Dimensions of Personalization in a Narrative Pedagogical Simulation for Alzheimer's Caregivers

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***Abstract*— In the context of the *Carezheimer* project, the authors propose to personalize a narrative simulation to improve daily living abilities of people caring for relative with Alzheimer's disease. This personalization engages learners in a story offering adapted action possibilities. In this paper, after a brief description and definition of personalization in training simulations, we describe the dimensions of personalization for a narrative-based serious game and explain how these dimensions impact the dynamic generation of narrative.**

Keywords—narrative simulation; interactive narrative; serious game; personalization; adaptativity; adaptability; Alzheimer; family caregivers

I. INTRODUCTION

Alzheimer Disease (AD) is long lasting and ultimately severely debilitating. Although deterioration is inevitable, the rate of progression of the disease is quite variable for each individual. The modification of the patient behavior at each stage of the illness makes caring for a patient with Alzheimer difficult and emotionally distressing for family members. Family caregivers generally prefer to avoid placing their elderly relatives in nursing homes. However, family-caregivers require considerable support and assistance to keep patients at home. In order to prepare them at best to go through the difficulties they will have to face off, we propose to develop a personalized interactive narrative which aim is to help caregivers to deal with their relative with Alzheimer Disease during daily activities thanks to a narrative simulation.

While number of serious games have been developed to help people to adopt appropriate behaviors in various difficult social situations, including in the health domain, these products remain static, proposing an almost rigid scenario to users. For example, the serious game "At-risk at the ED[1]" is about screening for patients in Emergency Departments with high quality 2D graphics and recorded voice, or EHPAD'PANIC[2] is a serious game which aim is to train caregivers in French long term care establishments for elders.

However, the outcomes of research evaluating the needs of family caregivers suggest that a strategy to support caregivers should be based on the key principles that each family has unique problems and that it is necessary to continue to provide support for caregivers throughout the duration of the disease rather than for only a short period of time [1].

Therefore, we propose to develop a dynamic simulation, flexible enough to support a high level of personalization and better meet the needs of family caregivers.

First, this article will propose a brief overview of personalization in simulations and more precisely in Interactive Digital Storytelling (IDS). Then we will discuss about dimensions of personalization and finally this article will express the dimensions of personalization into a generative IDS approach.

II. PERSONALIZATION IN SIMULATIONS

There is a long history of research in the domain of personalization and adaptation of learning modules and courses [2][3][4].

A. Definition of personalization

Personalization in interactive systems may be divided in three categories, customization, adaptability and adaptivity [5][6][7]:

- Customization is when the system allows the user to manually adapt the interface to her needs, modifications are only within the interface and do not include the system's functioning,
- Adaptable systems allow the user to change certain system parameters, thus the system adapts its behavior accordingly,
- Adaptive systems adapt themselves to the users automatically based on the system's assumptions about user needs without any explicit modification from the user.

B. Personalization in narrative-based serious games

As mentioned earlier, existing narrative-based serious games have limited personalization capabilities. This is due to the underlying technology, branching story graphs, that need to handwrite all possible variants, which leads to an authoring bottleneck [8]. However, several examples are worth mentioning. The CHESS project [9][7] is an interactive

[1] https://kognito.com/products/at-risk-emergency-department

[2] https://www.curapy.com/jeux/ehpad-panic

storytelling approach in which visitors' profiles are build semi-automatically so that the description of a given historical object is delivered differently according to the profile (three versions). PASSAGE is an interactive storytelling system in which a player's model is completed during execution, according to the chosen actions, so that some tailored events occur rather than others [10]. CARMEN'S BRIGHT IDEAS [11] is an interactive health intervention designed to improve the problem solving skills of mothers of pediatric cancer patients, HEART-SENSE [12] is a computer based training game designed to improve recognition of heart attack symptoms and shift behavioral issues so as to reduce pre-hospitalization delay in seeking treatment and GHD GAME [13] is more focused on the educational intervention through learning objectives.

