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Virtual Patient Simulation Training in Graduate Dysphagia Management Education—A Research-Led Enhancement Targeting Development of Clinical Interviewing and Clinical Reasoning Skills

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Abstract

Access to patients for clinical education is a challenge for educators and students across all health care professions. Led by colleagues in medical and nursing education, health care educators have increasingly embraced new teaching technologies such as virtual patient (VP) simulation training to support certain aspects of clinical education. This paper presents an account of the systematic, multi-year, research-led incorporation of computer generated virtual humans (i.e., embodied conversational agents) in a dysphagia management course targeting development of clinical interviewing and clinical reasoning skills in graduate speech-language pathology students.

The Case for Virtual Patient (VP) Simulation Training in Speech-Language Pathology Education

A growing problem in the field of speech-language pathology is the bottleneck of students between undergraduate and graduate levels of education. Graduate programs routinely reject more than 75% of applicants, in part due to the lack of clinical training opportunities for student clinicians (Polovoy, 2015). As a profession, we are experiencing large numbers of undergraduates in our programs, ample employment opportunities following completion of graduate training, but reduced opportunities to acquire required graduate training due in part to limited availability of clinical training! A logical question is, can simulation training in speech-language education help reduce this bottleneck by providing increased clinical training opportunities for a larger number of students? Virtual patients (VPs) enable students to practice clinical reasoning skills while integrating prior knowledge. Using VP applications, students “practice” skill acquisition in a safe

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environment without risk to an actual patient. In this way, VPs create increased educational opportunities to health care students–especially in fields where actual clinical training opportunities may be limited.

Types of VPs in Health Care Education

Virtual patients (VPs) simulation training takes many different forms depending on the educational objective. Examples include use of mannequins to teach invasive procedures (Harpham-Lockyer, Laskaratos, Berlingieri, & Epstein, 2015), use of virtual simulations to teach oral examination skills to emergency medicine residents (McGrath et al., 2015), use of VP simulation to teach nursing to evaluate and manage clinical deterioration (Liaw et al., 2015; Stayt, Merriman, Ricketts, Morton, & Simpson, 2015), and various applications to teach clinical reasoning skills to medical/surgical trainees (Close et al., 2015; Kleinert et al., 2015). The first publication using the term "virtual patient" in an educational category appeared in 1990 (Davis & Mark, 1990; Kononowicz, Zary, Edelbring, Corral, & Hege, 2015). Since then, publications on this topic have increased annually, with applications in medical education accounting mainly for this growth, reflecting increasing interest in this novel aspect of health care education.

Application of VPs in non-medical health care education has lagged behind that of our medical and nursing colleagues. Atwal, Money, and Harvey (2014) described occupational therapists' views on virtual reality design applications for pre-discharge home visitations (Atwal et al., 2014). Syder (1996) described how simulated clients were used to develop skills in speech-language pathology students (Syder, 1996). Zraick, Allen, and Johnson (2003) reported benefits such as consistency and safety of clinical experience from using standardized patients to teach interpersonal and communication skills to speech-language pathology students (Zraick et al., 2003). Wilson, Hill, Hughes, Sher, and Laplante-Levesque (2010) examined if first-year audiology students felt interactions with standardized patients and computer based simulations improved their ability to interact with clients and to perform basic audiometric assessment (Wilson et al., 2010). These examples indicate attempts to use cyber design applications, standardized patients, or computerized VPs to teach various aspects of clinical reasoning skills or processes to non-medical health care students.

Computer-Generated Virtual Humans

Since 2005, use of "interactive patient scenarios" have demonstrated the greatest growth in health care education and is currently the most common type of VP simulation training approach (Kononowicz et al., 2015). Interactive patient scenarios utilize a multimedia approach and have been helpful in teaching clinical reasoning skills. Virtual patients (VPs) utilized for dysphagia education in the University of Florida are a form of interactive patient scenario, specifically, computer-generated "virtual humans." "Virtual humans" or "virtual agents" often refer to different things for different people because of the wide variety of commercial, educational and research applications. The virtual humans we work with are a form of "embodied conversational agents," capable of holding conversations with users and also having a human embodiment. Examples of human components (i.e., embodiment) considered for inclusion in virtual humans include physical features, conversational capabilities, and behavioral capabilities (e.g., body movement and eye gaze).

