KEER2010, PARIS | MARCH 2-4 2010

INTERNATIONAL CONFERENCE ON KANSEI ENGINEERING AND EMOTION RESEARCH 2010

BUILDING CREDIBLE AGENTS: BEHAVIOUR INFLUENCED BY PERSONALITY AND EMOTIONAL TRAITS

Elisabetta Bevacqua[1 *] **, Etienne de Sevin**[1] **, Catherine Pelachaud**[1] **, Margaret McRorie**[2] **and Ian Sneddon**[2]

[1]*CNRS - Telecom ParisTech, Paris, France*

[2]*School of Psychology Queen's University, Belfast, UK*

ABSTRACT

How do we construct credible personalities? The current SAL (Sensitive Artificial Listeners) characters were constructed intuitively and can be unconvincing. In addressing a range of issues associated with this problem, this paper discusses a model of personality and associated emotional traits which are founded on sound psychological principles. We describe how the model was selected, and use a theoretical basis to explain characterization of agents. Our objective is to ensure that behavioural perception of a virtual agent credibly reflect aspects of the agent's 'actual' personality as prescribed. This is necessary if our agents are to be capable of sustaining realistic interaction with human users. Whilst yet to be tested, a series of further studies will evaluate perception of credibility by human viewers.

Keywords: Personality traits, Eysenck, emotional traits, virtual agents

1. INTRODUCTION

Accurate nonverbal cues such as facial expressions, head and eye movements, etc are fundamental to the credibility of virtual agents. However our knowledge about the expression and perception of these cues is limited and a comprehensive model of personality on which to base agent characteristics has yet to be developed [1]. In considering how personality dimensions affect various attributes of animated characters, this paper proposes a model of personality and emotional dispositions which has a solid theoretical basis. Our work is part of the EU project SEMAINE,

[*]**Elisabetta Bevacqua:** CNRS - Telecom ParisTech 37/39, rue Dareau 75014 Paris, France
elisabetta.bevacqua@telecom-paristech.fr

which aims to provide a multimodal system of conversational agents, or Sensitive Artificial Listeners (SAL). These virtual agents are designed to sustain realistic interaction with human users, despite having limited verbal skills. Four psychologically different characters (SAL agents) have been created to elicit different types of emotion - each employing individual dialogue strategies, and displaying uniquely different responsive reactions. In this paper we first present different theories of personality. Then in later sections, we explain how we kept a computationally appropriate level of complexity to model personality in virtual agents and how personality affects behaviours. Section 4 describes a model to build agents with different behaviour propensities. The four SAL characters are presented in the next section. We end this paper by introducing the SAL architecture where we detail how personality acts, not only on the behaviour characteristic of the virtual agents, but also on their communicative styles, in particular when being a listener.

1.1. Trait models of personality

Trait models of personality assume that traits influence behaviour, and that they are stable, fundamental properties of an individual. Individual Differences research on personality attribution tends to use (as its theoretical basis) one of the two main theories (five-factor structure [2] or three-factor model [3]), or alternatively the two core traits of extraversion and neuroticism, depending on task.

Selecting a theory of personality. Early trait research focused on a lexical (language based) approach. The five-factor model [2] is a modern lexical approach. It is one of the most widely used trait theories and posits five main, relatively independent personality dimensions: extraversion, neuroticism, openness to experience, agreeableness and conscientiousness. In comparison, Eysenck developed a model based on traits which he believed were heritable and had a probable biological foundation. Likely personality traits were identified from clinical and experimental literature, and the three main traits which met these criteria were extraversion-introversion, neuroticism-emotional stability, and psychoticism. Eysenck conceptualized each of these at the top of its own hierarchy. For example, sociable, active, lively, dominant etc are all narrow traits subsumed by the broader trait of extraversion, due to the fact that they all covary sufficiently with each other to load on the same large factor. Eysenck viewed extraversion and neuroticism as the two key dimensions of personality, and initially proposed a two-dimensional model. Psychoticism was added later, with high scorers characterized by hostile, aggressive, emotionally cold, and manipulative tendencies. Extraversion and neuroticism have also been associated with the basic assumptions of Gray's [4] two-dimensional model of impulsivity and anxiety. Gray proposed that people differ in sensitivity of their Behavioural Approach System (BAS, responsible for impulsivity) or Behavioural Inhibition System (BIS, responsible for anxiety). Gray believed that differences in sensitivity to reward and punishment are responsible for generating the types of behaviour associated with being impulsive/extraverted and anxious/neurotic. One of the benefits in adopting Eysenck's model are that its biological underpinnings could to some extent direct and justify specific response patterns of behaviour in developing the characters of conversational agents.