In the domain of Interactive Digital Storytelling (IDS), generative algorithms have been built in order to provide more agency to the user [14]–[19]. This kind of technology has potential in terms of personalization. Events being dynamically generated, different variants of the story that would be tailored to different users do not need to be manually written. Nevertheless, this potential has hardly been exploited so far. In Façade for example, the most emblematic system of that kind, the only element that is adaptable is the name of the character's player. SOLVE IT[3] is a 3D agent-based IDS application aiming at preventing HIV within young men who have sex with men. In this research, the adaptive potential of the approach is well acknowledged, in comparison with an interactive in which "updates to the scenarios, dialogue, and interventions were not feasible" [20]. The final simulation offers customization abilities ("dressing" the main character) but more advanced adaptable functionalities were not described.

In *Carezheimer*, the project presented in this article, the goal is to fully exploit the capabilities of generative IDS to provide a strongly personalized experience.

III. DIMENSIONS OF PERSONALIZATION

We plan to develop an interactive narrative endowed with both an adaptable and an adaptive mechanism. The user plays the role of a caregiver, interacting with the patient and possibly with other characters.

The system will start with an interactive psychological questionnaire, designed to initialize the user model variables, such as the level of the patient's disease, attitudes of the player and its environment. Attitudes will then be used to initialize the caregiver states and style. After this initialization, variables of personalization will be dynamically updated using information on the player's actions. Figure 1 shows variables acquired before the game thanks to an in-software questionnaire and variables dynamically updated during the play.

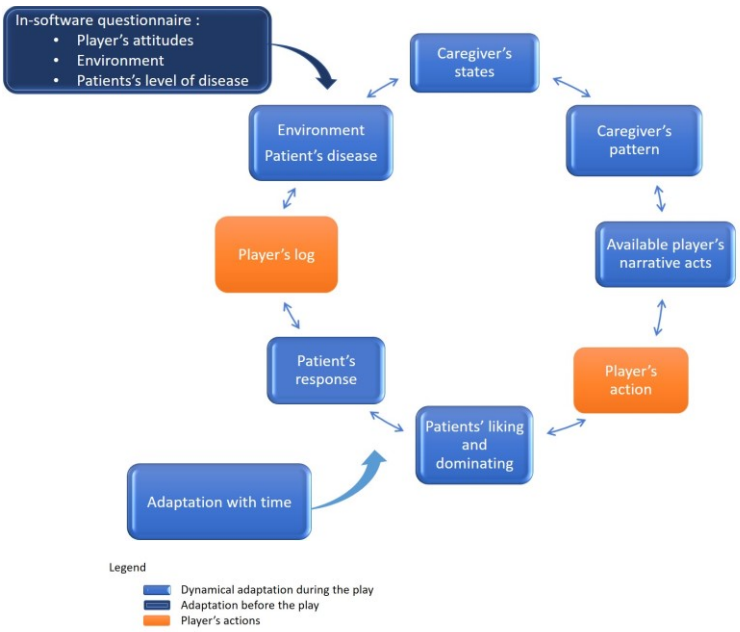

Figure 1 : Overview of the personalization mechanisms: questionnaire-based personalization, dynamical adaptation and long-term adaptation with time. Details on patterns and narrative acts are provided in Section IV.

Dimensions of personalization in the system, which correspond to variables in the real situation, help to provide a tailored experience to the user. These dimensions are divided into three categories, the first one related to the patient, another one to the environment and the last one to the caregiver.

[3] https://www.imedicalapps.com/2012/12/solveit-hiv-prevention-game-men-sex-men

A. Patient's modeling

Based on previous psychological research [21]–[23], five main dimensions of personalization regarding Alzheimer's neuropsychiatric symptoms were extracted:

- Apathy or indifference,
- Wandering,
- Rejection or resisting to care,
- Repeating questions,
- Anxiety/ Agitation.

These are the main symptoms observed in daily life of AD patients. However, they do not appear systematically. Therefore, the simulation will be personalized according to the degree of presence of the above symptoms in the patient.

Furthermore, the disease may be divided in three main levels: low, medium and high. Each level corresponds to a specific value of each of the neuropsychiatric symptom. The more the illness is advanced, the more neuropsychiatric symptoms are present in the patient's behavior, except for the symptom "repeating questions" which has a high value at the beginning of the illness and a low one in the high level phase. According to the questionnaire, variables can be different at the beginning of the simulation to fit to the patient's behavior. Then, when time passes and the more the simulation is played over months, the more advanced is the illness. Thanks to personalization approach, the simulation can therefore follow the evolution of AD and meet family caregivers' needs in the long run.

