

Interactive Simulations to Help Teenagers Cope When a Parent Has a Traumatic Brain Injury

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Traumatic brain injury (TBI) is a leading cause of long-term disability and death worldwide. This article describes an ongoing research project to design, develop, and evaluate interactive learning simulations that integrate educational materials for uninjured teenagers who have a parent with a TBI. By immersing players in an interactive environment that resembles the gaming world with which most teenagers are familiar, these simulations are designed to help players develop knowledge and skills in circumstances approximating real-life settings. We describe the steps we took, both to consult with families affected by TBI to understand the difficulties teenagers commonly face when they live with a brain-injured parent, and to weave some of these difficulties into a pedagogical drama that can be played as an interactive game.

Categories and Subject Descriptors: I.2.1 [**Artificial Intelligence**]: Applications and Expert Systems; I.6.8 [**Simulation and Modeling**]: Types of Simulation—*Gaming*; J.3 [**Computer Applications**]: Life and Medical Sciences—*Health*

General Terms: Design, Experimentation, Human Factors

Additional Key Words and Phrases: Interactive learning simulations, pedagogical drama, IDtension, traumatic brain injury

ACM Reference Format:

Dumas, J. E., Szilas, N., Richle, U., and Boggini, T. 2010. Interactive simulations to help teenagers cope when a parent has a traumatic brain injury. *ACM Comput. Entertain.* 8, 2, Article 10 (December 2010), 13 pages.

DOI = 10.1145/1899687.1899692 <http://doi.acm.org/10.1145/1899687.1899692>

1. INTRODUCTION

Traumatic brain injury (TBI) is a major public health concern. Studies conducted in countries such as Australia [Tate et al. 1998], China [Wu et al. 2008],

This research is supported by grants from the Swiss National Science Foundation (J. Dumas and N. Szilas, principal investigators), the United States Centers for Disease Control and Prevention, and the Indiana Economic Development Corporation (Y. Dumas and J. Dumas, principal investigators). Authors' addresses: J. E. Dumas, N. Szilas, U. Richle, and T. Boggini, University of Geneva, CH 1211 Genève 4, Switzerland; email: {Jean.Dumas,Nicolas.Szilas,Urs.Richle,Thomas.Boggini}@unige.ch. Permission to make digital or hard copies part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies show this notice on the first page or initial screen of a display along with the full citation. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post on servers, to redistribute to lists, or to use any component of this work in other works requires prior specific permission and/or a fee. Permissions may be requested from the Publications Dept., ACM, Inc., 2 Penn Plaza, Suite 701, New York, NY 10121-0701 USA, fax +1 (212) 869-0481, or permissions@acm.org.
© 2010 ACM 1544-3574/2010/12-ART10 \$10.00
DOI 10.1145/1899687.1899692 <http://doi.acm.org/10.1145/1899687.1899692>

France [Masson et al. 2001], India [Gururaj 2002], Italy [Baldo et al. 2003], Japan [Nakamura et al. 2006], Norway [Andelic et al. 2008], Switzerland [von Elm et al. 2008], the United Kingdom [Fleminger and Ponsford 2005], and the United States [McGarry et al. 2002] show that this concern cuts across national boundaries. Leading causes of TBI include motor vehicle crashes, falls, sports and recreation accidents, and violence. Reviews of brain injury epidemiology research [Tagliaferri et al. 2006; Finkelstein et al. 2006] show that TBI has a much higher rate of incidence than other medical conditions that attract much more public concern, such as breast cancer or spinal cord injury.

1.1 Traumatic Brain Injury and the Family

Most patients who survive a TBI regain general functional independence and can often return to work. However, many face significant physical and psychological problems that often affect them and their families for years [Kendall et al. 2006; Kneafsey and Gawthorpe 2004]. Major changes—mostly adverse—are evident in (a) individual adaptation (e.g., reduced mobility and independence, cognitive impairments, negative personality changes); (b) family relationships (e.g., conflict with spouses/partners, other caregivers, and children); (c) work or school adjustment of patient and relatives (e.g., decreased ability to meet job or school expectations, job loss, school dropout); and (d) socioeconomic standing (e.g., financial losses, unexpected medical expenses).

