Chapter 15

Affect-Sensitive Virtual Standardized Patient Interface System

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ABSTRACT

Virtual Standardized Patients (VSPs) are advanced conversational virtual human agents that have been applied to training of clinicians. These interactive agents portray standardized patient scenarios involving VSPs with clinical or physical conditions. VSPs are capable of verbal and nonverbal interaction (receptive and expressive communication) with a clinician in an effort to enhance differential diagnosis of psychiatric disorders and teach interpersonal skills. This chapter describes the design and development of both software to create social interaction modules on a VSP platform and individualized affective models for affect recognition. This author describes clinically relevant scenarios for affect elicitation and protocols for reliable affect recognition. Further, there is an elucidation of a VSP interface system that has the capacity to monitor the trainee's affective response using physiological signals. Research findings will be summarized from studies on (1) the usability and applicability of VSPs with training clinicians on various mental health disorders (e.g., adolescent male with conduct disorder; adolescent female who has recently been physically traumatized); and (2) preliminary use of the affect-sensitive system to systematically assess and manipulate aspects of VSPs to more fully develop cognitive and affective models of virtual humans with pathological characteristics.

INTRODUCTION

Traditional approaches to training clinicians in the interpersonal communication skills needed for assessment, diagnosis, and interview performance rely upon a combination of classroom learning and role-playing with human standardized patients. The importance of interpersonal communication is reflected in recent requirements

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for communication evaluation in medical schools. The Accreditation Council for Graduate Medical Education (ACGME; 2007) has emphasized the importance of interpersonal and communication skills in training clinicians. Residents are expected to: (1) create and sustain a therapeutic and ethically sound relationship with the patient; (2) use effective listening skills, eliciting and providing information using effective nonverbal, explanatory, questioning, and writing skills; and (3) work in an efficient manner with others. However, evaluation studies have revealed methodological deficiencies in many cases (Chant et al., 2002) and limited positive training effects (Hulsman et al., 1999). In an effort to increase interpersonal communication assessment, standardized patients (paid human actors) have been recruited and trained to exhibit the characteristics of an actual patient, thereby affording novice clinicians a realistic opportunity to practice and to be evaluated in a mock clinical environment. Although a valuable training approach, there are limitations with the use of human standardized patients that can be mitigated through simulation technology. For example, human standardized patients are expensive and cost several thousand dollars per student. Further, given the fact that there are only a handful of sites (for over 130 medical schools in the U.S.) providing standardized patient assessments of the clinician in training's communication ability as part of the U.S. Medical Licensing Examination (USMLE), the current model provides limited availability. Another concern is the issue of standardization. Despite the expense of standardized patient programs, the standardized patients themselves are typically unskilled actors. As a result of common turnover, administrators face considerable challenges for offering psychometrically reliable and valid interactions with the training clinicians. A related issue is the limited scope that the actors are able to portray. As a result, there tends to be an inadequate array of developmentally, socially, and culturally appropriate scenarios. For example, when a clinician has a pediatric focus and needs access to children, it is difficult for the clinician to pretend that the actor is a child. Finally, many clinical cases (e.g., traumatic brain injury) have associated physical symptoms and behaviors (e.g., dilated pupils, spasms, and uncoordinated movements) that simply cannot be accurately portrayed by human actors.

Design and Simulation of Pathologies

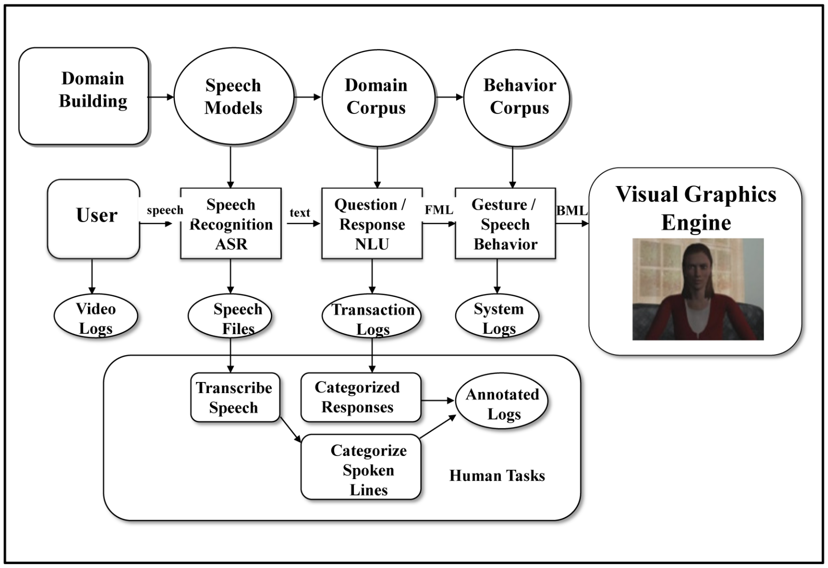
One proposed answer to some of the difficulties inherent in training persons with standardized patients, hence human actors, is to use virtual humans as patients. Virtual humans (VH) are developing into powerful interfaces that can enable greatly increased intuitive human like interactions. These virtual human systems consist of characters that have realistic appearances, can think and act like humans, and can express themselves both verbally and non-verbally. Additionally, these virtual humans can listen and understand natural language and see or track limited user interactions with speech or vision systems. Advances in simulated virtual humans afford the possibility of virtual standardized patients that reduce cost, ensure standardization and faithfully model physical symptoms. Virtual standardized patients (VSPs) are artificially intelligent (AI) virtual human agents that control computer generated bodies and can interact with users through speech and gesture in virtual environments (Gratch, et al., 2002). Advanced virtual humans are able to engage in rich conversations (Traum et al., 2008), recognize nonverbal cues (Morency et al., 2008), analyze social and emotional factors (Gratch and Marsella, 2004) and synthesize human communication and nonverbal expressions (Thiebaux et al., 2008). Building virtual humans requires fundamental advances in AI, speech recognition, natural language understanding and generation, dialog management, cognitive modeling and reasoning, virtual human architectures and computer graphics and animations. All of these technologies need to be integrated together into a single system that can work in unison, be expandable, flexible and plug-and-play with different components.

