Beyond Traits: Social Context Based Personality Model

Jaroslaw Kochanowicz
Institute for Media Innovation,
School of Computer Science
Nanyang Technological
University
Singapore 637553
jarek108@gmail.com

Ah-Hwee Tan
School of Computer Science
Nanyang Technological
University
Singapore, 639798
asahtan@ntu.edu.sg

Daniel Thalmann
Institute for Media Innovation
Nanyang Technological
University
Singapore 637553
danielthalmann@ntu.edu.sg

ABSTRACT

The relation between individual's personality and environmental context is a key issue in psychology, recently also in character simulations. This paper contributes to both domains by proposing a socio-cognitive, contextual personality model - a new voice in a century old problem of personality, but also an approach to simulating groups of more human-like agents. After analyzing the influence of popularity of 'trait personality models' on psychology and computer simulation, we propose Social Context based Personality model - a continuation and specification of the Cognitive-Affective Personality System theory. The discussion, model and implementation are provided, followed by an example application in a domain of school bullying. Extensive simulations were conducted as model's validation, showing model's potential in generation of contextual and multidimensional personalities both for individual and group simulations.

Categories and Subject Descriptors

I.2 [**Artificial Intelligence**]: General

Keywords

personality; multi-agent systems; social simulation

General Terms

Design, Human Factors, Verification

1. INTRODUCTION

The relation between individual's personality and environmental context is a traditional key issue in psychology, recently also becoming relevant in character simulations, from entertainment to serious cognitive and social simulations. This paper contributes to both domains by proposing Social Context based Personality (SCP) model. SCP is grounded in the relevant theory and research results, formalized, implemented for an example domain and the produced results are validated, proposing not only a new voice in a century old 'personality dispute', but also a promising approach to simulating more human-like groups and agents.

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1.1 Personality and simulations

Since psychology's early days, the concept of personality embodied the assumption that relevant individual features persist over lifetime and through contexts. Despite a century of intensive efforts to identify cross-situational consistencies, this assumption remains surprisingly unfruitful [28] and dispositional differences between individuals are smaller than changes within individual between situations [13]. A parallel and opposing tradition also exists: from Durkheim, Goffman to Collins, researchers undermined the importance of the individual traits, reducing individuals to containers of affects and cognitions manipulated by true sources of social agency: situations. This century old duality, branded 'the most persistent cleavage in the social sciences' [12], reappears in the computational modeling. In the last three decades, the development of robotic and virtual artificial humans (AH) went through extreme growth [41], as crucial in training, advertising and entertainment. Less obviously, also multi-agent or agent based social simulations are at the point where quality of non-rational components (including personality) is increasingly pointed out as the major limitation by agent system researchers [21, 20].

1.2 Beyond the 'trait models'

As affect modeling became a new field, standards in methodologies and representations appeared i.e. Five Factor Model (FFM) [26] as a personality model, PAD [27] as a mood etc. FFM's domination in AH models can be partly explained by its simple form, easily and convenient obtainable from questionnaires. This comes at a price, as application of FFM-like models in AH implies serious limitations. Drawbacks of 'trait models' are multiplied when they are used as generating mechanisms. They are designed as the analytical behavior descriptions, not as actual cognition prescriptions - a fact vastly ignored in AH modeling. As average attitude models, they generate uniform, unstructured personality undermining psycho-sociological believability by ignoring contextual cognitive-affective changes. In psychology, McAdams refers to FFM as describing 'surface, easily noticeable aspects of personality and neglecting more private or **context-dependent ones**' [24]. Practically, open or neurotic FFM-AH is open or neurotic without individualized situational variability - a flat, predictable character failing to surprise in a new context like a peaceful person, raging in a car. This critique is not exclusively aimed at FFM, other 'trait models', like PEN [14] share those issues.

Cognitive-Affective Personality System (CAPS) theory [28] - the empirically supported approach promising to concili-

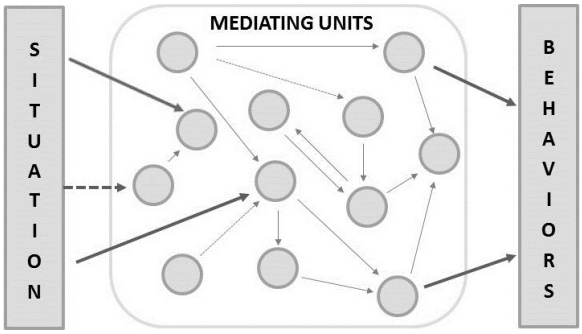

Figure 1: A high-level of abstraction of CAPS

ate the parties of the 'personality controversy', emerged recently. CAPS redefines personality - it is no longer a trait-set stable across contexts, but a pattern in a context based disposition changes - not 'what you really are' but 'what you are in which context'. Postulated changes result from activations in a network of cognitive-affective mediating units. Despite little research on intra-personal variability, much data currently supports CAPS, it is 'consistent with parallel findings showing significant amounts of variance attributable to Person X Situation interaction.' [6] and it has been determined empirically that distinctive and meaningful profiles of situation-behavior relations in fact characterize individual differences [28]. While promising, CAPS raises two related issues. To define personality in terms of context responses, one must define different contexts clearly. Such definition should ideally not be liberal - it must follow the psychologically relevant structure of situation. This is however problematic, as 'there is no consensus regarding the most important "psychologically active features of situations"' [1]. Secondly, if changes in dispositions are due to the network of hidden mediating units, what is their nature and how are they connected? Both issues are left unsolved by CAPS addressing them at high abstraction level (Figure 1).