To date, attempts to lessen the impact of TBI on family functioning have focused almost exclusively on adult caregivers, largely ignoring children and adolescents who live with an injured relative. Although less is known about the stresses of parental TBI on uninjured teenagers, the latter must learn to cope with major disruptions in their lives [Butera-Prinzi and Perlesz 2004; Sambuco et al. 2008]. Many are ignored or mistreated by their injured relative or neglected by their uninjured parent who struggles to meet the patient's needs. Adding to the adverse changes described above, these problems are frequently aggravated by confusion around what has happened to their loved one. Many teenagers never receive explanations they can understand, and are overwhelmed by feelings of sadness, hurt, guilt, anger, embarrassment, and loneliness that they cannot express freely at home or elsewhere—thus putting them at risk for behavioral and emotional problems. For example, in more extreme cases, TBI in parents is associated with pathological anxiety, depression, and suicidality in children and adolescents; increases in teen antisocial conduct, acting-out, and risk-taking; and increases in child responsibilities, often as a result of role reversal (e.g., when child has to act as caregiver for a parent or sibling) [Pessar et al. 1993; Urbach et al. 1994].

Obviously, focusing on caregivers makes sense, given that they usually shoulder the greatest burden of care and need support to maintain their own physical and mental health. However, to minimize the secondary complications associated with moderate to severe TBI, the literature just reviewed shows that attempts must be made to strengthen the coping skills of all family members

whose lives are disrupted by the injury. To that end, our research team is designing, developing, and evaluating learning simulations for teenagers who have a parent with a TBI. These simulations are interactive scenarios that reflect common challenges these teenagers encounter. These scenarios are intended to help them develop knowledge and skills in circumstances approximating real-life settings.

1.2 Simulations as Coping Tools

Simulations provide an immersive interactive environment that can be very effective in engaging and training “digital natives” [Gibson et al. 2006]. Traditional training relies on tell-and-test strategies in which learners are mostly recipients of information. These strategies provide few opportunities for practice and command varying levels of attention that may not be optimal for learning. In contrast, simulations immerse learners in an interactive environment in which they play active roles and have to make decisions that demand their attention. Simulations facilitate learning, less because they are entertaining than because they are experiential: they build knowledge and skills into virtual characters and environments, engage users in immersive interactions, and promote hypothesis testing by requiring frequent decisions that bear on outcomes [Gredler 2004]. By providing multiple opportunities for practice, they are well suited to the acquisition of task or procedural knowledge. This is particularly true of relatively short simulations (5 to 20 min.) that enable learners to focus on content, rather than on improving their gaming skills through hours of play [Aldrich 2007; Oblinger 2006].

Learning simulations have a long history [Crookall et al. 1986], and technological progress in virtual environments have opened new opportunities to engage users in computer-generated stories. To engage users as actors and learners in interactive scenarios that bolster their coping skills, narrative research aims to provide them with control over the story itself [Mateas and Stern 2000; Young 1999]. Different systems have been created for such a purpose [e.g., Aylett et al. 2006; Marsella et al. 2000]. To develop our simulations, our team is relying on IDtension, an interactive drama engine developed by Szilas [2003, 2007] and successfully applied to the fields of digital entertainment [Szilas et al. 2007] and of education and training [Szilas et al. 2003]. The user interface described here is based on an earlier, history-based interface, which we have improved and redesigned for this project.

The challenge we faced when the project began was not only technological, that is, to go beyond a conventional transmission model of learning to a truly interactive one. It was also pedagogical, that is, to develop believable scenarios that accurately reflect the daily reality many teenagers face when they have a parent with a TBI. To gain knowledge of this reality, we conducted focus groups with families affected by TBI and used the materials generated in these groups as the basis of our narrative writing. This article presents the first stage of this project, a text-based interactive scenario based on narrative materials collected in focus groups.

2. METHOD

2.1 Focus Group Input

To identify the needs of uninjured youths and determine how to address them within the framework of a computer-based interactive drama, we consulted families affected by TBI (i.e., parents and youths), as well as service providers. To do so, we obtained the collaboration of rehabilitation and support services organizations to conduct five focus groups, three in Switzerland and two in the United States. The senior author facilitated each group, which always lasted 2 to 3 hours.

