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A Role-Playing Agent with Programmable Personality and Emotions

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Abstract

Teachers and trainers use role playing cognitive agents to create realistic characters and have students interact with them. The educational aim of playing out characters could be to stimulate changing beliefs and behavior, assimilating new knowledge, or understanding other peoples' concerns and values. Characters that are programmable should be of a particular interest since they are supposed to allow teachers and trainers to create various hypothetical situations. The aim of our study is to explore programming agents' emotions and personality to create various characters. For that, we designed and prototyped a programmable cognitive agent. In a primary validation experiment participants interacted with six different characters and assessed their believability. A secondary validation consisted to thoroughly analyze the characters' behavior under the light of prior studies investigating emotion and personality-backed decision.

Keywords: *Cognitive agents; Emotions; Personality; Decision; Moral decision; Education*

1. Introduction

Realistically modeling individual decision making and reasoning is of increasing importance for many education researchers [1-7]. In this article, we are interested in role-playing cognitive agents used by teachers and trainers to allow students to experience various hypothetical situations through acting out virtual characters. The aim of role playing is to stimulate changing existing beliefs and behavior [8], assimilating new knowledge and meaning [9], or understanding other peoples' concerns and values [10]. Our research's interest goes to educational scenarios where the virtual character is required to make moral decisions. For this purpose we implemented a programmable cognitive agent called Programmable Agent based on Cognitive Attraction Networks (PACAN). The core module of that agent is a computational implementation of the cognitive attraction network-based moral decision model presented in [11]. Cognitive attraction networks will be introduced in Section 2. Users can program PACAN through a graphical interface. The programmability applies on PACAN's emotions, personality traits, and environment, and consists to set suitable parameters. Consequently, users can create a variety of PACAN "species". A second programming step allows users to select a particular PACAN species then instantiate different characters with different traits. The graphical interface of PACAN allows users to interact with the agent too. In every interaction iteration, the user can specify new events and see the dynamics of the character's emotions and decisions.

Like any computer virtual character, the most significant requirement for PACAN is the believability, which builds upon the ability of expressing appropriate and timed emotions and appearing to have personality of its own [12]. In order to assess PACAN's believability, six different characters have been set: two avatars, two car drivers, and two teenagers, all with different personality traits and different environments and decision

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circumstances. Then, participants were invited to interact with these virtual characters and assess their believability. Another part of validation consisted to compare the results of PACAN characters' behavior with conclusions of some relevant human psychological studies.

1.1. Related Work

The literature reports some relevant works which designed virtual characters for the purpose of educational role-playing. Corey *et al.*, [13] described their system that enables human tutors to build negotiation situations. Trainees can then negotiate with an animated virtual character. The conversation between the character and the trainee is stored to allow the tutor and the trainee to study the negotiation strengths and weaknesses. The system developed by Lester and Stone [14] was destined for learning middle school botanical anatomy and physiology. It consists of an animated character that assists users in exploratory learning. The character can interact with learners through text and voice. It is also capable of monitoring and planning progressive learning of the user. Kenny *et al.*, [15] designed a virtual patient that is meant to help psychotherapy students enhance their interviewing skills. The character incarnates specified history and symptoms of conduct disorder. Similarly, Stevens *et al.*, [16] designed a virtual character that plays the role of a patient so that medical students can interact with it to enhance their communication skills. All these virtual characters are designed for specific domains that are different from ours, which is moral decision. Besides, they do not contain a model of emotions and personality and they are not programmable.

Lim *et al.*, [12] designed and implemented a role-playing game destined for dealing with the cultural-awareness problem for children aged 13–14. The agent integrates Dorner's model of motivations and needs [17], and the model of Dias [18], which models planning and cognitive appraisal mechanisms. One difference between this agent and PACAN is that the former is not programmable. Besides, it considers personality as an emergent characteristic, while PACAN incarnates a personality model that has been validated through previous research works as it will be explained in Section 4.

The next section briefly presents cognitive attraction networks. Section 3 explains the moral decision model. Section 4 details the constructs of PACAN as a generic programmable agent. Instantiation of particular PACAN characters through parameter setting is explained by Section 5. Validation experiments are presented and discussed by Section 6. Finally, Section 7 concludes the article.

2. Cognitive Attraction Networks

Cognitive Attraction Networks (CANs) were used in [11]. We here briefly introduce them. Following the lead of folk psychology [19], a CAN builds on the belief-desire-intention (BDI) model [20]. Those three concepts are differentiated into the following mental entities: beliefs, moral beliefs, moral rules, goals, actions, and intentions. A CAN also uses the concepts of events and emotions. According to the folk psychology, beliefs are memorized facts like "the sun is bright". Actions may be general like "traveling" or specific like "traveling to Toronto". Planned actions are intentions, *e.g.*, "traveling to Toronto tonight". Longer run and more persistent planned actions are goals, *e.g.*, "feeding oneself" or "getting a BSc in Computer Engineering". For the sake of simplicity, we will use the word "goal" to designate goals and intentions. Events are propositions that relate something that has been perceived. For example, "the baby is smiling". Moral beliefs are the association of actions or goals either with good (G) or bad (B). For example, "lying to teachers is bad" is a moral belief. When the action is a general one, the moral belief represents a moral rule, *e.g.*, "lying is bad". In the sequel "moral rule" will designate moral rules and moral beliefs. Emotions are either positive (P), like hope, or negative (N), like sadness. A CAN does not address the sources and processes of emotions. We here adopt the definition of Roseman and Smith: emotions are the result of the subjective cognitive evaluation of events, intentions, and goals [21].

