

# Functional Modeling of Personality Properties Based on Motivational Traits

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## Motivation in the Cognitive Architecture MicroPsi

The cognitive modeling of personality traits—as exemplified by the well-known Five Factor Model (Digman, 1990; Goldberg, 1993)—requires the identification and suitable functional abstraction of underlying mechanisms within a cognitive architecture. We propose that these mechanisms are predominantly *motivational*, and are using the cognitive architecture *MicroPsi* (Bach 2003, 2009) for analysis and modeling.

MicroPsi’s motivational system can be characterized by a (pre-defined) set of demands of the agent, which are represented as urge signals. Changes in these signals determine valences: a change of a demand towards its target value creates a positive reinforcement (pleasure signal), while a negative change away from the target results in a negative reinforcement (displeasure signal). These signals can be used to create associations between the urges and situations that satisfy them (goals) or frustrate them (aversive situations). In accordance with the Psi theory (Dörner 1999), MicroPsi uses three groups of demands: physiological, social and cognitive.

The *physiological demands* (food, water, physical integrity/pain avoidance etc.) become active whenever the autonomous regulation of physiological parameters fails and provide for the basic survival. Here, survival itself is seen as an abstract concept and not a demand itself.

*Social demands* consist in a need for affiliation with others, and are mediated by social signals (‘legitimacy signals’), such as displays of affection, acceptance, rejection or reproach. The affiliation mechanism allows to structure social interaction beyond rational utility: purely social rewards are often sufficient to motivate an agent for cooperative behavior, without incurring the need to supply a material gratification and thereby affect the fitness of the group, or to discourage anti-social behavior without decreasing the agent’s material fitness by doling out punishment. A second social demand is called ‘internal legitimacy’: it corresponds to internal social signals that are related to the conformance to internalized social norms (‘honor’). Obviously, the list of social demands addressed in MicroPsi is incomplete; for instance, it lacks sexual needs (libido).

The group of cognitive demands spans needs for competence, a need for uncertainty reduction, and needs for aesthetics.

*Competence* is either epistemic (related to skills): it provides an estimate on the agent’s ability to cope with any specific task, by delivering a reward on its successful completion, and a penalty on failures. Thus, skill-acquisition can become a goal on its own. Furthermore, competence may be general, i.e. related to the overall ability of the agent to cope with the environment. General competence delivers a heuristics on the amount of risk an agent should take, and is measured as a floating average over successes and failures of the agent’s past actions.

*Uncertainty* reduction is aimed at discovering the outcomes of actions, and exploring the structure of objects and situations. Uncertainty reduction is satisfied by ‘certainty events’: the complete identification of an object, scene or frame, by fulfilled expectations (even negative ones), and by a long and non-branching expectation horizon. Conversely, uncertainty reduction is frustrated whenever the agent encounters unknown objects or events, discovers elements without a known connection to behavior, etc.

Uncertainty signals are weighted with the motivational relevance of their object. Generally, a high uncertainty will give rise to explorative behaviors, unless the agent has a low epistemic competence for exploration.

*Aesthetics* is a demand that directs the agent at seeking order, i.e. better representations (abstract aesthetics), or seeking out particular stimuli, based on evolutionary preferences, such as certain body schemas or landscapes (stimulus oriented aesthetics).

Each demand is characterized by several parameters:

- The *target value*  $v_d$  of the demand  $d$
- The *deviation*  $|v_d - c_d|$  from that value, represented by an urge indicator  $urge_d$ ,
- The *weight* of the demand (its relative importance, compared to other demands with the same urgency)  $w_d$ ,
- The *gain* (the satisfaction derived from a positive stimulus or consumption)  $g_d$ ,
- The *loss* (the penalty incurred from a negative stimulus or a frustration)  $l_d$ ,
- The *decay* (the autonomous increase of the deviation from the target value over time)  $f_d$ .

Even if no gain or loss is incurred, the decay ensures that the motivational parameters change relentlessly, and the agent is requiring to constantly replenish the demands. (For a detailed description, see Bach 2011).

