

Audiovisual Facilitation of Clinical Knowledge: A Paradigm for Dispersed Student Education Based on Paivio's Dual Coding Theory

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This article explores the application of Paivio's Dual Coding Theory (DCT) as a scientifically sound rationale for the effects of multimedia learning in programs of nurse anesthesia. We explore and highlight this theory as a practical infrastructure for programs that work with dispersed students (ie, distance education models). Exploring the work of Paivio and others, we are engaged in an ongoing outcome study using audiovisual teaching vignettes that we term simulation-based video teaching

interventions (SBVTIs) that we have applied to a range of healthcare providers in a quasiexperimental model. The early results of that study are reported in this article. In addition, we have observed powerful and sustained learning in a wide range of healthcare providers with our SBVTIs and suggest that this is likely explained by DCT.

Keywords: Distance education, dual coding theory, nurse anesthesia education, simulation-based learning.

Accommodating dispersed students is a challenge for virtually all institutions of higher learning and is a common model in use by many programs of nurse anesthesia. Increasingly, the logistics of providing distance education fall to Internet applications, teleconferencing, postal mail, electronic mail, and other approaches that afford interchange with students in widely disparate locales. Sir William of Occam proposed a theory (Occam's razor) in the 14th century that whenever possible, simplicity and economy should be applied in predicting and solving complex problems. We have for some time employed what we believe to be an Occam's razor approach to the complex challenges of distance and on-campus education of anesthesiology students, an approach fundamentally grounded in dual coding theory (DCT).

Simulation-Based Video Teaching Interventions

Over the last 5 years, our department has used to advantage the concept of the "living laboratory," a virtual, high-fidelity setting where activity, improvisation, success, and failure occur in the face of simulated patient and provider interaction. In our Center for Research in Human Simulation, we have gained experience and expertise in developing short video simulations of a variety of complex and relevant situations that clinicians encounter in delivering healthcare that are associated with patient injury. This work has largely been grounded in our commitment to contribute to the national patient safety improvement effort that is currently a high priority in the United States.¹⁻⁴ Recently, we have refined and extended

this effort into the realm of everyday university teaching. We believe that what we term *simulation-based video teaching interventions* (SBVTIs) have significant potential application to both on-campus and dispersed students in a variety of disciplines.

We define SBVTIs as the use of a focused video activity that employs realistic simulations that depict and explore essential information, serving as an alternative to real encounters, allowing the teacher full control without risk to any living being. These are designed to supplement traditional teaching approaches (eg, lecture, readings, bedside and field teaching, problem-based learning, and group discussions) and to augment these techniques to better engage students in the learning process and meet the diverse range of learning styles encountered in our students. The goal is to improve didactic and practical experiences, providing students with opportunities to learn from their own and others' experiences and mistakes in a risk-free environment. We also believe that SBVTIs have application to many other realms of on-campus and distance education and have begun to measure the cognitive impact of SBVTIs.

It is our view, and one substantiated by the literature, that multimedia learning, especially in the context of distance education, may be an efficient way to target a wide range of subject matter to a dispersed student audience. Furthermore, we find that the effectiveness of the approach can be explained in terms of its grounding in dual coding theory.