In a CAN, all moral rules and goals are associated with emotions and the latter have intensities. For example, emotion may reflect the affective importance of the goal. Some events are also associated with emotion, for example, “an accident on our street this morning”. Other events like “a neighbor is closing his door” may evoke no emotion. Binary association between two mental entities, like “cheating in exam – punishment” has an empirico-emotional valence. The latter results from the combination of the affective valence of “punishment” and the empirical evidence that cheating leads to punishment. CANs postulate that empirico-emotional links and valences emerge from the Hebbian rule. Further, they represent conceptual attractions. In other words, if two mental entities X and Y are linked together by a conceptual relation such as “X causes Y”, there is an attraction performed by Y on X. The intensity of the attraction is proportional to the affective valence of Y, and the evidence or plausibility degree of the relation between X and Y. For example, the action “cheating in exam” is attracted by the moral rule “cheating is B”. The relation here represents analogy. The intensity of the negative emotion associated with “cheating is B” and the degree of evidence of the analogy will determine the strength of the attractive link between the two entities.

Since cognitive attractions are assumed to emerge from the Hebbian rule, they are dynamic, just like synaptic links. Indeed, a new event may generate a new mental entity X. The process of storing X in the memory exposes X to the attraction of the existing relevant mental entities. Before X stabilizes in a network of associations, many attraction links and intensities can be changed and new mental entities might be created. Eventually, X might be altered because of the impact of the attracting forces. Let X be the action: “I will cheat in the next exam”. X is likely to be attracted by moral rules and goals. The attraction forces might alter X so it becomes: “I will cheat in the next exam but never after that”, for example. Besides, the negative and positive emotions of the attracting entities are propagated to X so that, at the end of the process, X will be associated with the emotion of the stronger attractor. This is what is called classification, judgment or decision. If X is attracted by equally strong but emotionally incompatible entities, it will end up with a combination of contradictory emotions, which is sometimes called hesitation or ambiguity.

To illustrate a CAN, let us formulate the moral decision problem, which is depicted by Figure 1. The moral decision problem is faced when a perceived event leads the subject to choose among two incompatible actions T and ~T (negation of T). Given a moral decision problem, the resolution process involves goals and moral rules. $G=\{G_1, \ldots, G_m\}$ is the set of goals and $R=\{R_1, \ldots, R_n\}$ is the set of moral rules. The action ~T is attracted by the rules R_1–R_p and the action T is attracted by the rules R_{p+1}–R_n. Every link (T, R_i) or (~T, R_i) represents a causality relation through which the subject believes that T or ~T causes the fulfillment of R_i. Such a link has an intensity that represents the subjective evidence degree of the causality relation. At the same time, T and ~T are attracted by the goals G_1–G_n. The links (T, G_i) and (~T, G_i) represent causality relations and have evidence weights.

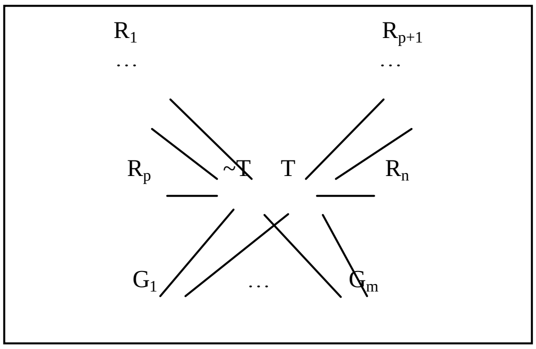


Figure 1. Moral Decision Problem CAN

3. Moral Decision Model based on CANs

Let us instantiate the CAN of Figure 1 through an example, which is a modified version of the one reported by [11]. Zed avatars live in a tribe. Their goals are to feed oneself, contribute in feeding the tribe, and be respected. At random intervals of time, food comes to the tribe either with high or low quantity. Accordingly, Avatars collect food in either high or low quantity. Avatars can also, at random intervals, offer food one to another. Every time a Zed has some food, he has to solve a moral decision problem: eat alone or share?

This example is summarized by Figure 2, where T = *share*, ~T = *eat-alone*. T and ~T are attracted by the moral rule R_1 = *do-good* and the goals G_1 = *no-hunger*, G_2 = *feed-tribe*, G_3 = *respect*. Empirical (evidence) degrees are written between square brackets and affective intensities between parentheses. A negative evidence value means that the action is subjectively believed to be incompatible with the moral rule or goal. Positive evidence values mean the opposite. Events are not represented in Figure 2. They are: *food-high*, *food-low*, and *fed-me*. They mean: “food is abundant and I collected enough”, “food is scarce and I did not collect enough”, and “some other avatars offered me enough food”, respectively.