Eysenck's three-factor model. Eysenck attempted to provide not merely a description of personality, but an explanation of cause, suggesting that individual differences in nervous system structure/functioning could account for the emergence of personality traits. The biological basis of extraversion suggests extraverts are less cortically aroused than introverts. Eysenck also draws on Hebb's [5] notion of 'optimal level of arousal'. This suggests that if extraverts have a lower baseline of arousal, then they should need more external stimulation, and be more comfortable under arousing conditions. Highly neurotic individuals tend to give extreme emotional responses to life events which have little effect on low scorers. This biological model thus predicts that neurotic individuals should show more autonomic nervous activity in stressful situations than those who are emotionally stable. Alternatively, M.W. Eysenck's Hypervigilance Theory uses a cognitive model as explanation, and predicts that as 'highly anxious' people are constantly looking out for signs of threat, they will use many rapid eye movements, and attend selectively to threat-relevant rather than neutral stimuli [6]. Psychoticism is less well understood, however levels seem to be much higher in males than females. Eysenck suggested psychoticism is linked to levels of male hormones (e.g. testosterone) which influence impulsivity.

Emotional Traits. It has long been assumed that there are individual differences in the predisposition to experience certain emotions. Neuroticism is primarily an emotional disposition 'negative emotionality', or the propensity to experience negative emotions. Similarly, extraversion 'predisposes an individual towards positive emotion' [7]. This would indicate stable and reliable individual differences in the propensity to experience global positive and negative affect. Furthermore, associations have been found between dispositions for individual positive emotions, and also between dispositions for individual negative emotions. In sum, this seems to indicate that the structure of emotional propensities form two largely independent hierarchies of correlated dispositions [8].

Integration of main trait theories. There is some evidence of overlap between Eysenck's three-factor model and the five-factor structure. Scores on personality questionnaires designed to measure the five-factor model correlate as predicted with Eysenck's inventories [7]. This is important as it provides evidence of some form of theoretical integration between the two models. Eysenck's traits of extraversion and neuroticism are virtually identical to the similarly named dimensions of the 'Big Five', and psychoticism seems to correspond to agreeableness and conscientiousness combined, suggesting these traits may be components of psychoticism [9].

2. COMPLEXITY/ADEQUACY

There is a continued debate in the literature as to which of the two main models is more theoretically appropriate for understanding human characteristics. What *we* must consider is which dimensions best reflect the various attributes of a virtual agent which will not necessarily possess the full range of characteristics typical of a real person. Whilst the diversity created by the trait models goes a long way to providing a comprehensive framework for our purpose, we have to ascertain whether such a level of complexity is too ambitious and unrealistic. Modelling personality as a reflection of complex multivariate solutions might be difficult if virtual agents need more easily controlled parameters [1]. In considering the balance between solid theoretical basis and the practicalities of parameter control, confining interpersonal behaviour to fewer dimensions would allow for more effective management. Eysenck's three-dimensional model would arguably serve as an acceptable foundation from which combinations of facets could be built. Its core dimensions of extraversion and neuroticism are undisputed and central to all major trait theories. Psychoticism is another scientifically useful construct in that it seems to reflect agreeableness and conscientiousness. The three-factor model has thus been selected as the basis for the current research project.