Developing Clinical Interviewing and Clinical Reasoning Skills Through VP Simulation Training

One common clinical skill that requires both patient interaction and clinical reasoning skill is the patient interview. Specific to patients with dysphagia this part of the clinical evaluation can be critical to pointing clinicians toward necessary components of the swallowing examination and even provides direction toward understanding the underlying cause(s) of dysphagia symptoms. Nevertheless, clinical interviewing skills are hard to teach. Students typically develop clinical interviewing skills through a combination of instruction and direct patient interaction. Virtual

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patient (VP) simulation training has been shown to be a valuable tool to augment teaching and evaluation of clinical interviewing skills in medical and nursing students (Deladisma et al., 2007; Dickerson et al., 2005; Guise, Chambers, & Valimaki, 2012; Johnsen et al., 2005). Furthermore, evidence also exists for beneficial effects of VP interactions on learners' clinical interviewing skills (Berman et al., 2009; Triola et al., 2006), but little in the field of speech-language pathology and specifically dysphagia management.

Fundamental to successful clinical interviewing is clinical reasoning—the central component of clinician competence (Norman, 2005). Clinicians apply clinical reasoning during the clinical interview to attain a working diagnosis that may then be subject to subsequent validation (e.g., through instrumental evaluations). Such working diagnoses are key to timely investigations and subsequent implementation of clinical management plans. Research suggests that deliberate practice with multiple examples may be the critical element in developing clinical reasoning expertise (Norman, 2005). Virtual patient (VP) simulation, with its accessibility and repeatability, is an educational technology that enables such practice (Cook & Triola, 2009). With increased expertise in clinical reasoning, successful clinical interviews may be achieved with less effort (Norman, 2005). Potential outcomes of improved clinical reasoning may therefore include the ability to obtain more pieces of important information through the interview (i.e., increased effectiveness, increased efficiency in obtaining this information, and improved precision in the working diagnosis; Cook & Triola, 2009).

A Systematic, Multi-Year, Research-Led Incorporation of VP Simulation Training Into Dysphagia Management Education

From 2011 to 2015, the dysphagia management course at the University of Florida systematically incorporated VP simulation training into our course design where students created and conducted clinical interviews of virtual humans. The overarching aims of this initiative were to evaluate its feasibility and utility for teaching dysphagia clinical interviewing and clinical reasoning skills in speech-language pathology students. Implementation and evaluation were carried out as part of a series of research studies:

1. Feasibility study (2011): Initial feasibility evaluation of VP creation in health care education setting.
2. Virtual patient (VP) creation studies (2012) and (2013): Evaluation of VP creation for developing clinical interviewing, clinical reasoning and interpersonal skills.
3. Empathy study (2014): Evaluation of VP creation for empathy training.
4. Selection-based interview study (2015): Explored feasibility and advantages of VP interviewing using an alternate selection-based interaction approach.

Each VP study ran throughout the duration of the course. All students enrolled in the course had to complete three mandatory VP interviews. Virtual patient (VP) creation was presented to students as an extra credit option. Successful completion of VP creation provided students with five additional points on the final course results. Students who signed up for VP creation completed both interviews with VPs as well as created their own VP. Beyond these similarities, research studies each year had different designs and hypotheses.

VP Creation Through Conversational Modeling Feasibility Study (2011)

We first explored the feasibility of students creating VPs in 2011 using the Virtual People Factory (VPF) application (Halan, Rossen, Crary, & Lok, 2012). Students were randomly assigned into groups of four or five and each group was assigned to create one VP. A dysphagia patient

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profile created by course instructors was given to each group. Profiles included a dysphagia diagnosis and patient background (Table 1). Student groups were then tasked to research the dysphagia profile associated with each condition and to develop an interactive conversation to include information that may be associated with such a patient.

Table 1. Virtual Patient Background Provided for the Initial Feasibility Study.

Name of Virtual Patient	**Diagnosis**	**Race-Ethnicity/Sex**	**Background/Personality**
Marty Graw	Esophageal Stricture	Haitian/Male	Anxious and amiable
Vinny Devito	Brainstem Stroke	Italian-American/Male	Loves food and spending time with family
Jackie Dauer	Supraglottic Laryngectomy	African-American/Female	Friendly 62-year old widow
Kahlua Lopez	Left Hemisphere Stroke	Hawaiian/Female	Lower middle class English is her second language
Johnny A Seed	Zenker's Diverticulum	Caucasian/Male	Elderly male Lively, happy, optimistic
John Smith	Head and Neck Cancer with Radiation	Unspecified/Male	None
Anne Animus	Mother of Baby with GERD	Caucasian/Female	Single Mother