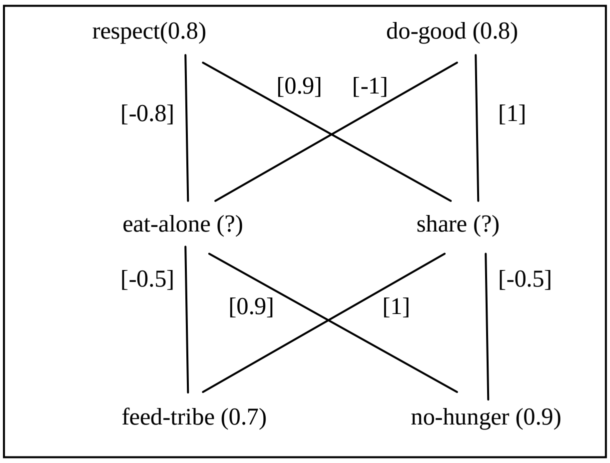


Figure 2. Zed’s CAN

According to [11] the moral decision is a two-step process [11]. The first step is called intuition. When an event is received, *e.g.*, *food-low*, it is immediately compared with goals in order to select the most relevant and desirable (affectively charged) one. It is also compared with schemata of action plans that have proven to increase positive emotions by satisfying the selected goal. This level is completely or almost unconscious. If there is any conscious reasoning at this level, it is very rudimentary and prone to errors. The result of the decision process at this step is an intuition. For example, after perceiving *food-low*, the most related and affectively positive goal *no-hunger* is selected as it has the greatest positive affective valence. Based on that, the action *eat-alone* is immediately inferred as it has proved in the past to satisfy the goal *no-hunger*. This is expressed by the evidence intensity (0.9 in Figure 2).

The second step is called conflict and deliberation. It starts right after intuition. A more elaborated and conscious reasoning process takes place. It involves attractors that have not been called during the intuition step, including those who are not compatible with the selected positively charged goal. In our example, these are *do-good*, *feed-tribe*, and *respect* (Figure 2). The actions associated with these goals are also evoked. In our example, this results in a conflict: *eat-alone* and *share*. Such a conflict is solved by comparing the attraction forces that are performed on the conflicting actions. During the deliberation process, conscious reasoning is used and the so called aberration takes place: emotion of some entities will be increased or decreased, new entities will be created by analogy, deduction, *etc*. Even moral rules might be altered. For example, one might infer “eat-alone is G”, which is extreme but likely to happen.

Under the light of this process, let us now formalize the moral decision. Let w_k be the affection intensity associated with the mental entity $E_k \in G \cup R$. Let d_{0i} and d_{1j} be the evidence degree of the link (~T, E_i) and the evidence of the link (T, E_j), respectively. The moral decision consists to calculate the attraction force applied on ~T: $A_0 = \sum_i w_i$ and the attraction force applied on T: $A_1 = \sum_j w$. If $A_1 > A_0$, T is decided, otherwise, ~T is decided.

Let us apply on our previous example. The empirico-emotional attractions performed on *eat-alone* and *share* respectively are:

0.8 X -0.8 + 0.8 X -1 + 0.9 X 0.9 + 0.7 X -0.5 = -0.98
0.8 X 0.9 + 0.8 X 1 + 0.9 X -0.5 + 0.7 X 1= 1.77

Therefore, the action *share* will be decided.

4. Generic model of PACAN

4.1. Emotions and Personality Traits

As stated earlier, PACAN incarnates a computational model of the moral decision model of [11]. PACAN is generic in the sense that it can be programmed to create various virtual characters.

The moral decision model of [11] does not contain a model of personality traits and emotions. Therefore, modified versions of the emotional model of Seif Al-Nasr *et al.*, [22] and the personality model of Rousseau [23-24] were chosen for PACAN. As defined by Seif Al-Nasr *et al.*, emotions and their meanings are presented in Table 1. The set of personality traits borrowed from Rousseau [23-24] is: (pessimistic, optimistic), (impulsive, thoughtful), and (selfish, unselfish).

Table 1. Emotions and their Meanings

Emotion	Meaning
Joy	Occurrence of a desirable event
Sadness	Occurrence of an undesirable event
Disappointment	Disconfirmed desirable event
Hope	Expectation of a desirable event
Fear	Expectation of an undesirable event
Pride	Action done by the agent and approved by standards

Shame	Action done by the agent and disapproved by standards
Reproach	Action done by the other and not approved by the agents' standards
Admiration	Action done by the other and approved by the agents' standards
Anger	Sadness + reproach

4.2. Set-based Formulation of PACAN

Here is a set-based formulation of PACAN. $G = \{G_1, \ldots, G_n\}$ is the set of goals, $R = \{R_1, \ldots, R_n\}$ is the set of moral rules, and $T = \{T_1, \ldots, T_n\}$ is the set of actions. Every entity $e \in G \cup R$ possesses an affective valence $w \in [0, 1]$, which expresses the importance or desirability of the goal or moral rule e. This defines the set $F = \{F_1, \ldots, F_n\}$ with for each $f \in F$: $f = (e, w)$ with $e \in G \cup R$ and $w \in [0, 1]$. Every $e \in G \cup R$ has one and only one affective valence $w \in [0, 1]$. External events are defined as the set $V = \{V_1, \ldots, V_n\}$. $M = \{M_1, \ldots, M_n\}$ and $P = \{P_1, \ldots, P_n\}$ denote the sets of emotions and personality traits, respectively. Let $D = \{D_1, \ldots, D_n\}$ be the set of evidences where for each $d \in D$: $d = (e, \theta, ret)$ with $e \in G \cup R$, $\theta \in T$, and $ret \in [-1, 1]$. A negative evidence value means that the action θ is believed to be incompatible with the moral rule or goal e. Positive evidence values mean the opposite. After an inferred action θ has been performed it may have an impact on the intensity of some evidence relations where it is involved. Let $TD = \{TD_1, \ldots, TD_n\}$ be the set of such impacts. For each $td \in TD$: $td = (\theta, d, rtd)$ with $\theta \in T$, $d \in D$, $rtd \in \{+, -\}$, and $d = (e, \theta, ret)$. The impact of the execution of θ on the evidence d (which contains θ) translates into the update of the value of ret:

$$ret(t+1) = ret(t) + C_{td} \qquad (1)$$

where C_{td} depends on the value of rtd as shown by Table 2. Simulations permitted to specify the parameter C_{td}.