## Application for Modeling Personality Traits

The motivational traits of agents can be defined as a set of physiological, social and cognitive demands  $D$ , each of

them annotated by a tuple  $(w_d, g_d, l_d, f_d)$ , describing the weight, gain, loss and decay of the respective demand. Using these parameters, it is possible to create agent models that conform to the Five Factor Model (FFM, or “Big Five”) established in personality psychology. The FFM suggests five dimensions of personality traits, which together can be used to characterize emotional/motivational dispositions of an individual:

- *Openness*: This describes the interest a subject takes in new situations, ideas and stimuli. Openness is associated with intellectual curiosity, appreciation of art, and non-conservatism
- *Conscientiousness*: This characterizes how organized/rigid a subject tends to be. Conscientious individuals tend to spend more time planning, attend carefully to details and attempt to follow plans and rules rigorously.
- *Extraversion*: This relates to the interest individuals take in interpersonal interaction, their surgency and expressiveness.
- *Agreeableness*: Individuals that are highly agreeable tend to avoid conflicts, are friendly and seek positive social interaction.
- *Neuroticism*: This amounts to emotional instability. Subjects with a high degree of neuroticism tend to experience negative emotions more strongly, are prone to anxiety and mood switches.

Modeling configurations of personality traits by choosing appropriate settings for the tuples  $(w_d, g_d, l_d, f_d)$  is straightforward. Since all of them are related to social and cognitive pre-dispositions, it is sufficient to look at the demands for *affiliation*, *competence*, *certainty* (= uncertainty reduction) and *aesthetics*.

For instance, a high degree of neuroticism can be expressed by choosing particularly high values for the loss and decay of *competence* and *certainty* (and possibly the other demands, too). In other words, the agent needs to replenish its competence and certainty very often, and it will react disproportionately to failures of doing so, and to frustrations of these demands. The continuous decay of *certainty* makes the agent prone to episodes of anxiety.

Conversely, an agent with the opposite settings, i.e., very low decays and losses on *competence* and *certainty* will not take a big hit on failure, and won’t need to seek out new competence and certainty rewards as often. Thus, it will display a greater degree of emotional stability and complacency (= low neuroticism).

A highly *open* agent can be modeled by a high decay on *competence* and *certainty*, too, so the agent is forced to seek out competence and exploration rewards. On the other hand, it should receive a high gain on satisfying its cognitive (and possibly social) demands. Thus, it will receive positive frequent and strong positive reinforcements of its explorative and competence building behaviors, resulting in a high tendency to seek out new situations and stimuli.

Our model determines *conscientiousness* with a strong loss factor of *competence* and *certainty*, combined with a

weak gain of *competence/certainty*. This means that the reward for exploration and skill acquisition is low, compared from the loss incurred by risking them. A high decay on *competence*, but low decay on the other drives can additionally result in a low interest in seeking out new social, aesthetic or exploratory challenges, while focusing on a high accuracy in the execution of plans and skills.

*Extraversion* is produced by a high decay of the *affiliation* demand, which therefore requires constant social interaction to be replenished. Strong gains on *affiliation* and *competence*, as opposed to weak losses on these drives result in a strong reinforcements due to social and competence successes, but only little aversion due to failures.

*Agreeable* agents are somewhat similar to extroverts due to a high decay on *affiliation* (and possibly *competence*), so they need to seek out social situations often. Unlike extroverts, they receive strong *affiliation* losses due to negative social signals, and gain little *competence*. Thus, they are likely to avoid arguments: they have little positive rewards to gain from them, but incur strong negative reinforcements if they do not succeed socially.

Currently, our model is restricted to simple multi-agent simulations. At the moment, we are using our model to design a series of problem solving scenarios that correlate personality properties with the performance of subjects (Greiff & Funke, 2009). As a result, we hope to provide a direct application of the model for psychometric purposes. Furthermore, well-defined problem solving scenarios present an opportunity to compare the performance of human subjects directly with that of computational agents and will thereby allow us to improve the motivational and emotional framework of our cognitive model.

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