Expressing the Personality of an Intelligent Room through Ambient Output Modalities

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***Abstract*—This paper deals with user friendly interfaces in ambient computing and its applications. In order to build more friendly ambient systems, some authors have proposed that the agent controlling the system should be provided with a mental model and should express personality traits and emotions "as if it were a person". Recent research in this domain is mainly based on the mediation of the ambient system by an animated virtual character, often endorsing the role of assistant. However, users can be distracted and side-tracked by such characters and even feel that they lose the control of the system. We explore here the feasibility of the direct expression of the emotional states and personality traits of the mental model of an ambient agent directly through the specific output physical modalities. First, we propose an alternative to the mediated architecture together with its specific agent model. Then, through two typical examples, we show how emotions and traits can be mapped onto ambient output modalities.**

Keywords — Personification, Ambient output modalities, Expression of emotions and traits.

I. INTRODUCTION

In this paper we rely on researchers that have claimed and showed that there is a usefulness of an intelligent environment to show psychological features such as emotions and traits. For example, in their 2005 survey on new technologies for ambient intelligence [1], Alcaniz and Rey discuss the impact of the implementation of psychological notions in future Intelligent User Interfaces (IUI): "The persona of an agent is the visible presence of the agent from the users perspective". The idea that an ambient should be perceived, hence reified as a personified agent, is currently growing. For example, Benyon has introduced the term 'personification technology', based on the notion of *anthropomorphism* [5].

In such ambient systems, we deal with three main entities: one or several human users; a physical environment capable of interacting with users through input/output modalities; a software agent controlling the physical environment and managing its interactions with users, hence called the ambient agent. In first ambient systems, the ambient agent was simply viewed as a global software controller. However, the need for more user friendly interface raises the issue of the relationships between the ambient agent and the users that is a) how the agent is presented to the users and b) how the users perceive the ambient agent. Two main strategies are:
— *Mediated personification*: the agent is represented by the introduction in the environment of a physical entity (a virtual character or a robot; being anthropomorphic or not) endorsing the role of the ambient system;
— *Direct personification*: the agent has no explicit physical presentation. Hence, it must be directly perceived and categorized through the output modalities of the system.

The advantage of mediated personification is that users are prompted to think that there is an intentional entity in the environment but they can fail to link it to the ambient agent (*e.g.*, considering it is another kind of user). The direct personification avoids this problem but raises another issue: how can we transfer the expression of psychological features of the ambient agent onto output modalities. In this paper, we explore a model of mapping emotions and personality traits upon the output modalities provided by an intelligent room.

The outline of the paper is as follows: In Section II, we present a short review of current research works dealing with the notion of personification. Section III describes our model for ambient personality, which implements two main notions: basic emotions and more complex personality traits. Section IV describes how actual output modalities of an intelligent room can be exploited to express the personality of a given ambient agent. Section V present a case-study upon the direct implementation of two psychological influence operators and shows their distinct impact on the execution of four actions in the ambient system. In Section VI, we open a discussion upon the propositions of Section IV and we sketch further lines of research stemming from this work.

II. RELATED WORKS

A. Mediated personification

According to Benyon [4], mediated personification technologies include on-screen avatars, robots and other autonomous systems imbued with character that demonstrate intelligence and affect, that know their 'owner' personally.

Indeed many authors are developing virtual graphical characters that can express human emotions. In the late decade, Conversational Assistant Agents (CAA) technologies [6] have produced some interesting results on factors such as *entice-ment*, *believability*, efficient *understanding* [21]. For example, in the IROOM project at CNRS [3], a virtual character interacts with users, as shown in Figure 1. However, Alcaniz and Rey note that several authors are opposed to agent based interface solutions and particularly to the personified type, claiming they remove user control and are distracting.