Table 2. Values of C_{td}

Rtd	C_{td}
+	0.1
-	-0.1

The set $VG = \{VG_1, \ldots, VG_n\}$ represents the impact of the events on goals. For each $vg \in VG$: $vg = (v, g, rvg)$ with $v \in V$, $g \in G$, and $rvg \in \{Y, N\}$. Y means there is an impact, and N means there is no impact. Similarly, we define the set TG, which represents the impact of actions on goals. For each $tg \in TG$: $tg = (t, g, rtg)$ with $t \in T$, $g \in G$, and $rtg \in \{Y, N\}$. $VM = \{VM_1, \ldots, VM_n\}$ is the set which contains the impact of events on emotions with for each $vm \in VM$: $vm = (v, m, rvm)$ with $v \in V$, $m \in M$, and $rvm \in \{+, -, *\}$. +, -, and * mean increasing, decreasing, and no impact, respectively. Similarly, we define the set TM of the impact of decisions (actions) on emotions: $TM = \{TM_1, \ldots, TM_n\}$ with for each $tm \in TM$: $tm = (t, m, rtm)$ with $t \in T$, $m \in M$, and $rtm \in \{+, -, *\}$.

To calculate the intensity of emotions $M_i \in M$, such as fear, joy, *etc.*, Seif Al-Nasr *et al.*, [22] adopted the equations of Price et al.[27] In our simulations, these equations resulted in incoherent emotional states. This may be due to the joint application with the conceptual attraction. Therefore, we adopted the general pattern of those equations:

$$M_i(t+1) = M_i(t) + \alpha\left(\textstyle\sum_k w_k\right)^p + \beta w_k \textstyle\sum_{j=1}^{n} ret_{jk} + \gamma\left(\textstyle\sum_{j=1}^{n} ret_{jk}\right)^q \qquad (2)$$

The calculation of the intensity of the emotion M_i is only performed if the latest event V_u or latest decided action T_u has an impact on it, *i.e.*, $vm_{ui} \neq *$, $rtm_{ui} \neq *$, respectively. Besides that, the calculation of M_i employs w_k, which corresponds to the affective valence of the goal G_k on which the event V_u or action T_u has an impact, i.e. $rvg_{uk} \neq N$, $rtg_{uk} \neq N$, respectively. For every goal G_k that fulfills this condition, the calculation of M_i uses all the evidence values ret_{jk} in which G_k is involved. Simulations permitted to specify the parameters of Equation (2). They are presented in Table 3. The signs + and – represent the actions of increasing and decreasing emotion intensity. Recall that, according to the definition of the sets VM and TM, the latest event or action may increase or decrease specific emotions, and may have no effect on others. So, for instance, the cell "Joy, +" in Table 3 should be read: "if the latest action or event has an impact on Joy that is of type +".

Table 3. Parameters used in Emotion Intensity Calculation

	Α	p	Β	Γ	q
Joy, +	0.7	1	0	0.4	0.5
Joy, -	0		-0.75	0	
Hope, +	0.7	1	0	0.4	0.5
Hope, -	0		-0.15	0	
Admiration, +	1	1	0	0	
Admiration, -	0		-1	0	
Reproach, +	0		1.5	0	
Reproach, -	0		-0.15	0	
Sadness, +	1.35	1	0	1	2
Sadness, -	0		-0.8	0	
Fear, +	1.35	1	0	1	2
Fear, -	0		-0.8	0	
Pride, +	0		0.8	0	
Pride, -	0		-0.05	0	
Disappoint. +	0		-0.15	0	
Disappoint., -	0		1.5	0	
Shame, +	0		0.8	0	
Shame, -	0		-0.05	0	

Table 4. Effect of Personality on Emotions (content of PM)
Ad: admiration, Jo: joy, Ho: hope, Pr: pride, Di: disappointment, Re: reproach, *Sh: shame, Fe: fear, Sa: sadness*

	Ad	Jo	Ho	Pr	Di	Re	Sh	Fe	Sa
Pessim.	*	*	VH- (-4)	*	VH+ (4)	*	*	*	VH+ (4)
Optim.	*	*	VH+ (4)	*	VH- (-4)	*	*	*	VH- (-4)
Impuls.	*	L+ (8)	*	*	L+ (8)	L+ (8)	*	L+ (8)	*
Thought.	*	*	*	*	*	*	*	*	*
Selfish	VH- (-4)	*	*	VH+ (4)	*	*	VH- (-4)	*	*
Unself.	*	*	*	*	*	*	*	*	*

