

# What can Computer Modelling tell us about Personality?

Final Paper

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## ABSTRACT

The knowledge gained from the computer modeling of the personality can help with understand our own differences better and help up create the more human-like and varied characters and agents to use in the technology. In this paper, I am going to be researching how well can computer modeling helps us with understanding how can personality give rise to the human differences through both modeling the personality and implementations that were created for a more practical purpose. I am going to be exploring personality from the perspective of stability of the personality, connection between emotions and personality and different personality models.

## KEYWORDS

Personality, Computer models, The Big Five, Reinforcement Sensitivity Theory

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## 1 INTRODUCTION

Personality has both the stable components and the components that are changing. This is why there are many definitions of personality. One definition that can be used for humans is that personality is systematic variation in the population, which is relatively time-stable and have a pervasive effect on cognition, emotion, and behavior. It is used to differentiate groups of people in term of their habitual traits of behavior [2]. This definition touches upon a couple of different things. Like, that personality is intrapersonal stable, but interpersonal different. It also affects different aspects of people, from cognition and emotions to behavior.

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There is also a more abstract definition that can apply to nonhuman and even nonliving entities like computer programs. In this case, the personality is a consistent reactive bias within the fringes of functionality [28]. This means that there is freedom to choose between different actions, but there is still consistency in these choices. So, an entity would make consistent choices in the similar situations. Unlike the previous definition, this one explicitly only applies to the behavior. It still keeps the intrapersonal stability. The interpersonal differences are only implied, but not mentioned.

So for this paper, I am going to be defining personality as behavioral differences that are intrapersonal stable. These differences come from cognitive processes like cognition and emotion and provide a way to study differences in people.

There are different models of personality, ranging from psychoanalytical, cognitive, trait theories to biological, behavioral and social learning theories. In the business sector, the most popular ones are based on Jung's theory of functions [17], the most famous one being MBTI [43]. With the general public, besides the theories based on the Jung's theory, the theories that are also popular are the ones based on the older knowledge, like the astrological signs [44] or Ayurveda types [42]. In the science, most widely spread theory is a trait theory based on the adjective grouping called The Big Five [15], but biological theories like Reinforcement Sensitivity Theory [4] are also popular.

There are different reasons why personality would need to be researched in the computer models. Cognitive computational models allow us to study things that are complex and difficult by studying the cognitive processes by studying the reactions the model have under certain condition [12]. Personality is a complex concept, involving things from genetics to the narrative personal history to the current situation the person is in and much more, which makes is a valid candidate for studying it.

Another reason is that perceived personality of the computer program can affect the actions of people using it. For example, people react differently to a robot with pink lips and high pitch voice that robot with gray lips and low pitched voice. People give more information, when they perceive that the robot or program is unaware of it, for example, the would give more information about dating to the male than female robot [30].

This also means that people will react differently to the computers expressing different personalities. In one study, they perceived that the bot in question had the stable personality [16].

In this following paper, I am going to be studying how computer modeling can help us understand the personality. In order to do this, I am going to be looking at three different aspects of personality. First I am going to be looking at the model that model personality depending on the two theories of personality, The Big Five and Reinforcement Sensitivity Theory. I am going to discuss what the simulations run on different, but similar, version of this model can tell us about personality. In the second part, I am going to be talking about the interpersonal differences in personality and intrapersonal consistencies of personality, using two different models, but concentrating more on the one created by Michel and Shoda. In the third part, I am going to be discussing the link between the emotions and personality, as emotions are frequently bundled together with personality when building a computational model of personality. Here I am going to be using multiple models and try to find a common abstraction to them and discussed the model that uses an alternative one.

There are some of the things that I am not going to discuss in this paper, even though they are a part of the personality and are being researched from the computational modeling perspective. This would be the models that are based on the social roles (example [32]) or models that only include individual traits without them being in an overreaching model (example [5]). I am also not going to be studying models using personality based on the Beliefs Desires Intention model (examples [33, 40]). I am also not going to be discussing computational models that have not been implemented yet, be it based on the Jung’s function system (example [22]) or The Big Five and cybernetics (example [6]).

