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Teaching Empathy in Healthcare: from Mirror Neurons to Education Technology

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Abstract While modern medicine is moving towards genetically based personalized treatment, we still marvel daily at the healing power of the therapeutic relationships with patients. We are now closer to understanding where in the brain lies our capacity to view the world from the perspective of other people. Empathy is the ability to identify another person's feelings and experiences and to view the world from their perspective. In healthcare provider–patient interaction, empathy improves interpersonal communication, fosters therapeutic alliance, correlates with patient and provider satisfaction, and improves patient care outcomes. Although the importance of empathy in healthcare is widely accepted, further work is due in clarifying the dimensions of empathy that are amenable to teaching and defining the role of healthcare providers' and patients' perception of empathy in treatment outcomes. Herein we will (1) provide a brief overview of neurobiology of empathy, (2) discuss the dimensions and conceptualizations of empathy as they apply to healthcare professions, and (3) discuss the body of literature on empathy teaching interventions, including technology options, with focus on virtual patient technology for medical, nursing, and allied health professions education.

Keywords Empathy · Virtual patient · Simulation · Communication · Medical errors · Medical student · Nursing · Allied health · Burnout

Introduction

Neuroscience, with its rapid biomarker discoveries, allowed scientists to characterize perception and understanding of others as distinct constructs within the domain of social processes (Cuthbert and the NIMH RDoC Workgroup 2014). As we continue to unveil the neuroanatomical and physiological underpinnings of these intrinsic elements of empathy, we begin to understand that empathetic capacity depends on understanding own individual self in relation to the actions and emotions of others (Singer et al. 2009).

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Healthcare providers' empathy allows patients to express feelings and opinions about medical concerns, decreases psychological distress and physical symptoms, and improves patients' overall function. Equally, empathy increases healthcare providers' work satisfaction (Stewart 1995). Empathy is therefore an important skill to acquire in health professions, but can empathy be taught? Empathy has been conceptualized as an innate trait, which cannot be taught but rather refined, vs. a professional state that can be learned (Kunyk 2001).

Healthcare curricula include a range of empathy education methods, like standardized patient (SP) interactions and patient shadowing (Stepien and Baernstein 2006). Although technology is broadly used in medical education and practice, its use to teach empathy is not well established (Foster et al. 2016). Nonetheless, virtual patient (VP) technology has been used to assess and teach empathetic communication in medical, speech pathology, and other health professions' students (Deladisma et al. 2007; Halan et al. 2015; Foster et al. 2016). This paper offers an overview of neurobiology of empathy, reviews the role of empathy in patient care, summarizes empathy education in healthcare curricula, and explores the role of technology in teaching empathy.

Neurobiology of Empathy

Empathy has been associated with the mirror neuron system (MNS). MNS fires when an individual performs an action (e.g., reaching for an object, smiling, shrugging shoulders) and also fires when humans observe somebody else performing the same action independent of performing the action themselves (Rizzolatti 2005). Mirror neurons were originally found in macaques in the F5 region of the premotor cortex and the inferior parietal lobule (Rizzolatti 2005). Brain imaging studies in humans have shown that they are correlated with the inferior parietal lobule, the lower part of the precentral gyrus, and the posterior part of the inferior frontal gyrus (Rizzolatti 2005). Neurons with mirroring properties could also be found in the supplementary motor area and medial temporal lobe (Mukamel et al. 2010). Information from higher-order visual areas feeds into the MNS, where the frontal MNS processes the goal, while the parietal MNS codes the motor aspect of action. Both areas relate to the limbic system via insula connections, which is thought to be the basis of empathy, emotional understanding, and imitative learning (Iacoboni 2009). Understanding how people express empathy and learning how to appreciate and display back emotion in a manner that suits varying circumstances involve insula and its role in prediction of uncertainty (Singer et al. 2009). Learning of risk, uncertainty, and associated feelings has been proposed to occur through reinforcement learning, a process that involves dopamine neurons (Singer et al. 2009).

Children with autism, who have impaired emotional understanding, exhibit decreases in gray matter in MNS (Hadjikhani 2005) and lower MNS activity during imitation and observation of emotional expressions (Dapretto et al. 2006), further implicating that a dysfunctional MNS may lead to a lack of empathy.

