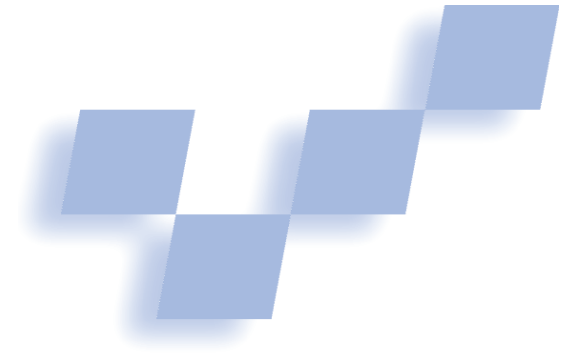


Virtual Conversations: An Interface to Knowledge



William G. Harless, Marcia A. Zier, and
Michael G. Harless
Interactive Drama

Robert C. Duncan
University of Miami

Conversim is a voice-activated multimedia model that gives users the illusion of having a conversation with a real person whose prestored images deliver spontaneous responses to queries.

In the early 1990s, research and development in the area of spoken language technology was supported and funded by the US federal government through the Defense Advanced Research Projects Agency. Fund recipients included the Massachusetts Institute of Technology, Stanford Research Institute, Carnegie Mellon University, Bolt Beranek and Newman Systems and Technologies, and Dragon Systems. The effort revolutionized spoken language technology and made independent speaker and continuous, real-time speech recognition systems a reality on large, powerful systems. Subsequent advancements in speech recognition technology by IBM, Dragon Systems, Learnout and Hauspie, Entropics, and other companies, resulted in the capabilities of independent speaker and continuous speech, real-time recognition in a PC environment.

Researchers have made numerous accomplishments in natural language dialogue models since the speech recognition breakthrough. Most, if not all, of these important developments involve avatars. These approaches include the Virtual Humans and Conversational Agents process embodied in the Research Triangle Institute's Avatalk¹ and the Center for Spoken Language Understanding (CSLU) Speech Toolkit.² In these models, the computer side of the conversation is constructed for task-specific purposes. Much work has also been done on the social and psychological implications of human-computer interactions³⁻⁵ (see also <http://www.vhml.org/workshops/HF2002/papers/gong/gong.pdf>).

In this article, we describe the Interactive Drama Inc. (IDI) voice-activated multimedia model called Conversim (conversation simulator), which lets a user conduct a virtual interview with a real person whose video images have been digitized and stored on a PC (see

<http://www.idrama.com>). The model consists of a series of Delphi programs that incorporate state-of-the-art speech recognition and digital video technologies and operate on a standard PC. The user speaks naturally into a microphone attached to the computer to engage the video character in a face-to-face, simulated conversation. For more information about Conversim, see the "Technical Note" sidebar.

Virtual Conversations interface

A Conversim dialogue typically begins when the user picks up a microphone and says, "Begin the session." The featured character comes to life onscreen and says "Hello." If necessary, the system displays a brief paragraph of text describing who the person is and the general subject of the conversation. A simple instruction tells the user to speak one of the questions scrolling at the bottom of the screen. ConverScroll, IDI's intelligent, nondirective prompting system displays these questions. The user can ask any of these questions, using the wording provided, or paraphrasing it, to activate the conversation. Instantaneously, the video character answers the question and the dialogue begins.

This beginning is all that's necessary to orient users. Users intuitively conduct the conversation from this point, taking advantage of the scrolling prompts. The user's voice controls the entire experience; the user never has to touch a mouse or a keyboard.

Figure 1 illustrates one possible interface. It's from a Conversim program about biological warfare featuring Joshua Lederberg, an esteemed scientist and Nobel laureate. IDI researchers interviewed Lederberg in front of a video camera, and he provided unrehearsed, spontaneous responses. The researchers digitized, edited, compressed, and stored the videotape in a database and developed a Conversim program. Using this database, any PC user can conduct a face-to-face virtual dialogue with Lederberg, who will relate basic facts and concepts to the user about biological warfare.