1.3 Research problem

The social and AH simulations need 'contextual', not just 'trait' personalities. While CAPS provides a foundation recognized by psychologists, it is too abstract for such application. It is uncertain which mediating unit types are relevant, how they are linked, how to parametrize them etc. CAPS as a theory needs a specific computational model and an approach to its application in actual simulations, preferably with an application example. For this purpose, the available research indicating influence of the context cognitions on behavioral disposition must be analyzed, relevant elements selected as mediating units and their connections specified. This theoretical contribution must be followed by a technical one: mediating units must be translated to formulas and a computational model implemented, parametrized and used in a specific domain. Generated results must be validated. By answering specific research questions using psychological data, eventual superiority to 'trait models' must be verified to prove feasibility of the model and the entire approach. This paper addresses all above aspects.

1.4 Article outline

Section 1 discusses psychological personality models, like FFM [2] and their consequences for social simulation and character modeling. Cognitive-Affective Personality System (CAPS) theory is identified as a promising starting point for solving those issues. Section 2 contains theoretical foundations (including discussion on overcoming limitations of CAPS, the role of social prototypes, connectionism and FFM in SCP). Section 3 is a presentation of SCP - a connectionist model grounded in research analyzing social context influence on personality states and behavioral dispositions. Section 4 is SCP's specification to the domain of bullying, serving both as a practical example and a base for validation of the underlying model principles. Simulations using this specification are described in Section 5, while Section 6 analyses their results in the context of the research questions. Section 7 contains summary.

2. APPROACH BEHIND SOCIAL CONTEXT BASED PERSONALITY MODEL

Before implementation and verification of SCP is possible, a number of theoretical issues must be adressed. First, certain social prototypes and their activating features are identified as the candidates for mediating units. Next, the role of FFM as states (not traits) is described. Finally, application of connectionist methodology is justified, and the connections between the mediating units are discussed.

2.1 Social prototypes as mediating units

The key problem of CAPS is an unlimited number of candidates for the relevant context elements and their cognitive encodings. Two initial observations are important. First, human cognition is inherently social to a degree that in terms of personality modulation a 'context' is approximated by the 'social context' in SCP. Secondly, human 'natural categories' are organized around 'prototypes' - reference points [30]. Social cognition is shaped by prototypical encodings [5] - humans not only store concrete information about the individuals or situations but also abstract representations and their features. Relevant prototype-related units are identified below.

Role prototypes. The influence of the primed social role on the personality states shows stable regularities [28]. Roles are substantial predictors of state manifestations and 'social role with its immanent demands is a reasonable concept for contextualizing personality' [1]. Also beliefs about the roles of others predict behavior [32] and attitude to others is based on roles attributed to them [31].

Group prototypes. The group identification is also a well established personality modulator. People identifying with a group behave differently and 'saliency of the group affects the perception of the environment' [8]. Moreover, people primed to see different group as relevant change differently, e.g. self-identifying as a general 'football fan' versus specific 'team follower' changes behavior dramatically [22]. Criminal, religious, professional and other groups are also known to lead to specific inclinations.

Situation prototypes. A situation is the broadest context representation, collective 'meaningful environment encountered by an individual at a given time' [9]. Research [39] proves that situation classes are good disposition predictors and everyday prototypical categorizations are highly shared: 'Naive perceivers agree about person-situation matches, sharing knowledge of the most prototypic behaviors and personality types associated with different types of situations. The

findings suggested that such knowledge about social situations might prove useful for the perceiver as actor to plan and regulate behavior.' [5].

Prototype features. Selecting social prototype classes, requires an inclusion of the features relevant to their activation as mediating units. Roles, groups and situations have been well studied in that regard. There is a consensus [1] that main dimensions in social role activations are perceived power and warmth. In the case of situations, valence and authority presence were noted as relevant [17], while for the groups, perceived competence and amiability are key dimensions [11]. Additionally, presence of specific, secondary features like symbols, uniforms or behaviors may also be linked to some prototypes and SCP accounts for that.

In summary, despite the innate inaccessibility of the cognitive process, prototypical encodings of social roles, groups and situations were linked to personality state changes, selected as mediating units and included with their activating features. This is justified by the discussed results and by the general evolutionary perspective on human cognition as specialized to support complex, abstract social structures. Notably, unlike their objectified, external correlates conceptualized in sociology, social roles, groups or situations as prototypical cognitions are inter-subjective i.e. subjective but partly synchronized between individuals. Crucially, both conditions of prototype activations and their effect on behavior are expected to vary between individuals. This intuition is proven empirically [38, 1] and inter-personal variability must be incorporated in the model.

2.2 FFM and mediating units: traits to states

Strong criticism of FFM as a personality model is not a postulate to eliminate it altogether. Instead of measuring static personality traits, it could be used to indicate transient states, understood as current behavioral tendency. Fortunately, this strategy was investigated in psychology. 'Personality states are considered as trait-content manifestations in short-term, continuous and concrete ways of acting, feeling and thinking that could be described in the same way as traits' [1]. The same source concludes, that as individuals on average can be described by FFM's values, so can their current behavioral disposition. FFM's five features as mediating units make perfect SCP 'output' layer also for two other reasons. First, it would make SCP a 'black-box, dynamic FFM' altering FFM values by hidden context interpretation. It could instantly take place of FFM in any architecture using it without other architectural changes - a relevant strength, considering FFM's popularity. Secondly, FFM is well investigated in terms of influences from other units, making it easier to obtain the parametrization data.