## 2 PERSONALITY TYPES MODELS

### 2.1 The Big Five

The Big Five is a trait-based theory with five main traits: Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism, forming the acronym OCEAN. The short list of adjectives describing each trait is given in the table below. These traits seem to be heritable and are rank stable through lifespan [9].

The theory was created by using the adjectives in the language, and then using the factor analysis to group people based on the correlations between different adjectives when compared to people describing themselves [15]. Some others compared people’s answers to different questionnaires [9].

This is a descriptive model and does not have explanatory power. Even so, there are some behavioral and neural correlates. In the behavioral side, these correlations are for example extroversion and openness to experience with risk taking [24], neuroticism to most personality disorders, extraversion with happiness and conscientiousness with good job performance [23]. On the neural correlates side, we have,

Trait	Description
Openness	intellect, curiosity, culture, independence, beauty appreciation
Conscientiousness	dependability, will to achievement, self-control, constraint
Extroversion	sociability, activity, assertiveness, positivity
Agreeableness	likability, conformity, sociability, altruism, friendliness
Neuroticism	negativity, emotionality, anxiety

**Table 1: The Big Five traits descriptions [9]**

for example, extroversion connected with the volume of medial orbitofrontal cortex and conscientiousness with lateral prefrontal cortex [7].

There are also factors above and below these five traits. Above them, there seems to be a two categories structure. The first category has three traits: neuroticism, conscientiousness, and agreeableness. The second has two traits: extroversion and openness. These factors have been connected to negative and positive valence [23] and to stability and plasticity [6].

The five main traits also consist of different factors. There are different divisions of these factors, but there is no strong consensus about it. The most popular questionnaire uses six different factors for each trait [23].

The example of a computer model of The Big Five model being implemented is in the chatbots, where they reply differently based on their personality [13].

### 2.2 Reinforcement Sensitivity Theory

The reinforcement sensitivity theory (RST) is the neuropsychological theory of among other things personality. The theory is built on the idea, that the organisms try to minimize the punishment and maximize the reward. There are three systems that are part of this theory: Behavioral inhibition system (BIS), Fight-Flight-Freeze System (FFFS) and Behavioral approach system (BAS) [3, 4].

In this system, the FFFS is responsible for all of the negative stimuli. It is responsible for the reactions such as fear and panic. It is activated, for example, when a person sees a spider. Or when we are faced with the person wielding a gun. This system is responsible for the punishment part.

BAS, on the other hand, is responsible for all the positive stimuli. It is responsible for all the positive reactions. It is activated when we see a cake that we want to eat. Or when we are anticipating the travel that we are about to start. This system is responsible for the reward part.

BIS is responsible for resolving goal conflict. This conflict can be between BAS and FFFS goals, but it can also be between two BAS or two FFFS goals. It is responsible for feelings of anxiety and depression. The BIS allows the humans to face the dangerous situation if there is a possible reward for it. For example, it can allow the person to go walking into the war zone, if this is the only way to get food for themselves.

It also allows the people to decide between to good decisions, for example, which cake to eat or what major to study.

BIS resolves the goal by increasing the negative valence by activating the FFFS even more. This connection between the BIS and FFFS could be the reason why in the original version of the theory both were responsible for the negative stimuli. But there is a difference in the behavior of the two systems. The FFFS would try to remove the source of the danger, while the BIS would try to approach it if there is a reason for it.

### 2.3 Connection Between RST and The Big Five

Gray's RST was created to address the problems with the Eysenck's theory [4]. Eysenck's theory was a three train theory, where the two main traits: extroversion and neuroticism, have a clear matching in The Big Five theory [9]. In the RST, the neuroticism is combined force of both reward and punishment, with the punishment given more weight. While extroversion is balancing the reward and punishment, with the reward given more weight [4].

One of the things that Eysenck's theory claimed is that introverts were generally more cortically aroused. Gray's RST says that since the introverts were more punishment-sensitive, and punishment is more arousing than reward, so they are more cortically aroused.