B. Relation between the caregiver and the patient

In our model, beside her neuropsychiatric symptoms, we consider that the patient's behavior is also influenced by her emotional state, which depends on social relations with the caregiver or any other person. The patient has the possibility to react according to her caregiver's wishes or at the opposite. To be able to determine which answer better suits to a given situation, the two following dimensions have been retained, based on previous work on autonomous agents [24]:

- Liking: the more the patient likes her caregiver, the more she will act in a positive way,
- Dominance: the more authority the caregiver can exert on the patient, the more the patient may be able to respond positively to requests.

Finally, the physical condition may impact the way the patient and caregiver may interact. It is necessary to adapt interactions according to physical capabilities of both the patient and the caregiver, for example, if the caregiver has a smaller physical stature than the patient, she may have difficulties to help when it comes to carry her.

C. Environmental variables

Care decisions are made through dynamic, complex, interrelated set of cognitive, behavioral and affective processes. These processes are influenced by a unique set of social and cultural factors implemented in the context of a family network:

- Income: the more income has the family network, the more help it can have with equipment or personal caregivers [25],
- Social network: number of relatives who take care of the patient may lower the burden of the caregiver,
- Presence of pets with the patient may help him to lower her stress level.

The future simulation will integrate these dimensions as facilitators or inhibitor of the daily life of patients and their family.

D. Caregiver related dimensions

1) Caregiver styles

According to Corcoran [23], the caregiver can fit to four different caregiving styles:

- Facilitating: Enhancing positive experience for the patient such as looking for support from others, promoting activities, all this requiring planning, preparation and direct involvement,
- Balancing: Enhancing through environmental control (alarms, baby monitors, etc.), restricting action in order to avoid or eliminate problems, using of parallel activities like watching football while the relative is busy with something else,
- Advocating: Monitoring and observation, not providing more assistance than is needed; « if she needs help, she will ask », use of parallel activities, asking others for help,
- Directing: Focusing on the physical health including nutrition, medical routines and hygiene, focusing on practical ways to solve the issues.

These styles have been completed by Davis and al. [22] with three additional styles:

- Adapter: Flexible in managing all situation with practical behaviors and switching them if necessary,
- Struggler: When faced with a problem, unable to find a proper solution, leaving the situation unsolved, expecting guidance from someone else,
- Case Manager: conceptualizing caregiving as a job to be done, asking help to others.

Each caregiver has a tendency toward certain caregiver styles. These styles express differently depending on situations and neuropsychiatric symptoms, meaning that not all seven styles will be applicable in a given situation. Some styles are better suited than others for dealing with an everyday situation. For example, in general, the Adapter style has more chances to avoid burdens.

2) Caregiver states

Finally, there are three states in dealing with the patient that are important for a caregiver for being able to live with her relative without being overwhelmed by duties [26]. We call state the necessary abilities for the caregiver to have in order to take

care of the patient while being in a good mood and in a healthy situation. These states are :

- Burden [27][28]: this corresponds to the difficulty of living with the relative and how much this interferes with the caregiver's own activity and life. The higher is the burden, the less the caregiver has energy, will and patience regarding the patient,
- Resilience [29][30]: this represents how much the caregiver accepts her caregiving role and does not fight against her duties,
- Daily functioning [31][32]: this is the ability of the caregiver to take care of daily living activities in the most efficient way possible.

Note that these states constitute not only dimensions of personalization but also the pedagogical goal of the whole serious game: lower the burden, increase the resilience and daily functioning.