Each time Lederberg answers a question, the system selects and prioritizes three more questions from the database that are relevant to that response and scrolls

them continuously to prompt the user's next question. We've categorized each primary response (a prestored video clip of the speaking character) by topic (such as history of biological warfare, biological agents, political issues, military issues, and so on) and assigned them a priority number that the system uses to determine the order of the scroll. If a secondary (follow-up) response exists, it becomes available only after its parent primary response is played. When available, secondary responses have the highest priority in the scroll. Although, tertiary, or follow-up, responses to secondary responses get the highest scroll priority when they become available.

The three prompts selected by the system continue to scroll until the user asks a question. If the system recognizes the user's utterance as one of the questions scrolling, it displays the appropriate video clip and eliminates that question from future selections. Eliminated questions won't reappear in the scroll queue for the remainder of the session.

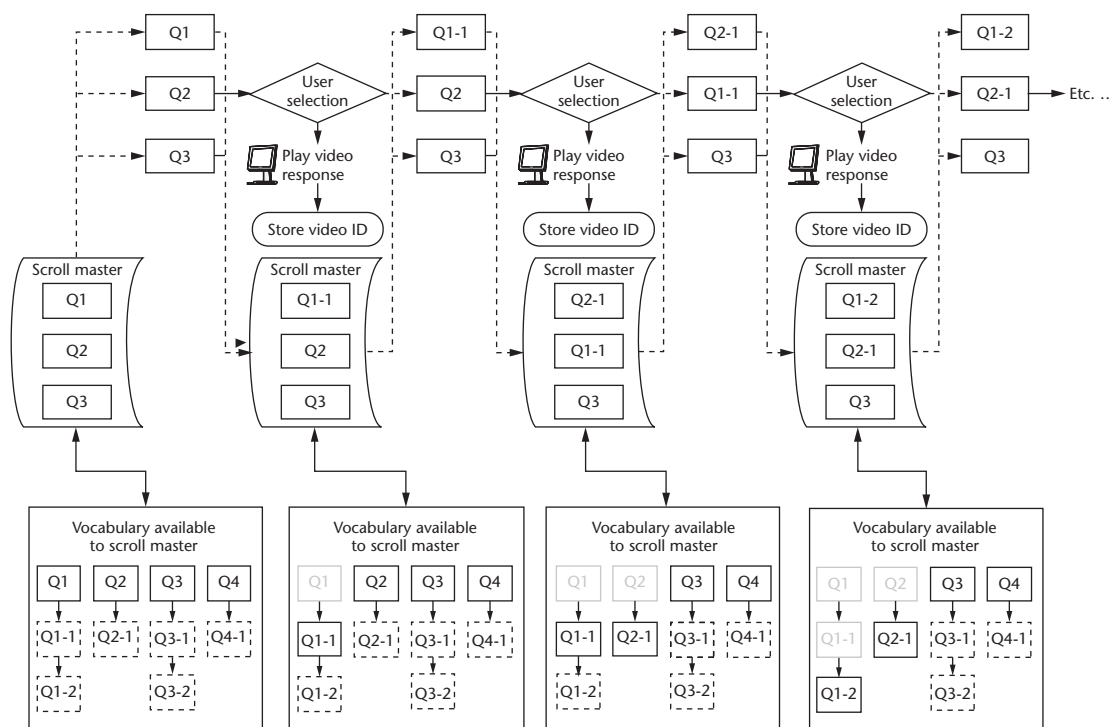
Likewise, the video clip that played in response to the recognized question is placed in a displayed video clips file. If the user asks a question and the system recognizes it as one pointing to a previously displayed video clip, the character won't respond to the question. Figure 2 illustrates this logic. The number of questions available is restricted only by the amount of video information recorded during the videotaped interview. Between

Technical Note

Conversim runs on a standard Pentium-based PC running Microsoft Windows 2000 or higher. It uses the Learnout and Hauspie ASR1600 independent speaker recognition engine to process user input queries. The video images are digitized and compressed in DivX format and stored on a CD-ROM. DivX software decompresses the video images for presentation so that no additional video boards are required beyond those in a standard multimedia configuration. All video images and software required to interact with a Conversim program reside on a single CD-ROM. The minimal recommended system is a 450-MHz Pentium II with 128 Mbytes of RAM, CD-ROM drive, 1024 × 768 resolution, and a sound card for microphone input and speaker output. Conversim will run on almost any computer of this caliber with these standard components.