Students constructed their VPs outside of class time. The VPF tracked the amount of time each student spent, but the amount of time spent was entirely voluntary. Students used the human-centered distributed conversational modeling (HDCM) process to iteratively refine content that their VPs were able to discuss (Rossen & Lok, 2012). In HDCM, virtual human creator(s) create an initial version of the corpus to form a simplistic virtual human. The new virtual human has low question to response ratio because the creators do not come up with all possible questions initially. Other individuals then interact with the new virtual human. Questions that the virtual human does not know an answer to are collated. The creators then review these questions to add new responses to questions, or match them to existing responses. Through several iterations of this process, the virtual human corpus is developed until the virtual human is robust enough to conduct fluent conversations with users. For our study, the refinement process was divided into three rounds of interactions. For each round, students first interacted with their own VP and then interacted with VPs from two other groups. By the end of the third round, every participant had interacted with all six other VPs, and had interacted with their own VP thrice.

The study showed that students were able to create VPs themselves using VPF. The main challenge was the time spent by students in coming up with alternate questions (i.e., different phrasing of the same question) for responses in the corpus. However, we were able to mine data from the seven VPs created that had robust conversational corpora to create a virtual dysphagia patient template. The dysphagia patient template thus created was utilized in studies of the following four years, greatly reducing the time and effort required to create a robust virtual dysphagia patient.

Evaluating Development of Clinical Interviewing, Clinical Reasoning, and Interpersonal Skills (2012, 2013)

In 2012, we built the Virtual Patient Pipeline (VPP) on top of the VPF web application as an independent application to ease the VP creation process. The VPP incorporated a dysphagia patient template by mining data from interaction transcripts of VPs created in 2011 using

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crowdsourcing and information reuse approaches (Rossen & Lok, 2012). The VPP enabled students to create VPs in four simple steps:

1. Choosing a name, description, and image.
2. Completing a template of pre-populated questions (and their alternate forms).
3. Interviewing the VP to add more information to it (i.e., patient training; Figure 1).
4. Crowdsourcing, where trained VPs are shared among peers who help to flag responses that are wrong during their interviews with them.

Figure 1. Sample Interaction With a Virtual Human Patient With Transcript of the Interaction and Discoveries Made Shown (Halan et al., 2012).

The three mandatory VP interviews conducted by students across the duration of the course were used for assessing clinical interviewing skills outcomes. Results from the study showed that, across the duration of the course, students who created VPs were able to identify the underlying diagnosis more accurately than peers who did not (Sia, Halan, Lok, & Crary, 2014). Furthermore, students who created VPs were able to provide more accurate supporting reasons for their diagnosis. In addition, students who created VPs were able to identify patient concerns better during VP interviews, and were also rated as being more empathetic.

Improvements were made in 2013 to the study design to address identified weaknesses (e.g., selection bias). For example, students in the control group interviewed at least five other VPs to ensure students in both control (VP interviews) and treatment (VP creation) groups spent equal time on VP simulation training. Results showed that all students reduced the number of questions per discovery (i.e., improved efficiency) between the first and second VP interviews. Students who created VPs also made more total discoveries during the second interview (Sia et al., 2014). In addition, an association was found between VP creation and students' ability to identify patient concerns ($p < 0.05$). The odds of students who created a VP identifying patient concerns was 11.33 times higher than the odds of students who only interviewed VPs.

Developing Empathy Through VP Creation (2014)

Race contributes to disparities in health care quality (Fiscella, Franks, Gold, & Clancy, 2000). Virtual patient (VP) simulations have demonstrated the ability to capture real-world racial and

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skin-tone biases during interactions (e.g., participant empathy towards a dark skin-toned VP is predicted by measured bias towards African-Americans; see Figure 2; Rossen, Johnsen, Deladisma, Lind, & Lok, 2008). Our hypothesis in the empathy study was that creating VPs of a specific race can help students understand and empathize with patients of that race. Each VP created had one empathetic opportunity that was spoken by the VP. Participants' responses to empathetic opportunities were rated by expert raters trained on the Empathic Communication Coding System (ECCS) scale (Table 2; Bylund & Makoul, 2005). Our results showed that students who created VPs and then interacted with VPs of the same race as the ones they created were found to be more empathetic than students who created VPs of a different race compared to the VPs they interacted with (Halan et al., 2015). Interestingly, we also found that empathy was more pronounced when students created patients with race discordant to their own race.

