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First Evaluational Results in the Development of Training by Animated Pedagogical Agents (TAPA)

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Abstract.

Training with Animated Pedagogical Agents is a promising new style of training especially fore children with disabilities. In this paper, we present the evaluation results of our training agent system called TAPA, which has a realistic moving body and body language features. TAPA is web based training system. TAPA allows children to access the training sources over the Internet through a user-friendly multimodal interface in a humanlike communication.

1 Introduction

Recent neuropsychological research assumes, that children with learning disabilities and memory deficit e.g. caused by neurological disease can benefit by special training of meta-memory strategies (Aldenkamp 1990; Haverkamp et al.1999). Though this kind of memory training requires a specialized coach who performs an individual and motivational support that is not often possible neither under educational nor school conditions.

Animated Pedagogical Agents (Johnson WL & Rickel J 2000). These little animated characters combine their behavior as lifelike virtual fellow and their role as individual trainer (especially suitable for children). The Agents aim to influence the emotional and as a result the motivational training experience of the users.

In the consequence we have designed and developed an autonomous training system called TAPA (Training with Animated Pedagogical Agents) that is primarily determined by dynamically interconnected diagnostic and training modules (Tebarth, Mohamad & Pieper 2000; Mohamad & Tebarth 2001). Basically the whole TAPA-system is designed for a web-based use with an individual and autonomous training at home, which is necessary to obtain a prolonged effect in large numbers of affected children.

However, to achieve direct motivation it is necessary for the system to receive information about the current attention status of the user as valid as possible. Therefore we are experimenting to capture the physiological values: electrical skin conduction, muscle tension and electrical fronto-

temporal activity and cross check them with user's task reply. In neuropsychological research these values are correlated with level of physiological arousal, can be expected to give indirectly hinds about emotional excitement and are used in other terms in the polygraphic examination (Tsuchiya T et al. 1991).
As a method to receive additional information about motivational status of the user we have designed a motivation panel (called fun-o-meter), on which the child could tell the system about his current level of motivation.
Responding to the risk of misinterpretation of these input data we developed some prototype scenarios that include different communication situations. The agent's job in this regard is to verify either falsify the interpretation of these input data by so-called repair questions or dialogues.

These repair questions were developed systematically with respect to the socio-psychological concept of meta-dialogue and can be expressed in formalized pattern (Pieper 2000). A logical model for the development of meta-dialogue was developed and tested.

Meta-Communication Example:

Subsequently to the agent's (A) request the child (C) has mistakenly quoted an increasing of motivation (m) via virtual

panel board (AC(m ↑) and C(m ↓)). Actually the child wanted to express its wish for a more motivating/funnier next task

that way. With respect to the child's constantly low physiological values the agent would begin the following dialogue:

A: "I see you found the last task very funny. But I would like to know more about that. Was the last task funnier as the

ones before? Please answer with Yes or No!"

C: "No."

A: "Ah, so you meant that the last task was as funny as the ones before? Yes or No?"

C: "No."

A: "Oh, so you actually wanted to say that the last task wasn't that funny than the last ones?"

C: "Yes."

A: "O.K. Now I understand. You didn't like the last task and you wanted to say the next one should become funnier?

Yes or No?"

C: "Yes."

With the agent's repair questions the situations now looks like that: C(m ↓) and CAC(m ↓) and AC(m ↓) ⟶ CA(m ↓') and A(m ↓') (see Tebarth, Mohamad & Pieper 2000) .

Result: The agent has to do some motivational work. Furthermore the agent knows that he has to explain again and more precisely how the child has to use the virtual motivation panel board.

As important for therapeutic effectiveness TAPA aims to improve the children's perception of their self-efficacy. One of the immanent problems in the delayed cognitive development is a distorted perception of self-efficacy/performance (Perleth, Schuker & Huber 1992; Schneider 1989). Due to repeated and continuous feedback by animated agents the child could learn to estimate its own performance more realistically.