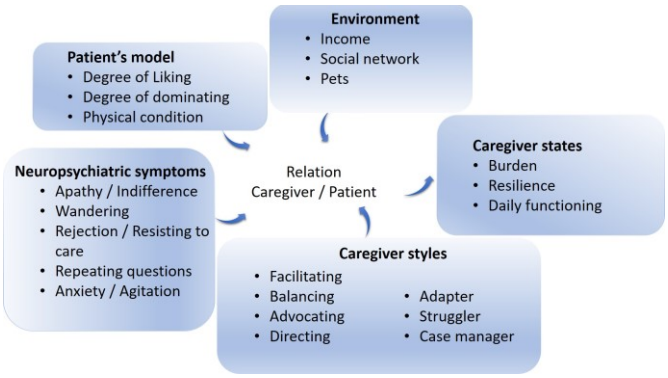

Figure 2 : Dimensions of personalization

E. Synthesis

Figure 2 shows an overview of dimensions of personalization in the *Carezheimer* project. During the interactive narrative, the player will have to deal with the patient's adaptive neuropsychiatric symptoms (NPS), patient's model, environment and her caring states to help her relative through daily activities. All these interactions with her relative will be performed accordingly to the player's caregiving style.

IV. Expressing the Dimensions of Personalization into a Generative IDS System

A. Outline of the generative technology and scenario

The type of systems used in the project is characterized by two fundamental properties:

- The chaining of narrative events/actions is decided on the fly, based on conditions on the state of an internal model,
- Actions themselves are generated dynamically, based on a logical description of the action and Natural Language Generation techniques (including template-based approaches) [33].

We will not enter into details of the particular algorithmic approach that will underlie the proposed serious game. However, two properties will be mentioned here, as they directly impact the way personalization dimensions will be exploited.

First, actions in the game are goal-oriented. Individual characters actions trigger (at least in part) because they enable to reach characters' goals. For example, a character may have the goal of satisfying her hunger, that may be reached either by cooking or by order some food. Systems using a goal-based approach include FearNot! [17], IDtension [16], all planning-based systems [34]. Note that some actions may fail, if certain conditions are (not) met, which leads to the concept of Obstacles. For example, while she is dressing a character may not find her pants.

Second, actions are generated via a limited set of Narrative Acts, that are general actions that involves other more specific actions. Examples of narrative acts include Order, Dissuade, Encourage, Congratulate, AskForHelp. Narrative acts are similar to Speech Acts [35], but are more specific as they relate to the narrative dimension of the simulation, as suggested by narrative theories [36][37]. Systems based on narrative acts include DEFACTO [14], IDtension [16], Storytron [38]. In Carezheimer, Narrative Acts will take as variables characters, objects, goals and actions. An example of an action build with the Narrative Act Order is: Order(John,Mary,goToBed).

Within this framework, we designed a non-linear story involving six main goals for the patient and the caregivers:

- Bathing and showering,
- Dressing,
- Self-feeding (not including cooking),
- Transferring (ability to walk, get in and out of bed, get in and out of a chair, go to one room to another),
- Personal hygiene (brushing, combing, styling hair),
- Toilet hygiene (getting to the toilet, cleaning oneself, getting back up).

Each goal can be triggered and reached independently, according to the player's and the system's decisions.

B. *Adaptations of the simulation*

1) *Adaptation to the patient*

The five neuropsychiatric symptoms identified in Section III.A.1 can lead to a dynamic modification of the simulation as follows:

- Apathy or indifference: An obstacle in the unfolding of many actions initiated by the user, that will trigger the goal of "motivating the patient". This approach has already been developed for the interactive drama "Nothing for dinner"[4][39],
- Wandering: The goal of wandering will be regularly triggered, possibly interrupting an ongoing action.
- Rejection or resisting to care: An obstacle will trigger when a caring action is initiated. Also, specific Narrative Acts will be played by the patient such as CRITICIZE (the patient criticizes the caregiver's actions or goals).
- Repeating questions: In the normal case, a Narrative Act such as ASK does not trigger again once the answer has been obtained, but in the case of the patient, information in memory will be quickly lost, leading to a repetition of the question.
- Anxiety/Agitation: This will be expressed via certain Narrative Acts, such as EXPRESSDOUBT or REGRET. In addition, stylistic variations of the same act can also express anxiety and agitation, at the linguistic and graphical levels.