The ability to process others' emotional states also relies on one's ability to recognize and symbolize others' faces. In patients with neurodegenerative diseases, damage to the right fusiform gyrus and the right medial orbitofrontal cortex (associated with facial recognition and respectively reward-value processing) is strongly correlated with ability to empathize (Rankin et al. 2006). Patients given placebo analgesia were less likely to be empathetic towards witnessing pain in others; however, when given the opioid antagonist naltrexone to block the placebo analgesia, patients' empathy for pain returned (Rütgen et al. 2015). This implies that empathizing for pain recruits similar neural components as first-hand experience of pain.

If empathizing requires the ability to experience an event first-hand (or at least internally imitate others' actions), could clinicians undergo training to enhance empathy and make future actions and behaviors more organic and intuitive? Neurofeedback and biofeedback training improved behavior in children with autism spectrum disorder, including improved emotion recognition and spontaneous imitation (Pineda et al. 2014; Friedrich et al. 2014). Mascaro et al. (2013) showed that participants who underwent compassion meditation training developed increased empathic accuracy and increased neural activity in the inferior frontal gyrus and dorsomedial prefrontal cortex. Voluntary enhancement of affiliative emotion, such as tenderness and affection, led to local increases in functional MRI responses in brain areas associated with affiliative emotion (septo-hypothalamic area and fronto-polar cortex) (Moll et al. 2014). Overall, preliminary evidence suggests that clinicians could undergo behavioral training to rewire their neural networks and achieve increased empathy towards patients.

Dimensions and Conceptualization of Empathy in Healthcare

Empathy, the phenomenon of understanding and appreciating how someone else feels, involves multiple aspects of healthcare provider's interaction with patients (Hojat et al. 2002; Stepien and Baernstein 2006; Neumann et al. 2011). Specifically, empathy includes a *cognitive* phenomenon that allows clinicians to understand and analyze the emotional state and behavior of another person, as well as an *affective* process of perception and reaction to another person's emotional state. This reaction could include verbal and non-verbal (facial expression, physiological reactions) responses to the empathetic challenges that occur in interpersonal interactions. Empathy (a state in which a person can differentiate between their own and others' emotions, to the benefit of the therapeutic relationship) is different from sympathy (a phenomenon when one becomes immersed and shares others' suffering), which can decrease objectivity and trigger emotional fatigue (Stepien and Baernstein 2006; Hojat et al.).

Healthcare Professionals' Empathy and Burnout

Self-assessed empathy declines in medical students and residents, as they progress through medical school and residency training, largely attributed to burnout and hidden curriculum (Chen et al. 2007; Hojat et al. 2009a; Brazeau et al. 2010; Neumann et al. 2011). While self-reported empathy declines from 2nd (preclinical year) to 3rd year (when students first attend clinical rotations), empathy rated by SPs during interactions with same students is higher for 3rd year than 2nd year students (Chen et al. 2007). Medical students who choose primary care and psychiatry are more empathetic than students who choose specialties with less human interaction (pathology, radiology, anesthesiology, and surgical specialties) (Hojat et al. 2002). Additionally, women medical students are more empathetic than men (Hojat et al. 2002; Berg et al. 2011; Bylund and Makoul 2002). Across health profession students, nursing students, midwifery, physical therapy, and occupational therapy students have high levels of self-rated empathy (Petrucci et al. 2016; Williams et al. 2014a, b).

Role of Empathy in Patient Safety and Medical Errors

Healthcare provider empathy improves treatment outcomes and reduces medical errors, yet the direct mechanism by which this process occurs is unknown. Knowledge to date points to the following components of this process: (1) healthcare provider factors (e.g., empathetic communication, critical reasoning, competence, as well as psychological and physiological substrates of all above factors) and (2) patient-related factors (e.g., perception of provider empathy, trust and engagement with the healthcare team, and the underlying physiology of each component). These factors coalesce into the treatment outcome which encompasses safety, medical errors, symptom relief, and quality of life. Empathy increases patient satisfaction and improves treatment outcomes (Stewart 1995). Rakel (2011) explored the effect of a medical encounter as usual compared to an encounter enhanced with empathy, empowerment, and patient education. Patients suffering with a cold, who gave their physicians a perfect empathy score on Consultation and Relational Empathy (CARE) measure, had significantly shorter and less severe illness and had significant change in inflammatory cytokine IL8 and neutrophil count, compared to those patients who gave their physicians lower empathy scores. In a prospective study in high and low socioeconomic areas, Mercer et al. (2016) found that physicians' general practitioners' empathy was the only consultation factor that predicted decreased symptoms and improvement in general well-being in patients from both socioeconomic groups, whereas number of physician visits, level of depression, or symptoms duration did not influence outcomes. In surgeons, empathy played a greater role in higher patient satisfaction and self-reported health status than emotional intelligence (Weng et al. 2011). In registered nurses, higher level of empathy, measured with JSPE, increases job satisfaction and work engagement and reduces nurses' intention to leave their job (Dal Santo et al. 2013). Physicians' communication skills are associated with reduced risk of medical errors and malpractice claims (Haslam 2007). In a 3-year prospective study of internal medicine residents, increased burnout and reduced empathy were associated with increased odds of self-perceived medical error in the following 3 months. Furthermore, having reported errors led to decrease in residents' quality of life and increased burnout and odds of positive depression screen in the following 3 months (West et al. 2006). Given the wide differences in empathy among categories of healthcare professionals on one hand and the large contribution of empathy to patient care outcomes, it is imperative to develop and deliver effective methods to teach empathy. Empathy is included in the teaching curriculum for all professions collaborating in the delivery of healthcare, with nuances specific to each field.