Adopting a “listening” rather than an “inquiring” attitude and following a topic guide, the facilitator relied on open-ended questions to invite group members to speak openly and to feel listened to, even if others disagreed; followed up on disagreements to encourage frank and respectful exchanges; sought to involve all participants (e.g., by soliciting the opinion of quieter group members, if needed); and kept the discussion on target. The topic guide was designed to invite discussion of how uninjured youths make sense of what is happening to their injured parent and to themselves as they adapt to the reality of TBI; and of how they cope with challenges at home, at school, and with peers. Specifically, the guide addressed four questions/topic areas with prompts for different issues relating to each area: (1) What is happening to my loved one? (2) What is happening to me? (3) How can I cope? And (4) How can I help my loved one cope? Prompts were worded according to participants (in the first person when youths attended the group and in the third person when parents or service providers attended).

The topic guide did not only invite discussion of the informational needs of youths with respect to TBI and its consequences, it also addressed their emotional needs, with particular attention to the steps youths take to cope in a positive manner. For example, when prompting discussion of how youths respond when a loved one has a TBI, the facilitator asked about common challenges they face (under “What is happening to me?”). Then the facilitator prompted the group to talk about how youths dealt with these challenges, attending both to effective and ineffective coping (under “How can I cope?” and “How can I help my loved one cope?”) and soliciting examples from group members, which now serve as building materials for the interactive scenarios that are central to our project.

Lively, open, and often moving discussions occurred in each focus group. To summarize these discussions, Dumas relied on meeting notes and transcripts to conduct a transcript-based analysis of each group [Kruger 1998]. Table 1 provides a few examples of the results of this analysis, which illustrate some of the challenges families face when a parent has a TBI.

2.2 The IDtension Engine

Developed in Java, IDtension calculates story events dynamically, according to the user’s actions. This enables the engine to generate truly interactive and much more complex stories than more traditional narrative systems in which

Table I. Challenges Families Face When a Parent Has a TBI

| Examples provided by teenagers |
|--|
| <p>I didn't want to talk to my mom about it [father's injury] ... It's hard to talk about stuff like that and I didn't want to make her cry. But my grandma was very supportive; I could tell her anything.</p> <p>He [injured father] has like rages, he gets like so angry ... and for like no reason at all.</p> <p>I started misbehaving a little in class like I had anger problems ... and my grades started to go down. It's hard to concentrate when your father is almost paralyzed on one side, so weak, and there are so many things he just can't do anymore.</p> <p>I just want to be a kid. I don't want that yet but I've had to live with it and try to do it. Make the right decisions and just be responsible with money and stuff to go forward in life.</p> <p>I told a couple of my friends what was going on and they were like really supportive and everything but others said nothing. Until one day it just hit me and I started crying ... I was, I can't do this. I can't act like I'm happy when I'm really upset, ya know?</p> |

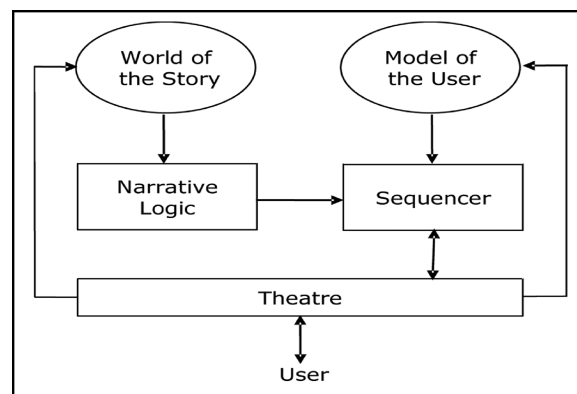


Fig. 1. IDtension architecture.

users have little control over plot development and outcome. Figure 1 illustrates the engine's architecture:

The World of the Story contains basic entities about the scenario (i.e., characters, goals, tasks, obstacles, and values) and facts describing the context (e.g., the story takes place at home, where the main character is preparing dinner).

The Narrative Logic calculates the set of all possible actions by each character from the data stored in the World of the Story. Actions can be generic or specific. Generic actions correspond to narratology-inspired fundamental narrative actions. They include events found in most stories, such as inform, encourage/dissuade, accept/refuse, and congratulate/condemn.

Specific actions or tasks are story-dependent and describe specific behaviors such as watching TV, taking an object, or shouting. Combined with other elements of the system, actions allow the story to develop in several directions, without having to script each direction in advance. This twofold articulation enables more generativity than most existing systems, that is, more can be generated with less authoring effort (see below). For example, Façade [Stern and

Mateas 2003] involves more authoring effort because it requires all narrative events to be specified in advance. Similarly, current planning-based systems [Pizzi et al. 2007; Saretto and Young 2001] allow for generic actions, but because these are not embedded in the engine as in IDtension, they must be written explicitly for each scenario.