Significance

In clinical education, faculty and learners must navigate the

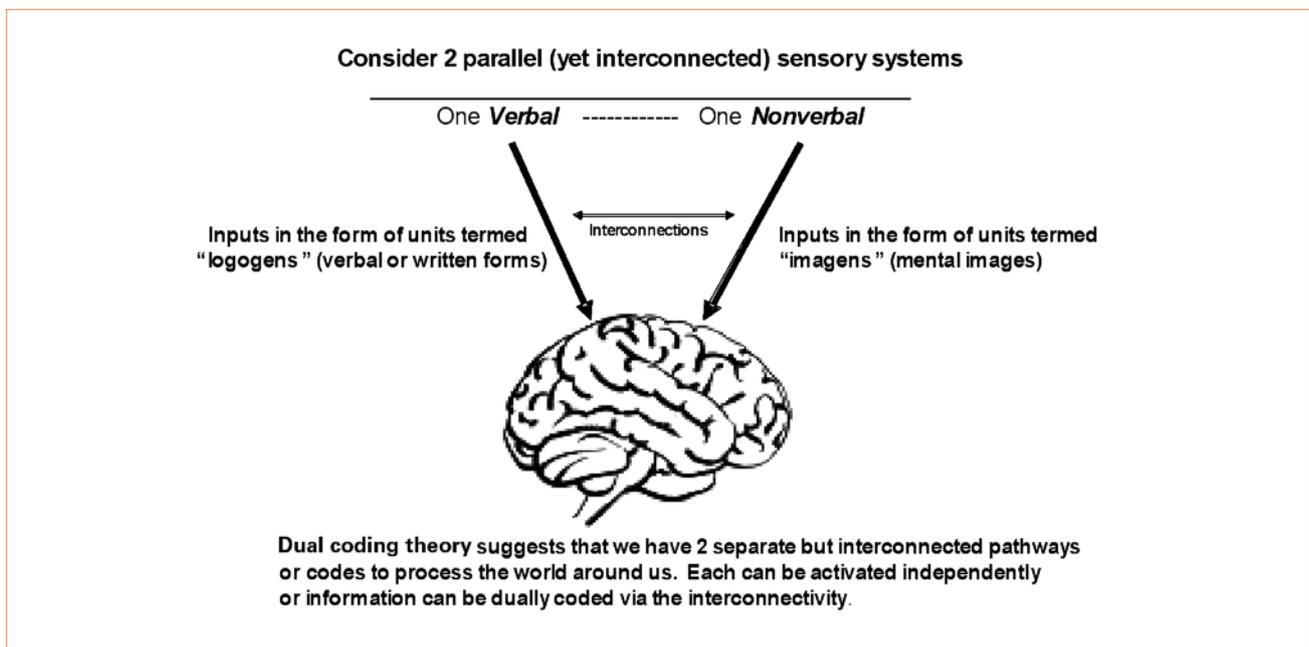


Figure. Dual Coding Theory Illustrated

complex domain of achieving educational goals yet providing quality, safe care to the patient. An inherent tension in this process is inevitable. Likewise, the informational blitzkrieg associated with the process can be bewildering to the student and daunting to the teacher.

We have developed a number of brief (4-8 minutes long) audiovisual presentations simulating real-life situations that draw clinicians into a scenario in a powerfully vicarious manner and that have high cognitive imprint. We term these *patient safety vignettes*, directed toward preventing and managing real-world negative patient events that surface in practice but would be difficult or dangerous to reproduce in living patients. We have spearheaded a patient safety initiative to bring the power of simulation to any interested professional, even in the privacy of his or her home, in the form of these multimedia safety vignettes.

Extending on this work, we see tremendous opportunity for developing SBVTIs for student learners. Simulation-based education is used in many industries, including medicine, nuclear power, aviation, maritime, and the military. We have experience in creating simulations that can be filmed, edited, and archived in a variety of exportable formats (eg, direct video streaming, CD, DVD, VHS). We believe that SBVTIs represent powerful and economically sound tools for education and might promote a greater discourse in both faculty-student and student-student interactions. We believe that other disciplines in the arts, sciences, technical fields, and even basic foundational course domains can find utility in the approach.

Dual Coding Theory

Clark and Paivio⁵ proposed DCT as a functional framework for cognitive psychology. Dual coding theory emerged from

original work by Paivio⁶ who proposed that equivalent weight be given to both verbal and nonverbal input. Paivio went on to produce a comprehensive text on this theory, entitling it *Mental Representations*.⁷ In brief, imagine 2 brain-mediated cognitive processing systems, one based on imagery (input units are termed "imagens") and 1 based on language (input units are termed "logogens"). While these subsystems can be viewed independently, there is great interconnectivity between the two, such that cueing and other forms of facilitation result in "dual coding" of information. The language system deals primarily with linguistic information, processing and storing information in discrete "logogen" units, while the visual system deals with the less discrete "imagen" units (Figure).

