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Should successful agents have Emotions? The role of emotions in problem solving

Dietrich Dörner (dietrich.doerner@ppp.uni-bamberg.de)
Ulrike Starker (ulrike.starker@ppp.uni-bamberg.de)
Otto-Friedrich-Universität Bamberg
Markusplatz 3
96047 Bamberg
Germany

Emotion and Cognition

In this article we examine whether emotions are helpful or even necessary for problem solving or not. We investigate the behaviour of a Psi-model with and without emotions. Psi is a theory of human "action regulation", a theory about how cognition, motivation and emotion are integrated in controlling human behaviour in complex and dynamic domains of reality (see Dörner et al. 2002). The Psi-theory is partially implemented as a computer program. In Psi cognition, motivation and emotion are conceptualized as information processes, generally as "calculation". How is it possible to generate "irrational" emotional processes as "rational" processes of "calculation"?

According to concepts of Belavkin & Ritter (2003) what is called "emotion" in our eyes is a controlling system which takes into account two relations of an organism to reality, namely the **uncertainty** (unpredictability) of the environment and the (estimated) degree of efficiency of an organism to tackle problems (**competence**). – When uncertainty is high an organism should be prepared for action, especially for flight or aggresssion, should exhibit a tendency to explore its environment, should exhibit a high degree of safeguarding behaviour. When competence is low an organism should try to avoid contact with too difficult problems, should try to enlarge its competence by looking for "efficiency" signals by trying to master problems which hitherto it has not been able to master. Emotions are based on such modes of being prepared for different forms of actions; additionally however internal parameters of cognitive processes are modified according to the degree of competence and certainty. One of these parameter is **arousal** (= general preparedness for action), another one is the **resolution level** of cognitive processes. A low resolution level means rough planning, superficial ("overinclusive") perception and shallow, conservative processes of recall.

A sudden decrease of competence for instance would mean a sudden increase of arousal, decrease of resolution level (to guarantee quick action), incomplete recall of possible modes of action for the situation at hand and rough planning of actions, hence swift and risky (undeliberated) action. This mode of action could be described as “anger”.

Prediction of human behaviour

In a series of experiments we examined the relation of the Psi-model to human behaviour. We used different forms of a complex, dynamic, maze like environment (the "island" Detje, 1998; Gerdes 2001) where human subjects had to play a kind of adventure game. They had to take care of the "survival" of a robot, which needed water and fuel (for instance in the form of sunflower seeds or hazelnuts) for its internal steam engine. The subjects had to explore the geographical form of the island, had to plan actions to find water and fuel, to preserve the robot from damage and they had to find as many "nuggets" as possible. The Psi version of an experimental subject was the same robot without the control of a human subject, but with the Psi-theory implementation serving as the robots "soul".

In several experiments it was possible to predict human behaviour to a satisfactory degree.

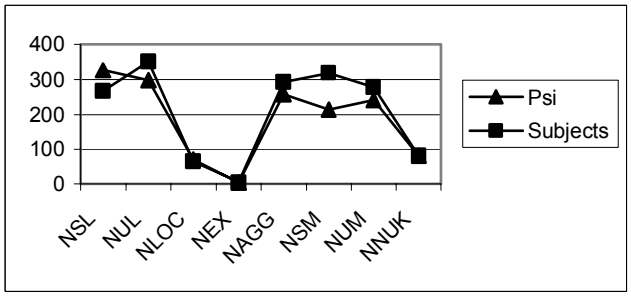

Figure 1: Behavior on the “Island”.

In figure 1 the results of an experiment of ElKady & Starker are shown. The averaged profiles of 20 different human subjects can be seen, compared with the averaged profiles of 20 different Psis. The profiles concern 8 different parameters of the behaviour for a 2-hour time period for the human subjects and an equivalent time period for the Psis. The names of the parameters mean:
NSL: number of successful locomotions on the island,
NuL: number of unsuccessful trials to move,
Nloc: number of places visited on the island (exploration activity),
Nex: number of breakdowns of the robot because of missing "food" or water or too much damage,
NAgg: approaches to an object (hazelnutbush, rock, etc.),

NsM: number of objects successfully manipulated,
NuM: number of unsuccessfull trials to manipulate an object,
NNuk: number of nuggets found.