3. BUILDING PERSONALITY

Our objective is to provide a sound theoretical basis to generate behavioural characteristics which will allow an observer to infer a personality. Personality predicts specific behaviours. Individual personality types are deduced from the answers to questions about behaviours. We need to do the opposite, and generate consistent sets of behavioural attributes (an agent's visual cues etc) from a personality. In doing so, it should be remembered that extraversion is not just linked with positive affect, but associated with a general level of activation and behavioural approach [10]; neuroticism similarly is related to behaviour avoidance. Both dimensions thus reflect differences in behaviour, affect and cognition [11]. In considering how they translate into behaviour, the conceptualization of personality and emotional disposition as organized at various levels might be helpful. Eysenck believed all levels are involved in behaviour, and similarly, those who use trait models point out the usefulness of examining patterns of facets within each factor [9]. Suggested links with nervous system functioning indicate it appropriate to use these dimensions to explain behaviour. Understanding 'why' would help guide our assumptions as to 'how' personality translates into 'which' behaviours. Such an approach would go some way to addressing the limitations of research in this area.

4. REPRESENTING AND MODELLING DISTINCTIVE BEHAVIOURAL CHARACTERISTICS

To model behavioural characteristics of virtual agents, we use the approach developed by [12] where an agent is defined by a *baseline*. The baseline describes how the agent behaves in terms of quality of movement and modalities used. It captures the global behaviour quality of the agent. The baseline specifies if an agent has the tendency to move slowly, with low amplitude or in a fast and hectic manner and if it displays mainly facial expression, gesture, head movement or torso. The first term refers to the execution of behaviours; it is also called behaviour expressivity or behaviour quality. The second term relates to the modalities the agent uses most to convey information. It is also called modality preferences. This parameter indicates if the agent uses mainly its face or its gesture to communicate. The baseline is defined as a set of numeric parameters: the agent's modality preference and the agent's behaviour expressivity. The modality preference refers to the agent's degree of preference in using each available modality (face, head, gaze, gesture and torso) to communicate while the behaviour expressivity is represented by a set of 6 parameters that influence the quality of the agent's movements as was proposed by [13]: the frequency (OAC parameter), speed (TMP parameter), spatial volume (SPC parameter), energy (POW parameter), fluidity (FLD parameter), and repetitivity (REP parameter) of the non-verbal signals produced by the agent. These expressivity parameters are defined for each modality: one set of parameters for the head movements, another set for the facial expressions, and so on.

5. DEFINITION OF CHARACTERS

These are the principles. The challenge now is to map the connections and consider how we translate these stable traits into personality-dependent actions. In other words, how do we get from this model to specific responses in particular situations? Within Individual Differences literature some of this work has been theoretically driven, e.g. considering how personality traits influence behaviour. Another focus has been on the perception of observable attributes, and exploring the links between impressions of personality and verbal/nonverbal behaviour. Accurate judgments of personality based on behavioural cues obviously depend on behavioural correlates, the existence of associations between these cues, and the personality parameters. The behavioural characteristics of virtual agents are artificial constructs. These constructs have to possess a believable coherence for the virtual agent to be convincing. This coherence has to be based in sound personality. This is fundamental to the individuality of any virtual agent, and can have a major effect on the perception of credibility by viewers. In considering associations between personality dimensions and the various attributes of a virtual agent, we should thus be aware of which behaviours actually affect a viewer's perception. The five major categories typically used to classify nonverbal behaviour are facial expressions, eye and visual behaviour (e.g. gaze), kinesics, paralanguage, and proxemics. So far we do not consider the last parameter, proxemics that describes the distance between interactants. In our current system the virtual agent talks to a single human subject. Thus this parameter is not useful in such a scenario. We do not consider it for the moment. On the other hand, by varying the other parameters we can create agents with specific behaviours characteristics [12, 13, 14]. Moreover these behaviours characteristics relate to personality traits.
In the following sections, we present the SAL agents. Each agent is defined by a personality trait. By using the description of the behaviour characteristics associated to personality traits, we instantiate the values of the behaviour parameters. We illustrate this process through four examples.

