Effects of Cognitive Complexity in Agent Simulation: Basics

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Gist of the message: 1/2

1. Role of cognitive complexity of individuals in problem solving (coping with complexity)
2. Personality traits & software agents with personality
   2.1 Agents with personality can represent human personality traits and personality facets.
   2.2 Agents with dynamic personality can update the values of their personality traits based on changes in their personality facets
3. As a personality trait, openness is related with cognitive complexity.

4. 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.

5. In realistic representation (modeling) of humans by agents, this point of view may be useful.
Cognitive complexity

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.

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.
### Characteristics of high and low cognitive complexity individuals

<table>
<thead>
<tr>
<th></th>
<th><strong>High cognitive complexity people</strong></th>
<th><strong>Low cognitive complexity people</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Information</strong></td>
<td>More open to new information</td>
<td>opposite</td>
</tr>
<tr>
<td><strong>Attraction</strong></td>
<td>Attracted to high cognitive complexity people as well as to low cognitive complexity people</td>
<td>Attracted to low cognitive complexity people with similar attitude</td>
</tr>
<tr>
<td><strong>Flexibility</strong></td>
<td>More flexible in thinking More fluency of ideas in creativity</td>
<td>opposite</td>
</tr>
<tr>
<td><strong>Social influence</strong></td>
<td>Change attitude more easily</td>
<td>More stable in attitudes</td>
</tr>
</tbody>
</table>
## Characteristics of high and low cognitive complexity individuals

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<th><strong>High cognitive complexity people</strong></th>
<th><strong>Low cognitive complexity people</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Problem solving</strong></td>
<td>Tend to search for more information</td>
<td>opposite</td>
</tr>
<tr>
<td><strong>Strategic planning</strong></td>
<td>Greater flexibility in considering alternatives</td>
<td>opposite</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>More effective at a communication dependent task</td>
<td>opposite</td>
</tr>
<tr>
<td><strong>Creativity</strong></td>
<td>Able to generate more novel ideas</td>
<td>opposite</td>
</tr>
<tr>
<td><strong>Leadership</strong></td>
<td>Show leadership</td>
<td>opposite</td>
</tr>
</tbody>
</table>
Figure 1: Different levels of information processing of an individual depending on the situational complexity
Figure 2: Comparisons of information processing curves of two types of individuals, i.e., high and low cognitive complexity individuals
• **Personality**
  is set of **predictable behaviors** by which people are recognized and identified.  
  (Costa & McCrae, 1992)

• **Personality traits**
  "**dimensions of individual differences** in tendencies to show consistent patterns of thoughts, feelings, and actions."  
  (McCrae & Costa, 1990)
Five factor model of personality [Ören, Ghasem-Aghaee, 2003]

Personality is represented by

30 facets grouped under 5 traits (factors):

Openness  (intellectual, creativity)
Conscientiousness  (moral, high goals to accomplish work successfully)
Extraversion  (sociability, positive affect)
Agreeableness  (nice person)
Negative emotions  (negative affect)

This five factor model is also called OCEAN model
When at least **any one of the 30 facets** changes its value, the personality may be affected and the model may be updated.
Representation of Personality
[Ören, Ghasem-Aghaee, 2003]

• 1. **Primary** characteristics
  – 1.1. Personality template
  – 1.2. Personality vector
  – 1.3. Personality chart

• 2. **Compound** characteristics
An analogy: Representation of color

<table>
<thead>
<tr>
<th>Color</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td>Green</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Discrimination $= 256^3 = 16,777,216$
Concise representation of personality (1/2)

- 5 variables (personality traits)
  (each depending on 6 personality facets)
- Variables are linguistic;
  hence values are fuzzy, e.g.:
  - high, average, low (+, =, -)
  - very high, high, average, low, extremely low (+++, ++, =, -, --)
  normalized numerical values can also be used, e.g.:
  - 100, 50, 0
Representation of personality

Personality A

Personality B

Discrimination: $3^5 = 243; 5^5 = 3125$
Agents with dynamic personality are (fuzzy) agents with personality where personality knowledge is updateable.
Personality Trait: Openness (OCEAN)

“Openness to Experience is tendency to be intellectual, interested in the arts, emotionally aware, and liberal.”