Paivio⁸ described an experiment where subjects viewed pairs of objects (eg, a tomato, a goblet) with conspicuous differences in the quality of "roundness." The subjects were instructed to describe which of the paired objects was "rounder." The paired objects were displayed sequentially as word-word comparisons, picture-picture comparisons, or word-picture pairings. The results, consistent with the tenets of DCT, revealed that the response times were faster for the image-image comparisons, slowest for the word-word comparisons, and intermediate for the word-picture pairings. In a classic demonstration of the theory, researchers observed that a verbal representation of a new face requires a substantial, sequenced, and time-consuming descriptive processing of the numerous, composite elements (eg, nose, eyes, lips, color, hair, lips, etc), whereas with visual input, there is a powerful concurrency of processing these individual elements into a composite (L. ChanLin, written communication, December 2006). Dual coding theory

suggests that the use of visualization enhances learning and recall, in no small part because images and words are processed at different sites in the central nervous system.

While SBVTIs are grounded heavily in the theoretical framework of DCT, we also believe they use to advantage the powerful nature of vicariousness. One principle of adult learning is that humans often learn best from their own mistakes.^{9,10} Humans also learn vicariously, often in a powerful manner, from observing the successes and failures of others. We embrace the view that observing successes and failures presents tangible opportunities to learn and develop robust systems for achieving cognition. The telling of a story, in this case through an audiovisual vignette, can be used to advantage as a teaching tool.¹¹

Hypothesis

It was hypothesized that audiovisual vignettes amplify cognition when compared to written/lecture information alone.

Study Method

Of the numerous filmed vignettes that we have produced, we have specifically tracked the cognitive impact of 2: a minute-long vignette that depicts a patient who inadvertently undergoes the wrong surgical operation (ie, wrong site surgery) and an approximately 9-minute-long film that tracks the events that lead to a hospitalized patient experiencing a preventable nerve injury to the upper extremity. Each of these vignettes was produced in our high-fidelity laboratory, which reproduces highly realistic conditions using “actors” knowledgeable about the venue (eg, real doctors, nurses, and technicians) and held precisely to the described reports of the actual events that led to the patients’ injuries (closed claims database, American Association of Nurse Anesthetists, Park Ridge, Illinois).

Following institutional approval by Virginia Commonwealth University Committee for Protection of Human Subjects, we exposed a variety of stakeholders, in a convenience sampling manner, to 1 of 2 arms to the study: (1) a group that viewed each of the 2 filmed vignettes depicting the events that led to the negative patient event, demonstrated the actual event occurrence, and demonstrated how the event could have been prevented; and (2) a group that read 2 case reports describing the same 2 negative events (wrong site surgery and peripheral nerve injury). These published case reports came from the US Food and Drug Administration’s MEDWATCH bulletin program, an ongoing series of published reports that alerts healthcare providers of negative patient events that occur. All participants agreed in advance to be contacted 6 to 12 months postexposure. Follow-up consisted of a mailed questionnaire that queried the participant on 4 dimensions of the filmed vignette or published material: (1) the ability to specifically recall the theme of the vignette or article, (2) the pre-

ventive action(s) displayed in the vignette or published report, (3) if the respective media (film or report) has subsequently affected their practice or work life in some “useful” manner, and (4) if the respective media (film or report) represented a “useful or highly useful” tool in the domain of patient care and safety.

Results and Limitations

Because our investigational work is still in its infancy, and for a variety of ethical and logistical reasons, the study currently lacks the elements of a randomized controlled trial. Therefore any outcome analysis must be considered rudimentary and preliminary in nature. Furthermore, it would be virtually impossible (without constant onsite work surveillance) to determine if the intervention(s) altered professional behaviors, and even then, baseline (preintervention) observation would be lacking. In this context, we report our findings.

To date, more than 3,000 stakeholders have been exposed to the filmed vignettes; we have successfully followed up with 1,844 at 6 to 12 months postexposure (group 1). Similarly, we have followed up with 185 stakeholders who experienced only the written reports of the patients’ injuries (group 2).