The University of Southern California's Institute for Creative Technologies (USC/ICT) is a world-recognized leader in virtual-human research. The VH work at USC/ICT offers an interactive experience. Further, our virtual humans are capable of listening to users, reasoning about the situation at hand based on sensor input and the situational context and choosing appropriate dialog and actions and delivering those actions in generated verbal output that is synchronized to realistic human like non-verbal animations.

The virtual human systems we develop include complex cognitive agents, question response agents, and culturally specific characters. These virtual characters have beliefs, desires and intentions, as well as daily routines that can be carried out within virtual worlds. These agents are based around a set of distributed components that communicate with each other and perform specific tasks (e.g. speech recognition). Although these agents do require time and effort for adequate development, we have tried to address this with a distributed underlying virtual human architecture. Given the distributed nature of the architecture, we are able to replace components without large integration efforts, which reduces the time needed to build or expand a given application. Additionally a set of tools is continually being developed to ease the task of creating these characters. The major components in the system, as seen in Figure 1 are:

- **Speech Recognition:** digitizes the user's speech and produces a string of words as output.
- **Natural Language Understanding and Dialogue Management:** parses the word string produced by speech recognition and extracts meaning and concepts to form an internal semantic representation.
- **Intelligent Agent:** reasons about plans and generates actions based on its internal state and the input from the verbal text or other multi-modal devices. Complex agents can be created using a cognitive architecture that reason about plans and actions and integrate a dialog manager and emotion model. Simple agents can be created with

Figure 1. Virtual patient data flow diagram



a question response system that picks a response based on statistical analysis of the input text. The output of the agent is a response output string and actions.

- **Non-Verbal Behavior Generation:** takes the response output string and applies a set of rules to select gestures, postures and gazes for the virtual characters.
- **Procedural Animation System:** synchronizes speech output with gestures and other non-verbal behavior to control the characters in the virtual environment.
- **Speech Generation:** performs speech synthesis from the text generated by the agent. Or alternatively a set of pre-recorded voice strings can be used as the speech.
- **Game Engine Graphic Display:** is the current underlying graphics engine used to display the character and virtual environment.

Building on the VH technology, VSPs fulfill the role of standardized patients by simulating a particular clinical presentation with a high degree of consistency and realism (Stevens et al., 2005). There is a growing field of research that applies VSPs to training and assessment of bioethics, basic patient communication, interactive conversations, history taking, and clinical assessments (Bickmore &Giorgino, 2006; Bickmore et al., 2007; Lok et al., 2006; Parsons et al., 2008). Results suggest that VSPs can provide valid and reliable representations of live patients (Kenny et al., 2007; Triola et al., 2006; Andrew et al., 2007). Additionally VSPs enable a precise presentation and control of dynamic perceptual stimuli; along with conversational dialog and interactions, they have the potential to provide ecologically valid assessments that combine the veridical control and rigor of laboratory measures approaching a verisimilitude that reflects real life situations (Parsons et al., 2008; Andrew et al., 2007).

Herein the reader will find a description of attempts in this author's lab to advance the state of the art in VSPs. Prototypes have been developed for mental health assessment (Kenny et al., 2007; Kenny et al., 2008a; Kenny et al., 2008b; Kenny et al., 2009; Parsons et al., 2009a) and extended the behavioral fidelity necessary to support such diagnoses (e.g., physical appearance, gestures and facial expressions, reactions to pain, sweating, etc.).

VIRTUAL STANDARDIZED PATIENT

The general architecture supports a wide range of VHs from simple question/answering to more complex ones that contain cognitive and emotional models with goal oriented behavior. The architecture is a modular distributed system with many components that communicate by message passing. Interaction with the system works as follows: the trainee talks into a microphone which records the audio signal that is sent to a speech recognition engine. The speech engine converts the signal into text. The text is then sent to a statistical natural language system that matches the input text to a question/answer pair which selects an answer. The answer is sent to a non-verbal module which applies rules to create the appropriate gestures and behaviors. A procedural animation system then synchronizes the gestures, speech and lip synching and plays a pre-recorded or generated voice of the input text for the character for final output to the screen. The user then listens to the response and asks more questions to the character.

Design and Simulation of Pathologies

One of the challenges of building complex interactive VSPs that can act as simulated patients has been in enabling the characters to act and carry on a dialog like a real patient that has the specific mental condition in the domain of interest. Additional issues involve the breadth and depth of expertise required in the psychological domain to generate the relevant material for the character and dialog.

Virtual Standardized Patient: Conduct Disorder

Teaching interviewing skills with VHs and VSPs is still a young discipline. There are no standard methods and metrics. The larger problem of teaching general interviewing skills is even less distinct as there are many techniques and it is not well understood how to properly implement those with a VSP. To alleviate this problem this author's lab at USC/ICT is concentrating on teaching skills required to diagnose a particular disorder. For example, we have developed a VSP with conduct disorder. Through an iterative process a proficient training set was developed. The first project involved the construction of a natural language-capable VSP named "Justin." The clinical attributes of Justin were developed to emulate a conduct disorder profile as found in the Diagnostic and Statistical Manual of Mental Disorders (DSM IV-TR). Justin (see Figure 2) portrays a 16-year old male with conduct disorder who is being forced to participate in therapy by his family. Justin's history is significant for a chronic pattern of antisocial behavior in which the basic rights of others and age-appropriate societal norms are violated. He has stolen, been truant, broken into someone's car, been cruel to animals, and initiated physical fights (see Figure 2). Our goal was to obtain objective data from an initial intake interview. This was accomplished by evaluating the questions asked by the trainee to the VSP and the corresponding answers.