(Acton-glossary)

“Openness refers the number of interests to which one is attracted and the depth to which those interests are pursued. It is also referred to as culture, originality, or intellect. It is about creativity.”

(Howard and Howard, 2001a)
### Personality descriptors based on the levels (or values) of the six facets of openness

<table>
<thead>
<tr>
<th>Facets of openness</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>low</td>
</tr>
<tr>
<td>Fantasy</td>
<td>focuses on here and now</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>uninterested in art</td>
</tr>
<tr>
<td>Feelings</td>
<td>ignores and discounts feelings</td>
</tr>
<tr>
<td>Actions</td>
<td>prefers the familiar</td>
</tr>
<tr>
<td>Ideas</td>
<td>narrower intellectual focus</td>
</tr>
<tr>
<td>Values</td>
<td>dogmatic conservative</td>
</tr>
<tr>
<td></td>
<td>medium</td>
</tr>
<tr>
<td>Fantasy</td>
<td>occasionally imaginative</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>moderate interest in art</td>
</tr>
<tr>
<td>Feelings</td>
<td>accepts feelings</td>
</tr>
<tr>
<td>Actions</td>
<td>a mixture of preference of the familiar and the new</td>
</tr>
<tr>
<td>Ideas</td>
<td>moderate curiosity</td>
</tr>
<tr>
<td>Values</td>
<td>moderate</td>
</tr>
<tr>
<td></td>
<td>high</td>
</tr>
<tr>
<td>Fantasy</td>
<td>imaginative, daydreams</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>appreciates art and beauty</td>
</tr>
<tr>
<td>Feelings</td>
<td>values all emotions</td>
</tr>
<tr>
<td>Actions</td>
<td>prefers variety tries new things</td>
</tr>
<tr>
<td>Ideas</td>
<td>broad intellectual curiosity</td>
</tr>
<tr>
<td>Values</td>
<td>open to new values</td>
</tr>
<tr>
<td></td>
<td>open to reexamining values</td>
</tr>
</tbody>
</table>
openness

<table>
<thead>
<tr>
<th>Personality type</th>
<th>low (Preserver)</th>
<th>medium (Moderate)</th>
<th>high (Explorer)</th>
</tr>
</thead>
</table>
| **Personality characteristics** | - Has narrower interests  
- Is more comfortable with the familiar  
- Is perceived as more  
  -- conventional  
  -- conservative  
- Is perceived not 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) |
Note: **Continuum of openness - Example**

**Traits (as well as facets) are not binary valued!**

A person may be 0.30 preserver (and 0.70 explorer).

The expression of the linguistic variables in terms of numerical terms is explained (among others) by Ghasem-Aghaee and Ören (2003).

![Diagram of Continuum of openness]

**Continuum of openness**
• **Agents**: Agents are autonomous software modules with perception and social ability to perform goal-directed knowledge processing, over time, on behalf of humans or other agents in software and physical environments.

• The *core* knowledge processing abilities of agents include: reasoning, motivation, planning, and decision making.
Additional abilities of agents are needed to make them more intelligent and more trustworthy:

Abilities to make agents *more intelligent* include anticipation, understanding, learning, and communication in natural language.

Abilities to make agents *more trustworthy* as well as assuring the sustainability of agent societies include being rational, responsible, and accountable. These lead to rationality, skillfulness and morality (e.g., ethical agent, moral agent).
**Fuzzy agents** are agents that can perform qualitative uncertainty reasoning with *incomplete and fuzzy knowledge* in some environment that contains linguistic variables.
Agents with personality are *fuzzy agents* with characteristics such as openness, conscientiousness, extraversion, agreeableness, and negative emotions in line with the five-factor personality theories to model human behavior.
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.
Conclusions

• **Openness**, as a personality trait, is related with cognitive complexity.

• Hence, updates on openness may have implications on cognitive complexity and to the decision making ability of
  – humans as well as
  – agents in problem solving.

• In realistic representation (modeling) of humans by agents, this point of view may be useful.