5.1. Defining representative behaviour of SAL characters

The design of the characters draws on the above. The application consists of a system of Sensitive Artificial Listeners (SAL), designed to sustain an interaction with a human user via generation of nonverbal behaviour in real time. SAL characters represent four psychologically different affective/personality types, which try to draw the user into their own emotional state. Poppy is outgoing (extraverted) and optimistic; Spike is angry and argumentative; Prudence is pragmatic and practical; and Obadiah is gloomy and depressed. As an example, we describe Spike in more detail.

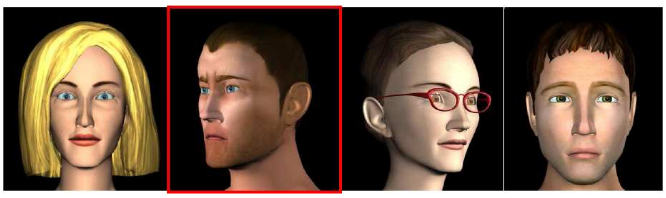

Figure 1: 3D Model of Poppy, Spike, Prudence and Obadiah.

Spike. Spike's dispositional qualities of being angry and argumentative relate to Eysenck's third factor of psychoticism (see Figure 1, Spike is highlighted in red). This trait reflects hostility, and involves elements of aggression, coldness, impulsivity, and lack of empathy. Individuals high in psychoticism are more likely to be verbally aggressive, argumentative (thus low on agreeableness), and inappropriately assertive in communication [15]. Eysenck's theoretical explanation for such behaviour proposed that psychoticism - like extraversion - reflected low cortical arousal, but was driven by abnormalities in neurotransmitter levels. He proposed links to levels of male hormones (e.g. testosterone), neurotransmitters and enzymes which influence impulsivity. According to Ekman and Friesen [16], facial expressions of anger are demonstrated with frowning eyebrows, staring eyes, and a closed mouth with depressed corners. Spike's facial appearance may thus be characterized by v-shaped eyebrows, with increased facial threat typified via prolonged direct eye gaze, wide eyes and open mouth [17]. Facial asymmetry and masculinity in male faces has been associated with lack of agreeableness and co-operation [18]. When communicating, low scorers on agreeableness display less visual attention, but more visual dominance. Disagreeable individuals do less back-channelling, indicating they listen less to conversational partners [19].

5.2. Introducing SAL characters in a virtual agent system

To introduce the SAL agents in our virtual agent system, we need to define a baseline for each of them. We determine the agents' modality preference and the expressivity on each modality according to the characters description proposed in the previous sections. Moreover, in our system we can model the agent's gaze behaviour by specifying the value of three gaze temporal parameters that define the agent's tendency to look at the user, to look away from the user and to sustain mutual gaze [14]. By tuning these different parameters we are able to create agents with different behavior quality types.

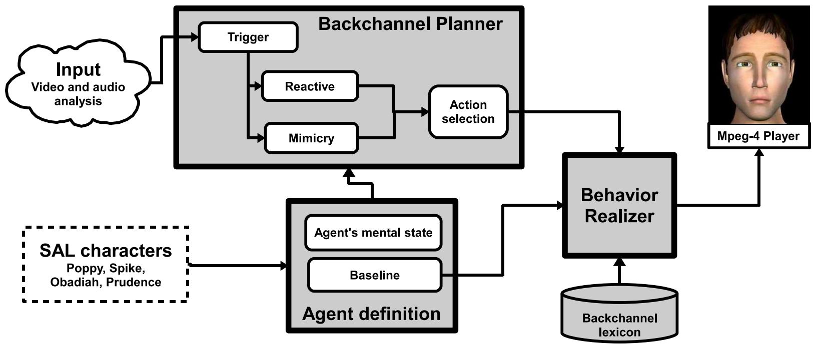

Figure 2: SAL architecture.

6. SAL ARCHITECTURE

Figure 2 shows the overall architecture of our system. A video camera and a microphone record user's movements and voice. This information is used in our system to determine the agent's behaviour while listening to the user. The agent can perform non verbal signals to show how it is reacting to the user's speech, if it is listening, understanding, agreeing and so on. This communicative behaviour is called backchannel [20]. The system is divided into three modules [21]: the agent definition, the backchannel planner and the backchannel realizer.