The Model of the User estimates the state of the user at any given moment in the narrative in order to provide the Narrative Logic and Sequencer with a means of gauging the impact of each possible character action on the user. Relying on the Model of the User, the Sequencer ranks the appropriateness of each action by estimating its impact on the user according to a set of narrative criteria designed to ensure the global coherence of the story, the timely occurrence and appropriate complexity of actions, and the maximization of dramatic conflict. The originality of IDtension at this level is that these criteria are not only based on psychological realism but also on narrative principles. This is different from character-based systems [Aylett et al. 2006] for Interactive Storytelling which, with few exceptions, only rely on individual characters' motivations. Furthermore, IDtension is distinct from most other approaches because the model is "ethical," in the sense that it evaluates impact according to values such as honesty, family, and friendship, and weighs the user's choices in ethical terms (e.g., valuing cooperation with other family members higher than confrontation). This feature reflects the central role that values always play in narrative.

The Theatre displays the story as it manages the computer-user interface. Each user choice is sent to all system modules: the Sequencer receives the set of possible actions from the Narrative Logic, ranks those actions in terms of likely impact on the user, and chooses one action to display, thus alternating actions chosen by the user and the system. The architecture (see Figure 1) is based on independence between the narrative logical level and its physical expression. IDtension can thus be used both for 2D texts [Szilas 2007] and 3D virtual environments [Szilas et al. 2007].

The attractiveness of IDtension lies in its generative nature and atemporal structure. A story is not made up of more or less preauthored "chunks" or "scenes" but is generated by an atemporal structure of characters, goals, tasks, obstacles, and values. To obtain a large number of possible actions without demultiplying the authoring effort, actions are described according to a second-order formalism. For example: `inform(x,y,goal(z,g,u))` means that a character informs another character that a third character has a given goal, with a fourth character as a parameter. It could produce the following dialog line: Olivia to Frank: "Did you know that Paul wanted to make dinner with Sophie?" In the formula above, "inform", and "goal" are hardcoded, while x, y, z, g, and u are variables that can take any authored-defined values.

As IDtension generates scenes interactively, they cannot be described explicitly, as in a script. This means that we do not use the term "scenario" to refer to a fully-scripted sequence of events (as in story graphs or movies), but to all the narrative materials available to the engine to dynamically produce the learning simulation. In other words, in IDtension, the scenario specifies different actions, as well as their consequences for the story characters, but

also allows the story to evolve according to the manner in which the user plays. For example, in the scenario described below, the main character's attempt to make dinner with his handicapped father is an action that, at times, increases his father's anger, rudeness, and lack of motivation. To respond to these emotional states, the main character, who is played by the user, can select among several actions, such as attempting to calm his father, leaving the room for a while, or seeking the advice of another character. The order of these actions is not predetermined (although precedence rules exist and can be modified to fine-tune the story), neither are the characters involved. Furthermore, any of these actions can have a variety of consequences. For example, father may calm down or become even angrier when the main character leaves the room.

3. RESULTS AND DISCUSSION

3.1 The Story of the Simula Family

Materials gathered in the course of the focus groups described earlier provided much of the inspiration for the story of the Simula Family. Frank is the story's main character. He is 16. His father, Paul, suffered a TBI a few years earlier and is very weak on the right side. Paul has important memory problems and is prone to sudden mood changes.

When the story begins, Frank is at home with his father Paul, his grandmother Olivia, and his younger sister Sophie. His mother Martina is still at work, and has asked him to have the dinner ready when she returns. Frank, played by the user, is initially given three choices: prepare the dinner on his own, prepare it with Paul, or let Paul prepare it alone. Sophie and Olivia intervene from time to time to give their opinion on Frank's actions (e.g., praise or criticize him) or to influence him. Generally, Sophie favors independence and is "selfish". For example, she may demand that Frank fix the DVD player so that she can watch her favorite show, even though Frank is busy trying to get the dinner ready on time. In contrast, Olivia favors cooperation and is "generous." For example, she encourages Frank to ask Paul for help to prepare the dinner, and usually offers help herself when asked. Paul often reacts abruptly and sometimes angrily to Frank's actions, forgets what Frank has asked him to do, or insists on drinking alcohol (something he is not allowed to do because it interferes with his medication). The phone rings from time to time and complicates matters further. All this distracts Frank from his goal of having the dinner ready when his mother returns. To make the story come to life, the user is faced with different situations in which, playing the role of Frank, he can collaborate or not with Paul. Collaborating invariably creates problems, but is the only solution to bring the scenario to an end.