2.3 Connectionism and mediating unit links

Due to the mediating unit *network* description provided by CAPS and the associative nature of the prototypical representations, choice was made to implement model using connectionist methodology. Also, extensive research on learning of such models will support planned future automatic application of SCP to new domains. This decision is also supported by the success of previous connectionist cognition models. Data about social prototype connections and their influence on personality states is scarce, spread among sources of different focus and methodology. Nevertheless, unmediated influence of social prototypes on personality states [1] is known. Personality shift related to e.g. role activation has relatively stable consequences for a given individual and is independent of other factors, like active goals. Therefore SCP assumes a direct link from social prototypes to dispositions. Also, an assignment of a role, group or situation prototypes influences each other, e.g. data on bullying [32] shows that situations ('cantina meetings', 'field drills') alter probabilities of role assumptions, similarly research on school life [17] reports that perceived role feasibility was influenced by 'lesson' or 'break' situations. Therefore SCP includes direct links between roles, situations and groups. It is important to note that SCP is a connectionist, but not a sub-symbolic model. All units and connections have easily verbalized, clear interpretations and SCP avoids drawback of many connectionist models often lacking in transparency or explainability.

3. PROPOSED MODEL

In this section, a Social Context based Personality model (SCP) is presented as an extension of CAPS based on the above discussion. First, the general architecture will be described, followed by the details of data processing.

3.1 General architecture

SCP consists of mediating units implemented as neurons, organized in several clusters, in four layers (Figure 3).

Input layer (I). Observed behaviors, objects, locations etc. trigger social prototypes, depending on the simulation. Such perceived elements are represented by units in this layer.

Feature layer (X). Abstract and more simulation independent features of context are represented in this layer in three classes related to social roles (**Xr**), groups (**Xg**) and situations (**Xs**). Xr includes general role indicators (power and warmth) and role-specific symbols (e.g. age, formal position etc.). Similarly, Xg and Xs contain general group (competence, amiability) and situation (valence, authority presence) indicators and specific group-symbols (uniform, flag etc.), and situation-symbols (time, place, objects etc.).

Prototype classification layer (Y). Actual social prototypes are represented in this layer. Three mediating unit classes are: social role classification of agents (**Yr**), situation classification (**Ys**) and social group classification (**Yg**). Neuron activations in those clusters represent agent's hypothesis that given prototype exists in current context.

Personality state layer (Z). Personality state changes induced by social context are grouped in this layer. Specifically, each of the FFM value is implemented as a unit whose activation indicates a shift in the given dimension.

The connections between the above clusters represent associative influences (Figure 2). Feature activating **(Ir, Ig, Is)** connections excite the feature layer based on the observation inputs. Feature to prototype **(Wr, Wg, Ws)** connections activate prototypes fitting to the current active features. Inter-prototype class connections **(Vrg, Vgr, Vrs, Vsr, Vsg, Vgs)** represent associations between the role, situation and group prototypes (e.g. 'lesson' situation may have excitatory influence on a 'teacher' role but inhibitory on a 'clown'). Intra-prototype class **(Vrr, Vss, Vgg)** connections are mostly inhibitive links implementing competition between prototypes of a given type. Disposition changing connections **(Pr, Pg, Ps)** induce personality state related to the activated prototypes.

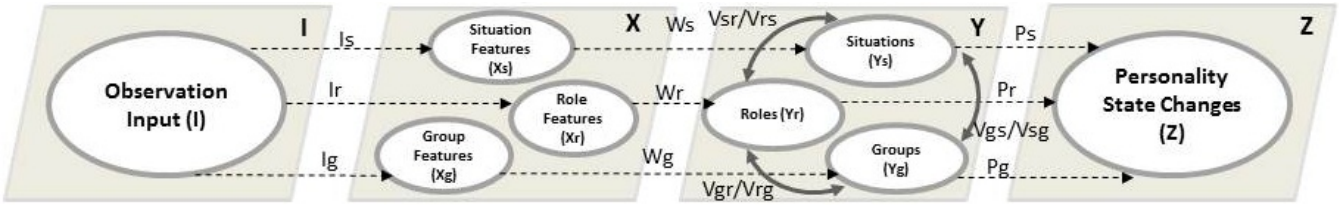

Figure 2: The SCP model

3.2 Details of data processing

All units are implemented as neurons, with activation and weight values ∈ [-1, 1]. Neurons in the clusters differ in type. The specifics of their processing are described below. Essential processing is performed in the prototype classification layer (Y). Role (Yr) and role feature (Xr) clusters exist in multiple instances, one for each of the maximum N perceived agents (including self), while situation and group prototypes and features uniquely describe global context. Circular local-global exchange between the individual roles (Yr) and situation/group (Ys/Yg) resembles the bottom-up and top-down flow also found in other cognition models [25].

3.2.1 Naming convention

Units in a given cluster are referred to with a lower index (e.g. Xg_i represents the activation of the i-th social group prototype), with roles and role features additionally indexed with agent number (e.g. $\mathrm{Xr}_{n,i}$ and $\mathrm{Vr}_{n,i}$ are i-th role feature and role prototype (respectively) of the n-th perceived agent). Connections are indexed with source and destination indexes (e.g. $\mathrm{Ws}_{i,j}$ is a connection between the i-th situation feature and the j-th situation prototype), again additional index in roles and role feature connections indicates an agent number (e.g. $\mathrm{Wr}_{n,i,j}$ refers to a connection between i-th role feature and j-th role prototype, for the n-th agent).

3.2.2 Input-to-feature processing

The input layer is a point of contact with the external world, and it's structure depends completely on the specific simulation environment. Similarly, while a list of relevant prototypes or features may be selected relatively stably for a given problem (e.g. 'defender' or 'victim' as roles in a bullying problem) their specific activation method relies on the simulation frame. Therefore, unlike with the prototype and personality state layers, it is impossible to generally prescribe them, however next section shows how this may be done for a specific domain.