Personality has been found to govern emotions in general. For example, susceptibility of extraverts to positive emotions, and neurotics to negative emotions has been shown by Mattheus et al. [26] and Rusting and Larsen [27]. More recent neuro-imaging studies confirmed these findings [28-29]. However, the relation between personality traits and the emotion processes is still not clearly understood [30]. This is probably because of the "difficulty of eliciting strong and differentiated emotional responses in a laboratory environment" [31]. So, at the best of our knowledge, there is no accurate model that maps the effect of personality traits to emotions. That is why we adopted an intuitive model of personality traits' impact on emotions, which is shown in Table 4. We consider the effect of traits on emotions as a regulatory one. Consequently, we calculate the intensity of the emotion after an event has occurred or an action has been decided using Equation (2) which is based on affective intensities and evidence degrees of goals. Then, the emotion's intensity is re-calculated based on the regulatory effect of the personality traits. The set of traits, (pessimistic, optimistic), (impulsive, thoughtful), and (selfish, unselfish), has been taken from Rousseau [23-24]. In Table 4, VH, H, M, and L denote very high, high, medium, and low impact, respectively. The signs + and – are used to express increasing and decreasing effects, respectively. So, for example, H+ means that the trait highly increases the intensity of the emotion. This shall be added to the set-based model of PACAN. Let PM = $\{PM_1, \ldots, PM_n\}$ be the set which represents the impact of personality traits on emotions. For each pm ∊ PM: pm = (p, m, rpm) with p ∊ P, m ∊ M, and rpm ∊ {VH+, VH-, H+, H-, M+, M-, L+, L-, *}. * means no impact. The calculation of the intensity of the emotion M_j is the following:

$$M_j(t+1) = (1 + 1/\mu)\, M_j(t) \tag{3}$$

The value of μ depends on the values VH+, VH-, etc. It is written between brackets in Table 4. It has been set after simulations.

5. Instantiation of specific PACAN characters

PACAN is a generic model because it allows setting parameters to create specific agents and their environment. For example, to validate PACAN, we created three types or "species" of characters: Zed (avatar), Driver (human driver), and Teen (human teenager). For that, G, R, T, V, TD, VG, VM, TG, and TM have to be specified. The sets M and PM are defined by the PACAN model but the instantiation might decide to use subsets of them. A second configuration step consists to specify other PACAN parameters in order to create characters of Zed avatars, human drivers, and teenagers with specific personalities. Therefore, the sets F, D, and P have to be specified.

The calibration of PACAN's parameters has been performed through the implementation of the Zed agent specification, which has been introduced in Section 3. This resulted in the content Table 2, Table 3, and Table 4. The complete specification of Zed is the following:

G = {no-hunger, feed-tribe, respect}.
R = {do-good}.
T = {eat-alone, share}.
V = {food-high, food-low, fed-me}.
M = {joy, sadness, disappointment, hope, admiration}.
P = {{pessimistic, optimistic}, {impulsive, thoughtful}, {selfish, unselfish}}.

The initial content of D and F is shown by Fig. 2. TD, VG, VM, TG, and TM are presented in Table 5–Table 7. The PACAN implementation we performed displays the emotions that are increased by events (+ sign in Table 6). This is intuitive because if a subject is sad, for example, and he perceived a new event that makes him happy, the joy expression on his face is likely to hide sadness.

Table 5. TD Content of Zed

Θ	(e, θ, rtd)	C_{td}
share	do-good, share, +	0.1
	respect, share, +	0.1
	no-hunger, share, -	-0.1
	feed-tribe, share, +	0.1
eat-alone	do-good, eat-alone, -	-0.1
	respect, eat-alone, -	-0.1
	no-hunger, eat-alone, +	0.1
	feed-tribe, eat-alone, +	-0.1

Table 6. VM and TM Content of Zed

	fed-me	food-high	food-low	eat-alone	share
Joy	+	+	-	*	*
Sadness	-	-	+	*	*
Disappointment	-	*	+	*	*
Hope	+	+	-	*	*
Admiration	+	*	*	*	*

Table 7. VG and TG content of Zed

	fed-me	food-high	food-low	eat-alone	share
no-hunger	Y	Y	Y	Y	Y
feed-tribe	N	Y	Y	Y	Y
respect	N	N	N	Y	Y

6. Validation Experiments and Results

PACAN has been implemented in Java with a graphical user interface (see Fig. 3). The latter contains buttons, which correspond to events, and instantly displays emotions and decisions. The user specifies the events. Every time an event is issued, PACAN processes the event and displays its new emotional status and the inferred action.

As stated in Section 5, tuning PACAN's parameters has been done through the example of Zed avatars. Zed is an interesting PACAN implementation because it represents a pattern of many real situations where people have to decide whether to share a scarce resource. This typically happens in situations like after natural catastrophes where food, water, and necessary supplies become scarce. From an educational perspective, Zed represents an illustration of the human emotion dynamics based on environmental events and personality traits that could be interesting to students to analyze and debate in class.