The trainee's interview questions were guided by the need to determine if the patient is internalizing or externalizing behaviors and for eliciting information regarding the four general symptom categories prevalent in conduct disorder:

- **Aggressive behavior:** fighting, bullying, being cruel to others or animals
- **Destructive behavior:** arson, vandalism
- **Deceitful behavior:** repeated lying, shoplifting, breaking into homes or cars
- **Violation of rules:** running away, engaging in non appropriate behavior for age

The VSP system is designed to provide answers to questions that target each of these categories and

Figure 2.

will respond to a variety of questions pertinent to these areas. Some responses by the VSP may be on target, off target, involve "brush away" responses, and in some cases, they may be irrelevant replies. The probability of a specific response being emitted is rated to the question asked. For example if the trainee asks: "How are things going at home" or "Are you having any problems at home" or "How are things going?". The system will respond with "My parents think I messed up." Further questions will lead to finding out that the patient has been running away. This will lead to marking one of the above categories true for the diagnosis in the trainees' interview. In order for the trainee to pass it will require responses in all of the categories. The total set of questions and responses are extracted from role playing exercises, initial subject testing, interviews with doctors and common sense for specific responses. In total a question set would consist of over 100-200 lines of text. The matching of questions to responses is a manual process with automated learning techniques to generate probability values.

Research has been completed to assess the system by (1) experimenter observation of the participants as they communicated with the VSP; and (2) questionnaires. To adequately evaluate the system, a number of areas were determined that were believed needed in the questionnaires:

- **Consistency:** The behavior of the VSP should match the behavior one would expect from a patient in such a condition (e.g. verbalization, gesture, posture, and appearance)
- **Adequacy:** The discourse between the VSP and the participants should provide adequate verbal and nonverbal communication
- **Proficiency:** The clarity, pace, utility of VSPs discourse with the participant
- **Quality:** The quality of the speech recognition of utterances spoken.

Basic usability findings revealed that the VSP had high-quality overall system performance. Participants reported that the system (1) simulated real-life experience; and (2) the verbal and nonverbal behavior was satisfactory. However, results also revealed that some participants found aspects of the experience "frustrating". For example, some participants complained that they were receiving anticipated responses and the system tended to repeat some responses too frequently. This was due to the speech recognition's inability to evaluate certain of the stimulus words. Further, there were too many "brush off" responses from the VSP when participant questions were outside the VSP's dialog set.

Although in the early stages of system development, initial outcomes have been favorable. We have collected (and continue to collect) quantitative and qualitative results. The VSPs fit well into usability testing. The clinicians in training were videotaped as they performed the interview with the VSP and this recording was stored for later analyses of their verbal communication, nonverbal behavior (e.g., gaze), and overall reaction to their interaction with the VSP. Ultimately, this reflects a general construct of believability. The construct of believability is typically understood as the extent to which data is regarded as true and credible. Among other factors, it may reflect an individual's assessment of the credibility of the data source, comparison to a commonly accepted standard, and previous experience (Magnenat-Thalmann et al., 2005). For the VSP work, this means that the clinicians compared their experience with the VSP to their general experience with human standardized patients and actual patients they see as a part of their clinical training. Findings suggested that the clinicians in training had positive response to the VSP and behaved as they normally would during a clinical encounter. However, two issues remain: (1) what was the phenomenological experience of these training clinicians as they interacted with the VSPs; and (2) how adequate are the appraisal models used in virtual human research at generating cognitive and emotional models (see discussion below: "2.2 Psychophysiology to enhance cognitive and affective models of virtual humans"). While the latter is lends itself well to a psychophysiological assessment approach (see discussion below: "2.2 Psychophysiology to enhance cognitive and affective models of virtual humans"), a review of the literature reveals that the former lends itself to theoretical speculation of the phenomenological experience of the clinician in training.

Phenomenonology of Clinical Encounters with Virtual Standardized Patients

The task of a clinician is exceedingly multifaceted, involving concurrent awareness of the patient's verbal and nonverbal communication, self-regulation of the clinician's own observation and management of countertransference reactions (Sternberg, 2000). The training of the clinician grows out of, and is governed by, therapeutic experience. To focus on a clinical encounter with a virtual standardized patient, then, is to focus on a complex context characterized by the clinician in training as he or she interacts with the simulation. For the clinician in training, the VSP will need to aid their commitment to the integrity of the context within which each novice clinician encounters the VSPs and that is organized around certain determinable constitutive features. The phenomenological approach taken in this author's lab reflects the four phenomenological areas postulated by Zaner (2006) for phenomenologicaly addressing the therapeutic relation: (1) **Immersion:** attainment of clinical knowledge by a trainee requires that the novice clinician put out of action all the convictions he or she has been accepting up to now; (2) **Reflective-Attentive shift:** herein reflection involves a shift of focal attention from active involvement in clinical cases for their own sake, to considering them as examples of the practice; (3) **Appeal to Evidence:** regardless of the clinician in training's desire for "Immersion" and "Reflective-Attentive shift", there still needs to be a judgment on the basis of soundest available evidence; and (4) **Clinical Ethics:** to consult as an ''ethicist'' on a simulated case means that the training clinician be focused on the simulated situation (e.g. context, persons simulated, issues, etc.) itself, for its own sake.