Medical Student and Nursing Education

Medical students acknowledge a cognitive and an affective component of empathy, leading at times to confusion about the most appropriate stance and a tension between "detached concern" and willingness to explore patients' feelings and emotions. Nonetheless, medical students recognize that this very exploration of emotion helps them be effective doctors (Jeffrey 2016). The tension between connection with and distance from patients is an intense concern to the students, who fear losing empathy and lack confidence in their own ability to handle complex psychosocial aspects of patient care (Jeffrey 2016). Pedersen (2010) emphasized the dichotomy between biomedical training and the training for empathetic communication (occurring separately, rather than being interwoven longitudinally throughout curriculum). Further, he emphasized the fundamental influence of empathy on physician's understanding of patients and its role in diagnostic and treatment decisions, recognition of own errors, creativity, and problem solving. The value and significance of empathy in nursing is synonymous to the profession itself (Ward 2012). Empathy is regarded as the most salient attitude and value of a nurse (Davis 2009) and an essential component of effective nursing care, central to the therapeutic nurse-patient relationship (Herdman 2004; Kunyk and Olson 2001; Maatta 2006; Williams and Stickley 2010). As such, the American Association of Colleges of Nursing emphasizes the importance of empathy development as part of the professional role of the nurse to nursing education (AACN 2008 and Benner

2010). Empathetic caregiver approach has been linked to positive patient outcomes (Williams and Stickley 2010; Hojat et al. 2011b; Rakel et al. 2011) and the lack thereof may threaten patient outcomes (Duarte et al. 2016). Consequently, a sizeable proportion of complaints against nurses is related to lack of empathy (Doyle et al. 2014). Empathy is taught in the form of behaviorally based micro-skills of listening and responding (Singer and Klimecki 2014; Williams and Stickley 2010) concomitantly within didactics, skills-laboratory, simulation, and during clinical rotations, along with learning basic nursing interventions. However, it was shown that empathy declines as nursing students' progress in their studies (Ward et al. 2012; Hojat 2009b). Thus, nurse educators continually seek teaching-learning strategies that enhance nursing students' empathy in order to foster positive patient outcomes (Ward 2012), improve the quality of care, and decrease the chance of miscommunication (Williams et al. 2015) that may potentially lead to patient care errors.

Allied Health Professions Education

The concept of empathetic care is not the purview of medicine and nursing only. All team members' contribution to patient care depends not only on clinical knowledge and procedural skills but also on communication skills that enable them to engage patients as active participants in their own healthcare (Fava et al. 2016). Physical therapy, social work, speech pathology, occupational therapy, pharmacy, nutrition, and radiology health care educators and practitioners agree that empathy is essential to better patient outcomes and an integral part of education and practice (Bayliss and Strunk 2015; Wagaman et al. 2015; Dirk et al. 2017; Meyer-Junco 2015). Physical therapy trainee studies, concurred with the results of the nursing emphatic research studies wherein students become less empathetic as they progress with their education (Bayliss and Strunk 2015). In one social work study, findings suggest that the use of empathy can be used to prepare social work practitioners to cope with burnout and help maintain their well-being and longevity in the field (Wagaman et al. 2015). New pharmacy practitioners can also benefit from empathy training to enable them to develop their own emphatic process, the outcome of which is better patient interaction (Meyer-Junco 2015).