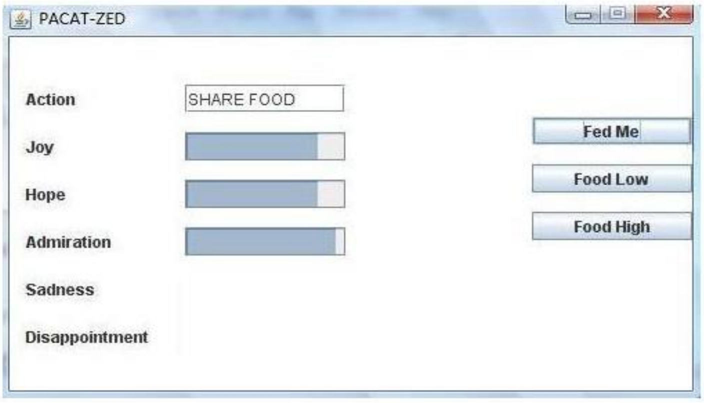
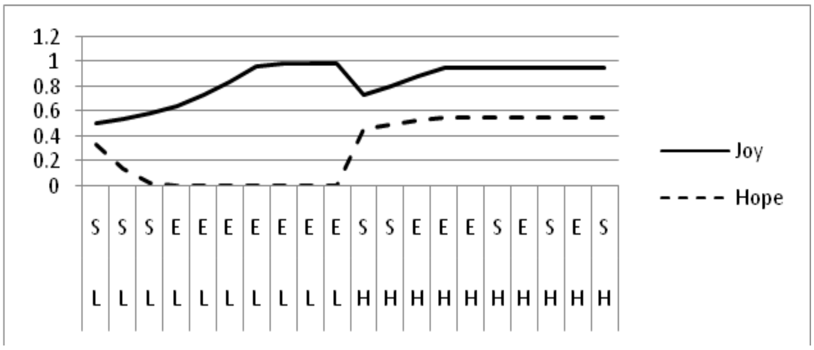


Figure 3. Zed User Interface



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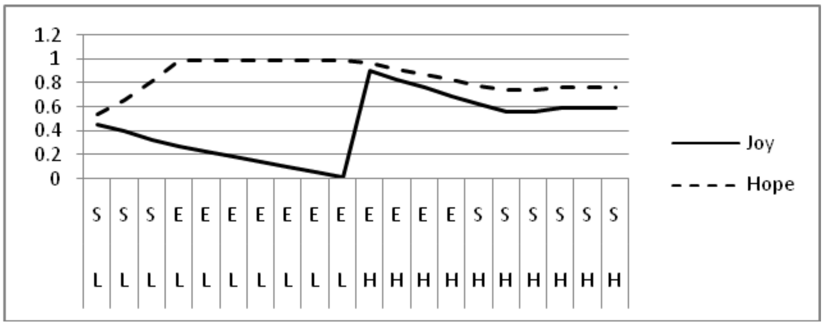

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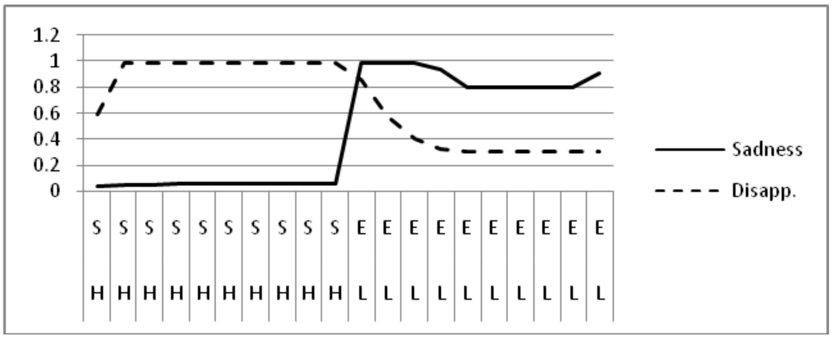

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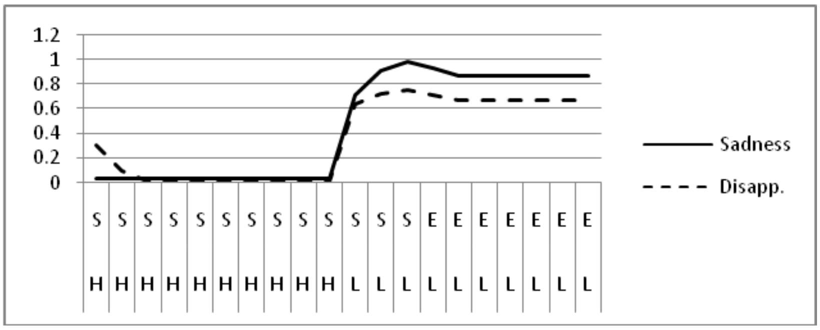

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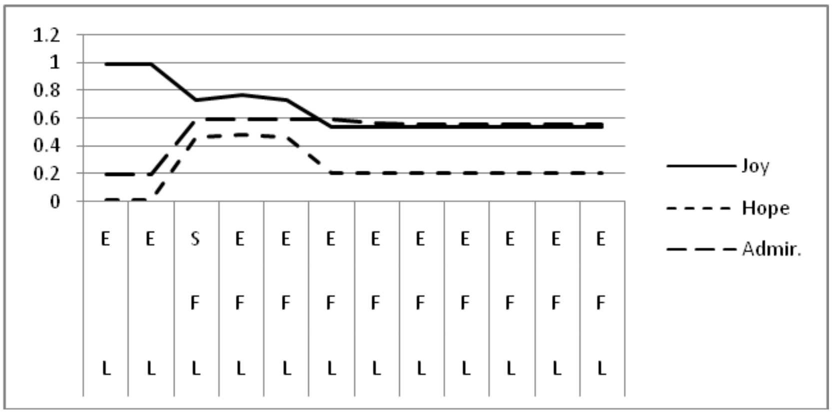