All the above mechanisms, by a combinatorial effect, enable many different scenario variations, without writing all corresponding paths in a story graph. Furthermore, they enable neuropsychiatric symptoms to be gradually increased or decreased, because they depend on continuous internal variables, notably the probability of some events or narrative acts to trigger.

2) *Adaptation to the caregiver states*

As mentioned in Section III.C.2, psychological researches have led to three main states useful for the player to fulfill his daily duties, which are the value of the burden, resilience and daily functioning.

As a model, these three variables will be used as clues to allow or to deny some narrative actions, regarding capabilities of the player for this states independently.

Each narrative act is associated to a set of three threshold values that determine whether this narrative act can trigger, according to the current values of burden, resilience and daily functioning. For example, if the player has a strong burden and has too many difficulties to achieve a task, then she will have access to narrative actions such as ASKFORCOMFORT(Mary,Mary's husband,task), meaning that Mary will ask her husband to comfort her for her role as a caregiver. This action will lower her burden and allow her to be able to continue caring her relative. On the contrary, if the burden is low, the player will not have access to this narrative action but to some others to continue within the game and achieve daily activities.

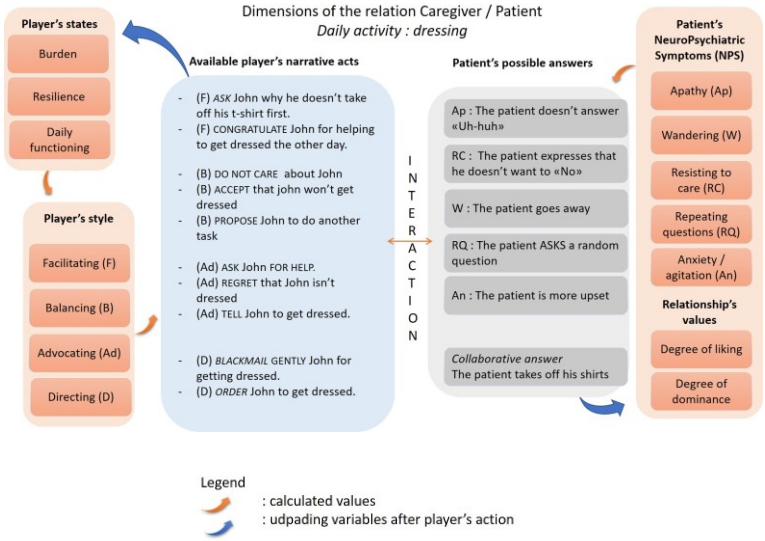

Figure 3: Examples of available narrative acts

[4] http://nothingfordinner.org/

Figure 4 shows a panel of narrative acts available to the player and the patient, according to the value of the three caregiver states. The example only concerns the "undressing" action within the "dressing" daily activity, the latter including a lot more actions to perform.

In addition to the filtering of narrative acts according to the caregiver states, patterns of behavior are proposed according the caregiver's style. Patterns describe the succession of caregiving style, as we can see in figures 4 and 5.

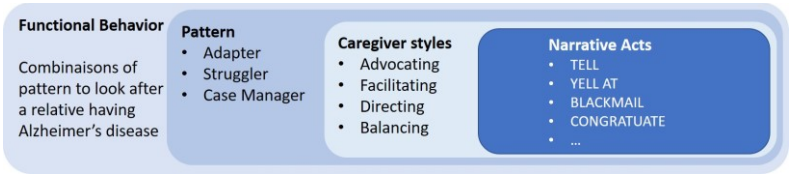

Figure 4 : Levels of description for player's behavior

Caregiver's behaviors are categorized according to the three styles defined above: Adapter, Struggler and Case Manager. Each pattern specifies the succession of caregiver styles. For example, the Adapter pattern is defined as an alternation of the Facilitating, Directing and Balancing styles, without the Advocating style. To each style is associated a given set of narrative acts. Figure 5 represents the occurrence of the successive different patterns that constitute a player's behavior.

The player can fit into one of the three different patterns defined above. The Adapter pattern is the optimal one and leads to the quickest way of success in realization of tasks. The two others patterns, Struggler and Case manager, resume most current dysfunctional behaviors caregivers can have. The player will have to modify her behavior, with the system's help, to achieve the tasks if her style fits to one of these two behaviors.