Teaching and Evaluation of Empathy

Teaching Empathy

Empathy training in medical and nursing curricula attempts to maintain and improve this core communication competency by using experiential learning, patient shadowing, communication skill workshops, patient narrative writing, and wellness programs (Charon 2001; Henry-Tillman et al. 2002; Stepien and Baernstein 2006; DiGioia and Greenhouse 2011). Each of these interventions leads to increased awareness of the role of empathy in caring for patients, but so far, limited information exists about their direct effect on treatment outcomes. Communication skills workshops involving lecture, role-play, and patient interviews followed by direct feedback given by faculty most effectively teach empathetic communication (Stepien and Baernstein 2006). Patient shadowing increases empathy and counteracts detachment from patients, thought to occur due to heavy workload and burnout (DiGioia and Greenhouse 2011). Riess et al. (2012) introduced empathy training modules (including neurobiology of empathy) to residents in six medical specialties and found that *patient-rated* empathy improved in the intervention and declined in the control group, although there was no significant difference in *self-reported* empathy. Furthermore, this study pioneered the comprehensive assessment of cognitive, behavioral-communicative, and emotional dimensions of empathy by trainee, patient, and expert, as outcomes of empathy training. These teaching methods have limitations: cross-sectional rather than longitudinal delivery, high SP cost, limited access to faculty supervision, and inconsistency of evaluation tools (Moulton et al. 2009). In addition, interventions to teach empathy have not yet been evaluated to assess whether they can directly increase patient safety or decrease medical errors. Although assessment of empathy is longitudinal as part of clinical skills exams in health professions, the existing interventions which teach empathy are largely cross-sectional (Stepien and Baernstein 2006; Sullivan et al. 2009; Riess et al. 2012). We suggest that to be effective, teaching empathy has to be reinforced throughout curriculum and be graded in complexity, to mirror the gradual exposure to patient care. Furthermore, such curriculum should provide immediate feedback on learners' empathy in real time to promote learning reinforcement. The key elements of such curriculum are shown in Table 1.

Evaluation of Empathy

Neuwirth (1997) placed an early spotlight on the relationship between physicians' communication skills and patient satisfaction and on the risk of negative outcomes when physician communication is lacking, and articulated a framework to recognize and respond to opportunities for empathy that patients volunteer during medical encounters. This framework has been since used to develop empathy measurement tools.

Self-Rated Empathy Measurement Tools

The Jefferson Scale of Physician Empathy became the "gold standard" in self-assessment of empathy and has

Table 1 Key elements of a longitudinal empathy curriculum for healthcare providers

Empathy teaching modality	Condition to be illustrated	Empathy learning moment	Empathy components in each curriculum course
• Virtual patient • Standardized patient • Patient narrative • Patient shadowing	Patient scenarios of increasing complexity: simple, symptom-focused complaints → illness complicated by social determinants of health	Patient-generated empathetic opportunities of increasing complexity: simple, symptom-focused → illness affecting multiple areas of function	• Teaching • Deliberate practice • Feedback • Assessment of empathetic communication

been validated in multiple categories of trainees and healthcare providers (Hojat et al. 2002, 2009a, 2011b). Individual Reactivity Index (IRI), an empirically validated self-rated 28-item scale (Davis 1983), measures the emotional (Empathetic Concern), cognitive (perspective taking), response to others' suffering (Personal Distress), and empathy for fictional characters (Fantasy) dimensions of empathy. The subscales for each dimension are intended to be used separately, which helps to distinctly analyze the clinicians' verbal (cognitive) empathetic response, as well as the emotional-behavioral (e.g., facial expression) response to empathetic opportunities (Hemmerdinger et al. 2007). Each item is rated on a 5-point scale (where 1 = Does not describe me at all and 5 = Describes me very well), with nine reverse-scored items. When studied prospectively in internal medicine residents, one-point increase in emotive and cognitive empathy on IRI was associated with 9% decrease in the odds of a self-perceived error in the next 3 months (West et al. 2006). While we focused here only on two frequently used, validated scales, we direct the reader to comprehensive reviews of empathy measurement tools (Hemmerdinger et al. 2007).

Patient-Rated Empathy Measurement Tools

Consultation and Relational Empathy (CARE) measure (Mercer et al. 2004) is a well-validated 10-item measure with each item measured on a 5-point scale from Poor to Excellent. Lower CARE scores of primary care physicians were associated with poorer patient outcomes (Mercer et al. 2016). CARE scores, as well as ability to decode patients' facial expression, improved as a result of an educational intervention on empathy (Riess et al. 2012). Jefferson Scale of Patient Perception of Physician Empathy (JSPPE) is a validated 5-item measure that assesses patients' satisfaction with their physicians and correlates with patients' compliance rates for tests (Hojat et al. 2010).