3.2.3 Feature-to-prototype processing

A prototype classification constitutes the most complex SCP processing. It consists of four phases: the feature classification (using Wg, Ws and Wr), the excitation through associations with other prototype classes (Vrg, Vgr, Vrs, Vsr, Vsg, Vgs), the inhibition in competition with elements of the same class (Vrr, Vss, Vgg) and the energy release phase.

3.2.4 Feature classification

In the feature classification phase, prototype neurons act as radial basis neurons. The Gaussian function

$$\rho(\|\mathbf{x}\|) = exp(-\|\mathbf{x} - \mathbf{c}\|) \tag{1}$$

often used with the Euclidean norm, creates a symmetrical Gaussian 'bell' curve. Instead, prototype neuron is not only parametrized by Gaussian curve center (**c**), but also by it's spread over the input dimension (**d**). This allows to define prototypes not only in terms of feature medians, but also their standard deviations, shaping the Gaussian curve accordingly. Resulting multidimensional Gaussian function takes the following general form:

$$\rho(x) = exp\left(-\sum_{i=1}^{n} \frac{(x_i - c_i)^2}{2d_i^2}\right) \tag{2}$$

As a result, in each step, the social role activation change due to feature classification, is given by:

$$\Delta_c \mathrm{Yr}_{n,j} = exp\left(-\sum_{i=1}^{|\mathrm{Xr}_n|} \frac{(\mathrm{Xr}_{n,i} - \mathrm{Hr}_{n,i,j})^2}{2\mathrm{Dr}_{n,i,j}^2}\right) \tag{3}$$

where $\mathbf{Hr}_{n,i,j}$ is prototype's center and $\mathbf{Dr}_{n,i,j}$ is the standard deviation in each of the feature space dimensions. The social situation activation change due to the feature classification, is equal to:

$$\Delta_c \mathrm{Ys}_j = exp\left(-\sum_{i=1}^{|\mathrm{Xs}|} \frac{(\mathrm{Xs}_i - \mathrm{Hs}_{i,j})^2}{2\mathrm{Ds}_{i,j}^2}\right) \tag{4}$$

with $\mathbf{Hs}_{i,j}$ and $\mathbf{Ds}_{i,j}$ as center and standard deviation respectively. Finally, the social group activation change due to feature classification, is equal to:

$$\Delta_c \mathrm{Yg}_j = exp\left(-\sum_{i=1}^{|\mathrm{Xg}|} \frac{(\mathrm{Xg}_i - \mathrm{Hg}_{i,j})^2}{2\mathrm{Dg}_{i,j}^2}\right). \tag{5}$$

with $\mathbf{Hg}_{i,j}$ and $\mathbf{Dg}_{i,j}$ as center and standard deviation.

The medians and deviations must be provided for all prototype-feature combinations, ideally based on the research data (parameterization example contains more details). After the values changes for all the prototypes are calculated, the actual activation values are updated before the next phase:

$$\mathrm{Yr'}_{n,j} = (1 - \mathrm{s}_c) * \mathrm{Yr}_{n,j} + \Delta_c \mathrm{Yr}_{n,j} * \mathrm{s}_c, \tag{6}$$

$$\mathrm{Yx'}_j = (1 - \mathrm{s}_c) * \mathrm{Yx}_j + \Delta_c \mathrm{Yx'}_j * \mathrm{s}_c, \text{ (x is s or g)} \tag{7}$$

where $\mathbf{s}_c$ is a classification phase step size, **Yr'**, **Ys'** and **Yg'** are the new, updated prototype activation values.

Prototype association phase.

After feature classification, the role, group and situation prototypes alter each other's probabilities based on their associations, e.g. certain roles are less probable in some

social groups or situations. In this phase, prototypes act as a simple energy exchanging system, in which each prototype excites prototypes positively associated with it and inhibits negatively associated ones. Specifically, change in the social role activation due to associations ($\Delta_a \mathbf{Yr}$) is given by:

$$\Delta_a \mathrm{Yr}_{n,j} = \frac{\sum_{i=1}^{|\mathrm{Yg}|} \left(\mathrm{Vgr}_{n,i,j} * \mathrm{Yg}_i\right)}{\mathrm{InYr}_{n,j}} + \frac{\sum_{i=1}^{|\mathrm{Ys}|} \left(\mathrm{Vsr}_{n,i,j} * \mathrm{Ys}_i\right)}{\mathrm{InYr}_{n,j}}.$$

where **InYr** is the incoming connection weight sum:

$$\mathrm{InYr}_{n,j} = \sum_{i=1}^{|\mathrm{Yg}|} |\mathrm{Vgr}_{n,i,j}| + \sum_{i=1}^{|\mathrm{Ys}|} |\mathrm{Vsr}_{n,i,j}|. \quad (8)$$

Scene activation change due to associations equals:

$$\Delta_a \mathrm{Ys}_j = \frac{\sum_{i=1}^{|\mathrm{Yg}|} \left(\mathrm{Vgs}_{i,j} * \mathrm{Yg}_i\right)}{\mathrm{InYs}_j} + \frac{\sum_{n=1}^{N} \sum_{i=1}^{|\mathrm{Yr}_n|} (\mathrm{Vrs}_{n,i,j} * \mathrm{Yr}_{n,i})}{\mathrm{InYs}_j}, \quad (9)$$

where **InYs** is the incoming connection weight sum:

$$\mathrm{InYs}_j = \sum_{i=1}^{|\mathrm{Yg}|} |\mathrm{Vgs}_{n,i,j}| + \sum_{n=1}^{N} \sum_{i=1}^{|\mathrm{Yr}_n|} |\mathrm{Vrs}_{n,i,j}|. \quad (10)$$