It seems apparent that virtual patients will play an important role in the future of psychotherapy education for psychiatry residents and psychology trainees. The use of virtual patients could be implemented in several ways. For example, virtual patients could be developed to recognize the essential features and common pitfalls of an initial psychotherapy interview so that they could give more specific, relevant, and reliable verbal feedback to the residents involved. In addition, the use of virtual patients illustrating common problems such as acting out, transference, intrusive questions, or seductive behavior would allow residents to have an experience with these anxiety provoking situations in a simulated setting before they occur in their practice. Finally, performance in virtual patient scenarios could be used as an additional source of data for the assessment of resident competency in the psychotherapy domain.

An issue that is bound to come up when discussing the training of clinicians using a simulated patient is the resident's perception of being assessed against a non-human agent. For this author's work, this issue is understood as a phenomenological issue inherent in any therapeutic relation. Following Zaner's (2006) phenomenological approach (mentioned above), there are four areas of interest for the novice clinician's interaction with the virtual patient. First, there is the issue of "Immersion" and the extent to which the clinician in training immersible. This is an important issue, because this author's own research has found that the extent to which a participant is capable of "absorption" and "hypnotism" are very important for social science research using virtual reality. The propensity of participants to get involved passively in some activity and their ability to concentrate and block out distraction are important factors to consider when conducting a study. Likewise, evidence suggests that immersiveness and hypnotizability play a role in the outcome of studies using virtual environments. Research into these moderating individual traits is of value because such research may augment participant selection (Macedonio et al., 2007). Second, there is the related issue of the "Reflective-Attentive shift", in which the clinician's acceptance of a virtual patient approach may be limited by the extent to which the trainee is able to shift attention from active involvement in clinical cases with virtual standardized patients, to considering them as examples of the practice. Of course, there is still the issue of the "Appeal to Evidence" and this is where the simulation really needs to present a very plausible and believable scenario so that the clinician in training is able to offer a judgment on the basis of soundest available evidence. Finally, it will be up to the trainer to help the novice clinician understand that the interaction with the scenarios involves an ethical focus that "suspends belief" in the fidelity of the graphics so that the focus can be on a potential real life scenario.

Virtual Standardized Patient: Trauma Exposure

For the next VSP, this author's lab constructed an adolescent female character called Justina that had been the victim of an assault and showing signs of PTSD (see Figure 3). The technology used for the system is based on the virtual human technology developed at USC and is the same as what was used with the previous VSP 'Justin'.

PTSD Domain

The experience of victimization is a relatively common occurrence for both adolescents and adults. However, victimization is more widespread among adolescents, and its relationship to various problem outcomes tends to be stronger among adolescent victims than adult victims. Whilst much of the early research on the psychological sequelae of victimization focused on general distress or fear rather than specific symptoms of PTSD, anxiety, or depression, studies have consistently found significant positive correlations between PTSD and sexual assault, and victimization in general and violent victimization in particular (Norris et al., 1997). Although there

Figure 3.

are a number of perspectives on what constitutes trauma exposure in children and adolescents, there is a general consensus amongst clinicians and researchers that this is a substantial social problem (Resick & Nishith, 1997). The effects of trauma exposure manifest themselves in a wide range of symptoms: anxiety, post-trauma stress, fear, and various behavior problems. New clinicians need to come up to speed on how to interact, diagnose and treat this trauma.

According to the most recent revision to the American Psychiatric Association's DSM Disorders (2000), PTSD is divided into six major categories; refer to the DSM-IV category 309.81 for a full description and subcategories;

A. Past experience of a traumatic event and the response to the event.
B. Re-experiencing of the event with dreams, flashbacks and exposure to cues.
C. Persistent avoidance of trauma-related stimuli: thoughts, feelings, activities or places, and general numbing such as low affect and no sense of a future.
D. Persistent symptoms of anxiety or increased arousal such as hyper vigilance or jumpy, irritability, sleep difficulties or can't concentrate.
E. Duration of the disturbance, how long have they been experiencing this.
F. Effects on their life such as clinically significant distress or impairment in social or educational functioning or changes in mental states.

Diagnostic criteria for PTSD includes a history of exposure to a traumatic event in category A and meeting two criteria and symptoms from each B (i.e., re-experiencing), C (i.e., avoidance), and D (i.e., hypervigilance). The duration of E (i.e., duration of disturbance) is usually greater than one month and the effects on F (i.e., social functioning) can vary based on severity of the trauma. Effective interviewing skills are a core competency for the clinicians, residents and developing psychotherapists who will be working with children and adolescents exposed to trauma. A clinician needs to ask questions in each of these categories to properly assess the patient's condition.

We aimed primarily to evaluate whether a VSP generate responses that elicit user questions relevant for PTSD categorization. Findings suggest that the interactions between novice clinicians and the VSP resulted in a compatible dialectic in terms of rapport, discussion of the traumatic event, and the experience of intrusive recollections. Further, there appears to be a satisfactory amount of discussion related to the issue of avoidance. These results comport well with what one may expect from the VSP (Justina) system.

In some of our earlier work, we found that the individual characteristics of study participants may impact the immersiveness and subsequent findings of a given study. Of primary importance is the extent to which a participant is capable of "absorption" and "hypnotism." Hence, individual differences may moderate presence and confound findings. The propensity of participants to get involved passively in some activity and their ability to concentrate and block out distraction are important factors to consider when conducting a study. Likewise, evidence suggests that hypnotizability plays a role in the outcome of studies using VR. Research into these moderating individual traits is of value because such research may augment participant selection.