Expert-Rated Empathy Measurement

Empathic Communication Coding System (ECCS) was developed and validated to code empathetic opportunities offered by the patient and clinician's verbal responses to these opportunities (Bylund and Makoul 2002). True to its purpose to assess how empathy is communicated, ECCS organizes the patient-generated empathetic opportunities into *emotion*, *progress*, and *challenge*, and codes clinician responses from level 6, *shared feeling and experience*, to *confirmation*, *acknowledgement of statement with* and *without pursuit, implicit* and *automatic recognition* and, finally, level 0, *denial of patient's perspective*. ECCS offers an adequate framework not only to code empathetic responses but also to give feedback to healthcare trainees on their empathetic responses (or lack thereof), as it occurs in interactions with patients (Foster et al. 2016).

Physiological Measures of Empathy

Attempts to correlate patient-rated empathy with clinician's non-verbal empathy cues, including facial affective mirroring of the patient, have been made by coding videotaped student interactions with VPs and SPs with respect to eye gaze, head nod, body lean, empathetic behaviors, level of immersion into the interaction, anxiety, and attitude, as well as overall empathetic response, using a 4-point, anchored scale (Deladisma et al. 2007). While the students' head nod and body lean were significantly more pronounced towards the SP, they displayed empathy towards the VP and overall students' verbal empathy correlated with their non-verbal communication. Riess et al. (2012) used the Eckman test (Eckman 1980) to assess resident physicians' ability to decode patients' facial expression of emotion. Handford et al. (2013) used reading the mind in the eye test (Baron-Cohen et al. 2001) and heart beat detection to objectively assess empathy with behavioral tasks and found that while empathy declined with age, clinical practice served to preserve empathy. Mercer et al. (2016) found that physicians' non-verbal communication (i.e., duration of smiles, positive facial expressions, and time spent with the patient) mirrored empathy rating on CARE measure, with communication in both domains being poorer with patients in lower socio-economic areas than those in affluent areas.

Future Directions in Measurement of Empathetic Responding Work by Marci et al. (2007) and Riess (2011) demonstrated that physiological concordance in skin conductance between patient and therapist correlates positively with patients' ratings of perceived empathy of their therapists. With the exception of a study (Handford et al. 2013) in which an interoception task was not associated with empathy, such work has not yet been expanded to healthcare trainees' physiological responses to empathetic opportunities offered by virtual, standardized or real patients. Correlating empathy with physiological (autonomic) manifestations in patients and healthcare providers would help further clarify where to direct teaching interventions to enhance empathy in patient–clinician interactions.

Overall, studies that employ interventions to enhance empathy rarely employ multidimensional measures of empathy; although in order to teach effectively, it is imperative to define the potential to affect each of these very dimensions. Table 2 lists relevant interventions that enhance empathy, the outcome measurement tools, and the empathy dimensions explored in each study.

Interventions for Teaching Empathy, Including Technology Options

In a meta-analysis that compares simulation with deliberate practice with traditional medical education, there is an effect

Table 2 Relevant studies of empathy teaching interventions, outcomes measured, and assessment instruments

Study	Intervention	Outcome measured	Method of empathy assessment			
			Self-rated	Expert-rated	Patient-rated	Objective
Bonvicini et al. 2009	Physician communication training workshop vs. wait list	Global empathy, hierarchical empathy at baseline and 6 months after training	–	Global Rating Scale (GRS), ECCS	–	–
Chen et al. 2007	Teaching as usual in 3rd year of medical school (the first year of clinical medicine)	Self-assessed empathy, empathy rated by SPs during OSCEs at the end of 2nd and 3rd medical school year	JSPE student version	–	OSCE empathy question	–
Riess et al. 2012	3 × 60-min empathy training modules delivered to medical residents (surgery, medicine, anesthesia, psychiatry, ophthalmology, orthopedics)	Empathetic and relational skills, facial expression decoding skills, knowledge of neurobiology of empathy, self-rated empathy	JSPE BEES	–	CARE	Ekman Facial Decoding Test Neurobiology knowledge test
Bond et al. 2013	Medical students who have taken the "Embodied Health" elective, within subject comparison	Empathy, perceived stress, self-regulation, self-compassion	JSPE, Cohen's Perceived Stress Scale, Self-regulation questionnaire, Self-compassion scale, Essay	–	–	–
Foster et al. 2016	VP interaction with empathy feedback vs. VP without empathy feedback in 1st year medical students	Empathy in interaction with standardized patient	–	ECCS	SP-encounter communication checklist	–
Lim et al. 2016	"Empathy Teaching Innovation" vs. control	Empathy (self-rated and patient-rated), OSCE	JSPE, OSCE self--assessment	OSCE marking sheet	JSPPE	–