Figure 2. High-Definition Virtual People Factory Avatars Allow VP Simulations to Capture Real-World Racial and Skin-Tone Biases.

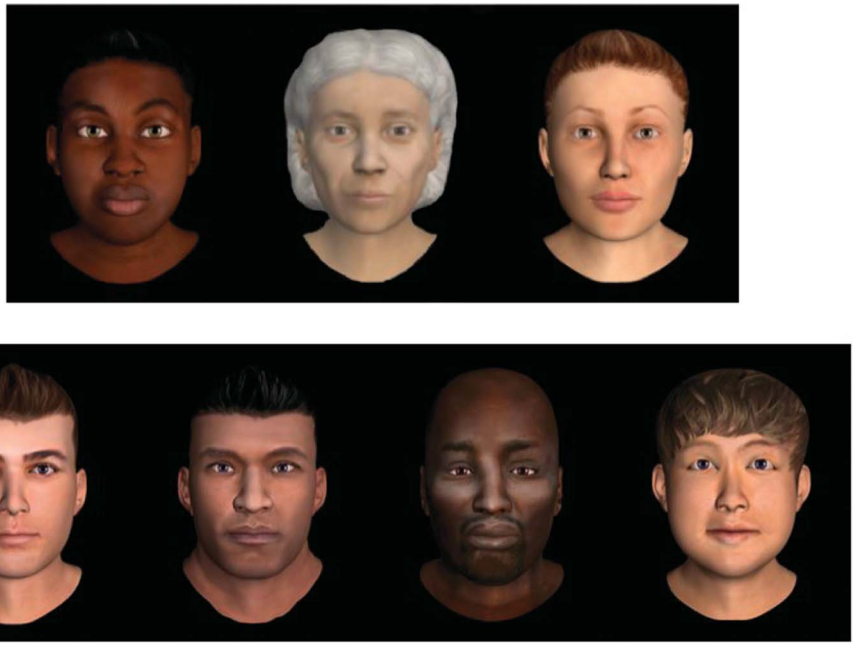

Table 2. Empathic Communication Coding System Levels With Examples From Participant Responses.

Level	Name	Example Response From Participants
6	Shared feeling or experience	*"I love to cook and eat, as well. I understand how difficult that might be."*
5	Confirmation	*"I'm so sorry to hear that. I know it can be hard, but we'll try to get to the bottom of this and get you better!"*
4	Acknowledgement with pursuit	*"Eating is enjoyable and we want to do everything we can here to get you back to where you can have a good quality of life."*
3	Acknowledgement	*"We're gonna do our best."*
2	Implicit recognition	*"We'll finish talking and see what we can come up with together"*
1	Perfunctory recognition	*"Do you only have trouble with liquids during mealtimes?"*
0	Denial	*"What has brought you in today?"*

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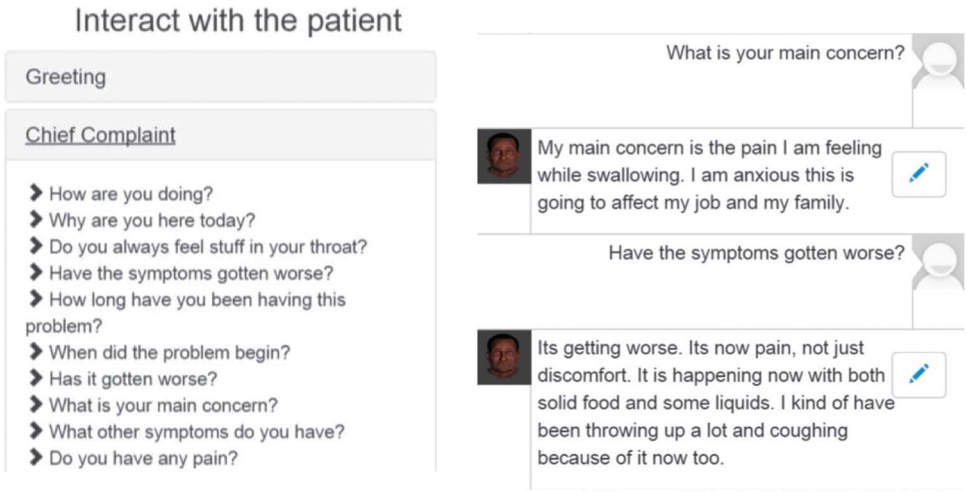
Comparing Chat-Based Vs. Selection-Based VP Interaction Models (2015)