Among others, Nuttin et al. [20] have explored various interactional situations involving a robotic assistant agent for ambient environments. Note that in the particular case of a

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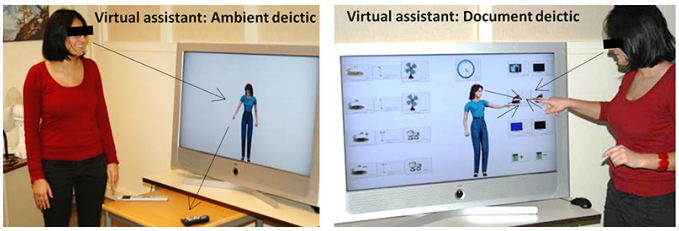

Fig. 1. Virtual assistant agent Elsi of the IROOM project. right) Elsi can explain (using text-to-speech) how ambient devices work through on-screen help; left) Elsi can find, point at and operate physical devices in ambient.

home room, they claim that "The domestic robot in this case, is a personification of the intelligent environment" on the basis that the robot is able to control the whole ambient, for example on behalf of users. Hence, the robot is supposed to be perceived by users *both* as a physical part of the ambient and also as the whole ambient. Indeed, it raises issues about users' cognitive representation of the ambient.

B. Direct personification

The difficulties with mediated personification have prompted a more direct method. For example, Richard [32] has proposed an approach to the personification of various kinds of data structures through the metaphor of "Subjectified personification as design strategy in visual communication", that is mainly seeing non human-like objects (*e.g.*, statistical data) as if they had human characteristics so that ordinary people can have a personal/immediate perception of them rather than logical/rational. Recently, a group of researchers have put forward the notion of Persuasive Feedback Systems (PFS), in the context of ambient environments. Persuasive systems aim at enticing people to modify their habits, not through authority exertion but through enticement and direct interaction with the system [25]. For example, Ko et al. [17] developed MugTree, that encourage people to drink water regularly and to keep a good water-drinking habit. Authors such as Fang and Hsu have showed in a survey [10] the positive influence of factors such as: attention calling (the way the system presents data meant to call attention to a user); aesthetic of the system; emotional engagement with the system. Also, systems have been developed to entice people to reduce their individual energetic consuming, for example by adding sparkling colored lights to the power cord of a device [13].

While the usage and the efficiency of virtual agents in order to personify ambient entities is still controversial, authors agree on the fact that ordinary people placed in an ambient environment, especially in small spaces, need to establish a personal and affective relationship (as in Affective Computing of Picard [23] or Computers As Social Actors of Nass et al. [19]) with the system as a whole.

III. A MODEL FOR AMBIENT PERSONALITY

A. Architecture

In this section, we describe the general architecture dedicated to the personification of an ambient agent. Here we only sketch its mains elements, focusing on the parts actually used in the Section IV. As stated above, two main strategies can used, involving either a mediated or a direct support of the personification of the ambient agent. These strategies are

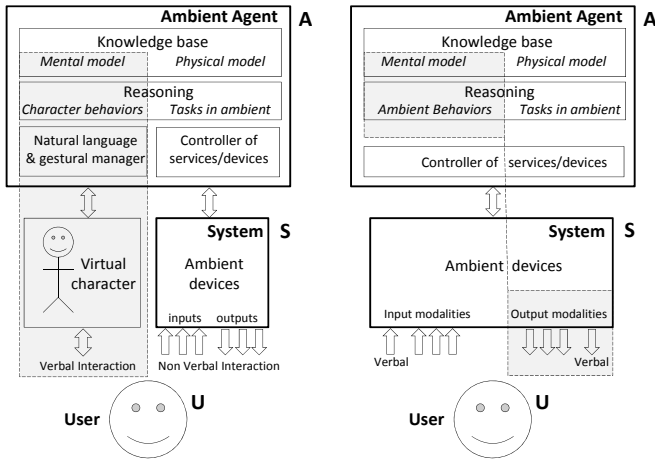

Fig. 2. Two main architectures for ambient agent personification. The personification process is enlightened in gray. Left) Mediated approach involving a virtual character; Right) Direct approach using ambient devices modalities.

illustrated in Figure 2 in order to facilitate their comparison. They share three main entities:
U: the User is an ordinary person who desires to use the ambient system.
S: the System is the physical part of the ambient environment.
A: the Agent is a software tool that endorses a role in a given ambient situation: helper, butler, partner *etc.*

In the mediated approach, personification is mainly supported through natural interaction with a virtual character. The management of the mental model of the ambient agent involves two specific modalities: dialog with the character in spoken language and expression of emotions and personality through gestural/facial animations of the virtual character. In this architecture, natural language is distinguished from devices input/output modalities; together with character animations, it prompts the user to categorize the character as an entity distinct from the ambient itself.