ECCS Empathic Communication Coding System, *SPs* standardized patients, *OSCE* objective structured clinical examination, *JSPE* Jefferson Scale for Physician Empathy, *BEES* Balanced Emotional Empathy Scale, *CARE* Consultation and Relational Empathy, *VP* virtual patient, *JSPPE* Jefferson Scale of Patient Perception of Physician Empathy size of 0.71 in favor of simulation (McGaghie et al. 2011). Notably, in this meta-analysis, the 14 studies included researched primarily procedural skills (e.g., laparoscopic skills, central venous catheter insertion, thoracentesis) (Berman et al. 2016). VPs are multimedia, screen-based interactive patient scenarios (Berman et al. 2016), which permit safe and repetitive practice, provide immediate feedback, help develop clinical reasoning skills, and can simulate rare but critical scenarios (Cook and Triola 2009; Foster et al. 2015). In the following section, we will describe the role of VP simulation in teaching communication skill and empathy in particular.

Millennial students are known to seek and accept technology-based teaching tools (Mohr et al. 2011), which include VPs. We designed VP technology to teach various aspects of communication in patient encounters, including empathy. We created Virtual People Factory (VPF) (Rossen et al. 2009), a web application that uses a crowd-sourcing approach to develop VP experiences and a web-service that provides support for presentation in multiple mediums. The system runs on the popular cloud computing platform—Amazon Web Services. Users perform interactions using a standard web browser. The VP is displayed as a 3D interactive character on the web page. The interaction is similar to an instant messaging conversation. For example, if the user types "how are you feeling?" the VP replies "I am not feeling too well" with both text on the screen and playing of recorded audio. To respond to user questions, VPF uses an unannotated corpus retrieval approach (i.e., uses natural language approaches to find a list of corpus stimuli that are most similar to the input stimulus) (Dickerson et al. 2005). VPF incorporates 3D computer graphics that displays a virtual human responding to the user's interaction. These virtual humans can present VPs of varying gender, skin tone, age, and weight and can display varying VP emotions based on the student's typed interactions. For example, if the user were to ask about family history of the pain, the VP can explain his fear that his father had similar pains and died of cancer while the VP image displays a facial emotion of concern. Finally, the system can also present scenario-specific interactions, such as presenting ophthalmoscope retina images, MRIs, or test results. Upon completion of the interaction, the learner can provide a differential diagnosis, complete surveys, and conduct a review of their VP interaction.

With the help of content experts (dental, medical, speech pathology, and pharmacy faculty and students), our team developed VP scenarios related to neurology, surgery, mental health, and other medical domains, to allow students to practice history taking, diagnostic reasoning, and empathetic communication (Deladisma et al. 2007; Kleinsmith et al. 2015; Foster et al. 2016). For example, we developed a VP scenario which exposes students to an actively suicidal patient through an interaction that can take place on a personal computer, using broadband internet connection (Foster et al. 2015). Such clinical scenarios would be difficult to reproduce in real life for each learner in a class with hundreds of students; however, by giving each student the opportunity to practice the critical competency of suicide risk assessment, the VP environment may have an important patient safety impact (Foster et al. 2015).

Early in the development of the VP scenarios, we identified that students respond empathetically to VPs utilizing both verbal and non-verbal means of communication (Deladisma et al. 2007). To optimize VPs created by our group, we retrieved, qualified, and quantified empathic statements from medical student–VP interaction transcripts. We adapted the ECCS to analyze empathy in studies of 144 student–VP interactions with a depression scenario. The mean empathic intensity of the students' responses on ECCS scale (ranging from 0 to 6) of 1–6 was of 1.5 (min. =0, max. =5, SD = 1.6), with a mean of 1.21 (SD = 1.4), 1.32 (SD = 1.5), and 1.74 (SD = 1.7) for 1st, 2nd, and 3rd year, respectively. The majority of student responses were coded as denial (47.46%) and implicit recognition (28%), but 18.21% of responses were coded as acknowledgement with pursuit. Based on these results, we proceeded to include immediate feedback and teach empathetic communication with a human-assisted VP model (Borish et al. 2014; Kleinsmith et al. 2015; Foster et al. 2016). In this model, medical students were presented with a VP with major depression, Cynthia Young, a 21-year-old college student who failed two courses, quit her job, and no longer cares about hygiene. Cynthia lost her beloved cousin in an accident, and during the interaction with trainees, she expresses intense distress and expresses emotion ("I dream about my cousin pretty much every night; when I think about her, it makes me cry") (Foster et al. 2016). Students either typed or spoke their responses to the patients' concern, and their responses were coded in real time by human experts who were reliable ECCS coders. Students received feedback on their empathetic responses to the VP immediately after the interaction ended (Foster et al. 2016).