3.2 MAPs—Motivated Action Plans

To develop Frank's story with all its scenes, situations, and events, we did not only rely on testimonials from focus groups, as mentioned before, but also on research in clinical, social, and health psychology, showing that people are better able to reach goals that are: (1) specific rather than vague; (2) proximal

rather than distal; and (3) focused on attaining positive outcomes instead of averting negative ones. This is particularly true when people can specify what they intend to do to reach their goals, that is, when they have cognitive maps to take them from their present state to a more desirable one. These maps—called motivated action plans by Dumas and Moreland [2007] and implementation intentions by Gollwitzer [1999] and others—are behavioral strategies that specify when, where, and how the person will act to reach a particular goal.

In Frank's story, IDtension gives the user different ways of coping with each new situation. At the beginning of the story, Paul, who is played by the user, has three choices: to prepare the dinner on his own, to prepare it with Paul, or to let Paul prepare it alone. Similarly, throughout the story, the user has choices to make to reach each new objective. Broadly speaking, these choices reflect the fact that, in most situations in which they are faced with a challenge, youths can cope in prosocial, antisocial, or asocial ways [Dumas and Moreland 2007]. Each choice proposed to the user in Frank's story corresponds to one of these three ways of coping. This contributed greatly to the pedagogical nature of the story, by giving the user the opportunity to test different ways of coping with difficult situations in the safety afforded by the game environment. We anticipate that, over time, this will enable the user to construct useful cognitive maps that may be applicable to real-life challenges.

3.3 From Story to Scenario

Development of a scenario with IDtension requires a structure in which characters, goals, tasks, obstacles, and values are central. Figure 2 provides an overview of this structure for the story of the Simula Family.

To go from story to scenario is a two-step process, which is both narrative and technical. First, once the story plot was set, we divided it into distinct narrative components to use as input for the IDtension engine. As mentioned already, the engine is built on the assumption that stories are made up of basic entities, such as characters, goals, tasks, obstacles, and values. The plot is relatively simple, and reflects a daily family reality: to make dinner. This becomes the overarching goal of the story's main character. This goal is made more complex by several subgoals, each of which can be reached by accomplishing one or more tasks (e.g., for the dinner to be ready on time, the main character must, with others' help, cut vegetables, cook the soup, and set the table). Obstacles often hinder the main character's attempts to accomplish each subgoal. These obstacles can be stressful at times, both because they are distracting and because they occur unpredictably. For example, the main character never knows when another character will cooperate or obstruct, or when the telephone might ring.

To increase the complexity of the story, we gave Sophie (Frank's sister) a main goal that often conflicts with Frank's main goal of preparing dinner. From the beginning of the story, Sophie wants to watch a TV-show, but the DVD player is not working properly. Unable to fix it herself, she has to ask Frank for help. This puts Frank in the position of having to decide how best to reach his goal, that is, by helping his sister, allowing her to distract him regularly whenever she asks for help, or ignoring her requests. In the same way, we made the story