1 Interface of a Conversim program about biological warfare featuring Joshua Lederberg.



2 Logic flowchart of ConverScroll, the intelligent system, which selects and prioritizes three queries and presents them to the user.

questions, the featured character's image remains active on the monitor in anticipation of the next question.

A control command appears on either side of the scrolling questions. Each command embodies a menu of subcommands that help the user navigate through the program. The user can change the topic of conversation at will by saying "topic choices," a command that will display a menu of the topics that the featured character is prepared to discuss. When the user chooses a topic from the menu, the system begins scrolling questions from that domain. In this manner, the user controls the order and flow of the dialogue. By saying "control options," the user can display a menu of items that will provide access to other resources in the program, such as a glossary, exhibits, photographs, and video clips.

New educational paradigm

The educational benefits of multimedia technology are well known and include dynamic, multisensory presentation of graphics, audio, and visual materials. The Virtual Conversations model embodies all these benefits and goes beyond to allow a direct interview of a video character. This added capability defines a new paradigm in education—one in which students can engage the teacher in a dialogue about a topic of interest. As previously described, students control the virtual dialogue's pace, while using natural language to ask the expert questions. They absorb the information at their own pace and can have the system repeat the expert's responses as many times as desired. Meanwhile, the continuous, dynamic scroll of relevant questions ensures that the student will never be at a loss for words.

Since conceptualizing this virtual dialogue model at the National Library of Medicine (NLM) in 1984, IDI developers have been particularly concerned about crafting the dialogue software to support believability on the part of the user. Unless the system actively supports the users' suspension of disbelief—to enable them to feel as though they're having a direct conversation with the virtual character—the experience is less effective. To support this, the interface must be nontechnical, aesthetic, intuitive, and driven by natural spoken language.

Furthermore, the system's ability to recognize the words and phrases spoken by users must be virtually flawless (more than 95 percent accurate); should the system misrecognize an utterance, its recovery must be seamless so as not to disrupt the user's involvement and the conversation's flow. Finally, the questions scrolling from the nondirective prompting system must be interesting and not odd or uncomfortable for a user to say. The virtual character's response must be relevant and provocative and must cause the user to want to ask more questions.

Since defining this paradigm, IDI researchers have developed numerous virtual dialogue programs and conducted several scientific experiments to answer three essential questions:

- Will students accept and like this new method of learning?
- Will experts and master teachers participate in this new technology?
- Will students learn from this method?

Student acceptance

Over the past several years, IDI research projects have focused on learner acceptance of the virtual dialogue method. With support from National Institutes of Health, National Institutes for Mental Health, and Centers for Disease Control and Prevention (CDC), IDI developed a variety of medical education applications of the virtual dialogue model:

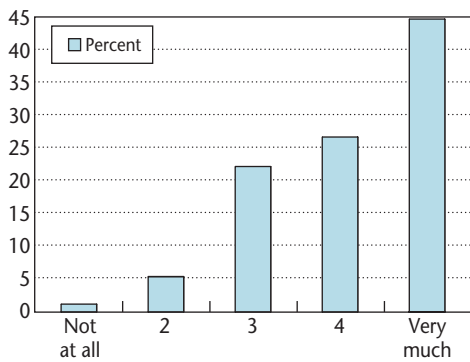
- *HIV risk assessment and counseling.* This series of four simulated patients lets students and practitioners rehearse HIV and sexually transmitted disease risk assessment and counseling skills. A contract from the CDC made this program development possible.
- *Training to diagnose depression.* Two simulated patients let students learn, and practitioners reinforce, the NIMH depression guidelines for identifying and better managing patients with depressive symptoms.
- *Triage.* IDI created this virtual dialogue simulation program for the US Army National Guard to train and evaluate medics. In this dynamic program, five soldiers are injured in an explosion. The user can dialogue with each casualty while making triage decisions; their survival depends on these decisions.
- *Breast cancer series.* This consists of three prototype programs. It lets women concerned about breast cancer conduct in-depth, hour-long virtual dialogues with an expert female oncologist, a nurse practitioner, and a breast cancer survivor in a feasibility study.
- *Brain injury education for family caregivers.* This series of eight hour-long virtual dialogues features experienced family caregivers and brain injury survivors. These programs provide peer support and educate families about brain injury and their role in rehabilitation.
- *Amputees and family caregivers.* This series consists of 11 programs that give recent amputees and their families practical knowledge and emotional support through one-hour virtual dialogues with experienced amputees and family caregivers. Significant positive attitudinal shifts were measured in the first phase of this experiment, which concerned users' perceptions of amputees and their potential for normalcy in their lives.

IDI researchers collected data from the formal experiments of these and other applications. The results support our belief that people who engage someone in a virtual dialogue will almost always

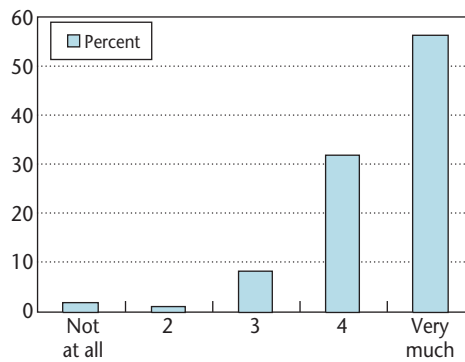
- feel as if they are talking to a real person,
- enjoy the experience, and
- become involved in the conversation that ensues.

Figures 3, 4, and 5 show a compilation of responses from 211 users in eight different experiments when asked about their experiences and whether and how much their experiences reflected these three characteristics. IDI researchers recorded responses on five-point Likert scales.

The single most important characteristic that distinguishes virtual dialogue from other more passive media



3 Responses for "I felt like I was speaking with a real person."



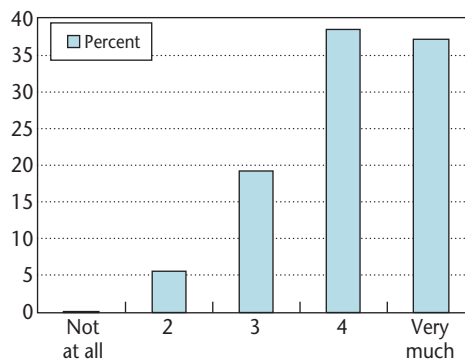
4 Responses for "I enjoyed talking with the character(s)."

approaches to learning is the fact that users feel as though they're in the presence of this real person. This active involvement in conversation with the video character gives each user the distinct feeling that he or she has actually met the person.⁶⁻⁸

Experts' participation

IDI has conducted research regarding whether true experts or master teachers would embrace the concept of virtual dialogue. The goal was to explore the feasibility of using virtual dialogue technology to interview knowledge experts; individuals who have achieved significant goals in their lives and can inspire people with their knowledge. In all, the following notable American experts agreed to be featured in virtual dialogue programs:

- Joshua Lederberg, the genetics pioneer mentioned earlier. He made his prize-winning contribution to the discovery of recombinant DNA in the late 1950s. He answers questions about biological warfare, a topic of grave concern to him.
- Congressman Major Owens, the senior representative from Brooklyn. He responds to questions about his political agenda to give students equal access to technology in education and, ultimately, to economic opportunity.
- Howard Frank, technology expert and dean of the business school at the University of Maryland. He answers questions about his innovative high-tech curriculum and about educating people to do business in the age of the Internet.
- Jack Germond, veteran reporter. He responds to questions pertaining to his 50-year career as a journalist. He shares his keen observations and insights about reporting, US politics, and every US president since John F. Kennedy.
- Senator John Glenn, former astronaut. He responds to questions about his early experiences as one of the first seven NASA astronauts and his historic flight on Friendship 7. He will also answer questions about his 24-year career as a US senator.
- James Gordon, a noted psychiatrist and White House health policy advisor. He discusses his efforts to bring complementary and alternative health care concepts into mainstream medicine.