In the direct approach, personification is mainly supported through the modalities of the ambient devices. Note that input/output spoken natural language can be used but it is not a distinguished modality. The advantage of this architecture is that users are not distracted or side-tracked by the character. However, the direct approach raises the challenge of the feasibility of the expression of the mental model of the ambient while only using the output modalities of the ambient devices. In Section IV, we give two typical examples showing how such a mapping is possible.

B. Contribution of psychology on personality traits

Several theoretical domains pertaining to the personality of an individual have been developed over years: Freudian psychoanalysis; taxonomies of personality traits, Maslow and Rogers' humanistic psychology, Bandura's social-cognitive theory, *etc.* Among them, taxonomies of personality traits have been widely used as a ground for studies in affective computing [26] and cognitive agents [12]. This is the reason why we will rely on them in this study.

*1) The Five Factor Model (*FFM*):* Historically, traits taxonomies have been synthesized according to two main ap-

TABLE I. NEO PI-R FACETS FOR THE FFM PERSONALITY DOMAIN.

FFM traits	NEO PI-R 30 facets	Each facet is defined by a single gloss describing its +pole
Openness	Fantasy	receptivity to the inner world of imagination
	Aesthetics	appreciation of art and beauty
	Feelings	openness to inner feelings and emotions
	Actions	openness to new experiences on a practical level
	Ideas	intellectual curiosity
	Values	readiness to re-examine own values and those of authority
Conscientiousness	Competence	belief in own self efficacy
	Orderliness	personal organization
	Dutifulness	emphasis placed on importance of fulfilling moral obligations
	Achievement-striving	need for personal achievement and sense of direction
	Self-discipline	capacity to begin tasks and follow through to completion despite boredom or distractions
	Deliberation	tendency to think things through before acting or speaking
Extraversion	Warmth	interest in and friendliness towards others
	Gregariousness	preference for the company of others
	Assertiveness	social ascendancy and forcefulness of expression
	Activity	pace of living
	Excitement-seeking	need for environmental stimulation
	Positive-emotions	tendency to experience positive emotions
Agreability	Trust	belief in the sincerity and good intentions of others
	Straight-forwardness	frankness in expression
	Altruism	active concern for the welfare of others
	Compliance	response to interpersonal conflict
	Modesty	tendency to play down own achievements and be humble
	Tender-mindedness	attitude of sympathy for others
Neuroticism	Anxiety	level of free floating anxiety
	Angry-Hostility	tendency to experience anger and related states such as frustration and bitterness
	Depression	tendency to experience feelings of guilt, sadness, despondency and loneliness
	Self-consciousness	shyness or social anxiety
	Impulsiveness	tendency to act on cravings and urges rather than reining them in and delaying gratification
	Vulnerability	general susceptibility to stress

proaches: 1) Questionnaires to assess the personality of an individual (generally, yes/no questions) have been used by by Eysenck's Personality Questionnaires (EPQ) [9]; 2) Lexical resources use glosses of personality adjectives found in dictionaries. They have resulted in the FFM taxonomy [11]. When one is interested in the taxonomy of the psychological phenomena, especially those related to personality traits, FFM is the most prominent taxonomy in the context of computational studies [14]. FFM is composed of five main classes, listed in the first column of Table I).

2) The facets of FFM/NEO PI-R*:* The FFM taxonomy being a very generic classification, several authors have tried to refine this taxonomy by dividing its classes into so-called *facets* [7], [29], [31]. The number of facets can vary from 16 in [29] to 30 in the so-called NEO PI-R taxonomy (NEO PI-R stands for **N**euroticism **E**xtraversion **O**penness **P**ersonality **I**nventory-**R**evisited) proposed by Costa and McCrae [7]. In the FFM/NEO PI-R taxonomy, each facet is bipolar, *i.e.*, associated with a concept (pole +) and its antonym (pole-). The 30 bipolar facets of FFM/NEO PI-R are listed in the second column of Table I, together with their gloss. FFM/NEO PI-R is a long standing model that provides a very precise facet list, hence we will rely on it in this study.

TABLE II. TAXONOMY OF MENTAL STATES.

	Arity	
Dynamicity	Unary	Binary
Static	Trait Ψ_T	Role Ψ_R
Dynamic	Mood Ψ_m	Affect Ψ_a

C. Mental model

We only describe the content of the sub part of the symbolic structure that is associated with the agent psychology. Moreover, we define a specific mind model simple enough to support the examples presented in section IV. It covers most significant notions discussed in the literature about mental states modeling [22], with some simplifications (*e.g.*, we consider traits and roles are static during a session). This model distinguishes four types of mental states according to their *dynamicity* and to their *arity*, as shown in Table II.