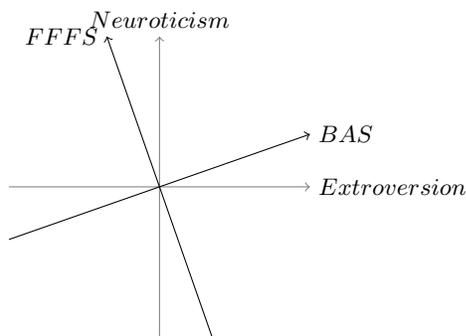


Figure 1: Connection between RST and Eysenck's trait theory [4]

This connection can also be depicted in the coordinate system like the one above. The coordinates of the RST are turned for 30° compared to the traits. This graph shows neuroticism and extroversion are both combinations of the BAS and FFFS dimensions. And that the extraversion is more correlated with the BAS, while the neuroticism is more correlated with FFFS.

### 2.4 Modeling

Here I am going to present the Read and Miller model that they discuss in a couple of articles [37–39].

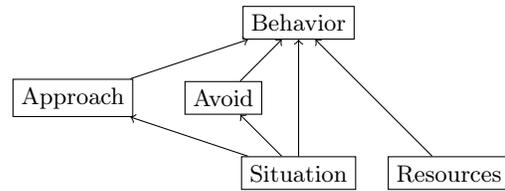


Figure 2: Read and Miller model [37–39]

As you can see in the upper picture, this model includes a couple of different components: situations, resources, approach layer, avoid layer and behaviors. Resources would be things that a person has or is. Some of these are money, wit, intelligence, status, social skills, attention span and things to talk about. Situations are the types of the situation that has different norms associated with it. Some examples include a date, review with the boss, wedding, party at work, family birthday, individual work and group work. Behaviors include things like ask for a date, surf web, tease and make fun, gossip, kiss up, drink alcohol, do a job, be silent and introduce yourself.

The approach and avoid layer have different goals that the person can have. They are using the old Reinforcement Sensitivity Theory, so they are calling the approach layer the BAS system and the avoidance layer the BIS system. The goals in the approach layer are things like sex, uniqueness, material gain, friendship, dominance, and fun. The goals in the avoid layer are goals like rejection or embarrassment, guilt, interpersonal conflict, and failure.

Considering the change in the Reinforcement Sensitivity Theory, these goals seem to be more something that people would fear and try to avoid by itself. Which is more in accordance with the FFFS system in the new revision [3], where FFFS system is connected with the feeling of fear and flight response or panic and freeze or fight response. That is why for the remainder of this section, when I am referring to these layers, I am going to be using terminology from the revised version. Also, in the revised version, the avoid goals were connected to the FFFS system, and not BIS like before.

The situation can affect what kind of goals does a person have in a certain situation. For example, sex is much more frequently connected to the situation of being on the date than the review with the boss. And some behaviors can only be executed when in the certain situation or when having certain resources. Or at least these can make a behavior much more likely to execute. A person having more social skills will more frequently use behavior of introducing themselves than being quiet. The same is true when a person in at the party, then when a person is alone.

The personality is then defined through the approach and avoidance layer. It can be either manipulated through the whole layer or just specific goals. In this model, it is assumed that the approach layer simulates the extroversion and the avoidance layer simulates the neuroticism. The general inhibition of the system, like how many goals can a different layer have or how many behaviors can get activated is connected to

the conscientiousness. It is a form of a goal conflict resolution, that is reminded of the BIS.

Inhibition is controlled through kWTA (k Winners Takes All) algorithm. The k value in the kWTA algorithm dictates how many nodes can be activated at one point in time. If the k is two, then only two nodes at any time can be activated, if using the absolute version of the algorithm. If using the averaged version of the algorithm, then only two nodes on average can be activated. The lower the number of k in the kWTA algorithm, the higher the inhibition and the level of the conscientiousness.