We applied these findings to our work with VSPs to investigate the relationship between a number of psychological variables and the resulting VSP responses. The primary goal in this study was evaluative: can a virtual standardized patient generate responses that elicit user questions relevant for PTSD categorization? Findings suggest that the interactions between novice clinicians and the VSP resulted in a compatible dialectic in terms of rapport, discussion of the traumatic event, and the experience of intrusive recollections. Further, there appears to be a fair amount of discussion related to the issue of avoidance. These results comport well with what one may expect from the VSP (Justina) system. Much of the focus was upon developing a lexicon that, at minimum, emphasized a VSP that had recently experienced a traumatic event and was attempting to avoid experienced that my lead to intrusive recollections. However, the interaction is not very strong when one turns to the issue of hyper-arousal and impact on social life. While the issue of impact on social life may simply reflect that we wanted to limit each question/response relation to only one category (hence, it may have been assigned to avoidance instead of social functioning), the lack of questions and responses related to hyper-arousal and duration of the illness reflects a potential limitation in the system lexicon. These areas are not necessarily negatives for the system as a whole. Instead, they should be viewed as potential deficits in the systems lexicon.

A secondary goal was to investigate the impact of psychological variables upon the VSP Question/Response composites and the general believability of the system. After controlling for the effects of these psychological variables, increased effects were found for discussion of the traumatic event, avoidance, individualized models for affect recognition hyper-arousal, and impact on social life. Further, the impact of psychological characteristics revealed strong effects upon presence and believability. These findings are consistent with other findings suggesting that hypnotizability, as defined by the applied measures, appears moderate user reaction. Future studies should make use of physiological data correlated with measures of immersion to augment and quantify the effects of virtual human scenarios.

There are several modalities such as facial expression, vocal intonation, gestures, and postures that are regularly used to evaluate and model the affective states of individuals interacting with a virtual human. In this author's lab, there is an attempt to take a take a multimodal approach that builds on the work of virtual human researchers, but extends the cognitive and affective modeling through the incorporation of psychophysiological data. This is done for the following reasons: (1) Psychophysiology is an important component left out of many cognitive and affective models used in virtual human research; and (2) physiological signals are continuously available and are arguably not directly impacted by technological limitations inherent in virtual human assessment of facial expression, vocal intonation, gestures, and postures.

Psychophysiology to Enhance Cognitive and Affective Models of Virtual Humans

Current cognitive and affective models found in virtual human research tend to use appraisal models that specify how events, agents and objects are used to elicit an emotional response depending on a set of parameters (e.g., goals, standards and attitudes) representing the subject. In principle, it is possible to model appraisal processes using classical symbolic AI techniques (Picard, 1997; Chwelos & Oatley, 1994). However, cognitive and affective models of virtual humans do not generally account for neurophysiological data (Fellous, Armony, & LeDoux, 2003). Further, as Magnenat-Thalmann and Thalmann (2005) have pointed out in their review of virtual human research, virtual human models of emotional responses tend to be generated from a cognitive point of view and do not adequately take into account the psychophysiological response. Although appraisal does play a role in many current theories of emotion, most contemporary psychologists studying emotion emphasize the importance of psychophysiological arousal and that emotions are to be understood as cognitive appraisals and are accompanied by autonomic nervous system activity.

Although many appraisal models contend that cognitive processes (e.g., sensory perception) present verification for the preeminence of appraisal in emotion, other theorists indicate that appraisal processes occur following perception and represent a separate cognitive process (Izard, 1993). Of course, while most would agree that perception is a necessary part of any sensory experience, it is not known whether perceptual processes are the foundation of cognitive models of emotion or if these emotions are concerned with higher order cognitive appraisals that assign meaning and valence (Eckhardt, Norlander, & Deffenbacher, 2004).

A major limitation to many appraisal models found in virtual human research is that they follow outdated appraisal models that assert specific patterns of physiological changes that may be observed in affect occurrence after the subjective experience of affect. Research in psychophysiology has not supported these cognition first models (Cox & Harrison, 2008). In fact, a common frustration to attempts at developing an adequate scientific approach to emotion has been focus upon constructing theories of the subjective appraisals. Again studies of the neural basis of emotion and emotional learning have instead focused on how the brain detects and evaluates emotional stimuli and how, on the basis of such evaluations, emotional responses are produced (Magnenat-Thalmann & Thalmann, 2005).

This author believes that a preferred approach to developing cognitive and emotional virtual human models would include psychophysiological inputs from the humans to the virtual humans during interactions. It is believed that these additional inputs can be developed into affect-sensitive VSP interfaces that go beyond conventional virtual human models designed by pure (i.e., devoid of psychophysiological metrics) cognitive appraisal principles. The resulting affect-sensitive VSP interfaces would be similar to brain-based-devices (BBDs) that are being designed based on biological principles and are programmed to alter their behavior to the environment through self-learning (Edelman, 2006). An example of such research is found in work to develop intelligent robots. A series of devices with sensors and computer-simulated brains have been built in Gerald Edelman's (2006) Neurosciences Institute in La Jolla. The brains are modeled on human anatomy, complete with versions of visual cortex, inferotemporal cortex, and hippocampus. They are not pre-programmed, but evolve neuronal connections in response to experience. These devices can learn to recognize patterns and navigate novel environments.

Although the development of such computational models for virtual humans would be difficult, researchers (Magnenat-Thalmann & Thalmann, 2005) have pointed out that computational approaches to emotional processing are both possible and practical. In the following, there is a description of preliminary attempts at incorporating psychophysiological metrics into an affect-sensitive VSP interface system. Our goal is to first develop the interface and then build upon the interface to model affect and enhance the VSPs' cognitive and affective models.