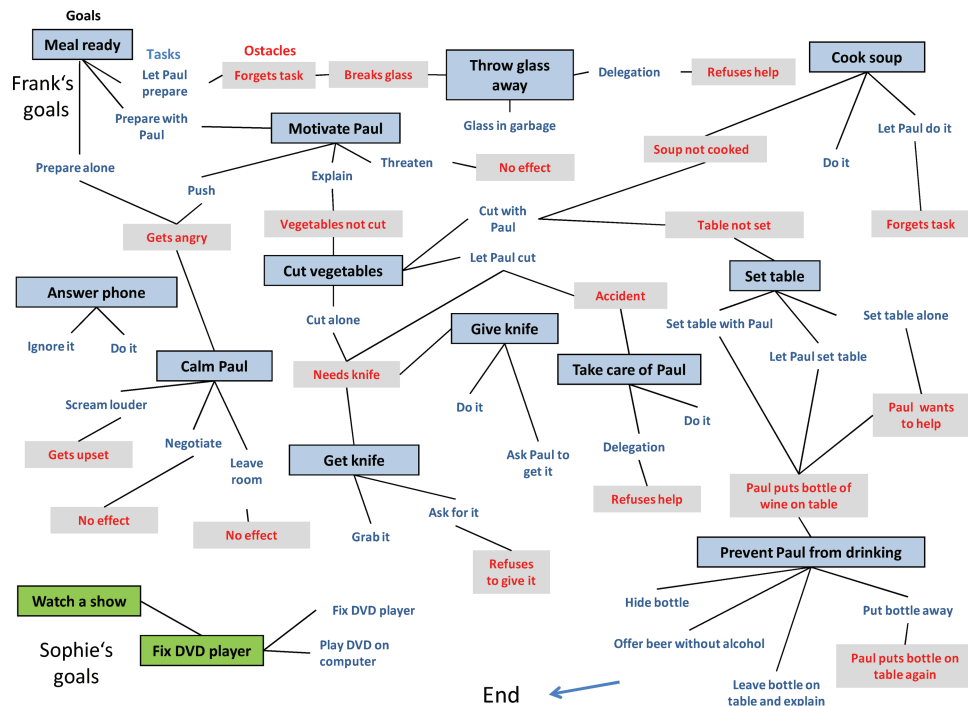


Fig. 2. Overview of the structure of the scenario of the Simula Family.

more complicated by insuring that the telephone rings at unpredictable times, again forcing Frank to decide how best to deal with that added distraction.

The IDtension narrative “toolkit” has rules like preconditions, causes, and constraints that allow the author to create a set of possible, coherent interactions, and to insure that they flow in a logical (i.e., plausible) manner as the story unfolds [Szilas 2007]. For example, the “delegation” feature gives the user the possibility of avoiding some objectives. If Frank, the user, does not want to fix the DVD player for Sophie, he can ignore her request or delegate this objective by asking another character to do it. The user can then go on with another goal while the system generates the behavior of the character to whom the objective has been delegated. In turn, that character can also delegate by asking a third character to take on the task.

Finally, as mentioned already, IDtension makes it possible to assign ethical values to tasks and characters. For example, in the present story, “collaboration” is a high value for Frank’s grandmother Olivia, but a low value for his sister Sophie. In accordance with these values, Olivia and Sophie often give Frank very different advice. For example, Olivia encourages Frank to collaborate with Paul by preparing dinner with him, whereas Sophie tends to dissuade him from doing so.

In a second step, each narrative component was described with dialog rules and texts. For example, obstacles can arise in different ways: one character may verbally oppose the suggestion or request of another character (e.g., by

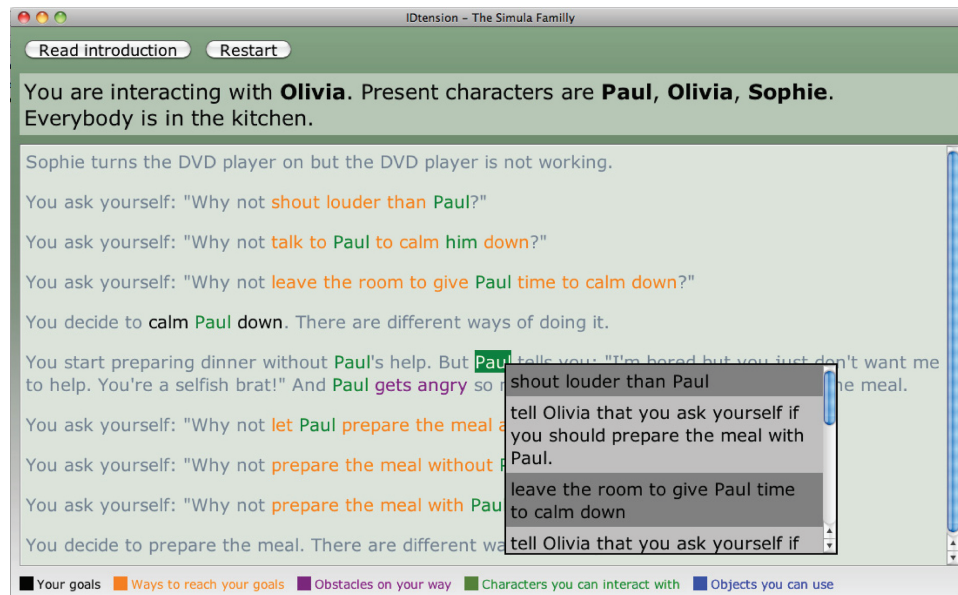


Fig. 3. User interface for the scenario of the Simula Family.

refusing to set the table) or may act in ways that are sure to create conflict (e.g., by putting a bottle of alcohol on the table). Similarly, successful execution of a task can provoke a positive or dismissive verbal reaction on the part of one of the characters.