Finally, group activation change due to associations equals:

$$\Delta_a \mathrm{Yg}_j = \frac{\sum_{i=1}^{|\mathrm{Ys}|} \left(\mathrm{Vsg}_{i,j} * \mathrm{Ys}_i\right)}{\mathrm{InYg}_j} + \frac{\sum_{n=1}^{N} \sum_{i=1}^{|\mathrm{Yr}_n|} \left(\mathrm{Vrg}_{n,i,j} * \mathrm{Yr}_{n,i}\right)}{\mathrm{InYg}_j}, \quad (11)$$

where **InYg** is the incoming connection weight sum:

$$\mathrm{InYg}_j = \sum_{i=1}^{|\mathrm{Ys}|} |\mathrm{Vsg}_{i,j}| + \sum_{n=1}^{N} \sum_{i=1}^{|\mathrm{Yr}_n|} |\mathrm{Vrg}_{n,i,j}|. \quad (12)$$

Activation values are updated before the next phase:

$$\mathrm{Yr'}_{n,j} = (1 - \mathrm{s}_a) * \mathrm{Yr}_{n,j} + \mathrm{s}_a * \Delta_a \mathrm{Yr}_{n,j}, \quad (13)$$

$$\mathrm{Yx'}_j = (1 - \mathrm{s}_a) * \mathrm{Yx}_j + \Delta_c \mathrm{Yx'}_j * \mathrm{s}_a, \text{ (x is s or g)} \quad (14)$$

where $\mathbf{s}_a$ is a simulation specific association phase step size and **Yr', Ys'** and **Yg'** are the new prototype activations.

Prototype inhibition.

After association influence is included, prototypes within one class inhibit each other to avoid multiple, inconsistent classifications. Therefore weights within one class are mostly negative, with the exception of neutrally/positively correlated exemptions (e.g. 'partner' and 'friend'). The activation changes due to inhibition equal:

$$\Delta_i \mathrm{Yr}_{n,j} = \sum_{i=1}^{|\mathrm{Yr}_n|} \left(\mathrm{Vrr}_{n,i,j} * \mathrm{Yr}_{n,i}\right), \quad (15)$$

$$\Delta_i \mathrm{Yx}_j = \sum_{i=1}^{|\mathrm{Yx}|} \left(\mathrm{Vxx}_{i,j} * \mathrm{Yx}_i\right), \text{ (x is s or g)} \quad (16)$$

the updated activation values take the following form:

$$\mathrm{Yr'}_{n,j} = (1 - \mathrm{s}_i) * \mathrm{Yr}_{n,j} + \Delta_i \mathrm{Yr}_{n,j} * \mathrm{s}_i, \quad (17)$$

$$\mathrm{Yx'}_j = (1 - \mathrm{s}_i) * \mathrm{Yx}_j + \Delta_c \mathrm{Yx'}_j * \mathrm{s}_i, \text{ (x is s or g)} \quad (18)$$

where $\mathbf{s}_i$ is a simulation specific inhibition phase step size and **Yr', Ys'** and **Yg'** are the new prototype activations.

Energy release.

The final processing stage in prototype layer is the energy release. It allows activated prototypes to 'cool down' when the conditions exciting them pass. This is realized by:

$$\mathrm{Yr'}_{n,j} = max(0, \mathrm{Yr}_{n,j} - \Delta_r), \quad (19)$$

$$\mathrm{Yx'}_j = max(0, \mathrm{Yx}_j - \Delta_r), \text{ (x is s or g)} \quad (20)$$

where Δ_r is the energy release speed.

3.2.5 *Personality state change layer*

SCP uses FFM, as agent's temporary disposition due to social context interpretation. For this purpose, the personality state change layer contains one neuron for each of the FFM states (Z_i, $\mathrm{i} \in \{1, 2, 3, 4, 5\}$). In each simulation step, the dispositional change for each dimension is:

$$\Delta \mathrm{Z}_j = \frac{\sum_{i=1}^{|\mathrm{Ys}|} \left(\mathrm{Ps}_{i,j} * \mathrm{Ys}_i\right)}{\mathrm{InP}_j} + \frac{\sum_{i=1}^{|\mathrm{Yg}|} \left(\mathrm{Pg}_{i,j} * \mathrm{Yg}_i\right)}{\mathrm{InP}_j} + \frac{\sum_{n=1}^{N} \sum_{i=1}^{|\mathrm{Yr}_n|} \left(\mathrm{Pr}_{n,i,j} * \mathrm{Yr}_{n,i}\right)}{\mathrm{InP}_j}, \quad (21)$$

where

$$\mathrm{InP}_j = \sum_{i=1}^{|\mathrm{Ys}|} |\mathrm{Ps}_{i,j}| + \sum_{i=1}^{|\mathrm{Yg}|} |\mathrm{Pg}_{i,j}| + \sum_{n=1}^{N} \sum_{i=1}^{|\mathrm{Yr}_n|} |\mathrm{Pr}_{n,i,j}|.$$

Finally, the new personality state - Z', is given by:

$$\mathrm{Z'}_j = (1 - \mathrm{s}_p) * \mathrm{Z}_j + \mathrm{s}_p * \Delta \mathrm{Z}_j, \quad (22)$$

4. PARAMETRIZATION EXAMPLE

This section contains SCP application in a specific domain. The problem of bullying has been selected for this purpose, due to a relatively extensive research on psychological consequences of the social context components allowing stricter validation compared to the previous models [21]. First, the basic assumed constants are presented, followed by parameters related to input, feature and prototype layers. Finally, the degree of data completeness is discussed.