Each of them is associated to a weight $w \in [-1, 1]$, where $[0, 1]$ denotes the intensity of the concept, $[-1, 0]$ is the intensity of the antonym of the concept and 0 the "neutral" position (neither the concept nor its antonym stand).

Traits (Ψ_T) correspond to typical personality attributes in FFM/NEO PI-R, considered as stable during the agent's lifetime.
Roles (Ψ_R) represent a static relationship between the agent and another entity in the ambient (typically the user). We define two main categories of roles:
— *Authority*: the right the agent feels to be directive toward the user and reciprocally to not accept directive behaviors from the user This role is often antisymmetric such as: Authority(X,Y) = -Authority(Y,X) where '-' denotes the antonym relation.
— *Familiarity*: the right the agent feels to use informal behaviors towards the user. This role is often symmetric.
Moods (Ψ_m) represent factors of an agent varying with time thanks to heuristics and biases, according to previous mental state of the agent and to the current state of the world. Moods are dynamic mental states that are often expressed through a set of simple emotions, as defined by Eckman [8].
Affects (Ψ_a) in this study, they will denote the dynamic relationships between the agent and the user. We distinguish at least three kinds of affects:
— *Dominance*: the agent feels powerful relatively to the user. It is often antisymmetric such as: Dominance(X,Y) = -Dominance(Y,X);
— *Cooperation*: the agent tends to be nice, caring and helpful with the user. It is not necessarily symmetric;
— *Trust*: the agent feels it can rely on the user. It is not necessarily symmetric.

IV. MODAL EXPRESSION OF AMBIENT PSYCHOLOGY

A. Assistant agents for ambient environments

In recent work at CNRS, we have implemented Conversational Assistant Agents in an ambient system [3]. Presently, in the IROOM project, agent/user interactions are supported by two main modalities:
— *Natural language* for control/command and assistance is based on Speech Recognition (SR) and Text to Speech (TTS).
— *Personification* is based on the display of virtual animated characters, on various kinds of screens, as illustrated by the ambient layout, shown in Figure 3.

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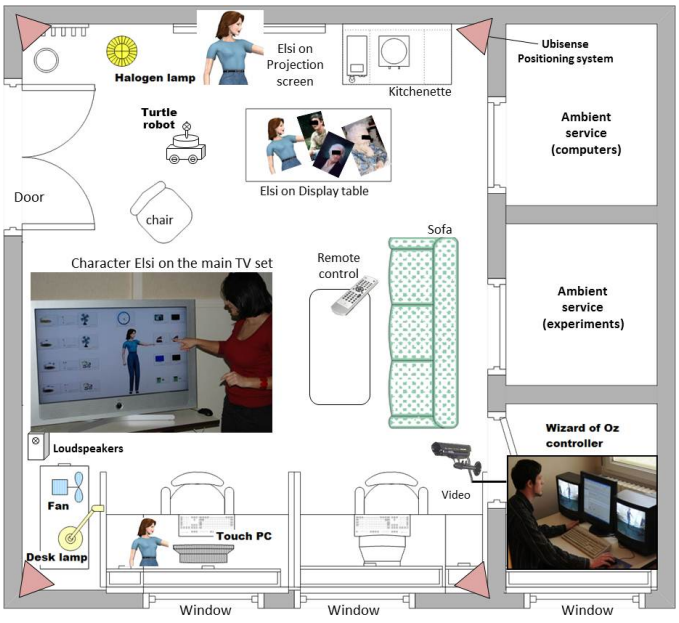

Fig. 3. Layout of LIMSI IROOM project.

Our main objective was to provide ambient systems with assistance capabilities exhibiting two main characteristics:
— *Rational assistance* is supported by an assistant agent about the control/command of the system;
— *Psychological behavior* associated with moods and traits, is performed by the agent in order to increase two important interactional factors: acceptability and naturalness.