There are a couple of interesting simulations that were run on this model. The first one is connected with the conscientiousness [38] and is connected to the inhibition and goal conflict resolution. It is a very brute force approach, but it is interesting for two reasons. The first is, that the authors were trying to see if with this they can produce the personalities with different conscientiousness levels. The second is that it helps us see if this kind of inhibition can serve the role of the goal conflict in the similar way than BIS can.

In this simulation, the levels of the kWTA algorithms were manipulated in order to get personalities with different conscientiousness level. With this, they have created three distinct personalities with different levels of consciousnesses. The higher the inhibition the fewer goals or behaviors can be activated, the more the model simulated the conscientious person.

Inhibition	Goal-Directed Behavior	Other Behavior	Description
High	89.75%	5%	Efficient
Middle	80%	5.5%	Less-efficient
Low	94%	29.38%	Impulsive

**Table 2: Conscientiousness simulation [38]**

In the table above we can see how many times the certain groups of behaviors were activated. The number above tells in how many simulations the goal-directed and non-goal-directed behavior were activated. Because it is possible that no behavior gets activated and in the cases with lower inhibition, that multiple behaviors get activated, the numbers do not sum up to 100.

The simulation showed that having low conscientiousness level leads to having a lot more nongoal-directed behavior. But then, as the conscientiousness level increases, the goal-directed behavior first drops, along with the nongoal-directed behavior. Then the goal-directed behavior starts rising again, without increasing the nongoal-directed behavior. So a low conscientiousness person would be one that is impulsive, the high one would be efficient, and the middle one would be the one that can stay on more or less right course, but procrastinates a lot.

So this answers our first question, is it possible to create personalities with different conscientiousness by just limiting

the amount of goals and behaviors that can be present at the same time. The answer to this question is yes, as it did create the different personalities.

One of the interesting conclusion that I got from this is, that people that have a very small amount of conscientiousness are more likely to multitask, but that might be just a result of the way this was implemented and tested, as the highest level of conscientiousness did not allow for multitasking at all. While it is true that multitasking involves constant switching between tasks and this have consequences on productivity [21], and it is also true that level of conscientiousness is correlated with productivity [41]. But concluding that conscientious people are multitasking less so they are more productive because of this is dangerous.

The second conclusion, which I think is also interesting is, that in order for people to be more productive by exhibiting more conscientiousness-like behaviors, they would need to go through the dip first, where they would not achieve as much, before raising their levels again. While it does makes intuitive sense, when thinking about it is a pretty surprising result. Makes me wonder what is the exact relationship between people's goal-oriented and non-goal-oriented actions, to which I have no solution.

The second point that could be seen from this simulation is the connection between the conscientiousness and the BIS, which acts as goal conflict resolution system. There is a positive correlation between the BIS and conscientiousness [18]. But conscientiousness was also correlated with FFFS, and neuroticism and agreeableness were correlated with BIS. So it seems that using the questionnaire data, the link between the two is not that clear. Some other studies have also found an opposite result [1].

Also, the kWTA algorithm chooses to suppress all but the strongest k elements, in this case, behaviors or goals. But BIS system is more concerned with goal conflict between the two approximately equally activated units [1]. Also, conscientiousness here was tested with the amount of goal-directed behavior. But goal-directed behavior could also be connected to the Goal-Drive Persistence subset of BAS, which is expressed as persistence in accomplishing long-term goals.

Also, comparing the results to the different personality types described by Corr and Kurpić [1], it does not seem like the results show a difference between a low BIS and high BIS personality descriptions.

So even though this looks like it could take place of the BIS system, when perused more closely it does not seem like it could be used like that. So this model does not explicitly include the BIS system, but only BAS and FFFS. It still provides a good way to simulate the different levels of conscientiousness and helps us study it.

They also tried the simulations with manipulating the whole approach and avoidance layer or by simply manipulating the specific goals in this layers [38]. In all of these simulations the results were the same. The stronger the goals are activated, the more likely the behavior in question is to

get activated as well. The patterns are the same, no matter if the whole layer or just a specific goal is manipulated.