5 Responses for "I felt involved with the character(s)."

- Donald A. B. Lindberg, current director of the NLM. A physician and a visionary, he has led NLM to the forefront of medical research and biotechnology. He answers questions about current NLM programs and the library's progress during his directorship.

This series of experts will be distributed to schools, libraries, and resource centers. IDI is currently placing copies in institutions identified by the experts (such as the NASA John Glenn Research Center in Cleveland, Ohio; Congressman Owens' office; the NLM, and so on). Howard Frank sent a microphone and a CD-ROM copy of his virtual dialogue program to 200 students who applied for admission to the Maryland MBA program so they could "talk to the dean" before making their final choice of schools.

Learning gain

In June 2001, IDI conducted an experiment to determine the intensity of cognitive activity in subjects engaged in a virtual dialogue with an expert, as determined by knowledge gain. The researchers hypothesized that an individual in a military environment can significantly and rapidly gain new knowledge on a given subject through one-on-one discourse with a content expert, using virtual dialogue technology. A secondary objective was to obtain measures from military users that would determine the acceptability of the learning method, or lack thereof, in a military environment.

The researchers' original intent was to develop a virtual dialogue with a military commander, which could be used in a field study with Special Operations Forces (SOF) personnel at Fort Bragg, North Carolina. However, the events of 11 September 2001 led the director and faculty of the US Army John F. Kennedy Special Warfare Center and School to recommend that a virtual dialogue with an expert on Middle Eastern culture be developed instead. It was essential that the speaker be Moslem, well educated, and articulate about the nature and affairs of Middle Eastern cultures. Therefore, the virtual dialogue program developed to conduct the research for this contract features a native Pakistani, Abdul Mohsin Mian, professor of biochemistry at the University of Miami. The program lets a user learn from this Middle Eastern native about Afghanistan's geography, culture, religion, and people who are involved in the current political circumstance.

Research design

The participants in the experiment were military and civilian personnel at Fort Bragg's Special Warfare Center. All participants conducted a 35-minute virtual dialogue with Mian on two topics related to Afghanistan. They also completed pre- and post-session questionnaires, including a knowledge test designed to measure learning gain. In addition, they answered questions measured on Likert-type scales that concerned their acceptance of the method.

Mian did not have a wealth of personal, firsthand knowledge about the current situation in Afghanistan. However, he did have an intense interest in, and an experiential context for, the flood of information being delivered through the media. This circumstance provided the unique research opportunity to compare the knowledge gained by the test subjects during a 35-minute virtual dialogue with this Middle Eastern native perceived to be an expert to the knowledge gained from 11 weeks of usual access to the intense media coverage of the same information. In other words, would this new paradigm involving virtual dialogue with an expert, in and of itself, enhance the knowledge gain of interested users? Since the experiment at Fort Bragg occurred only 11 weeks following the 9/11 attack, it was reasonable to assume that these test subjects, in particular, were interested in the topics and had spent at least a normal amount of time seeing and hearing the information from various media sources. Subjects were blind to the rationale for the pretest—that is, they weren't told that the pretest would consist of questions about information to which they had been exposed through the media.

To measure the acquisition of facts and concepts by the field-test participants, the researchers distinguished facts and concepts from Mian's opinion in all his spoken responses in the virtual dialogue program. For example, a statement by Mian such as "Bin Laden was born in Saudi Arabia" was considered a fact; a statement such as "Bin Laden hates America because of the military presence in Saudi Arabia" was considered to be a concept (that is, a statement that has appeared in the media and is generally believed to be true); while the statement "America should review its foreign policy concerning

Israel and Palestine" was defined as an opinion. The researchers counted the facts and concepts in each of the domains that subjects would see. The pre- and post-tests only measured the acquisition of a fact or a concept. This eliminated Mian's opinions from the comparison, since they weren't necessarily a part of the general information provided by the media and other sources.