However, the presence of a virtual agent on screen was interpreted by most users as the existence of an entity separated from the ambient system, hence prompting the user's mental scheme $\langle User, Ambient, Agent\rangle$. In this tripartite model, the agent is not viewed as consubstantial of the ambient system and this can lead to misunderstandings in user/agent interaction. This is especially serious in a situation where the user seeks help about the ambient that is already suffering from cognitive overload.
This is the reason why in this study, we propose a framework capable of prompting a bipartite user's mental scheme $\langle User, Ambientagent\rangle$. In this model, the user interacts **directly** with the ambient system "as if it were a person", hence called the $Ambientagent$, having the new requirements:
— *Natural language* in oral mode, becomes a prominent modality, though it remains globally unchanged;
— *Personification* is no longer supported by a virtual character;
— *Rational assistance* is unchanged;
— *Psychological behavior* is no longer expressed through virtual character modalities, hence it is necessary to find alternative modalities to express moods and traits.

In summary, the feasibility of such a direct mode of interaction relies on the possibility to express psychological behaviors in terms of ambient modalities, especially **output** modalities. In the following, we will focus upon the expression of moods and traits.

B. Expression of Ambientagent's moods

1) Ekman's basic emotions: As stated in Section III-C, moods are dynamic mental states that are often expressed through emotions, hence we restrict here to the expression of moods as emotions. Research on human psychology has developed several models of emotions. Typically, emotional states refer to Paul Ekman's six basic emotions [8] (see their list in Table IV-left) even if other authors, *e.g.*, Frijda, have proposed more advanced models.

TABLE III. OUTPUT MODALITIES OF THE IROOM ENVIRONMENT.

Devices	*Activities*
Character display	*also used for information display*
Text to Speech	Agents' oral expression
Screens	TV, mural screen, touch PC *etc.*
Devices	*producing an output effect*
Air control	fan, heater, cooler*, scent dispenser*
Light control	lamps, electric curtains*
Sound control	music loudspeakers, alarms
Static appliances*	coffee-machine, cooker, fridge *etc.*
Robots	autonomous moving machines
Atmosphere	*main components*
Luminance	level, color (hot, cold, red, green…) and dynamics (waves, flash)
Music *(backgd)*	level and mood (chill, cheer, sad …)
Alarm	level, type and dynamics (bip, honk…)
Temperature*	level
Scent*	level and theme (spring, gas, sweat…)
Devices	force and specific action

*Not yet implemented.

2) Expression of Eckman's emotions through output modalities: In this case, we consider the output modalities of class atmosphere as in Table III. We fill one or more features (level, theme, type, *etc.*) in order to express Ekman's emotions. Table IV reveals two main results:
1. any atmosphere component is used, at least three times;
2. any emotion can rely on several modalities (at least three).
This shows that ambient output modalities can support the expression of basic emotions. Note that it does not imply that people would actually perceive and categorize them correctly.

C. Expression of Ambientagent's personality traits

1) The R&B framework: Previously, we have proposed a framework, called R&B (for Rational and Behavioral agents) [27], in order to express personality traits in terms of their psychological influences/alterations over the rational process of an artificial agent achieving a particular goal γ. This research is based on the principle of sub determination of plans: it states that for a goal γ, the planning module of a rational agent often produces several plans $\pi_i \in \Pi_\gamma$ that achieve γ. Typically a 'best' plan $\pi^\star$ is chosen in Π_γ by adding cost functions that rank π_i and sort Π_γ.

In the R&B framework, plan sub determination is preserved thus making it possible for Π_γ to be submitted to the influence of so-called psychological operators $\omega_i \in \Omega$. For example, the deliberation cycle of BDI agents [24], prompts a set Ω_{BDI} that can be partitioned into eight main classes: preference upon goals; preferences upon actions; norms and duty filtering; scheduling heuristics; modalities of action execution; optional actions; expectations (hopes, fears); appraisal of results of actions. (see [27] for a list of 30 operators associated with trait Conscientiousness).

2) Definition of a personality: Considering the FFM/NEO PI-R taxonomy, it is possible to define the personality $P(x)$ of a person x as a set of facets, activated in +/- mode. For

TABLE IV. EXPRESSION OF EKMAN'S EMOTIONAL STATES.