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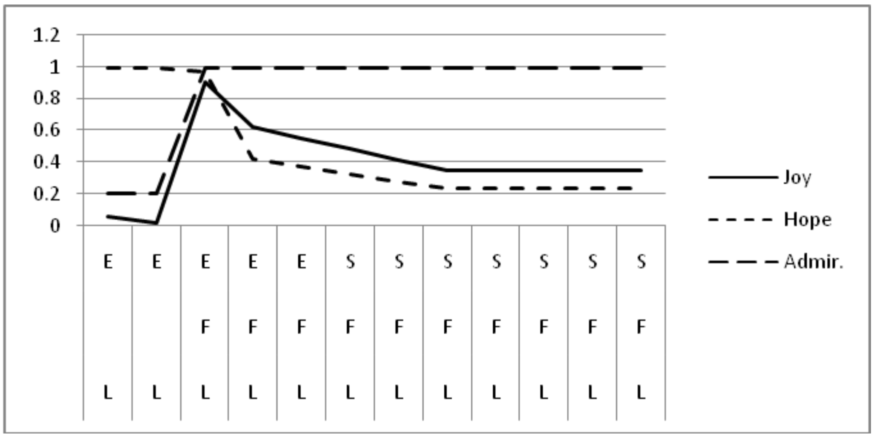

(4.c.2)

Figure 4. Emotional Dynamics of Zed

6.1. Believability Tests of PACAN Characters

Two believability tests have been conducted. In the first one, PACAN has been used to instantiate two PACAN-Zed (or simply Zed) characters. Zed01 is selfish, impulsive, and pessimistic, and Zed02 is unselfish, thoughtful, and optimistic. But instead of interacting through the interface of PACAN, we fed the system with pre-specified series of events that simulate different circumstances. PACAN has been programmed to log the emotional valence and the inferred decision at the end of each iteration. Figure 4 depicts the results. The Figures 4.x.1 relate to Zed01 and the others to Zed02. Figure x.1 and Figure x.2 (same x value) represent the same experiment performed with Zed01 and then with Zed02. For example, the test illustrated by Figure 4.a.1 represents a situation where food quantity has been configured to be low (the letter "L" in the figure) during 10 iterations then to become high (the letter "H" in the figure) during the next 10 iterations. The letters "S" and "E" represent the actions *share* and *eat-alone*, respectively. The valence of joy and hope emotions are considered. As stated earlier, we chose to display only emotions on which the latest event or action has an increasing effect. The letter "F" in Figure 4.c.x represents the event *fed-me*. Figure 4.c.1, for example, represents emotions and decisions of Zed01 during 10 iterations where food kept being low and some other avatars of the tribe fed Zed01 during the last 8 iterations of the test.

In the first believability assessment of PACAN, 26 participants were recruited among faculty members and students of the CCIS College at KS University. For every participant, a 10-minute presentation on Zed01, Zed02, PACAN, and Figure 4 has been done but with no comment on the content of Figure 4. Then, the participant was asked to carefully read Figure 4 and rate in the scale of 0 to 10 how realistic and consistent are these couples of concepts: events and actions, events and emotions, personality and actions, and personality and emotions. Sometimes participants were sitting in the same room but they were instructed not to communicate with each other. Table 8 summarizes the results.

Table 8. Indicators of PACAN-Zed Believability

Events - Actions		**Events – Emotions**		**Personality - Actions**		**Personality - Emotions**	
M	SD	M	SD	M	SD	M	SD
0.78	0.18	0.82	0.14	0.87	0.17	0.85	0.18

When looking to the indicators of PACAN-Zed believability (Table 8) we find that respondents judged the emotions of PACAN-Zed as highly consistent with events (mean=0.82) and personality traits (mean=0.85). They ranked the compatibility of actions with personality traits even higher (mean=0.87) but they felt that actions are less compatible with events (0.78).

In the second believability test, in addition to Zed, two other character types have been programmed. One is called Driver and the other is called Peer. Driver plays the role of a human car driver who has to make the decision whether to drive in the emergency lane in order to avoid traffic congestion. Events are:

- Fast: the driver notices that he is driving fast.
- Slow: the driver notices that he is slowed down by the traffic congestion.
- Gas-low: the quantity of fuel in the car is low.
- Late: the driver notices that he is late for a meeting, for example.
- People-did-it: the driver saw many other drivers going on the emergency lane.

Actions are:

- Go: drive in the emergency lane.
- No-go: do not drive in the emergency lane.

Peer plays the role of a teenager, which is subject to the pressure of his peers who want him to smoke cigarettes like them. Events are:

- With-friends: the teenager is sitting with his friends who are smoking and want him to smoke.
- With-others: he is sitting with his friends who are smoking and want him to smoke. Other teenagers are present.

- With-others-smoke: the same situation as the previous one and the other teenagers are smoking and making pressure on him to do so.

Actions:

- Go: smoke a cigarette.
- No-go: do not smoke.

A believability test has been conducted but this time through having participants interact with PACAN characters via the graphical interface. (This method of research validation has been adopted by Seif Al-Nasr *et al.*, [22]) The same aspects as the previous test have been assessed: the extent at which the effect of the environment and the personality on emotions and decisions of PACAN fits the human common sense. 21 participants were recruited among students of the CS Department at KS University. None of them has participated in the first test. Zed, Driver, and Peer have been installed on a laptop. Two characters of every agent type have been programmed. Zed01, Driver01, and Peer01 are selfish, impulsive, and pessimistic. Zed02, Driver02, and Peer02 are unselfish, thoughtful, and optimistic. The author brought the laptop to the participants' classrooms. Only one participant at a time could use the laptop. Before starting with the simulation, participants were given a five minute introduction to PACAN, Zed01, Zed02, Driver01, Driver02, Peer01 and Peer02, and how to use the graphical interface. Then, they were allowed to use the system during five minutes for every one of the six characters with no interaction with the author or other persons. They were free to choose the order of using the six characters. Every interaction iteration with a character consists to choose an event and see the displayed action decision and emotion change on the screen. Participants have been asked to perform at least five iterations with every character. After that, they were asked to fill out the questionnaire about the believability of Zed, Driver, and Peer, in an anonymous way. The questionnaire consisted to rate in the scale of 0-10 the consistency of the above mentioned couples of concepts. 21 questionnaires have been collected and analyzed. Table 9 summarizes the results.