One way this could be used is to see what levels would produce the most natural response in the model [39]. The final result was, that the default activation for the approach layer should be higher than the avoid layer. But the input to the avoid layer should have higher influence than the input the approach layer. This means that the most natural reaction is given when it is a lot easier to activate the BAS than the FFFS system. But that FFFS system can rise a quicker and quickly overcome the BAS goals. They did say that the relationship between the change and levels and results was not linear, but they did not say which function it was. Considering that the small changes could bring quick changes results, I am guessing some sort of exponential function or something similar which would produce the same effect.

Another way this could be used is to simulate different personalities, for example, the socially withdrawn one [39]. The manipulations were based on the rejection sensitivity concept. In order to do this, the goals of social rejection and avoiding interpersonal conflict become more sensitive, which will allow them to be activated more frequently.

The results did produce the socially withdrawn personality. In 86% of cases, the behaviors leave, be silent and stay in the periphery were activated. In the normal person, the antisocial behavior like that was activated in just 25% of the cases. So even changes in just small amounts of specific goals can lead to quite big differences, partly leading support to the upper point about what function connects changes in sensitivity and change in activation.

But also, from this we can conclude that FFFS system is a possible culprit for the antisocial behavior, as in the model that does not have an explicitly modeled BIS system is still able to produce this antisocial behavior. Social withdrawal can mean the flight response, which would be clearly in the domain of FFFS. Only once the person decides to fight their social withdrawal and tries to reconnect to the society does the BIS gets activated and produces social anxiety.

On the very similar way, but only with manipulating the whole BAS, FFFS and inhibition system the three pairs of different personalities were created: extroverted and introverted, confident and anxious, and industrious and lazy [39]. The first pair was created by giving the BAS different sensitivities. The second pair was created by giving FFFS different sensitivities and the third pair was created by using different inhibition levels.

But instead of explaining it on this model, I am going to try to explain it in the simplified model that they have created to be used in agents to simulate the personality [37]. The following formula is used in order to demonstrate the workings of the model:

$$R = 1 - \frac{1}{1 + \gamma[I + S - DvC]_+}$$

There are a couple of elements. Each situation comes with the behaviors that are more or less likely to happen (S). For example, the kissing is much more likely to happen in a date

than when at work. On the other hand, working is much more likely to happen at work, than in a date or at the party.

But each person also has a probability of actually taking certain action (I). For example, an asexual would prefer to have as little sex as possible, while a sex loving person will want to have as much as possible.

These probabilities get summed and they corrected by the general inhibition level (DvC). The two probabilities together have to be higher than the inhibition level in order to be even taken into account. Otherwise they are simply treated as 0.

So the difference in this DvC level would be the difference in the conscientiousness level. The higher the DvC level needed, the more conscientious is a person, the more the activity needs to be activated to reach this level. This would eliminate most of the activities that would be unsuitable for the situation or that the person doesn't want to do them. I will imagine that in order for the model to work, how much a person wants to do something would need to be related to the goal-directed behavior. Though the last point is just my assumption, as this was not mentioned in the article.

So what we are left off is the person who always pursues goals in a situation-specific manner. But what there is also a danger of is that no activity is activated and the agent is just going to not decide on any action. When they use it in their stories, for example, to simulate the dating scene [36] or information gathering from a shopkeeper in Kurdish Arabic setting [45], they usually have a story with the structure already predefined. But it is something to keep in mind for usage of the general study of personality and using it in a setting with no predefined story.

The goals that can pass this threshold are then corrected by  $\gamma$ .  $\gamma$  can be either the BAS or FFFS coefficient. The approach goals related actions get corrected by the BAS coefficient, while the avoid goals related actions get corrected by the FFFS coefficient. This coefficient is then responsible for the personality. BAS controls extroversion while FFFS controls the neuroticism.

This works by pitting the FFFS actions and BAS actions among each other. the higher the number for the final result, the more likely the action is going to be activated. In order to reach the highest number, the 1 needs to be subtracted with the smallest possible amount. Since the amount subtracted is a division of 1 and the calculated part, this calculated part needs to be as high as possible. So the higher the  $\gamma$  for the specific action, the more likely it will be executed.