Mental states	Luminance	Music	Alarm	Temp.	Scent	Device
None	= neutral	= chill	0	=	0	= unspecific
Joy	+ hot	+ cheer	0	=	+ spring	+ Robot.move
Sadness	- cold	- sad	0	-	0	- Robot.move
Fear	+ red *blink*	0	+ danger *	+	+ gaz	+ Robot.hide
Surprise	+ neutral *flash*	0	+ oops 1	=	0	0 Robot.stop
Anger	+ red	+ harsh	+ rap *	+/-	+ sweat	+ Fan.run
Disgust	- Gloomygreen	0	0	-	0	= unspecific

*0 is none = is neutral + is higher than neutral or none (- is lower). 1 executed once; * denotes repetition.*

example, suppose Paul is lazy and easily stressed whereas Lucy is a hard-worker, trustful and modest. Their personality can be transcribed in FFM/NEO PI-R facets (see Table I):
$P(paul) = \{C_{-selfdiscipline}, N_{+vulnerability}\}$
$P(lucy) = \{C_{+selfdiscipline}, A_{+trust}, A_{+modest}\}$.

3) Example of operators of influence: Each facet in $P(x)$ activates a set of psychological operators $\omega_i \in \Omega$ that influence plans (and actions in plans) when they are performed by x. Among operators associated with FFM/NEO PI-R facet $C_{+selfdiscipline}$ an obvious one is $\omega_{hardworker}$, which is a hyponym of +pole definition: "capacity to begin tasks and follow through to completion despite boredom or distractions" (Table I) *resp.* ω_{lazy} is a hyponym of the -pole facet. We have extensively detailed how facets are linked to psychological operators in previous works [27] [28], but this discussion is beyond the scope of the paper.

V. CASE-STUDY

A. Implementation of influence operators

Considering the classes defined in Section IV-C1, we restrict for this example to two kinds of influences that are complementary:
1) *Plan alteration*: the $Ambientagent$ has the capability to avoid performing an action a_i part of a plan π either by providing the user with a dialogical Rebuke or by substituting a less-hard-to-perform Alternative action. Respectively, the $Ambientagent$ can add optional actions. For example: pleasant actions; cleaning-up *etc.* (Note that an optional action must not prevent a plan to achieve its goal).
2) *Action manners*: the $Ambientagent$ has the capability to perform an action a_i in a Partial manner or in a Slack manner. Respectively, actions can be executed in an Exceed manner (make more coffee than asked) or in an Efficient manner (*e.g.*, focused, precise, quick).

B. Example: a lazy vs hardworker ambient

As an example, we will contrast the actual behavior of an agent associated with operators of influence associated with the positive pole and respectively the negative pole of facet Self-discipline of trait Conscientiousness of the FFM/NEO PI-R taxonomy: operators ω_{lazy} and $\omega_{hardworker}$.
— Table V implements an ambient associated with operator ω_{lazy}. In column 1, are listed four examples of actions that can be performed by an ambient agent associated with the IROOM. For each action, two alterations (Rebuke, Alternative) and two manners (Partial , Slack) are used. For example, a "lazy ambient", when requested to open a room's curtain, will react by executing one or several influences described in Table V: saying "it is too shiny outside!"; propose to switch on a lamp; just open the curtain just a little and/or slowly.
— Table VI implements $\omega_{hardworker}$, using in this case two alterations (pleasant, Clean-up) and two manners (Exceed, Efficient). Hence, when asked to open a curtain, a "hardworker ambient" will react in a very different way. It will efficiently do: comment on the weather, switch off active lamps, and also open other curtains.

TABLE V. INFLUENCES OF ω_{lazy} UPON FOUR ACTIONS IN AMBIENT.

Ambient Actions	Rebuke[a]	Altern.	Partial	Slack
Open a curtain	too shiny!	lamp on	yes	yes
Play music	.[b]	.	yes	.
Set timeout	.	post it	.	.
Clean floor	bag full! battery low	.	yes	yes

[a] Rebukes are expressed in spoken modality (abridged here).
[b] no influence is applicable.

TABLE VI. INFLUENCES OF $\omega_{hardworker}$ UPON ACTIONS.

Actions	Pleasant	Clean-up	Exceed	Eff.
Open a curtain	add comment on weather	switch off lights	open other curtains	yes
Play music	choose joyful, add light...	class CDs	set sound very loud	.
Clean a floor	add scent, music, light...	clean tools (broom)	clean other floors	yes

VI. DISCUSSION

Table IV reveals two main results: a) any atmosphere component is used, at least three times b) any emotion can rely on several modalities (at least three). This shows that ambient output modalities can support a form of expression for basic emotions (*resp.* for personality traits). Indeed, it does not imply that people would actually perceive the modalities and moreover, would correctly categorize expressed emotional states and personality traits. Further experiments with subjects placed in the IROOM environment are required. For example, one could experiment how user's profiles (sex, culture, age, *etc.*) influence the perception of ambient emotional states.

