IGERT: Integrative Approaches to Bilingual Cognition and Interaction

This project launches a new initiative to integrate Ph.D. education and research in Computer Science and Psychology, with extension planned to Linguistics and Education. The project’s specific focus will be the connections between cognitive models of language and cognitive models in human-computer interaction, with a particular emphasis on bilingualism. The principal research efforts will involve understanding (1) the nature of bilingual language processing, combining cognitive and computational methods, and (2) how to develop real-time conversational systems based on cognitively accurate models for bilingual populations, especially at time scales of 300 milliseconds and below. The project will play a major part in a university-wide initiative on research and education in the interdisciplinary field of language and cognition. The project will serve as a model for development for integrating doctoral programs across college and departmental boundaries. Students served by the project will include significant numbers of Hispanics; over 70 percent of UTEP’s 19,000 students are Mexican-American, and another 12 percent are Mexican nationals. The project’s full proposal would request levels of funding more modest than the maximum offered by the IGERT program.

1. List of Participants

The project will be directed by David Novick, Associate Vice President for Academic Affairs and SBC Professor of Computer Science, who was formerly chair of the Department of Computer Science. His primary administrative responsibility is to create bridges among faculty across college and departmental boundaries to support imaginative, synergistic research. Novick’s research has focused on computational pragmatics, especially models of dialogue. He is bilingual in English and French.

Serving as co-PIs will be

- **Nigel Ward**, Associate Professor of Computer Science. Ward studies real-time responsiveness for spoken dialog systems, with a focus on the timing, phonetics, and meaning of non-lexical utterances. His dissertation research at Berkeley focused on improving the quality of Japanese-English machine translation. Ward is bilingual in English and Japanese.
- **Wendy Francis**, Assistant Professor of Psychology, with promotion to Associate Professor expected by the fall of 2005. Francis’s studies the functional organization of bilingual memory, transfer processes in human memory, and representation of words and concepts in long-term memory. Francis is bilingual in English and Spanish.
- **Ana Schwartz**, Assistant Professor of Psychology. Schwartz studies the cognitive nature of bilingual and multilingual language processing. Schwartz is bilingual in English and Spanish.

The project, which principally spans UTEP’s Colleges of Engineering and Liberal Arts, will include other faculty from the Departments of Computer Science and Psychology. As the project matures, faculty from other colleges and departments are expected to join, particularly from the Department of Languages and Linguistics, where faculty have conducted extensive research on the nature of bilingual language and some are already collaborating with the principal investigators. Faculty expected to participate in the program, and for whom a c.v. is provided with this proposal, include:
Vision, Goals, and Thematic Basis

The University of Texas at El Paso (UTEP) is a doctoral-intensive research university. As part of the University’s centennial strategy to increase its strength in research and Ph.D. education, UTEP envisages interdisciplinarity as a key factor in its long-term development. The proposed project on integrative approaches to bilingual cognition and interaction aligns remarkably well with this strategy. UTEP’s vision for research and Ph.D. education has three main elements: Interdisciplinarity, relation to UTEP’s distinctive location and population, and the quality of our Ph.D. graduates. The specific vision for this project, then, is

- To make real our interdisciplinary aspirations by forging a new collaboration between the Departments of Computer Science and Psychology, a collaboration that bridges both disciplinary and administrative boundaries and that will serve as a model for future UTEP initiatives.
- To leverage our research strengths in human-computer interaction and the cognition of language to address research issues that have specific importance for El Paso’s bicultural bilingual population and border location, and that will have growing importance for the nation as a consequence of both demographic trends and increasing globalization.
- To develop institutional culture and mechanisms that will systematically assure high quality in UTEP’s doctoral graduates for years to come.

To attain this vision, the project’s goals are

- To create a new generation of Ph.D. graduates who have interdisciplinary training and experience in computer science and psychology as an integral part of their education. These graduates should be able to work knowledgeably with other disciplines.
- To serve as a model for UTEP in developing new interdisciplinary initiatives at the doctoral level.
- To advance the state of knowledge in cognition, language and human-computer interaction, with a particular emphasis on bilingualism. UTEP has started a new interdisciplinary initiative in language and cognition that involves 20 faculty from five of the university’s six colleges, and this project should serve as a major intellectual driver of the initiative’s research.
- To develop cross-disciplinary professional training for doctoral students that can serve as a model for other UTEP programs.