2 TAPA-Prototype

2.1 Psychological Training Concept

As elaborated on 6th ERCIM-Workshop (Tebarth, Mohamad & Pieper 2000) meta-memory means to know about the own memory functioning. Under positive conditions children develop in the age between 8 and 10 years some kind of knowledge about their memory and how it works (Hasselhorn 1996; Perleth 1992).

Children with cognitive disorder or development delay often have the risk of not developing these working-strategies (Schneider 1989). Especially in children with learning disabilities clear delays and even lacks of the meta-memory development can be observed. From that point it was exiting to find that these children can benefit from an instructional coaching and are able to catch up with their contemporary playmates (Hasselhorn & Mähler 1992; Perleth, Schuker & Huber 1992; Perleth 1992).

The here developed TAPA is based on four main training components and considers the last research result. All steps are introduced, explained and supervised by animated pedagogical agents.

1. Specific memory strategies and learning strategies
2. General meta-memory knowledge
3. Feedback for an appropriate perception of performance/self-efficacy
4. Attention and concentration training

To impart these contents in an attractive and playful way to children we embedded the training in an exiting and fairytale contextual story:

The child is invited to help the little gorilla Bonzi and the magician Merlin to rescue their friend Peedy the parrot who was kidnapped by the terrible Zorgo-Skeleton. On their way to Zorro's creepy castle they have to survive several adventures as there are buying some ingredients for a magic soup in a witch shop, opening an enchanted gate with the help of an thousand year old turtle, defeating the terrible Zorgo and liberating Peedy out of its dungeon. All adventures contain memory tasks that require the correct use of meta-memory strategies. The whole story consists of sequential episodes involving the several agents. Different scenic graphics are combined to a virtual world, which helps to tell the story.

Leading agents (Bonzi and Merlin) introduce themselves to the child and interview the child regarding learning-self-concept and estimation of own cognitive performance and abilities. The child's answers are used for adaptivity and evaluation. In the training scenes tasks will be offered by different side agents (e.g. Zorgo). The child has to solve them under the assistance of the leading agents. Later this kind of tasks should allow a transfer to every day tasks using the learned knowledge in real situations (Perleth 1992).

Regarding the emotional modelling we had to define and variegate gesture, gaze and facial play of the agents. In different situations the agents have to show different emotions e.g. to be happy and to show that in gestures to the child. So we built a model with all possible emotional states. Those emotional states should be applied in an optimised way to the current situation.

Furthermore we had to integrate the individual agent into its environment to keep a consistent and closed training context. All agents communicate to each other and to the virtual world and its objects. This allows them to react to any change in this world and to perform finally an adaptive behaviour to the child.

2.2 Emotion Modelling

For a long time emotions have been kept out of the deliberate tools of science; scientists have expressed emotion, but no tools could sense and respond to their affective information. But now there are many systems that can elicit and detect emotions. At the moment the main research areas for the usage of emotional systems are entertainment and education**.**

However, there are situations in which human-computer interaction could be improved by having the computer adapt to the user, and in which communication about when, where, how, and how important it is to adapt involves the use of emotional information.

Indicating that factors important in *human-human* interaction are also important in *human-computer* interaction. In human-human interaction, it has recently been argued that skills of so-called "emotional intelligence" are more important than are traditional mathematical and verbal skills of intelligence. These skills include the ability to recognize the emotions of another and to respond appropriately to these emotions. Whether or not these particular skills are *more* important than certain other skills will depend on the situation and goals of the user, but what is clear is that these skills are important in human-human interaction, and when they are missing, interaction is more likely to be perceived as frustrating and not very intelligent.