The data collection instruments developed for this study included pre- and post-knowledge tests and an acceptance questionnaire. Pre- and post-knowledge tests measured knowledge gain and consisted of true or false items concerning the facts and concepts covered by the expert (Mian) in the virtual dialogue program. The program included a variety of topics related to the Afghan culture, people, and then-current status of the political and military situation. For the experiment, the dialogue topics were limited to Islam, Afghanistan, Bin Laden, and the Taliban. The researchers created four sets of pre- and post-tests, one set for each of these four domains. Each instrument contained 10 true or false items. The researchers added a "not sure" category to the conventional true or false format of the pretest to ensure the truth of circumstance—that is, to eliminate guessing and yield a more accurate baseline measurement of each subject's knowledge. The content of the pre- and post-tests was identical. The test questions concerned only the facts and concepts Mian expressed in his responses. His personal ideas and political positions weren't included in the test material.

The acceptance questionnaire contained seven specific questions with associated Likert-type scales designed to measure each participant's acceptance of the virtual dialogue method. Elements of believability, enjoyment, interest in the topic, and respect for the virtual character were among the measurements obtained.

Experiment

Three IDI researchers and two IDI field test monitors conducted the experiment at the Special Warfare Center. They set up four laptop computers in the corners of a single, large room. The subjects wore headphones when they conducted the virtual dialogue with Mian so that they wouldn't be distracted by the dialogues that the three other subjects were conducting simultaneously. Nineteen subjects, males and females, enrolled in the testing; 16 completed their session. The group was extremely heterogeneous and included 12 Special Forces military personnel and seven civilians.

The participants received a brief (2-minute) orientation to the study and the method, then took the pretests in all four domains to establish baseline data concerning their knowledge about these topics. The subjects then began their session with the topic of Islam, and they were left to interact independently with the virtual dialogue program. While the subjects dialogued with Mian on this initial topic, the IDI statistician scored their pretests to identify the domain about which they knew the least. If a subject had a low pretest score on any of the other topics besides Islam, he or she dialogued with Mian about that topic. If no such distinction could be made, the subject was allowed to choose the second topic. The dialogue sessions lasted

approximately 35 minutes. At the end of the session, each subject completed the acceptance questionnaire and the post-tests covering Islam and the second topic. A field test monitor also interviewed the subjects briefly about their experience.

Data analysis

This was a repeated measures experiment with each participant acting as his or her own control group. The researchers analyzed learning gain using paired t-tests. The proportion increase in a domain multiplied by the number of items available in that domain yielded an estimate of the number of new items learned during the interaction, thus indicating ongoing cognitive activity. Table 1 shows the results obtained from the pre- and post-tests of knowledge in the four domains (group-specific test scores). These are the average pre- and post-test scores and the change scores for the entire subject group. The p values in the table show that the knowledge gain by each group was significant. Figure 6 shows these group-specific pre- and post-test results as a bar chart.

Sixteen subjects interacted with the expert about Islam. On average, subjects scored 23 points higher on the post-test concerning Islam, thereby increasing their knowledge by 53 percent. Those who selected Afghanistan improved their score by 17 points and their knowledge by 57 percent. Subjects who selected Bin Laden scored 38 points higher on the post-test and realized a 127 percent increase in knowledge. Those subjects who spoke with Mian about the Taliban realized the greatest increase. This group averaged 58 points higher on the post-test, a 322 percent average increase in knowledge.

Figure 7 shows the overall increase in learning for all 16 participants. The average score for all four areas was 32.7 percent on the pretest and 62.3 percent on the post-test. This represents a rate ratio (post-test percent divided by pretest percent) of 1.91 or an overall average increase in learning of 91 percent.