Which means that if the  $\gamma$  for FFFS is the same than  $\gamma$  for BAS, then the personality is going to be balanced and the action will depend a lot on the situation. But if  $\gamma$  for FFFS is higher than  $\gamma$  for BAS, then the FFFS actions will have a higher final number and they will be more likely to be activated, leading to a more FFFS-like behavior, like the social withdrawal that we saw before.

The model has produced the personalities, that react differently, with different levels of traits, depending on the situation

they are placed in. But they are providing the different average level of the traits, which will become a point when I am discussing the consistency of personality in the next part.

What this shows us that the behavior is dependent on both the personality ( $I$ ,  $\gamma$  and  $DvC$ ) as is it on the situation ( $S$ ), which will be discussed in the next segment. It also shows that by simply manipulating the sensitivity of some elements we can produce a variety of personalities with the same model.

What I am interested in is on what is the inclination of a person to do some action based on. I imagine that in real life it would be based on the experience and habits. But here there is no mechanism to actually make agent learn these. So it seems to be arbitrary chosen. But is also something that I would consider a part of personality and I would like to see have more care being put into this part of the model as well.

Because while I know this agent model was a simplified version of the upper model it was based on, and it was probably included in order to make actions more lifelike. But it was dealt with it in a bit arbitrary way for a person that is using computer modeling to study personality.

I have to still mention is that I have taken the model description from the text and equation and ignored the picture of the model. That is because the same picture is used in multiple articles [36, 37, 45] and it does not depict what the text and equation are actually saying. The numbers do not match up, yet they are the same in all of the mentioned articles. So it could be that maybe I am wrong and instead of the picture, the text and equation are wrong. Why I am less inclined to believe it is because the text did change somehow between the articles, but not the picture.

### 3 CONSISTENCY OF PERSONALITY

Originally personality was thought as something that was consistent across different situations. Taking situational factors into account was originally misunderstood as something that makes personality erratic and random. Mischel argued that there are things called psychological factors, which could change the behavior of people in that situation. The example he gave was that children could wait longer for a reward if they were told to imagine something [26].

Michel and Shoda in their paper [27] showed both going through the interview data and computer modeling that personality can be intersituationally different, but still consistent in an overall manner. They showed this with a simulation where modeled people still reacted similarly in similar situations, did have different reactions in situations that were not similar and had different average levels of actions, which was an indication of traits.

The example that they studied was a group of children in the summer camp and their reactions. Two relevant psychological features were found: valence and whenever the person was speaking to the peer or adult. These features were then used in the if-then relationships. So if a person was in a positive situation with the peer, then it would react

in a certain way. The results showed that people have similar reactions in similar situations, but different ones in the different situations.

They managed to show the same results with their computer models. There, the model reacted consistently depending on the psychological features of the situation. They were constant in their reaction to the similar situation, but they vary between situations. The model was also able to show different average levels of actions, in this case, friendly behavior, which can be seen as the indication of the people having different basic personality traits.

The same result was shown with the Read and Miller model, where they simulated six different personalities. These personalities had situational specific behaviors as well, but different average behaviors [39].

Michel and Shoda have used psychological features that they could extract from the descriptions of the children's behavior [27]. And while they give some suggestions about it [26], they don't do this in a systematic way that would allow us to compare different studies.

In order to make that kind of comparison simpler, the factor analysis was performed on the answers to the Riverside Situational Q-Sort questionnaire [35]. They found the eight situational features: deception, intellect, adversary, mating, positivity, negativity, duty, and sociability.

They were working under the assumption that the situational factors are similar to the personality factors, so they linked six out of eight factors to the big five personality traits. They reversely linked deception and agreeableness, intellect was linked to openness, positivity was linked to extroversion, negativity to neuroticism, duty to conscientiousness and sociability to both extroversion and agreeableness.

What we could see here through an analysis of the consistency of personality is the importance of the effect of situations on the person. This is interesting to me, as it is the opposite approach than how personality is treated in the organizational science. There, if people talk about personality, it is how personality is consistent, so it can be predicted how a person will act in a specific situation.