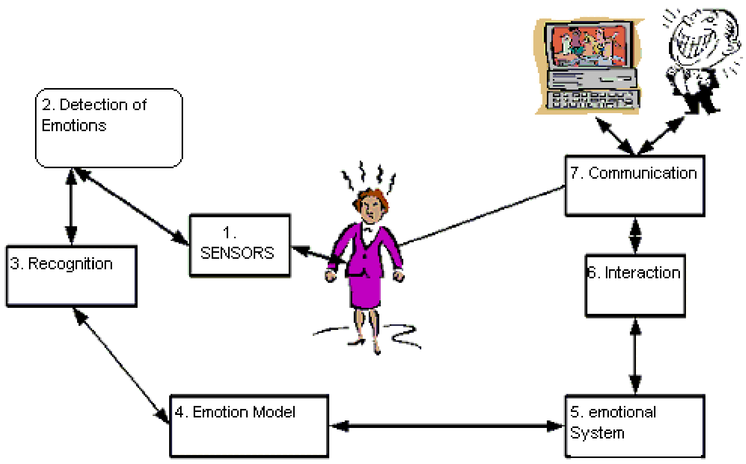

Figure 1: Emotional System

2.3 Architecture of The Emotions component

In addition to recognition and response to user emotions, there are other aspects of affective computing, such as the use of emotion-like mechanisms within the machine to help make decisions, adjust perception, and influence learning.

The TAPA system is determined by the pedagogical interface agents architecture, an immersive story playing in a virtual world, where the training units are encapsulated into the story. The agents in that virtual world have their emotional states (artificial) based on status of their environment and on the goals they want to achieve. The goals of the agents depend mainly on the training units, the user's preferences and emotional status (natural).

The main issue here is how to model the emotions and to derive behavior depending on them. It is very important to distinguish between the emotions of the agents that might called 'artificial emotions' and how to model them and derive behavior depending on them and the responding 'natural emotions' on the user's side which could be captured through sensors and verified by input data entered by the user himself or third person.

Artificial emotions mustn't be complaint in their complexity and diversity to natural emotions, because their primary aim here is to improve the motivational rule of agents to avoid indifference on user's side.

The artificial emotions include many aspects, which could be divided into:

2.3.1 Internal

1. *Task/goal oriented:* e.g. if the agent wants to give award to the child, it would not be very helpful to get sad but to be happy
2. *Environment influence:* e.g. if something happens suddenly it would be suitable to be surprised and to show an appropriate behavior reaction
3. *Character:* every agent has its own character, so the emotions should follow an individual personality concept
4. *Time:* synchronization is a very important issue, so we are dealing with many agents simultaneously; the behavior of each agent must be suitable to the behavior of all others at that moment.

2.3.2 External

1. *Sensors:* measuring physiological values as there are skin conduction, heart rate and blood pressure known as good parameters for status of emotional excitement
2. *Direct manipulation:* through the 'fun-o-meter' or any other data entered by the user or others.

The here-applied cognitive model of emotions is based on the OCC model (Ortony 1988) and the agent personality model FFM (McCrae&John 1992).

According to the OCC model, emotions are simply classes of emotion eliciting conditions such as the agent's beliefs, goals, standards, and attitudes. An interesting set of emotions is crucially dependent on the agent's attitudes. The agent might be *happy for* its interlocutor if the agent likes the interlocutor and experiences *joy* over a state of affairs that it presumes to be desirable for the interlocutor. Otherwise, if the agent dislikes the interlocutor, it might *resent* its interlocutor for the same reason. A similar symmetry can be found with the *sorry for* and *gloat* emotion types (Prendinger H. Ishizuka M. 2002).

The emotional states are expressed in the system by victors (emotion, value) e.g. (happy,0.73).

We used Microsoft Agents (Microsoft 1999) to implement the agents.

2.4 Technical description of TAPA

The TAPA system can be divided into tow subsystems, the authoring subsystem and the run time subsystem.

The authoring system allows the Author (Designer) to combine multi modal items (sound, natural language, agents, images, buttons, etc.) and build up the story in a suitable way for children. The output of the authoring tool is an XML file for every training unit, the XSLT files have to be created at the moment manually.

The run time subsystem (interpreter) is javascript based, it reads an XML training file, XSLT files and the user/device profile.