In this line, psychologists already have endeavored since the '70, a lot of research about the impact of ambient outputs upon people: Ambient temperature related with aggressive behavior [2] ; it has also been studied in conjunction with horn honking [15]. The influence of ambient odors on creativity, mood, and perceived health has been investigated by many authors since Knasko [16]. All these works bring a convergent positive pattern that people effectively perceive ambient

physical output modalities and that their behaviors are altered by them. Hence, we think that there is a case for further investigating the direct personification hypothesis.

Moreover, people do not react uniquely to ambient modalities. This has been successfully addressed by psychologists working in the ambient context: Ethnic differences [30]; FFM model-based differences [18], *etc.* Actually, what people make of the cues sent by the environment entails a new area of research.

VII. Conclusion and future work

In this study, we have proposed a framework to express the emotional states and personality traits of an ambient environment directly through its output modalities, as an alternative to the mediation of the ambient by a virtual conversational agent. Our approach is based on three supports: 1) the well-used models for emotions (Ekman) and traits (FFM/NEO PI-R); 2) the R&B framework stating how psychological features can be implemented in terms of influence operators over the rational decision making process of artificial agents; 3) the experimental ambient environment (IROOM project at CNRS) providing a set of output modalities. We have shown the feasibility of the approach through an illustrative example. In future works, we are going to extend this framework to the handling of roles and affects and to carry out experiments, involving subjects in the IROOM, in order to assess to what extent users perceive the psychological expression of the $Ambientagent$.

References

[1] M. Alcaniz and B. Rey. New technologies for ambient intelligence. In G. Riva, F. Vatalaroa, F. Davide, and M. Alcaniz, editors, *Ambient Int.*, pages 3–15. IOS Press, 2005.

[2] C. A. Anderson, K. B. Anderson, N. Dorr, K. M. DeNeve, and M. Flanagan. Temperature and aggression. *Advances in Experimental Social Psy.*, 32:63–132, 2000.

[3] Y. Bellik, I. Rebai, E. Machrouh, Y. Barzaj, C. Jacquet, G. Pruvost, and J. P. Sansonnet. Multimodal interaction within ambient environments: an exploratory study. In *12th IFIP TC13 Conference in Human-Computer Interaction, INTERACT'09*, volume 5727, pages 89–92, Uppsala, Sweden, 2009. LNCS.

[4] D. Benyon, K. Höök, and L. Nigay. Spaces of interaction. In *Proceedings of the 2010 ACM-BCS Visions of Computer Science Conference*, ACM-BCS '10, pages 2:1–2:7. British Computer Society, 2010.

[5] D. Benyon and O. Mival. Landscaping personification technologies: from interactions to relationships. In *CHI '08 extended abstracts on Human factors in computing systems*, CHI EA '08, pages 3657–3662, New York, NY, USA, 2008. ACM.

[6] J. Cassell, J. Sullivan, S. Prevost, and E. Churchill, editors. *Embodied Conversational Agents*. MIT Press, 2000.

[7] P. T. Costa and R. R. McCrae. *The NEO PI-R professional manual*. Odessa, FL: Psychological Assessment Resources, 1992.

[8] P. Ekman, W. V. Friessen, and P. C. Ellsworth. *Emotion in the human face*. Pergamon Press, 1972.

[9] H. J. Eysenck and S. B. G. Eysenck. *Manual of the Eysenck Personality Questionnaire*. London: Hodder and Stoughton, 1975.

[10] W. C. Fang and J. Y. Hsu. Design concerns of persuasive feedback system. In *Proceeding of the AAAI Workshop on Visual Representations and Reasoning*, july 2010.

[11] L. R. Goldberg. Language and individual differences: The search for universal in personality lexicons. *Review of personality and social psychology*, 2:141–165, 1981.

[12] J. Gratch and S. Marsella. A domain-independent framework for modeling emotion. *Journal of Cognitive Systems Research*, 5(4):269–306, 2004.

[13] A. Gustafsson and M. Gyllenswärd. The power-aware cord: energy awareness through ambient information display. In *CHI '05 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '05, pages 1423–1426, New York, NY, USA, 2005. ACM.