Psychophysiology to Enhance Cognitive and Affective Assessment of User

The tendency of virtual human researchers to rely upon modalities such as facial expression, vocal intonation, gestures, and postures results in limitations due to "communicative impairments" (both nonverbal and verbal) inherent in the technology. This is very much the case regarding expression of affective states. Although these vulnerabilities place limits on traditional conversational and observational methodologies found in much virtual human research, psychophysiological signals are (1) continuously available; and (2) are arguably not directly impacted by these difficulties. As a result, psychophysiological metrics may proffer an approach for gathering robust data despite potential virtual human technology limitations. Furthermore, there is evidence that psychophysiological activity of persons immersed in virtual environments is associated with (1) trait differences (immersability; Macedonio, 2007) and (2) state differences (intensity of the environment; Parsons et al., 2009b, Parsons et al., 2009c; Meehan et al., 2005). These findings from virtual reality research reflect the finding that transition from one affective state to another is accompanied by dynamic shifts in indicators of autonomic nervous system activity (Bradley, 2005).

Psychophysiologically-Driven Interfaces for Adaptive Virtual Standardized Patients

According to Fairclough (2009), the next generation of intelligent technology will be characterized by increased autonomy and adaptive capability. Such intelligent systems need to have ample capacity for real-time responsivity (Aarts, 2004). For example, to decrease the intensity of a simulation if a user is overloaded by stimuli within a learning environment, or to make the simulation more challenging if the user is bored. The psychophysiological computing approach proffers the VSP a means of monitoring, quantifying, and representing user context and adapt in real-time.

A primary focus of the work described herein is the development of VSPs that are capable of real-time adaptive responding to affective processing of novice clinicians during clinical training paradigms and to enhance cognitive and affective models of virtual human technology. In what follows, there is a description of the current VSP task design and affective modeling techniques that are used during studies of interactions between novice clinicians and VSPs. The biocybernetic adaptation (Pope et al., 1995) of the affect-sensitive VSP system during interaction with a novice clinician can be summarized as follows: First, psychophysiological signals from the novice clinician are recorded while she is interacting with the VSP system. Next, the psychophysiological signals are filtered and quantified to operationalize relevant psychological constructs (e.g., frustration, user engagement, alertness) for incorporation into a unique psychophysiological profile for that user. 3) The psychophysiological profile is input into a database that has been developed from expert opinion, psychophysiology literature, and multimodal data (facial expression, vocal intonation, gestures, postures, dialectical interactions, and psychophysiology) gleaned from previous subjects interacting with VSPs (Kenny et al., 2007; Kenny et al., 2008a; Kenny et al., 2008b; Kenny et al., 2009; Parsons et al., 2009a). The VSP system next finds the best matching stimuli from its databases with respect to the intensity level of an affective state. An assessment of user state may be achieved via the development of discriminant algorithms (Liu, Rani, & Sarkar, 2005) or neural networks (Gevins et al., 1998; Laine et al., 2002). Finally, the system adapts the VSP's representation of the interaction and behavior accordingly.

Psychophysiology and Affect Modeling

Individual (Parsons et al., 2009b) and cohort (Parsons et al., 2009d) differences have been shown to impact results gleaned from psychophysiological assessments using virtual environments, which reflects the need for psychophysiological assessment of persons interacting with VSPs. In addition to extending the validation of VSPs, this author's lab uses psychophysiological metrics to develop a psychophysiological interface for VSPs that can adapt VSP scenarios to the user's psychophysiological processing of information. More specifically, psychophysiological measures such as heart rate, skin conductance responses, facial electromyographic response recordings, respiration, electroencephalographic recordings, and eyetracking can be continuously recorded while subjects interact with the VSP. These recordings can be processed in real time to gain information about the user's current state of emotional and cognitive processing. This information can then be relayed to the virtual environment in order to change for example, the behavior of the VSP. If the user is distressed by the current state of the interaction, a psychophysiological pattern of increased heart rate, increased skin conductance levels, a more rapid rate of respiration, increased corrugator muscle activity, decreased alpha wave activity and diversion of gaze may develop. Allowing for access to this information about the user's current emotional state offers the VSP an increased capability to understand the dynamics of the current interaction and develop a context appropriate response or behavior change.

In order to have reliable reference points, this author's lab has been running subjects through a protocol in which they interact with our VSPs. A primary goal has been to develop a reference knowledge database that is based on relevant data from literature, expert consensus, and actual psychophysiological data gleaned from persons interacting with VSPs.

Virtual Standardized Patient: Assessing Bias

Data for the reference knowledge database is initially being modeled off of data from previous experiments. In addition to the experiments mentioned above, this author's lab has also run subjects through protocols in which we measured the activation and control of affective bias using 1) startle eye blink responses; and 2) self-reports as human participants interacted with VSPs representing both the human's race and another race (Parsons et al., 2009a). We also assessed the differences in psychophysiological responses of humans interacting with VSPs representing same and different sex groups. By measuring eyeblink responses to startle probes occurring at short and long latencies following the onset of same compared with other ethnicity VSPs, we were able to examine affective processes associated with both the activation and potential control of bias.

A number of studies have used startle eye blink to successfully detect positive and negative affective responses (Blascovich, 2000; Lang, 1995). Startle eye blink has been found to adequately detect implicit affective race bias (Amodio, Harmon-Jones, & Devine, 2003). Part of the reason that the startle response is a good choice for this research is that a relatively simple and brief, but intense stimulus (i.e., usually a 100 db, 50 ms burst of static) can result in a primitive, defensive reflex. In previous studies, researchers have found that the startle response is increased or potentiated by stimuli that evoke a negative affective response and decreased or inhibited by stimuli that evoke a pleasant affective response or appetitive stimuli (Lang, 1995). The startle response has also been shown to be effective in predicting affective reactions to people of a particular race (Amodio et al., 2004).