The training unit can be invoked over the Internet from an IE explorer (> Version 5.0) and the user can enjoy the training.

The user profile and the tracking data are stored in an MS Access database.

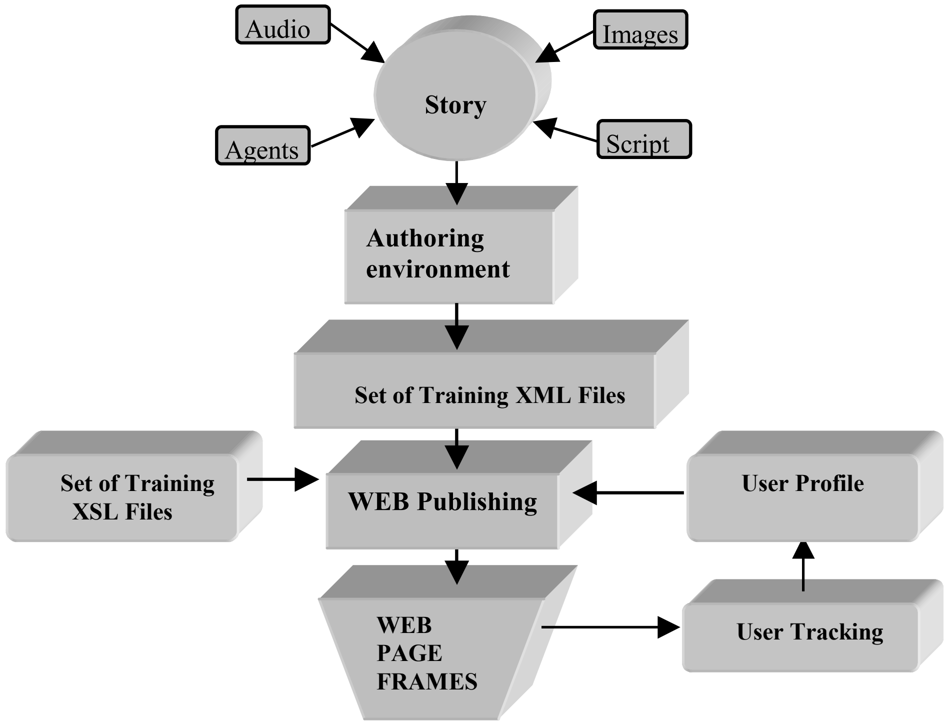

Figure 2. Technical Aspects of TAPA

3 First Results

At the hospital for children at the university of Bonn we confronted in a first evaluation step 10 children with a seizure disease and 5 healthy children with the prototype of TAPA.

	Children with Epilepsy (n=10)	**Healthy Children (n=5)**
Type of Epilepsy	7 with rolando 3 with absence	
Average Age In years	11.9 (sd=1.5)	11.2 (sd=2.4)
Sex	6 male	3 male
Every-Day Memory Performance assessted by parents (5 point-Likert-scale, 1=very high to 5=very poor)[1]	*3.2** (sd=1.0)	*1.4* (sd=0.6)
School Degrees	*2.6* (sd=1.0)	*2.0* (sd=0.7)
NUMBER OF FRIENDS	2-3	4-5
Child's Ability of Self-Perception assessed by parents		
Estimation of own Cognitive Performance (5 point-Likert-scale, 1=very adequate to 5=very inadequate)	3.0 (sd=0.9)	2.0 (sd=1.4)
Frequency of Overestimation (5 point-Likert-scal, 1=very low to5=very high)	2.2 (sd=0.8)	1.6 (sd=0.9)
Frequency of Underestimation (5 point-Likert-scale, 1=very low to 5=very high)	1.5 (sd=0.9)	1.0 (sd=0.7)

Table 1: Characteristics of Test Persons

With respect to the small number of test persons that could be realized up to now it has to be mentioned that an statistical evaluation has to remain as far as necessary on case study level for the time being.