These field test subjects had acquired 30 percent of the information being measured by the pretest, information that had been covered in the media blitz during the two months following the 11 September event. After 35 minutes of virtual dialogue with a person whom the subjects perceived to be an expert, they demonstrated a 91 percent gain in learning, almost doubling their knowledge about the topics covered in the dialogue.

The learning experience for several individual subjects during the 35-minute session was even more dramatic. Seven of the 16 subjects who completed the pre- and post-tests increased their score in the range of 100 to 250 percent. One subject had an extraordinary gain of 333 percent. These results indicate intense cognitive activity.

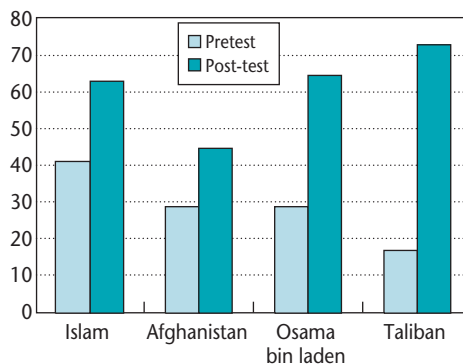
Facts and concepts acquisition

The researchers estimated the number of new facts and concepts within a domain that were acquired by any participant by multiplying the pre- and post-test rate difference in correct responses times the number of facts and concepts available in that domain. (Recall that each subject completely exhausted the questions available within a domain.) As an example, a pretest score of 20

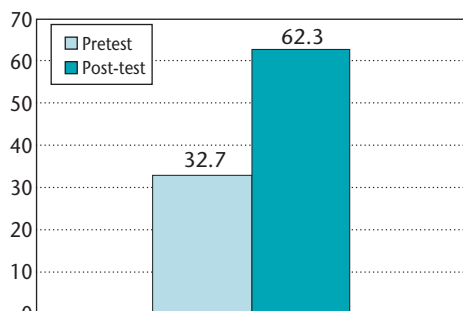
Table 1. Group-specific test scores (mean ± standard error).

Group	n	Pretest	Post-test	Change	P*
Islam	16	43 ± 4.1	66 ± 2.9	23 ± 2.6	0.0001
Afghanistan	3	30 ± 5.8	47 ± 3.3	17 ± 3.3	0.0377
Bin Laden	8	30 ± 4.6	68 ± 6.5	38 ± 8.0	0.0022
Taliban	5	18 ± 3.7	76 ± 7.5	58 ± 5.8	0.0002

*Paired t-test



6 Pre- and post-test data of knowledge gain.



7 Percent of overall increase in learning.

percent and a post-test score of 40 percent on Islam would show a gain of $0.2 * N$, where N is the number of facts and concepts available on Islam.

On average, subjects acquired 55 new facts and concepts during the session. Nine of the 16 participants learned more than 50 facts and concepts during their session; one gained 92 new concepts and one subject acquired 116 new facts and concepts during his virtual dialogue session with Mian.

Discussion

The IDI researchers analyzed the data to ensure that a bias wasn't introduced by the decision to have a "not sure" choice on the pretest but not on the post-test. Of the 320 items asked, 119 (37 percent) were marked "not sure" on the pretest. Of these 119 items, 72 (61 percent) were answered correctly on the post-test, where subjects had only true and false as options. If the subjects were guessing, the researchers would have expected a correct answer rate of 50 percent on those 119 items. The 61 percent achieved by the subjects is significantly greater than 50 percent at $p=0.007$ using the chi square test for proportions. Furthermore, the 61 percent cor-

rect answer rate for the pretest “not sure” answers is close to the overall post-test correct answer score of 65 percent. The researchers concluded from these results that there wasn’t a bias introduced by the availability of a “not sure” option in the pretest and that the objective of truth of circumstance was achieved by this strategy.

The overall learning gain for the group of subjects was an impressive 91 percent, almost doubling their knowledge in 35 minutes. In fact, one half of the 16-subject population more than doubled their knowledge about the topics covered by the dialogue and the pre- and post-tests.