Individual differences in levels of bias were predicted using E. A. Plant and P. G. Devine's (1998) Internal and External Motivation to Respond without Prejudice scales (IMS/EMS). Since participants with varying levels of IMS and EMS may differ in their responses to general affective stimuli unrelated to ethnicity, we presented general affective pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005). Finally, we obtained participants' responses to the Attitude Toward Blacks/Whites scale to compare the predictive ability of both the VSP interaction and the IMS–EMS with a traditional attitude measure of prejudice.

Eye blinks were collected and scored as electromygraphic (EMG) activity of the orbicularis oculi muscle of the left eye according to standard procedures (Blumenthal et al., 2005; Biopac, Santa Barbara, CA). One small (4 mm) silver-silver chloride (Ag-AgCl) electrode was placed on the left eyelid directly below the pupil while a second 4 mm electrode was placed approximately 1 cm lateral to the first. The impedance between the two electrodes was measured and deemed acceptable if below 10 KΩ. A large (8 mm) Ag-AgCl electrode was placed behind the left ear to serve as a common ground. Startle blinks were identified in each portion of the recordings as follows:

an interval (from 20 to 150 ms) adjacent to each startle probe was searched for the largest spike whose absolute value exceeds a high threshold (of 150 μV).

A difference score between the median blink amplitude to African American VSPs and Caucasian VSPs was determined. The difference score was then analyzed in terms of IMS and EMS scores. As all participants reported similar levels of internal motivation to respond without racism, they were separated into two groups of higher and lower external motivation scores. A one-way ANOVA was performed to determine if high vs. low external motivation related to physiological responses to different racial groups of virtual patients. The difference score tended to be lower in those with high external motivation to behave in a non-racist manner. Those who were lower in external motivation had a larger difference score between startle amplitudes while looking at African American vs. Caucasian VSPs.

The larger difference score reflects larger startle amplitudes to African American VSPs, suggesting an implicit negative bias towards that group. The difference between the low EMS and high EMS groups was not significant but suggests need for future analyses into the ways in which motivations can influence behavior at even automatic levels.

While the findings of the study are interesting, our current interest in this dataset is the modeling of user representation. We are currently running additional subjects to enhance the modeling through the inclusion of other modalities such as facial expression, vocal intonation, gestures, and postures, which may be amalgamated with psychophysiology to increase the complexity of the user representation.

Psychophysiological Computing as a Means of Providing User Context

Psychophysiological computing represents an innovative mode of human computer interaction (HCI) where system interaction is achieved by monitoring, analyzing and responding to covert psychophysiological activity from the user in real-time (Parsons et al., 2009a; Parsons et al., 2009c; Plant & Devine, 1998; Allanson & Fairclough, 2004). These systems operate by transforming psychophysiological data into a control signal (or an input to a control signal) without a requirement for any overt response from the user.

Psychophysiological computing captures spontaneous and subconscious facets of user state, opening up bandwidth within the HCI by enabling an additional channel of communication from the user to the VSP. As such, information exchange between human and VSP is rendered symmetrical as the psychophysiological interface constructs, consults and responds to a dynamic representation of the user.

Psychophysiological Assessment

We are collecting psychophysiological (e.g. heart rate; skin conductance; respiration; etc) data from users at USC via Biopac sensors. These data are being filtered and quantified to operationalize relevant psychological constructs (e.g., frustration, user engagement, alertness). These data will be correlated with other metrics (e.g. verbal and nonverbal receptive language) to enhance user interactions with the VSP. Specifically, we aim to gain psychophysiological data that we will analyze in order to quantify or label the state of the user so that we may develop an affect-sensitive VSP interface system. Following Fairclough (2009), we envision user state assessment as something being made with reference to absolute (e.g., heart rate exceeds 80 percent of normal baseline) or relative criteria (e.g., heart rate has risen 20 percent since the previous data collection epoch); alternatively, the assessment provided by the system may be categorical in nature (e.g., pattern of heart rate activity and changes in skin conductance level indicate that the person is in a negative rather than a positive emotional state). Based upon the user's psychophysiological responses to interacting with the VSP, enhancements may be made to the VSP's interactivity.

Psychophysiological Validity

As part of our ongoing data collection and data analytic process, we are endeavoring to validate the psychophysiological protocol: 1) Content validity is being established through careful selection of psychophysiological variables based on a review of existing literature (i.e., that a precedent exists for specific variables to tap those psychological constructs targeted by the system designer); and 2) Concurrent validity of the psychophysiological interface (i.e., degree to which a particular psychophysiological measure(s) can be demonstrated to predict the target psychological dimension). Further, we are establishing the reliability of the psychophysiological inference across a range of representative test conditions (e.g., high vs. low levels of operator stress) and individual differences among users.

VIRTUAL STANDARDIZED PATIENTS FOR TECHNOLOGY INTEGRATION IN HIGHER EDUCATION

Although traditional approaches to training clinicians in the interpersonal communication skills currently include a combination of classroom learning and role-playing with human standardized patients, there are limitations that can be mitigated through the integration of simulation technology. For example, while human standardized patients are expensive and cost several thousand dollars per student, the integration of virtual patient technology into the curriculum would be relatively inexpensive because it would require a one time programming cost. Further, given the fact that there are only a handful of sites (for over 130 medical schools in the U.S.) providing standardized patient assessments of the clinician in training's communication ability as part of the U.S. Medical Licensing Examination (USMLE), the current model provides limited availability. The integration of virtual patient technology would allow for the exact same virtual patient technology to be integrated and implemented at multiple locations. Another concern is the issue of standardization. Despite the expense of standardized patient programs, the standardized patients themselves are typically unskilled actors. As a result of common turnover, administrators face considerable challenges for offering psychometrically reliable and valid interactions with the training clinicians. The integration of virtual patients would allow for a standardized administration, standardized scoring, and standardized interpretation of the novice clinicians learning across multiple presentations and interactions. A related issue is the limited scope that the actors are able to portray. As a result, there tends to be an inadequate array of developmentally, socially, and culturally appropriate scenarios. For example, when a clinician has a pediatric focus and needs access to children, it is difficult for the clinician to pretend that the actor is a child. Finally, many clinical cases (e.g., traumatic brain injury) have associated physical symptoms and behaviors (e.g., dilated pupils, spasms, and uncoordinated movements). While these signs and symptoms simply cannot be accurately portrayed by human actors, they are a relatively straightforward programming issue for use with a virtual standardized patient.