Agent definition. The agent definition module contains the information that characterises a SAL agent: the baseline (as we have seen in Section 4) and the agent's mental state, which describes what the agent thinks about the user's speech. In our system, we define the mental state as a set of communicative functions the agent wishes to transmit during an interaction. We consider twelve communicative functions, a subset chosen from the taxonomy proposed by Allwood et al. [20] and Poggi [22]: agree, disagree, accept, refuse, believe, disbelieve, interest, not interest, like, dislike, understand and not understand. Each communicative function is associated with a set of behavioural signals that must be performed to convey the given function. Such sets, defined through perceptive tests [23, 24], are contained in a dictionary called *backchannel lexicon*. The interlocutor's communicative functions depend on several factors like the content of the speaker's speech, the listener's own beliefs, and the relationship between the two parties and so on. We are well aware that the value of the listener functions should vary during the interaction. However, at present, for sake of simplicity, we link the agent's mental state to the emotional traits that differentiate the four SAL agents. Consequently, each SAL agent shows signals that are compatible with its emotional traits. Spike, who is angry and argumentative, conveys negative communicative intentions, in particular dislike, disagreement and lack of interest. Being gloomy, Obadiah tends to convey negative communicative intentions too, in particular disbelief, refusal and lack of understanding. Poppy, the happy one, provides backchannel signals that are the expression of positive communicative intentions, as liking, acceptance and interest. Finally, Prudence, who is sensitive and pragmatic, conveys positive communicative intentions, in particular agreement, belief and understanding.

Backchannel Planner. The backchannel planner module computes the agent's behaviors while being a listener when conversing with a user. This component encompasses two modules called reactive backchannel, and mimicry. Research has shown that there is a strong correlation between backchannel signals and the verbal and non verbal behaviors performed by the speaker [25, 26, 27]. For example, the listener tends to provide a backchannel signal when the speaker gazes at him [27]. From the literature [25, 26, 27] we have derived some probabilistic rules to decide *when* a backchannel signal should be triggered. Our system analyzes speaker's behaviors looking for those that could prompt an agent's signal; for example, a head nod or a pause of the user's voice will trigger a backchannel with a certain probability. Then, the reactive backchannel, and mimicry modules compute *which* type of backchannel should be displayed. The *reactive backchannel module* uses information about the agent's beliefs towards the speaker's speech to calculate the backchannel signal. Such an information is contained in the agent's mental state. The *mimicry module* determines which signals would mimic the agent. We are interested in this type of backchannels since researches have shown that mimicry helps the interaction [28, 29]. The backchannel planner calculates all the possible signals and a selection algorithm determines which backchannels to display among all the potential signals that are outputted by the two modules.

Action Selection. The action selection algorithm selects when a backchannel is displayed and which one it is. This issue is related to an action selection problem. Tyrrell [30] defines the task of action selection mechanism for an agent as 'determining, from a set of available conflicting actions, the most appropriate ones'. As explained before, two types of backchannels can be triggered: reactive and mimicry backchannels. Both backchannels can be potentially conflicting at the signal level. For example, the mimicry module could generate a smile to mimic the user, whereas the reactive backchannel module could generate a tension on the lips determined by the communicative function ‘disagree’ [23, 24]. There is a conflict at the signal level; only one of these two backchannels can be displayed and a selection is necessary to choose the most appropriate one relative to the context of the interaction. Inspired from the free flow hierarchy approach [31], no choice is made in the triggering module and all potential (conflicting) backchannels are sent to the backchannel selection algorithm. To have a basis for comparison, the latter first normalizes all backchannels priorities according to the user’s level of interest (estimated by the agent) as it is a good indicator of the success of the interaction [32]. Then if there are conflicting backchannels, the selection algorithm chooses the most appropriate backchannel to be displayed by the ECA. Personality has also an influence on the backchannel selection by modulating the number of displayed backchannels (e.g. Poppy shows a lot of backchannels while Obadiah much less). We have introduced a function defined as the probability of displaying backchannels. It is modeled as a polynomial function. Four functions have been defined and associated to one personality. They can vary in real-time in order to take account the current emotional states of the agent. For example, Poppy shows less backchannels when she is less aroused.