4.1 Parametrization procedure and strategies

The SCP parametrization includes determinations: a) role, situation and group prototypes; b) associations between them; c) their link to personality states; d) prototype features; e) their link to prototype activations; f) identification of the input elements; g) their link to feature activation; h) SCP

Table 1: Role influence on personality[1,36].

	O	C	E	A	N
Friend	-0.18[1]	0[1]	0.52[1]	0.2[1]	-0.1[1]
Student	-0.09[1]	0.38[1]	-0.24[1]	0.12[1]	0.08[1]
Bully	0.15[36]	-0.21[36]	0.31[36]	-0.19[36]	0.22[36]
Victim	-0.07[36]	-0.35[36]	-0.23[36]	-0.26[36]	0.31[36]
Defender	0.11[36]	0.36[36]	0.29[36]	0.42[36]	-0.36[36]
Outsider	-0.13[36]	0.41[36]	-0.27[36]	0.04[36]	-0.10[36]

Table 2: Role associations[4]. * is questionnaire data

	(1)	(2)	(3)	(4)	(5)	(6)
(1)Student	0	-0.07*	-0.23*	-0.15*	-0.17*	0.02*
(2)Friend	-	0	-0.55*	-0.19*	0.3*	-0.21*
(3)Bully	-	-	0	0.33[4]	-0.0[4]	-0.39[4]
(4)Victim	-	-	-	0	0.11[4]	0.2[4]
(5)Defender	-	-	-	-	0	0.09[4]
(6)Outsider	-	-	-	-	-	0

influence on agent architecture using it, e.g. by linking unit activations with agent action or plan probabilities. Solutions to a)-e) are domain specific i.e. are shared by simulations within a given domain, while f)-h) are simulation specific and will vary within domain with time scale, detail level, focus etc.

A model parametrization should ideally be based on the solid research as much as possible. At the same time, investigation of contextual influence on personality state expressions is a relatively new and unexplored perspective, data in most domains is scarce and incomplete at best and depending on the application (e.g. entertainment vs. scientific) criteria may vary. While in serious social simulations using SCP, it is reasonable to obtain such data as part of the effort, in smaller applications it may be reasonable to find a compromise between existing data, own research and common sense. Also entertainment oriented projects using SCP for rich character generation may focus on subjective believability tests rather than actual human data, as appeal not realism is their goal. While all those strategies are valid in some cases, an example parametrization presented relies on the existing scientific research wherever possible (around 70% of parameters) and own questionnaires investigating correlations between social prototypes.

4.2 Domain selection and basic assumptions

Model and approach validation requires implementation in a specific domain. To base parametrization on sound research, a well researched domain with rich multi-agent interaction is needed. The problem of bullying meets this criteria. Due to an extensive research on the relevant social context components and their psychological consequences, a more data based model and stricter model validation are enabled. Below, the basic parametrization assumptions are listed:

- max. number of agents assigned the roles in perception is five, first position is observer's self image.

- external agent roles share feature distributions and associations with other units, i.e. $\mathrm{Wr}_n = Wr_m$, $\mathrm{Pr}_n = Pr_m$, $\mathrm{Vgr}_n = \mathrm{Vgr}_m$, $\mathrm{Vrs}_n = \mathrm{Vsr}_m$, for N=5 $\geq m, n > 1$.

- prototype associations are symmetrical i.e. Vgr = Vrg, Vgs = Vsg, Vrs = Vsr.

Table 3: Role features[29]

		Bully	Victim	Defender	Outsider
Schol. comp.	mean	2.3	2.8	3.9	3.2
	deviation	0.65	0.66	0.51	0.65
Social acc.	mean	2.5	2.9	4.3	3.3
	deviation	0.8	0.65	0.52	0.65
Appearance	mean	2.10	2.5	3.1	2.50
	deviation	0.72	0.68	0.65	0.89
Conduct	mean	2.20	3.19	4.2	3.50
	deviation	0.34	0.33	0.38	0.48

4.3 Prototypes and personality states

The first task at hand was a relevant prototype selection. Many studies have demonstrated the existence of meaningful role prototypes and a general consensus exists. Most researchers name Bully, Defender, Outsider, and Victim roles (capital letters indicate specific mediating unit) as the key ones, some add additional, e.g. aggressor roles: Assistant and Reinforcer [16]. For our purposes, the four most popular roles were sufficient. Their associations and influence on personality states can be found in Tables 1 and 2. To allow non-bullying role-playing, a Friend and a Student prototypes are included as affiliation and power roles[33].

The situational conditions significantly change patterns of role selection, personality states and consequently intensity, frequency and character of bullying episodes. In the school bullying, differences between the structured Lesson and the unstructured Breaks were pointed out [17]. These are also prototypes used in this example. Finally, also group-specific influence on the personality state manifestations in bullying is documented. As the example is focused on the school bullying, Students, Friends and Gang-like prototypes were chosen. Data on personality states in context need then to be approximated from the existing data on personality traits, in this case in-person variance for each of the personality states provided by Bleidorn [1] was combined with the research on roles-personality links [29, 32, 36, 4]. The final unknown parameters: situation and group consequences for personality states, associations between them and social roles were obtained using questionnaires in which 20 individuals were asked series of questions probing context influence (e.g. 'how probable is it to take role X in situation Y?').