Another approach we took to enhance communication skills in medical students was to create back stories by adding cut scenes to VPs to enhance empathy, intended to depict various moments from the life of the VP with depression in order to convey to the learner how the patient's medical condition was affecting them in daily life (Cordar et al. 2014). Based on patient shadowing (DiGioia and Greenhouse 2011), the key advantages of VP shadowing are low cost, and the fact that while in real life, patient shadowing only provides insights into a patient's hospital life, cut-scenes can go beyond the clinical setting and provide insights into a patient's home and work life. We found after interacting with a virtual human with a back story, medical students were perceived by the SPs as more empathetic compared to the students who interacted

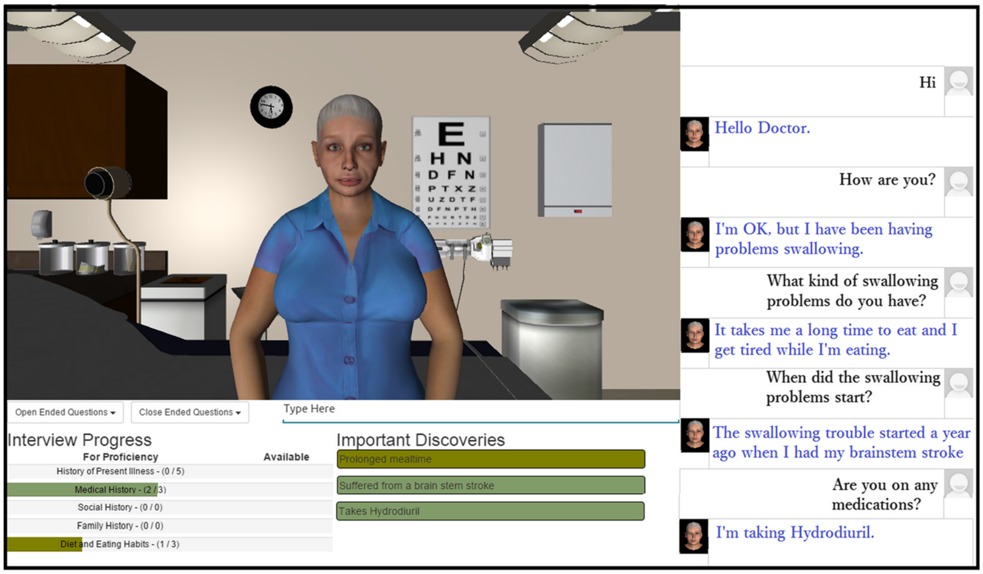


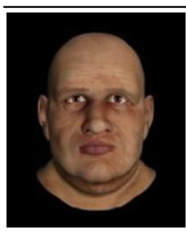
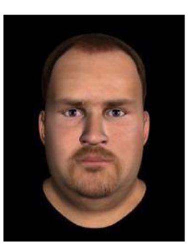
Fig. 1 Sample interaction between a healthcare student and a virtual dysphagia patient

with the virtual human without a back story (Cordar et al. 2014).

Our previous work has also explored teaching empathy by having healthcare students create their own VP characters. Understanding the patient's perspective is an important requisite for being empathetic (Maxfield et al. 2011). Facilitating opportunities for healthcare students to take the patient's perspective is imperative for empathy training and at the same time challenging to achieve through traditional methods of communication skills training. We explored having speech pathology students create the conversational content for VPs suffering from dysphagia and observed if creating a VP dialog improved their empathy. We thus created a VP with Parkinson's disease and dysphagia, who is concerned about the burden that his cough and difficulty swallowing place on his family (Halan et al. 2015) (see Fig. 1).