As discussed above there are a number of ways in which the integration of virtual standardized patient technology can enhance clinical training in communication. The contribution of a virtual standardized patient to increased doctor patient communication is important and may enhance multifarious aspects of health outcomes. For example, increased doctor patient communication has been found to offer elevated compliance (Cegala, 2000), improved health outcomes (Stewert et al., 1995), increased patient satisfaction (Jackson, 2001), and a decrease in malpractice risk (Levinson and Roter, 1997). Given a virtual standardized patient's ability to simulate a particular clinical presentation with a high degree of consistency and realism, a virtual standardized patient may increase communication skills. Further, virtual standardized patients can be developed for special populations (e.g., children; octogenarians; neurological disorders) that cannot be adequately represented by a human actor (human standardized patient). Hence, a virtual standardized patient may help clinicians, educators, and health service administrators better understand clinician-patient communication that is unique.

CONCLUSION

In this chapter, there was a discussion of the ways in which advanced technologies (i.e., virtual standardized patients can move beyond traditional approaches to training clinicians in assessment, diagnosis, interviewing and interpersonal communication. The traditional approaches rely upon a combination of classroom learning and role-playing with human standardized patients. Much of this work is done with actors that have been recruited and trained to exhibit the characteristics of an actual patient, thereby affording novice clinicians a realistic opportunity to practice and to be evaluated in a mock clinical environment. Although a valuable training approach, there are limitations with the use of human standardized patients that can be mitigated through simulation technology. For example, human standardized patients are expensive and cost several thousand dollars per student. Further, given the fact that there are only a few sites providing standardized patient assessments as part of the U.S. Medical Licensing Examination, the current model provides limited availability.

In addition to issues of availability of trained actors, there is the issue of standardization. Despite the expense of standardized patient programs, the standardized patients themselves are typically unskilled actors. As a result of common turnover, administrators face considerable challenges for offering psychometrically reliable and valid interactions with the training clinicians. A related issue is the limited scope that the actors are able to portray. As a result, there tends to be an inadequate array of developmentally, socially, and culturally appropriate scenarios. For example, when a clinician has a pediatric focus and needs access to children, it is difficult for the clinician to pretend that the actor is a child. Finally, many clinical cases (e.g., traumatic brain injury) have associated physical symptoms and behaviors (e.g., dilated pupils, spasms, and uncoordinated movements) that simply cannot be accurately portrayed by human actors.

In this chapter a series of experiments were described to elucidate the usefulness and effectiveness of an affect-sensitive VSP Interface System. While self- report data are widely used in virtual human research, they are susceptible to modification by a participant's awareness of the social desirability of particular responses, reducing the sensitivity of the measures, implicit behavioral and psychophysiological responses are automatic and thus considered less susceptible to self-conscious influences (Schwarz, 1999). A further issue discussed in this paper was that the current cognitive and affective models found in virtual human research tend to use appraisal models generated from a cognitive point of view and do not adequately take into account the psychophysiological response.

It was contended that a preferred approach to developing cognitive and emotional virtual human models would include psychophysiological inputs from the humans to the virtual humans during interactions. It is believed that these additional inputs can be developed into affect-sensitive VSP interfaces that go beyond conventional virtual human models designed by pure (i.e., devoid of psychophysiological metrics) cognitive appraisal principles. The resulting affect-sensitive VSP interfaces would be similar to brain-based-devices (BBDs) that are being designed based on biological principles and are programmed to alter their behavior to the environment through self-learning.

In summary, effective interview skills are a core competency for training clinicians. Although schools commonly make use of standardized patients to teach interview skills, the diversity of the scenarios standardized patients can characterize is limited by availability of human actors. Further, there is the economic concern related to the time and money needed to train standardized patients. Perhaps most damaging is the "standardization" of standardized patients—will they in fact consistently proffer psychometrically reliable and valid interactions with the training clinicians. Virtual Human Agent technology (e.g., virtual standardized patients) has evolved to a point where researchers may begin developing mental health applications that make use of virtual reality patients for training.

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KEY TERMS AND DEFINITIONS

Standardized Patient: Actor that has been trained to act as a real patient in order to simulate a set of symptoms or problems.

Virtual Human: Embodied agent with a graphical front-end that is capable of engaging in conversation with humans employing the same verbal and nonverbal means that humans do (e.g., gesture, facial expression).

Virtual Standardized Patients: Advanced conversational virtual human agents programmed to portray standardized patient scenarios (e.g., mental or physical conditions) for the training of clinicians.

Immersion: State of consciousness where a person immersed in a virtual environment has diminished awareness of physical self due to his or her being surrounded in an engrossingvirtual environment

Psychophysiology: Domain of psychology that is emphasizes the physiological bases of psychological processes

Psychophysiological Computing: Computer system that can recognize, interpret, and process real-time psychophysiological activity and use it as input data

Affect Modeling: Detection of emotional information using sensors that capture data about the user's physical state or behavior. Recognizing emotional information requires the extraction of meaningful patterns from the gathered data (e.g., parsing the data through various processes such as speech recognition, natural language processing, or facial expression detection)

Validity: Extent to which a concept, conclusion or measurement is well-founded and corresponds accurately to the real world.