While working with TAPA the children's behavior were observed through a psychologist. Here was essentially focused on the emotional mimic expressions and finally rated regarding affective

[1]Table 1 p=0.05 significant different to control group

quality and quantity. The reply-behavior of the children concerning the instructed memory tasks was recorded in the TAPA-database. Further information about perception and experience of agents were charged in a subsequent questioning of the children. Beyond that parents were asked through questionnaire for their children's learning and performance behavior and ability of self-estimation. As demonstrated in recent psychological research the here investigated children with seizure disease showed a poorer memory performance than the healthy children (see Table 1). Furthermore there was found a tendentious higher risk of misestimating of own cognitive performance in the children with epilepsy. Interestingly within the group of epileptic child this ability of self-perception was correlated significantly high with the every-day-memory performance (Kendall-$\tau = 0.8^{**}$ (sign. on p=0.01). Further remarkable but not unexpected significant correlations of these two items were found to average school degrees (Kendall-$\tau = 0.7^{*}$ (sign. on p=0.05). Next to the verification of described cognitive characteristics of epileptic children the prestudy was mainly aimed to evaluate the functionality of the different basic communication situations as there are:

- *Diagnostic interactions:* measuring child's meta-memory performance
- *Therapeutic interactions:* child's profit of agent's instructions
- *Motivational interactions:* influence of agent setting on child's motivation

	Children with Epilepsy (n=10)	**Healthy Children*(n=5)***
Childs ' Motivation *Children were asked for motivation and fun working with TAPA.* (10 point-scale, 1=low to 10=high)	*7.1* (sd=2.6)	*5.3* (sd=3.7)
Instructional Effectiveness Number of children who solve memory tasks before agents' treatment. Number of children who solve memory tasks after agents' treatment.	1 of 10 9 of 10	3 of 5 5 of 5
Childs' Perception of Agent HCI		
Agent's Liveliness/Genuineness Number of children who believe agents Are still active when TAPA is off.	6 of 10	3 of 5
Agent's Personality Number of Children who recognize Agent's characters correctly.	6 of 10	5 of 5
Agent's Transparency Number of children who interpret Agent's behaviour/emotions correctly.	9 of 10	5 of 5

Table 2: Treatment Effectiveness and Child's Perception of Agents

Concretely it was here important to find out how the children perceive the agent HCI and especially if they accept the agents as virtual teacher. With respect to the other items of interest we investigated furthermore the level of motivation during the TAPA-lesson and the effectiveness of the instructed memory strategies.

As demonstrated above TAPA performed an effective treatment instructing the children how to use memory strategies successfully. Based on only a small number of test persons this important

result has to be verified in further studies. There are also hinds that the specific memory tasks examining the meta-memory performance are especially difficult for the children with epilepsy as expected.
The child's` statements about their motivation to have another lesson (11 of 15) as well as their fun working with TAPA showed that there is especially in the handicapped children an acceptable but not optimal grade of motivation.
With respect to unwanted high age we see here an explanation confirmed by correlation between age and child's estimation of age appropriate of TAPA (Kendall-τ = 0.4* (sign. on p=0.1)). 8 of 15 children were of the opinion that TAPA is a program developed for younger children (as there are actually intended an average age of about 10 years).
Regarding the child's` perception of agents we have to note furthermore that TAPA realized a satisfying transparency of behaviour, but personality/character as well as liveliness are suboptimal obtained.

4 Conclusions

Despite the (for the time being) low number of test persons the first results seem to give a promising perspective for the further development of TAPA. We could show that even a prototype of TAPA is able to obtain a clear training effect in the intended sense. Concerning the acceptance and suitability of agent's interface there can also be drawn a positive conclusion however the criteria were not reached optimally in every respect.

Nevertheless for the future it will be necessary to perform a more complex evaluation design to enable the not yet realized technical integration of physiological emotion measuring. In this connection it has to be pointed out that this prototype was managed without an actual adaptive control in the emotional regard.

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