But this version makes more sense. People have different roles that we play in our life, like the role of the student, the role of the citizen,... In the way, these roles provide the situational and cognitive push that Mischel [26] mentioned that is needed to have a more consistent, not personality dependent behavior. But even so, there are differences in our behaviors in at least some situations, which makes personality still an interesting thing to study.

### 4 PERSONALITY AND EMOTIONS

Moffat has created a theoretical model linking the personality and emotions [28]. In his model, the emotions and personality differ only on the duration and spread.

So emotions can be thought as short-term, focused personality and personality can be thought of as long-term, global emotions.

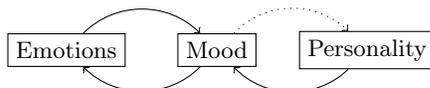
	Focused	Global
Short	Emotions	Mood
Long	Sentiment	Personality

**Table 3: Model of Emotions and Personality [28]**

When implementing the emotions in computer models, the model that is most frequently used is the OCC model. In this model, the emotions are evaluations to the psychological situations. They are internal mental states that focus on the affect. They differ from each other based on the psychological situations that gave rise to them and in how they are cognitively elaborated. Their appraisal also depends on what type of evaluation is done and valence of the evaluation. It can be done based on the three criteria: goals, where an outcome is evaluated, standard, where the process is evaluated and taste where the attribute of the object is evaluated. It includes 22 emotions in 6 categories [29].

Both The Big Five and OCC model [14] were charted in the PAD space. PAD stands for Pleasure, Arousal, and Dominance and it is a spatial representation of the emotions. Pleasure refers to the valence of the state. Arousal refers to the level of stimulus activity. Dominance refers to the level of control the person has over the surroundings. The PAD model was developed in order to have basic dimensions for emotions, in order to study them without the baggage of folk psychology. But because these dimensions can be computationally easily represented, they are often used in the computer modeling of the emotions, temperament and personality [25].

Most personality models that use emotions use it in a personality-mood-emotion type of structure, where they differ in the duration. [10, 11, 14, 19, 20, 31]. In these models, the personality is usually the most permanent and is expressed through The Big Five topology. The mood is in the middle and is usually just one good-bad dimension, though there are exceptions with one using two different moods [11] and the other using PAD model [14]. The emotions are the most fleeting and are usually expressed through the OCC emotional model, though sometimes they use the subset of 6 emotions and sometimes they add 2 additional ones: surprise and disgust.



**Figure 3: Connection between Personality, Mood and Emotions**

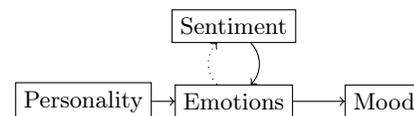
These models usually let the mood be the one with the intermediary influence. Mood can be influenced by both personality and emotions. On the other hand, there is usually no direct connection between the personality and emotions. Instead, usually some sort of input induces an emotional

reaction. This emotional reaction can influence how does the mood change. On the other hand, the mood can influence how strong an emotional reaction will be. For example, the person that is in a bad mood will not feel as much joy out of a conversation with their loved ones than one that is in a good mood. But this conversation can still change the mood of the former for better. As seen from the example, the input can also affect the emotions felt.

The personality can also affect the change of the mood. For example, a person that is high on neuroticism will be much more likely to switch their mood to the worse than a person that is low on neuroticism. So personality influences the probability of these changes. At least some models, like [14] also implement the decaying of the mood, returning to the default levels.

Few models also depict that a prolonged mood would be able to affect the personality, but it is not a frequent feature of the model.

There are some models where these connections are a bit different [31]. For example, in this model, besides the three main categories, there is also sentiment.



**Figure 4: Connection between Personality, Mood and Emotions**

Unlike in the previous models, here the emotions have the primary role. In this model, there are the connections between the personality and emotions, where the personality defines the possibility of the feeling of emotions and not of mood changes. For example, if the model is programmed with higher neuroticism, then it will be more likely to feel anger, anxiety, and depression. Or if it has high agreeableness, then it will more likely feel trust and sympathy.