Conclusion

What do such positive results mean? First, users have no difficulty using the technology, and they enjoy this new method of learning. Second, experts are willing to appear in virtual dialogue form because of the educational possibilities that this method provides. Third, if the program is crafted properly, a user who conducts a virtual dialogue with an expert will experience a significant and rapid gain in new knowledge.

The researchers believe that the fundamental characteristic of virtual dialogue technology creates a profound learning experience for the user—one in which virtually all of the knowledge embodied in the expert’s answer to the user’s question is acquired by the user. The findings indicate that virtual dialogue represents a new educational paradigm with extraordinary teaching potential.

We plan to continue to make technological and aesthetic refinements to the Conversim model and explore the uses of this new paradigm in the curriculums of K–12, undergraduate, graduate, and professional education. Research projects will be defined and conducted in each of these domains to validate the findings reported here. In addition, we’ll conduct follow-up studies to measure users’ retention of knowledge gained through virtual dialogue methodology. ■

References

1. R. Hubal et al., “The Virtual Standardized Patient-Simulated Patient-Practitioner Dialogue for Patient Interview Training,” *Proc. Medicine Meets Virtual Reality 2000*, J.D.D. Westwood et al., eds., IOS Press, 2000, pp. 133-138.
2. S. Sutton and R. Cole, “The CSLU Toolkit: Rapid Prototyping of Spoken Language Systems,” *Proc. 10th Ann. ACM Symp. User Interface Software and Technology*, ACM, 1997, pp. 85-86.
3. C. Nass and Y. Moon, “Machines and Mindlessness: Social Responses to Computers,” *J. Social Issues*, vol. 56, no. 1, 2000, pp. 81-103.
4. N. Braun, “Conversational Video Interaction,” *Proc. Assoc. for the Advancement of Computing in Education*, AACE, 1999, pp. S1200-1201.
5. E. Andre et al., “Integrating Models of Personality and Emotions into Lifelike Characters,” *Proc. Workshop on Affect in Interactions—Towards a New Generation of Interfaces*, A. Paiva and C. Martinho, eds., German Research Center for Artificial Intelligence, 1999, pp. 136-149.
6. W.G. Harless et al., “TIME Project Interactive Patient Sim-

ulations: Experiential Learning in the Medical School Classroom,” *J. Medical Education Technologies*, vol. 2, no. 4, Spring 1992, pp. 3-7.

7. W.G. Harless et al., “A Field Test of the TIME Patient Simulation Model,” *Academic Medicine*, vol. 65, no. 5, May 1990, pp. 327-333.
8. W.G. Harless et al., “Virtual Dialogues with Native Speakers: The Evaluation of an Interactive Multimedia Method,” *CALICO J.*, vol. 16, no. 3, 1999, pp. 313-337.



William G. Harless is president and CEO of Interactive Drama. His research interests include computerized education, interactive simulation, and experiential learning strategies. Harless has an MA in liberal education from Saint John’s College, an MS in business administration from the University of Alabama, and a PhD in psychology and learning theory from the University of Oklahoma.



Marcia A. Zier is executive vice president of Interactive Drama. Her research interests include the development of the Conversim model and the application and effectiveness of virtual dialogue technology. Zier has a BA in French from Washington State University and an MA in liberal education from Saint John’s College.



Michael G. Harless is director of multimedia design at Interactive Drama. His research interests include the aesthetics and artistic design of IDI products, including the graphical user interface of the authoring system and the integration of digital video for Conversim. Harless studied communications theory at the University of California, Los Angeles, and theater/television production at Montgomery College in Maryland.



Robert C. Duncan is a professor of biostatistics at the University of Miami. His research interests include the experimental design of clinical trials and socio-educational models. Duncan has a BS in physics from Rice University, and an MS and a PhD in biostatistics from the University of Oklahoma.

Readers may contact William Harless at Interactive Drama, 7900 Wisconsin Ave., Ste. 200, Bethesda, MD 20814; wgharless@idrama.com.