Chat-based VPs rely on interviewer experience to progress the interview, which may frustrate students who lack the requisite interviewing skills. Such frustrations may be further aggravated by a chat-based interaction method's varying performance. As a result, chat-based VP interactions may inhibit students' from completing an interview successfully. On the other hand, a selection-based interaction method (Figure 3) has the advantage of displaying available, answerable questions (Pence, Dukes, Hodges, Meehan, & Johnson, 2013). As a further benefit, questions offered in selection-based interviews act as models for the appropriate progression of a clinical interview. Our results demonstrated that students gained patient information from VPs more efficiently using the selection-based interaction method (Carnell, Halan, Crary, Madhavan, & Lok, 2015). Feedback from students supported the proposal that selection-based interaction may be appropriate for student learners (Cook & Triola, 2009) and that selection-based VP interactions provided modeling opportunities for them.

Figure 3. Example of a Questions List for Selection (Left) Into A Student's Virtual Patient Clinical Interview (Right; Carnell et al., 2015).



Future Steps

Having established the feasibility and educational benefits of incorporating VP simulation training into the graduate dysphagia management course, our team is currently examining how we can extend the scope and capabilities of such training even further.

Incorporation of Clinical Assessment Components

Virtual patients (VPs) are well suited to present abnormal findings to advanced learners. Virtual patients (VPs) can guarantee active learning experiences in health care students curriculum. Future VPs can incorporate multiple platforms that present a variety of abnormal findings. One example of abnormal findings that are well presented by VPs is cranial nerve palsies. Due to the lack of curriculum planning of neurological exams of cranial nerve palsies, health care students often complete their education with a minimal set of experiences and exposure to patients with such conditions. One platform that future VPs can incorporate is the Neurological Examination Rehearsal Virtual Environment (NERVE). Neurological Examination Rehearsal Virtual Environment (NERVE) is a virtual platform to both learn information on cranial nerves and practice patient

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interviewing, examination, and diagnostic skills with patients presenting with cranial nerve disorders (Kleinsmith, Rivera-Gutierrez, Finney, Cendan, & Lok, 2015). Neurological Examination Rehearsal Virtual Environment (NERVE) has been used by hundreds of medical students and is freely available for education purposes (Nervesim.com, 2016.).

Apart from cranial nerve palsies, mucosal injury (e.g., post radiotherapy) and general oral health/hygiene (e.g., in elderly nursing home cases or hospitalized but debilitated cases) may be incorporated in an oral examination platform that may include the use of photographs or videos from real patients with a variety of abnormal conditions of different severity. Imaging studies—both fluoroscopy and endoscopy—may also be incorporated in VPs for more complex cases that may be subsequently used for guiding treatment planning.

Demonstration of Patient Responses to Treatment Choices

Speech-language pathologists (SLPs) are required to come up with a management plan for their patients after completing a thorough evaluation that may include results from instrumental exams. The SLPs management plans may include compensatory strategies, rehabilitative strategies, or both. In the future, clinicians in training may be asked to choose, propose, or describe treatment strategies for their VPs and then follow-up with a real time evaluation of the success or impact of these strategies on their VPs.

All of these examples have one thing in common—they focus on clinical reasoning skills—learning to make good clinical decisions. As such, a "complete" VP could be an invaluable aid in teaching novice graduate students basic clinical reasoning strategies from the patient interview all the way through applying treatment options. Such an experience is likely to give student clinicians a degree of experience and make them more comfortable and hence more effective in a real world clinical training experience.

Conclusion

Virtual patient (VP) simulation is a valuable tool for clinical educators for both training as well as assessment of clinical reasoning in student clinicians. Training using VP simulation improves clinical interviewing skills with VP creation potentially more beneficial than conventional VP interviewing alone. Furthermore, results from our studies suggest positive effects with regards to interpersonal skills and empathy. Feedback from students about the VP creation process has been favorable, including the applicability of VP creation as a learning tool. Nevertheless, VP simulation training cannot fully replace clinical interaction with, or clinical management of real patients. Hence, integration of VP simulation training into traditional clinical education curriculum is needed. Good integration determines how well such novel educational technologies are received and how much students benefit from them (Berman et al., 2009). The implementation of VP simulation training in dysphagia management or other areas in speech-language pathology education should therefore be carefully considered by educators so as to avoid redundancy and to achieve best learning outcomes for students.

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