In this experiment we used Psis with different "personalities". The personality of a Psi-subject is the profile of parameters of the emotional regulations; such parameters are for instance the gradient of the increase of arousal (in the case of an increase of a need) or the gradient of the decrease of competence when inefficiency is noticed.

It is obvious from figure 1 that human behaviour and the "theoretical" Psi-behaviour are in good accordance; similar to earlier experiments (Dörner et al. 2002) the canonical correlation between the Psi-Simulations and the human subjects is r=.88 and is highly significant.

Psi with and without emotions

To examine the role of emotions we compared the 20 Psi-subjects with different "personalities" of the above mentioned experiment with the same Psi-subjects for which we fixed the parameters for "arousal" and "resolution level" on a medium level. (The same manipulation was used by Hille 1997 with a forerunner of the actual Psi-system. Hille found out that generally "emotional" systems were more successful than unemotional ones.) Table 1 shows the results of the T-Tests for the two groups of artificial subjects.

Table 1: T-test comparing psis with and without emotions.

T-Test	T	Df
NsL	2,92**	38
NuL	1,34	38
Nloc	-3,05**	20,25
Nex	-7,96**	36,21
Nagg	1,76	38
NsM	20,33**	20,20
NuM	-2,71**	38
NNuk	14,62**	19,20

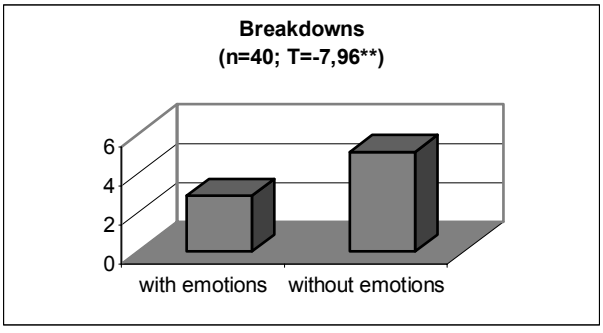

Figure 2: Mean number of breakdowns.

It is obvious that there are highly significant differences with respect to many of the behavioural parameters of the two groups. The emotional Psis especially were much more successfull in collecting nuggets and in preserving themselves from damage (see figure 2 and 3).

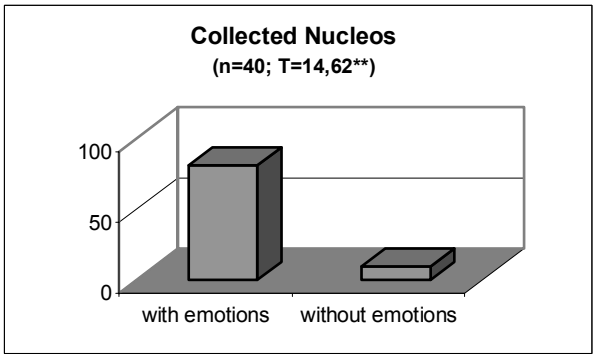

Figure 3: Mean number of collected nucleos.

Discussion

Obviously the emotional modulations of parameters like preparedness for flight or aggression, the modulation of arousal and resolutionlevel increase the strategic flexibility by adapting the behaviour to the respective state of uncertainty and competence. An "emotional" system is more able to adjust its behaviour to the requirements of the situation at hand with respect to uncertainty and competence.

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References

Belavkin, R.V., & Ritter, F.E. (2002). The Use of Entropy for Analysis and Control of Cognitive Models. *Proceedings of the Fifth International Conference on Cognitive Modeling* (pp. 75-80). Bamberg: Universitäts-Verlag.

Detje, F. (1998). Das Inselspiel (The Island Game). Computerprogram. Bamberg. Institut für Theoretische Psychologie.

Dörner, D. (2003). The Mathematics of Emotions. *Proceedings of the Fifth International Conference on Cognitive Modeling* (pp. 75-80). Bamberg: Universitäts-Verlag.

Dörner, D., Bartl, Ch., Detje, F. Gerdes, J., Halcour, D., & Schaub, H. (2002). Die Mechanik des Seelenwagens. Bern: Huber.

ElKady, A., & Starker, U. (in preparation). Personality and Problem Solving. A Simulation Study.

Gerdes, J., Dörner, D. (2003). Psi2D Reality-Simulation System. Computerprogram. Bamberg. Institut für Theoretische Psychologie.

Hille, K. (1988). Die „künstliche Seele". (The Artificial Soul) Doctoral Dissertation, Otto-Friedrich-Universität Bamberg.