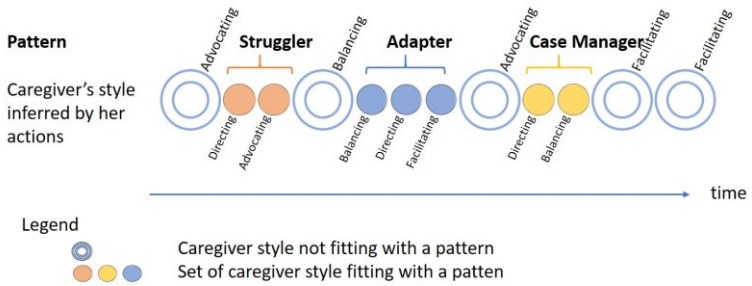

Figure 5 : Example of a player's behavior in terms of patterns and styles.

According to all the system's variables, the personalized narrative interactive storytelling will gently help the player in an implicit way, with a tailored selection of available narrative acts, to adopt a functional behavior. For example, if the player starts following the good pattern (e.g. Adapter), then the patient's mood is getting better, the caregiver's experience gets also better (decreasing the value of burden, increasing resilience and daily functioning) and the system adapts speech acts available to pursue in the good direction. However, if the player chooses narrative acts belonging to dysfunctional behaviors, variables of burden, resilience and daily functioning change according to her actions leading to different speech acts available. Thus, goals take more time to be solved as more narrative acts need to be performed to achieve each task.

3) Adaptation to difficulty

Another important dimension is to adapt the difficulty of the game to the player, so the player stays focus and interested in the game.

If the user is not able to reach goals, then the game can detect it and dynamically assist her in the simulation by two ways:

- Making task easier by solving sub-goals that intervene in the task, for example pet will never have to be cleaned or radio may shut down by itself after a while,
- Guiding the user towards actions that will solve the situation, for example with a relative who may INFORM or INVITE the player to perform an action.

On the contrary, if the user is reaching goals to easily, it is possible to add difficulties by several ways:

- Increasing the difficulty by inserting obstacles into the performing of the task. For example, the patient will need more solicitation for doing a task, or need to be reassured more often. It is also possible that the patient will urinate on himself if the caregiver has solicited him too roughly.
- Adding secondary goals in parallel, for example material issues or distractions such as a relatives coming

or a pet needing attention. Events like a shower's dysfunction may appear, or the postal worker ringing at the door needing attention.

- Increasing the global pacing so that the player has to stay focus and increase the speed of her actions. For example, if the patient has an initial positive answer and the player does not play fast enough with another action, then the patients react negatively.

4) Adaptation to the environmental variables

Environment variable such as the income, number of relatives helping the patient, social environment and number of pets will be defined before the play thanks to the preliminary questionnaire.

Each variable may have an impact on daily activities. For example, having a pet may lower the level of agitation of the patient, having a high income allows the player to use more electronic devices useful for everyday life. Besides, having an important social environment may lower the burden of the player, helping her with some tasks or being reassured talking with friends.

Then, relatives, pets, material and the disease will evolve according to the time of play. As a consequence, the disease will only get worse, material will become less suitable for the level of disease, breakdowns will appear more often, and pets or relatives will age or even die.

V. CONCLUSION

This article presents an advanced approach to personalize the learning experience in a narrative-based serious game, via both adaptable and adaptive mechanisms. The proposed method is based on 1) a questionnaire that will be filled by the caregiver to initialize the dimensions of personalization, and 2) the user's actions during the simulation. Precise personalization is made possible by interactive narrative technologies.

Once the game developed, a controlled experiment, comparing family caregivers using the personalized version of the software with family caregivers using a non-personalized version will be performed in a laboratory. Each participant will interact with the narrative simulation for a single experimental session and then fill a questionnaire. Statistical analyses will be performed on this questionnaire about the game perception.

Furthermore, we want to assess qualitatively the effect of simulation use on the overall level of caregivers' burden. We will assess the level of stress before and after the intervention and explore through semi-structured interview the different factors that have contributed to the modifications.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the Swiss National Science Foundation (SNSF) for its support.

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