

# Effects of Cognitive Complexity in Agent Simulation: Basics

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**ABSTRACT:** Software agents with personality can represent human personality traits and personality facets. Agents with dynamic personality can update the values of their personality traits based on changes in their personality facets. In this article, the importance and role of cognitive complexity in decision making in problem solving is stressed and the fact that as a personality trait, openness is related with cognitive complexity is pointed out. Hence, dynamic updates of openness corresponding to the changes in its facets can be used to update the values of cognitive complexity which in turn can affect the decision making abilities of the agents used in simulation.

**KEYWORDS:** dynamic personality, personality update, cognitive complexity, fuzzy agent

## 1. INTRODUCTION

*Agents with personality* are software agents which can represent human personality traits. They can represent human personality at coarse grain or fine grain levels. *At coarse grain level*, they can represent some or all relevant characteristics such as openness, conscientiousness, extraversion, agreeableness, and negative emotions in line with the five-factor personality theories to model human behavior. *At fine grain level*, the facets of each personality trait are also represented. Several studies exist on agents with personality. For example, Rizzo et al. [1997] describe work aimed at realizing

believable agents that perform helping behaviors influenced by their own personalities. Schmidt [2002] presents the framework of the PECS (Physic, Emotion, Cognition, and Social Status) architecture where a system-theoretical methodology is used for specifying agents' personality traits. Allbeck and Badler [2002] present work toward representing agent behaviors modified by personality and emotion. To this end, they describe a parameterized action representation (PAR) for building future behaviors into autonomous agents and controlling the animation parameters that portray personality, mood, and affect in embodied agents. Egges et al. [2003] describe a generic model for personality, mood and emotion simulation for conversational virtual humans. Rousseau and Hayes-Roth [1997] report work on actors with flexible personalities.

At fine grain level, a realistic refinement is *dynamic personality* to take into account the variability of personality traits based on the changes in corresponding personality facets. When at least any one of the 30 facets changes its value, the personality is affected and *personality update* can take place, i.e., the personality should be re-evaluated with the implications of the corresponding personality. Personality update corresponds to a discontinuity and model update. For a generalized view and implications of discontinuity and model update see Ören [1991]. Series of personality updates would also allow realization of evolutionary models of personality.

A systematic presentation of human personality knowledge, including dynamic personality processable in fuzzy logic for human behavior simulation is given in [Ören and Ghasem-Aghae, 2003; and Ghasem-Aghae and Ören, 2003]. *Fuzzy agents* are agents that can perform qualitative uncertainty reasoning with *incomplete and fuzzy knowledge* in some environment that contains linguistic variables. (*Fuzzy agents with dynamic personality* are (fuzzy) agents with personality where personality knowledge is updateable. The effect of cognitive complexity in decision making within complex situations has been known since a long time [Athey 1976; Ören 1978] and the relationship of cognitive complexity and one of the personality traits, i.e., openness is also well accepted [McCrae, 2000]. These facts lead to tying cognitive complexity with personality update in fuzzy agents with dynamic personality.

## 2. PERSONALITY KNOWLEDGE AND DYNAMIC PERSONALITY

The term personality refers to the sets of predictable behaviors by which people are recognized and identified. These sets of behaviors go by the name of personality traits or factors. A contemporary view of traits considers in five dimensions, i.e., five-factor model of personality or the big five personality traits: (*Openness, Conscientiousness, Extraversion, Agreeableness, and Negative emotions*) and each has six *facets* [Costa and McCrae 1992; Howard, 2000, p. 433; Acton 2001; Howard and Howard, 2001a, b; Ören and Ghasem-Aghae, 2003]. Cognitive complexity is related with openness [McCrae, 2000]. Table 1 is reproduced from Ören and Ghasem-Aghae [2003] to summarize the personality descriptors and corresponding personality types and characteristics related with openness.

Table 1. Personality descriptors based on the levels [or values] of the six facets of **openness** and corresponding personality types and characteristics

Facets of <b>openness</b>	Levels		
	low	medium	high
Fantasy	focuses on here and now	occasionally imaginative	imaginative, daydreams
Aesthetics	uninterested in art	moderate interest in art	appreciates art and beauty
Feelings	ignores and discounts feelings	accepts feelings	values all emotions
Actions	prefers the familiar	a mixture of preference of the familiar and the new	prefers variety, tries new things
Ideas	narrower intellectual focus	moderate curiosity	broad intellectual curiosity
Values	dogmatic, conservative	moderate	open to new values open to reexamining values
Personality type	<b>Preserver</b>	<b>Moderate</b>	<b>Explorer</b>
Personality characteristics	- has narrower interests - is more comfortable with the familiar - is perceived as more -- conventional -- conservative - is not perceived as -- more authoritarian	- can explore the novel with interest when necessary [but too much would be tiresome] - can focus on the familiar for extended periods of time [but would develop a hunger for novelty]	- has broader interests - has a fascination with novelty and innovation - would generally be perceived as liberal - reports more introspection and reflection
Social roles	applied scientists financial managers performers project managers		architects, artists, change agents; entrepreneurs, theoretical scientists [social and physical]

### 3. COGNITIVE COMPLEXITY

In most decision making processes, ability of coping with complexity is a fundamental issue and influences the quality of the decisions. Based on Athey's work [Athey 1976], Ören [1978] elaborated on the importance of increasing cognitive complexity of an individual to increase his/her effectiveness in coping with complex situations. Figure 1 shows different levels of information processing of an individual depending on the situational complexity. For a low situational complexity, the individual may need to have low level of information processing to cope with the situation. If the situational complexity increases, his/her information processing level may also increase. However, for each individual there is a critical point beyond which the level of processed information, hence the individual's information processing effectiveness is decreased. After the critical point, an increase in the situational complexity may worsen the individual's ability to cope with complexity, by causing a decrease in his/her level of information processing.