Backchannel Realizer. The backchannel realizer instantiates the backchannel output from the action selection module into a set of signals. This step considers also the agent’s definition: the baseline and the agent’s mental state. For each communicative function in the mental state that the agent intends to transmit, the backchannel realizer determines the corresponding non verbal behaviours from the backchannel lexicon taking into account the agent’s modality preference and its expressivity parameters. Finally, the resulting animation is played on a graphic window where the virtual agent is shown.

7. CONCLUSION

In this paper we have presented a model of personality and emotional traits for virtual agents. We have applied this model to SAL agents. The model we have adopted from the different theories of personality is the Eysenck’s model. Four distinctive agents have been designed with a given personality each. For each of them, personality affects the agent’s global behaviour quality as well as their backchannel productions (frequency and type of signals). Whilst the benefits have yet to be tested, it is anticipated that the coherence across the behavioural characteristics generated in this way will add a depth to people’s perception of the characters - thus sustaining the ‘believability’ of the character for longer. Perceptive tests with human users will be conducted in the near future.

8. ACKNOWLEDGEMENTS

This research was supported by the STREP SEMAINE project. We are greatly thankful to Martine Delage for the facial models of the SAL agents.

REFERENCES

[1] Arya, A, Jefferies, L, Enns, J, and DiPaola, S. Facial actions as visual cues for personality. *Computer Animation and Virtual Worlds*, 17:1–12, 2006.

[2] McCrae, R and Costa, P. Validation of the five-factor model of personality across instruments and observers. *Journal of Personality and Social Psychology*, 52:81–90, 1987.

[3] Eysenck, H. *The Measurement of Personality*. Lancaster: Medical and Technical Publishers, 1976.

[4] Gray, J. The psychophysiological nature of introversion-extraversion: a modification of eysencks theory. In Nebylitsen, V and Gray, J, editors, *Biological Bases of Individual Behaviour*, pages 151–188. Academic Press, 1972.

[5] Hebb, D. Drives and the CNS (conceptual nervous system). *Psychological Review*, 62:243–259, 1955.

[6] Eysenck, M and Byrne, A. Anxiety and susceptibility to distraction. *Personality and Individual Differences*, 13:793–798, 1992.

[7] Costa, P and McCrae, R. Influence of extraversion and neuroticism on subjective well-being: happy and unhappy people. *Journal of Personality and Social Psychology*, 38:668678, 1980.

[8] Reisenzein, R and Weber, H. Personality and emotion. In Corr, P and Matthews, G, editors, *Cambridge Handbook of Personality*. Oxford University Press, 2008.

[9] Goldberg, L. The structure of phenotypic personality traits. *American Psychologist*, 84:26–34, 1993.

[10] Rogers, G and Revelle, W. Personality, mood, and the evaluation of affective and neutral word pairs. *Journal of Personality and Social Psychology*, 74:1592–1605, 1998.

[11] Revelle, W and Scherer, K. Personality and emotion. In *To appear in the Oxford Companion to the Affective Sciences*. Oxford University Press (in press).

[12] Mancini, M and Pelachaud, C. Distinctiveness in multimodal behaviors. In Padgham, L, Parkes, D, Müller, J, and Parsons, S, editors, *Proceedings of Conference on Autonomous Agents and Multi-Agent Systems (AAMAS08)*, 2008.

[13] Hartmann, B, Mancini, M, Buisine, S, and Pelachaud, C. Design and evaluation of expressive gesture synthesis for embodied conversational agents. In *3th International Joint Conference on Autonomous Agents & Multi-Agent Systems*, Utretch, 2005.

