDI logic, *viz.* a logic of mental attitudes. The next step is to formalize the coping process in the same framework. Our aim here is to provide the theoretical basis of an agent architecture rather than an implementation. We only give here an overview of our framework (*cf.* [9, 10] for more details).

Applications for virtual agents endowed with coping strategies. A model of coping offers interesting application prospects. First, it could make embodied conversational agents once more realistic and believable by allowing them to expose coping behaviours that are considered irrational by standard models of dialogue. Second, an agent who knows some coping strategies could help the user to cope with his own emotions, either during his interaction with the system (intelligent interfaces, pedagogical agents) or during his everyday life (design of Ambient Intelligence Systems [11]). Third, the use of context-dependent coping strategies could increase the believability and unpredictability of human-like characters for virtual worlds or video games, and thus improve the user's immersion and pleasure in the virtual world.

Existing work. Meyer [4] describes the triggering of emotions following [12] and represents their influence on behaviour through unconscious action tendencies (in the sense of [13], for example anger induces aggression), that differ from the conscious coping efforts that we want to formalize here. Gratch and Marsella [5] implement some coping strategies from the COPE model [14] in the EMA agent. This agent's behaviour is very believable, but its mental state is represented by a complex structure inspired from planning, while we propose to use BDI logics, a more generic formalism. Elliott's Affective Reasoner [6] computes the agent's emotions according to the OCC typology [8] and matches them with an action from a database mixing coping strategies with other types of reactions. This is a functional agent architecture, but what we want to provide here is a generic formal model that could be a basis for such implementations.

Psychological basis. We refer to Lazarus and Folkman's definition of coping [2] as "constantly changing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person". We then build on the COPE model [14], a set of fifteen *coping* strategies, *viz.* particular kinds of reaction against a negative emotion (for example denying the reality of a situation that makes us sad, or planning actions against a situation that makes us angry).

Our formalism. We consider coping strategies as actions, and express their conditions and effects in terms of the agent's mental attitudes. We then propose a process leading the agent to the choice and application of a particular strategy in a given situation, depending on his personality. Our logic allows us to prove some indirect effects of the use of coping strategies on the agent's subsequent behaviour. We illustrate the functioning of our framework on an example from a virtual world for the training of firemen.

Conclusion. For now, our BDI framework does not manage the intensity of emotions; as a consequence we assume that the execution of a coping strategy simply makes the emotion disappear, instead of making its intensity decrease. But we believe that BDI logics also offer interesting properties: first they have a great explanatory power of the agent's behaviour and allow to reason about it; second they are one of the most widely used tools for describing agents architectures [15].

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