Table 9. Indicators of the Believability of PACAN-Zed, PACAN-Driver, and PACAN-Peer

	Events - Actions		**Events - Emotions**		**Personality - Actions**		**Personality - Emotions**	
	M	SD	M	SD	M	SD	M	SD
Zed	0.74	0.16	0.76	0.13	0.83	0.16	0.84	0.18
Driver	0.84	0.08	0.81	0.11	0.88	0.11	0.91	0.07
Peer	0.75	0.10	0.71	0.14	0.77	0.18	0.79	0.19

From Table 9, we find that the indicators of PACAN-Zed believability (Table 9, line 1) are not very different from those collected during the previous test (Table 8). The greatest difference between the two tests relates to the consistency of events-emotions, which has decreased by 7% (mean=0.82 to mean=0.76). Believability of PACAN-Peer is similar to the one of PACAN-Zed except that events-emotions is relatively low (mean=0.71). PACAN-Driver is the most believable character (mean=0.81-0.91). If we compare the results of the three characters we find that personality-emotions is more believable than personality-actions, and the latter more than events-emotions and events-actions.

To conclude, we can say that the believability of PACAN characters has ranged from 0.71 (minimum mean value in Table 8 and Table 9) through 0.91 (maximum mean value in Table 8 and Table 9).

6.2. Emergent Behavioral Properties of PACAN-Zed

A "second order" validation of PACAN-Zed has been to compare our simulation results with those of some relevant cognitive studies. Interestingly, two behavioral aspects of PACAN-Zed have been identified as fitting proved cognitive facts. These are emergent properties that have not been intentionally designed and implemented in PACAN. This analysis has not been conducted with PACAN-Driver and PACAN-Peer.

- Positive mood implies more risky choices

This has been proved through the study reported by De Vries *et al.*, [32]. This behavioral aspect has been experienced by Zed01. When food became suddenly abundant, joy increased, which pushed him to share food twice (despite he is selfish) and then he stopped sharing (Figure 4.a.1). This happened again with Zed01 when he has been rescued during food scarcity. He shared food once as his joy increased and then he continued eating alone again (Figure 4.c.1). However, Zed02 has not shown such a behavior. These observations reveal the importance of studying the relation between personality traits and the results of De Vries *et al.*, [32].

- Recent decisions condition subsequent ones

This has been the conclusion of the study conducted by Avrahami and Kareev [33]. Zed02 has experienced this behavior pattern. Indeed, when circumstances changed, Zed02 did not abruptly changed his action to eat alone or to share food. He waited a few cycles before changing his behavior (Figure 4.a.2, Figure 4.b.2, Figure 4.c.2). The fact that Zed01 did not behave according to this pattern suggests that the result of Avrahami and Kareev [33] could be biased by the personality traits. This merits further investigation.

At the end of the test sessions, some participants verbally commented on their experience. The author manually recorded their remarks. Interestingly, two behavioral patterns have been noticed by some participants:

- Regret. 6 participants considered as regret the fact that Zed01 suddenly decided to share food then he stopped sharing (Figure 4.a.1 and Figure 4.c.1).
- Compromise. 5 among the previous 6 participants have seen as compromise the fact that Zed01, at the end of Figure 4.a.1 has decided to alternate sharing food and eating alone.

7. Conclusion

In this paper, a Programmable Agent based on the Cognitive Attraction Networks (PACAN) has been built and tested. PACAN is meant for role-playing, primarily for education and training purposes. The programmability of PACAN allows the user to set the environment of the character, its personality traits, and its emotions. To augment the believability of PACAN, a model of emotions and a model of personality have been integrated.

To validate PACAN, three sorts of characters have been created: an avatar living in a tribe where food is sometimes scarce and having to decide whether to share food, a car driver who is late for a meeting and hesitating to drive in the emergency lane, and a teenager subject to peer pressure to smoke cigarettes. Two different characters of these three have been programmed by specifying particular personality traits. Every character has to make decisions after perceiving new events. A first validation test consisted in having participants assess the emotion and action evolution graphs of the avatar character obtained after the author interacted with the avatar by specifying events and recording emotions and actions. Another test has been to have participants interact with each of the six characters through the graphical interface. They specified the events and observed the emotions and actions of every character. Then, participants have been asked to rate the believability of the characters. Results suggest that PACAN's believability ranges from 71% through 91%.

Despite PACAN is meant for education and training, its usefulness for this particular purpose has not been measured. This is left for a future work where we intend to deploy it for teaching and training and measure the relevant educational indictors. Another limitation could have emanated from the fact that participants have rated the believability of the driver's behavior as the highest compared with the avatar and the teenager characters. This might be because our participants, being students, understand better or even over-estimate the feelings and behaviors of anxious drivers, while they do not well understand feelings and behaviors of avatars and teenagers. This suggests that our results might have been biased by the participants' demographics. This merits a future investigation as well.

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