UTEP currently offers a Ph.D. in Psychology and a Ph.D. in Computer Science through a track in its Computer Engineering Ph.D. program; approval for splitting Computer Science as a separate Ph.D. program is pending before the Texas Higher Education Coordinating Board (THECB) and is expected shortly. Looking ahead, UTEP has planning authority from the THECB for a Ph.D. in
Hispanic Linguistics and has pending a proposal for a Ph.D. in Teaching and Learning that focuses on communication, culture and cognition in teaching and learning, themes that fit well with the research focus of this proposal. The project will integrate faculty from these new Ph.D. programs.

UTEP has recognized that it faces challenges in creating a better environment for interdisciplinary research, and substantial efforts are already underway to address these issues. These efforts include reorganizing the College of Engineering to emphasize research collaboration instead of departmental affiliation, hiring faculty across department and college boundaries, breaking down barriers to collaboration through cross-organizational efforts such as a university-wide Research Collaboration Team. This project proposes to complement these efforts through collaboration at the level of research teams, through joint research, joint research groups, and joint training of doctoral students, following the guidance of Klein (1990, 1996), Bromme (2000) and Lattuca (2001) with respect to interdisciplinary programs.

3. Major Research Efforts

The major research efforts in this project grow from the confluence of cognition and computation, particularly for language, interaction and bilingualism. The project’s faculty and students will address core research questions that require insight and expertise from both psychological and computational perspectives. These questions primarily involve understanding (1) the nature of bilingual language processing, combining cognitive and computational methods, and (2) how to develop real-time conversational systems based on cognitively accurate models for bilingual populations, especially at time scales of 300 milliseconds and below.

Participating faculty will come from primarily from the Departments of Psychology, Computer Science, and Languages and Linguistics, and from the College of Education. Nearly all of the participating faculty are bilingual or even trilingual. UTEP and the El Paso / Ciudad Juarez metropolitan area, as one of the largest border communities in the world, form an ideal place to study these issues. El Paso, with about 700,000 people, 75 percent of whom are of Mexican-American ancestry, ranks as the nation’s 22nd-largest city. Ciudad Juarez, which borders El Paso to the south, has about 1.3 million people. Reflecting their community, over 70 percent of UTEP’s students are Mexican-American, and an additional 12 percent are Mexican nationals.

Cognitive Models of Bilingualism

Project personnel will study the cognitive nature of bilingual language processing through the integration of cognitive-behavioral measurement and computational modeling. A central issue in the study of bilingualism is how two separate languages come to be represented and processed within a single cognitive system. For example, are bilinguals able to selectively activate one of their languages while completely suppressing or “turning off” the unintended language? Or are both languages necessarily co-activated and interacting? Recent research on both bilingual language production and comprehension suggests that during the initial stages of cognitive processing, both languages are activated in parallel (e.g., Brysbaert, 1998; Dijkstra, Van Jaarsveld, & Ten Brinke, 1998; Jared & Scuza, 2002). Furthermore, this parallel, co-activation is not under the conscious control of bilinguals and occurs despite their linguistic intentions. Current models of both bilingual language comprehension and production have been successful in simulating this co-activation of bilingual language processing by assuming that both languages are represented within a single network (e.g., Dijkstra & Van Heuven, 1998; 2002). However, the
design and implementation of these models have been primarily based on decontextualized linguistic tasks such as single word identification and picture naming. To date there are not any published studies that have specifically examined how bilinguals activate and select languages within a larger, more meaningful context. As such, these models, and the theories upon which they are based, do not provide an adequate account for how languages are processed in contextually rich environments.

Thus one major research focus will be to improve and extend current theories of bilingualism processing to rich and interactive contexts through an integrated combination of behavioral measures and modeling. This research will be carried out by the collaborative efforts of faculty and students in the departments of Psychology and Computer Science. The faculty are particularly well suited for such an endeavor given their shared interests and expertise in linguistics, bilingualism and the cognitive nature of real-time, interactive processing. Specific research projects will involve (1) the cognitive organization of bilingual memory and language systems (representations) and (2) how bilinguals access memory and language representations (processes). The cognitive organization issues deal with a fundamental issue of redundancy vs. efficiency in representation, and can be examined at several levels of language representation. For example, Francis deals primarily with the conceptual, syntactic, and lexical levels, whereas Schwartz deals primarily with lexical, phonological, and orthographic levels. Access to language and memory representations is also examined at different levels of complexity and in different contexts. Ongoing research also involves manipulation, sampling, and measurement of the 4 main forms of language (i.e., reading, listening, speaking, and writing). Francis has focused recently on how bilinguals access vocabulary in language production, how they access the meanings of words in language comprehension, and the conditions under and processes by which learning transfers across languages. These questions are investigated primarily using established memory techniques. A new direction for Francis is investigating how language proficiency impacts memory processes, such as encoding, retrieval, forgetting, use of strategies, rate of learning, and types of errors. Schwartz’s research program focuses on how semantic and/or language context may influence accessibility of lexical, phonological, and orthographic representations in the two languages. A new direction in her line of research is the incorporation of eye-movement tracking methodology to more precisely measure processes of bilingual reading.