[14] Pelachaud, C and Bilvi, M. Modelling gaze behavior for conversational agents. In *IVA03 International Working Conference on Intelligent Virtual Agents*, volume LNAI 2792, pages 15–17, Germany, 2003. Springer.

[15] McCroskey, J, Heisel, A, and Richmond, V. Eysenck's big three and communication traits: three correlational studies. *Communication Monographs*, 68:360–386, 2001.

[16] Ekman, P and Friesen, W. *Unmasking the Face. A Guide to Recognizing Emotions from Facial Clues*. Englewood Cliffs, New Jersey: Prentice-Hall, 1975.

[17] Tipples, J. Wide eyes and an open mouth enhance facial threat. *Cognition and Emotion*, 21:535 557, 2007.

[18] Noor, F and Evans, D. The effect of facial symmetry on perceptions of personality and attractiveness. *Journal of Research in Personality*, 37:339–347, 2003.

[19] Smith, B, Brown, B, Strong, W, and Rencher, A. Effects of speech rate on personality perceptions. *Language and Speech*, 18:145152, 1975.

[20] Allwood, J, Nivre, J, and E., A. On the semantics and pragmatics of linguistic feedback. *Semantics*, 9(1), 1993.

[21] Bevacqua, E, Mancini, M, and Pelachaud, C. A listening agent exhibiting variable behaviour. In Prendinger, H, Lester, J, and Ishizuka, M, editors, *Proceedings of 8th International Conference on Intelligent Virtual Agents*, volume 5208 of *Lecture Notes in Computer Science*, pages 262–269, Tokyo, Japan, 2008. Springer.

[22] Poggi, I. *Mind, hands, face and body. A goal and belief view of multimodal communication*. Berlin: J. Weidler, 2007.

[23] Heylen, D, Bevacqua, E, Tellier, M, and Pelachaud, C. Searching for prototypical facial feedback signals. In *Proceedings of 7th International Conference on Intelligent Virtual Agents IVA 2007*, pages 147–153, Paris, France, 2007.

[24] Bevacqua, E, Heylen, D, Tellier, M, and Pelachaud, C. Facial feedback signals for ECAs. In *AISB'07 Annual convention, workshop "Mindful Environments"*, pages 147–153, Newcastle upon Tyne, UK, April 2007.

[25] Maatman, R, Gratch, J, and Marsella, S. Natural behavior of a listening agent. In *5th International Conference on Interactive Virtual Agents*. Kos, Greece, 2005.

[26] Ward, N and Tsukahara, W. Prosodic features which cue back-channel responses in english and japanese. *Journal of Pragmatics*, 23:1177–1207, 2000.

[27] Bertrand, R, Blache, P, Espesser, R, Ferr, G, Meunier, C, Priego-Valverde, B, and Rauzy, S. Le CID (corpus of interactional data): protocoles, conventions, annotations. In *Travaux Interdisciplinaires du Laboratoire Parole et Langage d'Aix-en-Provence (TIPA)*, volume 25, pages 25–55. 2006.

[28] Chartrand, T and Bargh, J. The Chameleon Effect: The Perception-Behavior Link and Social Interaction. *Personality and Social Psychology*, 76:893–910, 1999.

[29] Cassell, J, Nakano, Y, Bickmore, T, Sidner, C, and Rich, C. Non-verbal cues for discourse structure. In *Proceedings of the 39th Annual Meeting on Association for Computational Linguistics*, pages 114–123. Association for Computational Linguistics Morristown, NJ, USA, 2001.

[30] Tyrrell, T. The use of hierarchies for action selection. *Adaptive Behaviour*, 1:387–420, 1993.

[31] de Sevin, E. An action selection architecture for autonomous virtual humans in persistent worlds, 2006. PhD. Thesis. VRLab EPFL.

[32] Peters, C, Pelachaud, C, Bevacqua, E, Poggi, I, Mancini, M, and Chafai, N. E. A model of attention and interest using gaze behavior. In *Proceeding of IVA'05: Intelligent Virtual Agents*, Kos, Greece, September 12-14 2005.