In IDtension, all narrative components are written in open, standard XML (Extensible Markup Language) and all textual components are written in a separate .csv (comma-separated values) spreadsheet. This makes it easy to create narrative tension in each scenario before testing it and modifying it as necessary. It also makes it easy to translate scenarios into different languages.

The practical exercise of authoring a small but rich and bug-free scenario suitable for field-testing provided valuable feedback to improve the engine itself. For example, the engine sometimes generated logical but absurd sentences, such as “Paul tells Olivia that Frank did not manage to shout loud enough to calm Paul down”. Regardless of the anaphora problem (repetition of Paul), the problem is that it does not make sense that the addressee of the “calming down” goal discusses that goal with a third party. We thus added a new feature to the engine, which enables the author to choose to inhibit such discussions. Also, the need to have a phone regularly ringing during the story was made possible by introducing the notion of recurring goals. However, we had to improve that feature so that the goal would not be activated right at the start of the scenario. Last but not least, the graphical user interface, displayed in Figure 3, was greatly improved, compared to its initial version: selecting which character to interact with was greatly simplified, and all clickable elements are now immediately visible, with a color code helping the user choose which element to click.

3.4 The User's Experience

The scenario begins with an introductory screen that describes the story's characters and informs the user that the main character, Frank, has to prepare dinner before his mother's return. From that point on, the user takes on the role of Frank and can choose to prepare dinner in different ways or to interact with other characters to discuss his choices. The user does not know that collaborating with Paul is the only way of bringing the scenario to an end. However, the user discovers it as the scenario progresses or as the user plays the scenario several times in different ways.

Figure 3 illustrates the user interface. The top of the window tells users who they are interacting with, who is also present, and where everybody is. On the right of that information, a button enables users to choose to interact with different story characters, and thus change the story flow. The story unfolds in the center of the window, with the text scrolling as users play. Users play by placing the cursor on any of the highlighted parts of the text (including parts that are no longer visible but that remain accessible by scrolling down). This opens a smaller window in which all available actions are listed for selection. The bottom of the window serves as a reminder to users that text of different colors gives them options to move the story in different directions.

3.5 Evaluating the User's Experience

The Simula Family scenario is complex. It has been designed to overwhelm users, who quickly discover that preparing dinner with a handicapped father is a much more challenging task than it may initially appear. We do not expect most users to complete the scenario the first time they play with it. However, as the IDtension engine enables the story to unfold in several directions, we expect that teenagers will find it engaging to play with the main characters and to explore how the decisions they make contribute to different story outcomes.

Preliminary testing of the scenario is currently underway with teenagers who have a parent with a TBI. This testing has been carefully planned to provide each user with relevant information and answer their questions, both before and after they play with the scenario. Working with teenagers individually, a trained research team member introduces the simulation, thereby helping users anticipate what will occur and integrating incoming information with what they know already [Pollock et al. 2002]. Teenagers are then able to go through the simulation one or more times and to explore how different decisions made as the story unfolds contribute to different outcomes. The research team member sits behind the youth, takes notes, answers questions, and provides technical assistance as needed, but does not intervene to determine the course of the simulation. Debriefing takes place immediately after teenagers have played with the simulation. Evidence shows that this is essential in order to help users make sense of the materials with which they have interacted, to relate these materials to their own world, and to contribute to experiential learning. Debriefing is also essential to ensure that users understand the materials and that they have not been adversely affected by them [Fanning and Gaba 2007; Peters and Vissers 2004]. Finally, debriefing allows users to give us

essential feedback as we work to improve the scenario's content and presentation. The team member writes a summary of this discussion, which we intend to use in later qualitative analysis of the teenagers' input.

The interactive simulation we have described here is the first step in the development of other simulations to help teenagers cope when a parent has a TBI. We are also actively working to go from text-based to graphic simulations that use real-time, 3D rendering, as this will provide users with the kind of very believable interactive experience that our culture has taught them to expect.

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