4.4 Prototype features and input layers

Features activating chosen prototypes were selected from existing data. SCP role characterization used a subset of Harter's Self-Perception Profile for Children [18]. The distribution of features was based on existing data [29] (Table 3). Warmth and competence (used e.g. in the stereotype content model [15]) are group prototype features. Situations are characterized in terms of influence on the goal realization and the type of goals primed: 'the essence of a situation is its affordance of human goals, and that situations are largely characterized by two specific principles of goal processes (what happened, is happening, or might happen to people's goals) and goal contents (the specific goals afforded in the situation)' [40]. Schools are arenas of social status pursuit with supervision and structure as primary situation features determining pursuit limits [17]. The final step of the SCP specification involves input layer. Both general and prototype specific features were linked to world observations of the specific simulation setting e.g. a group warmth is a

Table 4: Personality influence on actions[36]

	O	C	E	A	N
Physical attack	-0.12	-0.26	-0.19	-0.34	0.08
Verbally attack	0.04	-0.05	0.15	-0.30	0.20
Hostility	-0.33	-0.16	-0.30	-0.24	0.33
Protection	0.12	0.26	0.19	0.34	- 0.1
Task following	0.0	0.45	0.0	0.21	-0.11

function of the average friendliness; a student's role is linked to a task (study) focus and uniform presence.

4.5 Multiple agents and actions

The above parametrization provides a general SCP - a 'statistical personality' i.e. representing average personality state related tendencies in the researched group. In the simulation, multiple characters may be generated either by SCP's partial randomization (resembling normally distributed population) or manual modification (e.g. when specific game character is to be created). The former method was used here. SCP is embedded in the agents by linking mediating unit activations with agent actions. Role attributions influenced target probabilities while research [37] investigating link between personality and aggressive actions was used to determine crucial action probabilities (Table 4).

5. SIMULATIONS

Simulations using the above parametrization are described below. The general setup, character and scenario generation are presented, followed by an example simulation run.

5.1 Simulation world and scenario generation

To provide input and interaction, agents were embedded in a simple world that included location, time, teacher and agents (students) capable of perceiving and acting towards each other. Each agent included a SCP. In each simulation step the perception of the world led to a decision to study or not and determined actions toward each of the other agents: friendly/hostile affect, verbal/physical attack or protection.

To validate the model, multiple agents and scenarios were generated. 600 'student' agents were automatically created by introducing random variation to the generic SCP, according to the reported parameter distributions wherever possible. They were placed in several scenario types (lesson, break, transitions) with world randomized within scenario boundaries e.g. a class scenario included different teachers.

5.2 Example simulation run

To give an example, one of the generated scenarios with five agents will now be presented. It is a 'Break to Lesson transition' scenario including bullying in a classroom setting around a lesson beginning, with a teacher arriving soon after.

Initial inter-agent perceptions are neutral/friendly. Soon Agent2 sees Agent1 as a Victim (Figure 3), mostly due to the strong link between Inadequacy and Victim in his cognition. This leads to Bullying/Bully prototype activations and finally a verbal attack on the Agent1 (T = 5). Aggression received by the Agent1 leads to his classification as a Victim by other agents (T=5). Agent3 joins the bullying (Figure 4). His Bully role however is much more related to loosing Conscientiousness that makes the physical attack probable (Table 4). Finally, physical attack on Agent1 by Agent3 takes place (T= 13). The transition to the Lesson

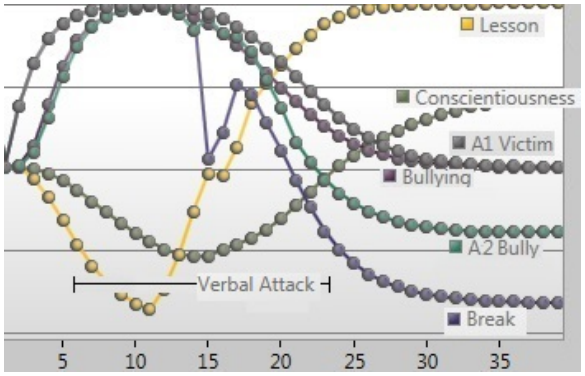

Figure 3: Selected prototype activations of Agent 2

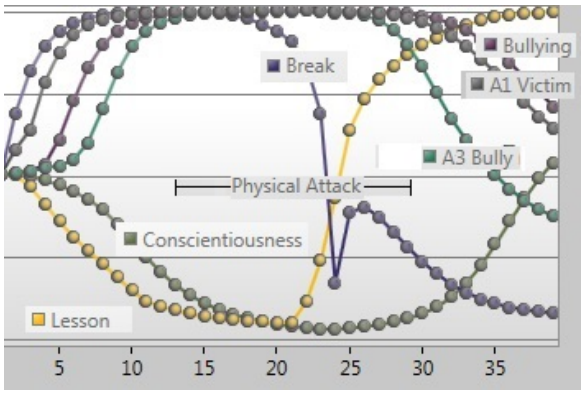

Figure 4: Selected prototype activations of Agent 3

influences bullies differently (T=10). Link to Inadequacy makes Bully role easily triggered in the Agent2, but its inhibition due to Lesson is stronger- he drops Bully role and attacks before the teacher arrives (T=20), while Agent 3 is only pacified by teacher's presence. All agents perceived their group as students/friends and gang/students after the physical attack.

Among others, this example interaction generated by the system exemplifies SCP's capabilities to generate various types of bullies, victims etc. with subtly different characteristics (here: verbal instigator and physical bully-follower) changing character depending on environment and other's behavior. Agents are capable of priming other's social interpretations, even causing global group identity changes by spreading their own situation interpretation e.g. leading to escalations long after the initiator is withdrawn.