To date, 418 physicians, 797 nurse anesthetists, 327 registered nurses, and 302 hospital administrators have been assessed in terms of the cognitive imprint of the filmed vignettes (group 1, n = 1,844). A comparison group of 185 subjects exposed only to written reports was selected and stratified on the basis of professional cohort. In each cohort there was subject matching of age, gender, years of experience representing 10% of the group 1 population: 42 physicians, 80 nurse anesthetists, 33 registered nurses, and 30 hospital administrators. These subjects, who experienced only the published reports, were assessed in terms of the cognitive imprint of the MEDWATCH bulletins. Access to the participants occurred at a variety of national and state healthcare meetings. Participation in the study was entirely voluntary in nature. On follow up, observations were made (Tables 1 and 2).

Because of the preliminary nature of the inquiry, we report only descriptive statistics, suggesting that inferential statistics, though likely demonstrating group differences of great magnitude, are not of particular relevance at this stage of the research.

Discussion in the Context of the Current and Published Work

Dual coding theory provides a framework upon which to analyze the current study findings and to extrapolate what applications filmed vignettes and graphics might have in the context of the modern student. Rieber,¹² in the context of how computerized graphics affect learning, described 4 primary and practical roles for illustra-

Observation	Respondents (%) n = 1,844
Recalled the theme(s) of the film.	100
Recalled the specific preventive/corrective actions displayed in the filmed vignettes.	68
Indicated that the filmed vignettes subsequently affected their practice or work life in a "useful" manner.	47
Indicated that the filmed vignettes represented a "useful or highly useful" tool in the domain of patient care and patient safety.	93

Table 1. Follow-up Observations for Group 1 (only saw film)

Observation	Respondents (%) n = 185
Recalled the theme(s) of the written report.	9.5
Recalled the specific or preventive/corrective actions in the report.	4.5
Indicated it "might have had an impact" on subsequent practice.	12.0
Indicated that the published paper represented a "useful or highly useful" tool in the domain of patient care and patient safety.	17.0

Table 2. Follow-up Observations for Group 2 (only read report)

tions/graphics in cognitive imprinting: a cosmetic function, a motivating or curiosity-raising function, an attention focusing function, and a practice or visual feedback function. Realistic, relevant video has the capacity to invite the observer/learner, *in a highly vicarious manner*, into the role of the active participant. Video demonstration, unlike words, may have the ability to enliven abstract concepts, demonstrate real-world applications of complex principles, motivate the learner, organize thoughts and actions of highly cognitive processes, and heighten learner attention and interest.

Our research extends the work of previous investigators. Parkin and Dopgra¹³ in a nonexperimental study, found that structured videotapes to supplement lectures in child psychiatry was useful in more than 90% of the exposed medical student population. Kamin et al^{14,15} demonstrated in separate investigations that critical thinking skills were amplified in students exposed to filmed vignettes by creating an atmosphere that promoted vicarious learning. Mayer,¹⁶ interrogating 40 studies divided into various presentation designs, revealed that multimedia presentations to college students improved problem solving ability significantly. The Mayer study argues for the DCT framework as one that reintegrates verbal and visual information to organize and synthesize received (and retrieved) content.

Current and Future Applications

Dual coding theory argues that inputted information may be easier to absorb (retain) and use (retrieve) when dual coding of that information occurs. Although DCT has been criticized by a number of scholars,^{12,16,17} it appears to be the primary framework that specifically addresses

the issue of graphics in cognitive processing, and it offers a practical recipe for university faculty to develop and apply instructional interventions.

The nature of our work involves teaching students to perform many complex and risky interventions in patients. Examples include (often under conditions of considerable stress) placing a breathing tube into the lungs, injecting powerful medications with highly adverse potential, anesthetizing the nerves that come directly off the spinal cord, ensuring the safe operation of technologically sophisticated equipment, etc. We are currently developing and refining SBVTIs that provide equivalent and effective educational approaches for both our dispersed and on-campus students in these specific interventions. We believe that the SBVTIs bridge the gap between the textbook and the real patient and provide a uniquely equivalent experience for our dispersed and on-campus students.

Simulation-based video teaching interventions allow our faculty to export high quality, realistic educational media that uses to advantage DCT and the human ability to experience phenomena vicariously. While our attention is largely focused on the clinical domain, we believe that SBVTIs have application in a wide range of university teaching domains and may have particular merit with respect to distance education. We see the SBVTIs as an Occam's razor approach to the growing and complex challenges of providing equivalent educational experiences to on-campus and dispersed students.

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