Student empathy was measured by rating the responses to empathetic opportunities during interactions with previously created VPs that were completed at the beginning and end of the VP creation process (shown in Table 3). The student's responses to the empathetic opportunities were rated by 40 people without medical background, recruited through Amazon's Mechanical Turk system. Each person who rated the empathetic opportunity responses was asked to imagine

Table 3 Student-virtual patient interview excerpts

Virtual patient	Virtual patient characteristics
 Vinny DeVito	Elderly Italian American male Diagnosis: dysphagia due to brainstem stroke "Can you tell me if I can ever start eating like before? I'm a food guy and love eating. It sucks that all that I've been able to eat is pureed food for the last year. Please tell me if I would ever get back to my original diet." "I am worried if I will ever be able to lead a normal life again."
 Marty Graw	Middle-aged Haitian male Diagnosis: dysphagia due to esophageal stricture "Doctor, imagine you being sick all the time. How would you feel about being sick and coughing while talking to your patients? My condition is the same. I am a chef but cannot even taste any of the food I'm cooking." "This health problem could not have come at a worse time. I'm already stressed about financial problems and my daughter's depression and now I have these issues as well. Can you give me at least some temporary relief so that I can handle my other issues first? Then I don't mind falling sick again."

himself as a patient who posed the empathetic opportunity to a doctor and then rate the response on a 7-point Likert scale with 7 being very empathetic and 1 being least empathetic (Halan et al. 2015).

The average rating of all the 40 people was the empathy rating score for that participant. Results show that there was a significant increase ($F_{2, 25} = 5.25$; $p < 0.05$) in the empathy rating of students who created VPs between the 1st VP interview conducted before the creation process started (Mean = 3.02; SD = 0.79) and the 2nd VP interview conducted at the end of the creation process (Mean = 4.21; SD = 1.07) (Halan et al. 2016). A similar study shows that speech pathology students who created VPs of a particular race and then interviewed VPs of the same race were significantly more empathetic when compared to students who interviewed VPs with a race discordant to the one they created (Halan et al. 2015). These results highlight the benefit of enabling healthcare students to gain the patient's perspective by creating VPs themselves.

VPs allow introducing environmental and social determinants of behavior in the scenario, to vary not only the skin tone, gender, age, and weight of the VP but also their English language proficiency, sexual preference, involvement in stigmatizing behaviors (i.e., alcohol or drug use), family, and work context. The VP system can be trained based on hundreds of students' responses to VPs, thus, it can become tuned to how students will react and empathize with virtual humans. The system can take the trainees' empathetic responses and provide feedback on how the trainee could best address an empathetic opportunity. The clinical content of the VP scenarios can be enriched based on responses and feedback from trainees who interact with the system. In addition, the VP content can be correlated for seamless integration into the healthcare professions' curriculum.

Future Directions

Empathy is a fundamental component of the patient-physician relationship, and its role in patient care outcomes is beginning to emerge. So far, studies testing interventions to enhance empathy in healthcare professionals have predominantly measured students' self-assessed empathy. Much work is due in delineating whether the emotional and cognitive aspects only or the behavioral aspect of empathy change as well, upon teaching. Comprehensive measurement of all dimensions of empathy will allow us to detect which dimension is amenable to teaching and skill reinforcement. VPs are ideal teaching tools because they allow standardization and have built-in capability to record the trainees' responses to empathetic opportunities. Enhancement of such VP systems with technology like the Noldus Face Reader (2015) which records and codes facial affective behavior throughout the simulated interaction or using psychophysiological indexes of autonomic nervous system functioning to examine changes in study participants' physiological empathetic responding (Gross and Levenson 1997; Kreibig 2010) could elucidate which dimension of empathy best responds to teaching (communication-verbal, behavioral, or emotion-based, physiological dimension). Further, empathy-teaching tool enhancements could objectively measure whether the effect of teaching empathy persists in each dimension. To train empathetic communication in healthcare students, VPs through their capability to (1) teach and reinforce empathetic communication longitudinally, (2) provide immediate feedback on empathy in real time, and (3) reach a large number of students who can practice and reinforce the skill repetitively and cost effectively, are ideally suited to establish acceptable individual performance levels in empathetic communication. Furthermore, future technological enhancements can add objectivity and breadth of measurement of empathetic challenges offered by patients and help further clarify which component(s) of empathy best respond to teaching, thus allowing us to target those very components with educational interventions.

Compliance with Ethical Standards

Conflict of Interest Benjamin Lok is a cofounder of Shadow Health, Inc. Shadow Health sells virtual patient curricula to primarily nursing and pharmacy schools. The University of Florida has licensed Shadow Health's intellectual property of the virtual patient work as of August 2008. The work presented here is clearly separate from Shadow Health, and there are no direct ties between the contained work and Shadow Health's products.

None of the other authors has any conflicts of interest.

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