6. RESULTS AND VALIDATION

To verify the presented model, statistical data on bullying incidents was compared with the data generated in multiple simulation runs similar to the example presented above. 600 'student' agents were automatically created by introducing random variation to the generic SCP and placed in semi-random scenarios. This section provides confrontation of those results with several data types, investigating both SCP's 'black-box' behavior and internal states.

6.1 Role frequency and stability

The most basic validation is a bullying frequency test.

Table 5: Pure/mixed bullies and victims[23].

Group	SCP	'Trait personality'	Live humans
Pure bully	31(5.1%)	72(12%)	36.5(6.1%)[23]
Pure victim	45(7.5%)	83(13.8%)	47.5(7.9%)[23]
Victim-bully	46(**7.6%**)	7(**1.2%**)	42.7(**7.1%**)[23]
Total	600(100%)	600(100%)	600(100%)

Bullying statistics are well known - victims constitute between 7% and 15% of youth (with most research reporting 10-13% [32, 3, 23]) while bullies between 6% and 12%. Numbers are higher in younger children and difficult youth, but proportions are maintained. This data corresponds well to the SCP's results: **15.1% victims and 12.8% bullies**.

Such results are however potentially obtainable with a well calibrated 'personality trait' model. The actual challenge, is the low to medium role stability shown by both longitudinal and short-term research [34, 35, 7]. SCP's potential ability to recreate such instabilities, compared to the 'personality trait' model is one of the main research questions. Aggressive victims or victim-bullies who switch roles depending on a context constitute around 33% of those involved in bullying or victimization [23]. As experiments confirm (Table5), the mediated and context based model is superior in addressing such phenomena. SCP's performance is compared to a static personality trait simulation, otherwise identical to the one described in section 6. The normal distribution of personality traits, scaled to the generate the desired victimization (15% ratio) over the identical number of characters and scenarios was used. The 'trait personality' generated predictably static bullying behavior: only 7 out of 162 bullies/victims (**4.3%**) showed opposite behavior, making victim-bullies **1.2%** of the total population (Table 5). Corresponding numbers for SCP (**38%** of victims/bullies, **7.6%** of total population) show SCP's superior ability to generate mixed, contextualized behaviors coherent with the psychological data.

6.2 Subjective role attributions

While previous section compared external behavior of SCP and 'trait personality' agents, this one investigates features absent in 'trait models': subjective role attributions. Many socio-psychological problems are measured from both subjective and objective perspectives. The difference is profound and the link between objective and subjective perspectives itself creates research topics e.g. how individual's subjective perspective may spread to group and manifest into objective behavior. Models using subjective social prototypes as units mediating personality may address such questions - a feat impossible for 'trait personality' or rule based agents. Some examples are presented below.

6.2.1 Objective causes of victimization

SCP allows an analysis of role attribution caused by separating external contributions to given prototype activations and comparing results with human data. For instance, research [32] states that **11%** of victims and **23%** of the witnesses regarded characteristics of the victim (as opposed to context) as causes of bullying. The contribution in simulated data was **8%** and **33%** respectively and reflects the reported trend. The cited research does not report the (presumably higher) numbers for bullies (**48%** in simulation).

Similar analyses are important in explaining the cognitive basis of social phenomena, far surpassing the issue of bullying. Cognitive, personality mediating models like SCP promise insights into crucial problems e.g. like mechanics of Fundamental Attribution Error [19], unobtainable otherwise. This way SCP could be parametrized and used to formulate theories i.e. about the mechanisms of subjective social role playing.

6.2.2 Subjective popularity, objective victimization

The previous section depicted regularities of internal prototype activations, but casual and statistical analysis of relations between subjective perception and objective events is entirely possible with SCP. As an example, relation between the objective victimization and subjective popularity and acceptance will be investigated.

Popularity is a proven predictor of victimization. If, for the purpose of this example, peer acceptance and rejection are equated with 'friendly' and 'unfriendly' role attributions by peers, specific statements may be addressed e.g. 'correlation between victimization and peer rejection (r = .57) was stronger than that between victimization and peer acceptance (r = -.36)' [10]. An agent's acceptance ratio was calculated using time over which others attributed the Friend prototype and degree of 'friendliness', similarly the rejection was based on a Victim role prototype. The global correlation between the objective victimization (amount of received aggression) and rejection acceptance and was **0.73** and **-0.22** respectively and reproduced human data reasonably.

The relation between popularity and roles was also assessed. The collective popularity ratios for victims, bullies and outsiders were **-0.39**, **-0.21** and **0.25** respectively, confirming that 'not-involved children have been found to be more popular than bullies who, in turn, were found to be more popular than victims' [3]. Another research, states that only 1% of subjects lacked a friend and all of them were bullied [32]. Out of all agents, 0.3% was not nominated as a Friend by any agent and 5.1% never received 'friendly interaction'. Regardless of the assumed definition of 'having a friend', all were bullied.

7. SUMMARY

In this article a new personality model (SCP) has been presented, addressing relevant limitations of existing solutions. It has been implemented and parametrized for a specific domain. The generated results were tested against the existing data showing model's ability to generate context dependent behavior and model's properties were superior to that of 'trait personality models'. Moreover, SCP simulated many relations between subjective and objective elements of bullying reflecting those found in research on actual people - purpose for which, unmediated 'trait models' cannot be used at all. SCP and context-based approach to personality were shown promising in the context of both social simulation and individual character generation, from serious scientific applications to entertainment.

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