[14] O. P. John, R. W. Robins, and L. A. Pervin, editors. *Handbook of Personality: Theory and Research*. The Guilford Press, 3rd edition, 2008.

[15] D. T. Kenrick and S. W. MacFarlane. Ambient temperature and horn honking: A field study of the heat/aggression relationship. *Environment and Behavior*, 18(2):179–191, 1986.

[16] S. C. Knasko. Ambient odor's effect on creativity, mood, and perceived health. *Chemical Senses, Oxford University Press*, 17(1):27–35, 1991.

[17] J. C. Ko, Y. P. Hung, and H. H. Chu. Mug-tree: a playful mug to encourage healthy habit of drinking fluid regularly. In *Proc. of UBICOMP'2007*, page 2007, Innsbruck, Austria, 2007.

[18] M. R. Mehl, S. D. Gosling, and J. W. Pennebaker. Personality in its natural habitat: Manifestations and implicit folk theories of personality in daily life. *Journal of Personality and Social Psychology*, 90(5):862–877, 2006.

[19] C. Nass, Y. Moon, E. Kim, and B. J. Fogg. Computers are social actors: A review of current research. In B. Friedman, editor, *Moral and Ethical Issues in HCI*, pages 137–162. Cambridge University Press and CSLI Publications, 1997.

[20] M. Nuttin, D. Vanhooydonck, E. Demeester, and H. Van Brussel. A robotic assistant for ambient intelligent meeting rooms. In *Ambient Intelligence*, volume 2875 of *LNCS*, pages 304–317. Springer, 2003.

[21] A. Ortiz, C. M. Del Puy, D. Oyarzun, J. J. Yanguas, C. Buiza, M. Gonzalez, M. Feli, and I. Etxeberria. Elderly users in ambient intelligence: does an avatar improve the interaction? In *Proceedings of the 9th conference on User interfaces for all*, ERCIM'06, pages 99–114, Berlin, Heidelberg, 2007. Springer-Verlag.

[22] A. Ortony. On making believable emotional agents believable. In Robert Trappl, Paolo Petta, and Sabine Payr, editors, *Emotions in humans and artifacts*, pages 189–211. MIT Press, Cambridge, MA, 2003.

[23] R. W. Picard. *Affective computing*. MIT Press, 2000.

[24] A. S. Rao and M. P. Georgeff. BDI agents: From theory to practice. In *Proc. First Int. Conference on Multi-agent Systems (ICMAS-95)*, pages 312–319, 1995.

[25] W. Reitberger, M. Tscheligi, B. de Ruyter, and P. Markopoulos. Surrounded by ambient persuasion. In *CHI '08 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '08, pages 3989–3992, New York, NY, USA, 2008. ACM.

[26] P. Rizzo, M. V. Veloso, M. Miceli, and A. Cesta. Personality-driven social behaviors in believable agents. In *AAAI Symposium on Socially Intelligent Agents*, pages 109–114, 1997.

[27] J. P. Sansonnet and F. Bouchet. Expression of behaviors in assistant agents as influences on rational execution of plans. In *Intelligent Virtual Agents (IVA 2010)*, volume 6356 of *LNAI*, pages 413–419, Philadelphia, PA, 2010. Springer-Verlag.

[28] J. P. Sansonnet and F. Bouchet. Extraction of agent psychological behaviors from glosses of wordnet personality adjectives. In *Proc. of the 8th European Workshop on Multi-Agent Systems (EUMAS'10)*, Paris, France, 2010.

[29] G. Saucier and F. Ostendorf. Hierarchical subcomponents of the big five personality factors: A cross-language replication. *Journal of Personality and Social Psychology*, 76(4):613–627, 1999.

[30] M. Schaller, J. H. Park, and A. Mueller. Fear of the dark: interactive effects of beliefs about danger and ambient darkness on ethnic stereotypes. *Pers Soc Psychol Bulletin*, 29(5):637–49, 2003.

[31] C. J. Soto and O. P. John. Ten facet scales for the big five inventory: Convergence with NEO PI-R facets, self-peer agreement, and discriminant validity. *Journal of Research in Personality*, 43(1):84–90, 2009.

[32] R. The. Subjectified personification as a design strategy in visual communication. In *Master of Science report*. School of architecture and planning, MIT, 2010.

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