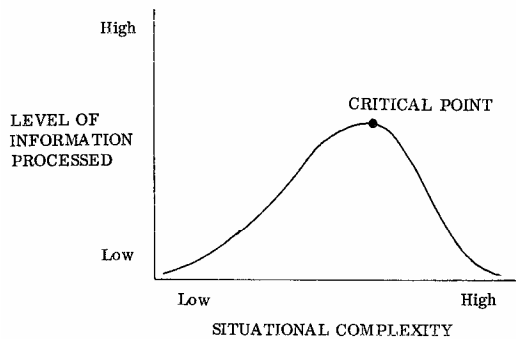


Figure 1. Relationship between situational and behavioral complexities

The information processing curves of two types of individuals, i.e., high and low cognitive complexity individuals are compared in Figure 2 where two important points are shown: First,  $c_h$ , the critical point of high cognitive complexity individual is

higher than  $c_l$ , critical point of low cognitive complexity individual. Thus increasing the cognitive complexity of an individual – within the applicable limits of course– may increase the range of situational complexity within which he/she can perform effectively. Or depending on the task, it may be advisable to assign an individual with cognitive complexity commensurate with the task. Second, for a given situational complexity, the level of information processed by a high cognitive complexity individual  $i_h$  is greater than  $i_l$  which corresponds to a low cognitive complexity individual.

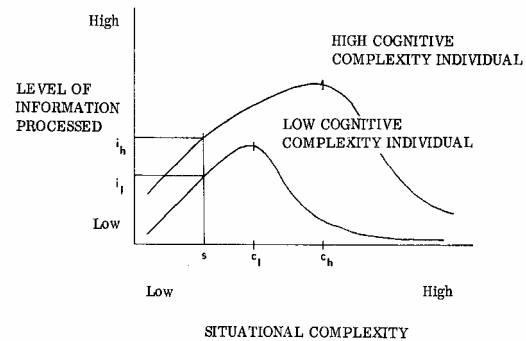


Figure 2. Comparison of the information processing curves of two types of individuals

Additional characteristics of high and low cognitive complexity individuals (with relevance to managers) are summarized in Table 2, based on Streufert and Swezey, [1986]. As stated by Streufert and Swezey, [1986], “persons who are high in cognitive complexity are able to analyze (i.e., differentiate) a situation into many constituent elements, and then explore connections and potential relationships among the elements. ... Complexity theory assumes that the more an event can be differentiated and the parts considered in novel relationships, the more refined the response and successful the solution. ... high complexity people are very flexible in creating new distinctions in new situations.”

Table 2. Characteristics of high and low cognitive complexity individuals  
(with relevance to managers)

	<b>High cognitive complexity people</b>	<b>Low cognitive complexity people</b>
<b>Information</b>	More open to new information, search across more categories of information, and rely on their integrative efforts	opposite
<b>Attraction</b>	Attracted to high cognitive complexity people as well as to low cognitive complexity people	Attracted to low cognitive complexity people with similar attitude
<b>Flexibility</b>	More flexible in thinking; more fluency of ideas in creativity	opposite
<b>Social influence</b>	Change attitude more easily.	More stable in attitudes; more prone to polarize on an issue; less affected by environmental changes. Attitude change can be easier if information is made highly salient.
<b>Problem solving</b>	Tend to search for more information; often less certain after a decision, especially if verification is unavailable.	opposite
<b>Strategic planning</b>	Better strategic planners due to: - consideration of more information, from more perspectives, - greater flexibility in considering alternatives.	opposite
<b>Communication</b>	More effective at a communication-dependent task. More resistant to persuasive attacks, especially if trained in counter arguments.	opposite
<b>Creativity</b>	Able to generate more novel, unusual, and potentially remote views and actions.	opposite
<b>Leadership</b>	Show leadership; High integrators in which they are able to relate complex patterns of many elements.	opposite

In Chapter 12 of the handbook of emotional intelligence, it is indicated that “openness has also been associated with other cognitive or quasi-cognitive variables, including moral reasoning, cognitive complexity and wisdom” [McCrae, 2000]. The relationship of cognitive complexity and openness as a personality trait inspires applicability of personality update concept of dynamic personality to cognitive complexity. The personality facets which affect openness are: fantasy, aesthetics, feelings, ideas, and values. The dominant facet, i.e., the one having the largest weighted value determines

openness. Any value change in any of the personality facets affecting openness may induce a personality update and change in the value of openness to affect the cognitive complexity of the individual.

#### 4. CONCLUSIONS

Model update is a promising modeling methodology [Yilmaz and Ören, 2004]. Dynamic personality is yet another aspect of model update and would allow, as clarified in another article [Ören and Ghasem-Aghaee, 2003], reflections of the changes of

personality facets in the corresponding personality traits with relevant implication on the behavior of agents. In another article, representation of dynamic personality in fuzzy agents was presented (Ghasem-Aghae and Ören, 2003). In this article, we pointed out to the fact that openness, as a personality trait, is related with cognitive complexity and hence updates on openness may have implications on cognitive complexity and to the decision making ability of the agents in problem solving.

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