How strong the emotions are is also depending on the object that the intentionality of emotion is directed on. If this object has a sentiment connected to it than this sentiment can regulate the emotion present. For example, if there is a sentiment of a spider connected to fear, then when seeing a spider, the fear felt will be much stronger. The sentiments can be preprogrammed, but they can also be created. When the emotion felt reaches the threshold, then the new sentiment is created to connect the object present and the emotion felt.

The emotions felt can also affect the mood that it is felt.

In the lower table, there are some connections between personality and mood and personality and emotions that were explicitly mentioned in the articles about the models.

These models of emotions and personality were used in different problem areas, like in the designing the games [31], in the education programs, like the anti-bullying program [8], in chat-bots [14]

There are also some indications from other fields that connection between the personality and emotions exist at least

Trait	Connection	Citation
Openness	Quicker changing standards, positive attitude towards new things	[10]
Conscientiousness	Speed of goal adoption, speed of goal abandonment	[10]
Extroversion	Positive attitude towards other people, quicker shift into positive mood with other people	[10, 19]
Agreeableness	Speed of goal adoption because of somebody else, speed of goal abandonment because of somebody else, compromising standards for somebody else, positive attitude towards other people, slower mood shifts, quicker shift into positive mood	[10, 19]
Neuroticism	Smaller goals, quicker mood changes, higher possibility of going into negative mood	[10, 19]

**Table 4: Connections between personality and mood/emotions**

in a way that it would be plausible to be able to be enacted in the way the more general model describes above. The problem is that this model seems like it lacks a memory. The second one tries to solve this by including the sentiment. This way some features in the environment, like the cockroaches or snakes, can induce specific emotions that have an effect on the personal being. The more general model presupposes this information comes from the outside.

But in the second model, the problem is that mood has no role. Sure, it is nice to see personality directly impacting the emotions, as there are correlations that extroverted people feel more positive emotions and people with high neuroticism feel more negative emotions. But the mood is there just like an indicator. But in reality, it can have a big impact on the person's emotions and behaviors. An example would be in a depression [34].

Also, when looking at the implementation of these models, a lot, but not all, of times the values and connections are hard coded, and only the values can change based on the connections. A lot of times the justification is that it is computationally simpler and that the agents need to be created to use as little of computer resources as possible.

Which is a completely valid stance, if the main goal is to create agents that are able to express emotions and act differently from each other. Not that well of an idea, if the accuracy and the knowledge that one can get from models like that about human cognition is the primary factor.

Both of these are valid models and they have practical use in the programming of the emotions inside the synthetic agents. It just that they don't seem to be as well suited for explaining system of human emotions.

## 5 FINAL DISCUSSION

For conclusion, I would like to say that computer modeling can be used for studying personality. This has been shown through this paper with examples from modeling the specific theoretical model of personality, to showing how computer modeling can show us which of the personalities theories are possible, with the example of intrapersonal consistency and inter-situational differences. And then the computer modeling had shown the relationship of personality with other concepts, in this case, emotions.

While I want to be positive, there are a couple of things to be taken into account. There are at least two different primary objectives to model the personality on the computer. The first it to be able to create agents with human-like behavior. The second is to help us learn about our human personalities. Based on my limited knowledge of the field that I have gained, I would say that the former is somehow more present than the later.

This is important because these differences in primary objectives can cause the differences in how something is implemented. The personality creation group can use and ignore the theories of personalities as it sees fit. As long as the result is correct, this works well. Which did lead to hard-coding different values and assuming connections where they were none.

Not that the personality studying group is not making mistakes as well. In these paper, a lot of times the computational model of personalities is not yet finished. Even when it is finished, the number of simulations that they run on them is extremely low. There is an assumption that was implicit in some papers that the model would behave the same in the same or similar situation no matter how many times the simulation is run. Which, if true, could also be a result of the way the model is constructed.

Even so, I want to end on the positive note. While there are some things a person needs to be careful, I think it is a valid method that can tell many new things about our personal differences.

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