Real-Time Conversational Systems

Project personnel will also study computer-based conversational systems, particularly with respect to (a) real-time interaction based on human models and (b) bilingual conversants. Historically, spoken language understanding research developed from the speech recognition (SR) tradition with its emphasis on identifying words and phrases. Current systems have largely evolved through a series of heuristics-driven enhancements to existing speech recognizers. This evolution has led to an emphasis on “getting the words right” as the measurable goal of a spoken language component, and system enhancements are viewed as “improving the performance of the recognizer.” Thus the state of the art is, approximately, the sort of robotic formal interaction common in androids in science fiction movies, where the two conversants produce complete sentences and take turns rigidly. Especially for real-time interaction, such an SR-centered approach does not offer a sound theoretical basis for understanding how cues from various sources contribute to or eliminate possible interpretations of an utterance and how these cues might be usefully exploited in systems. Our research program, therefore, calls for understanding how various cues contribute to system performance in the context of conversational systems. (Ward & Novick, 1995; Ward, 1997). These cues can be non-lexical (Ward, in press) and non-verbal, such as gaze (Novick, Hansen & Ward, 1996; Nakano et al., 2003).
Thus a second major project goal is progress toward building systems that are satisfying to talk to, that will feel attentive, supportive and responsive to users, particularly in bilingual contexts. To do this we need to model “real-time social skills,” primarily the ability of a person to infer the other's needs, intentions, and feelings at a 100-millisecond time scale. The main challenge in building systems to do this is that of discovering the cues and rules that people use, since the details of interaction at this level are below conscious attention, and far from trivial to uncover. So far we have built systems which produce back-channels (e.g., “uh-huh”) at natural timing, which chose appropriate acknowledgments (e.g., “right, yeah, good”) based on the user's ephemeral emotions, which pace an explanation adaptively to the user's needs, and which control a simulated spaceship in response to prosody of the user's advice. We are currently analyzing more phenomena and designing spoken dialog systems capable of other “sensitive” and natural interactions. This includes recording human-human dialogs in controlled domains and analyzing the prosodic and contextual cues that humans use.

In our research, we interpret these real-time cues as expressing pragmatic dimensions of the interaction. Ward has long studied real-time conversational interaction in bilingual contexts. He described the detailed phonetics of non-lexical items in English and Japanese and compared the timing of back-channels in English and Japanese (e.g., Ward & Tsukahara, 2000). Ongoing research in Ward and Novick’s current NSF award is looking at similar issues for speakers of Spanish. Novick was the first researcher to model dynamic turn-taking in computational agents (Novick, 1988), and his subsequent modeling of the role of gaze in conversation (Novick, Hansen & Ward, 1996) extended prior work by psychologists (notably Argyle & Cook, 1976; Kendon, 1978). These results were in turn relied on by developers of avatar-based videoconference systems (e.g., Colburn, Cohen & Drucker, 2000) and extended by researchers creating multimodal systems (e.g., Nakano et al., 2003). Open questions now include issues such as modeling gaze in natural multi-party conversations, modeling conversational gaze at the 100-millisecond time scale, and understanding difference in gaze behaviors in bilingual contexts. These questions are now better suited for research than in 1996 because gaze-tracking technology has improved significantly and because the research environment at UTEP enables interdisciplinary collaboration among the computationally oriented computer science researchers and the cognitively oriented psychology faculty, some of whom use gaze-tracking methodologies in their current research on bilingual cognition.

4. Education and Training

Our approach to education and training builds on prior experience with interdisciplinarity at other universities (e.g., Klein, 1990, 1996; Weingart & Stehr, 2000; Lattuca, 2001) and at UTEP itself, where we have experience with interdisciplinary doctoral programs in, for example, Environmental Science and Engineering. Bromme (2000) discusses specifically what it takes to get beyond calls for interdisciplinarity to its practice. He cites grounding—that is, the attaining common understanding among people with different experiences—as the key principle. Interestingly, much of the work of Novick and Ward in studying human-computer conversation grows from the same body of work on which Bromme based his discussion of grounding. This suggests that this project is particularly well positioned to succeed in going from exhortation to practice. But beyond building on this experience, the project will develop new means of interdisciplinary training of doctoral students both by necessity and by design.

An integrated educational will be necessary for this project because of the difficulty of working in this interdisciplinary intersection. First, simple introspection on language and interpersonal interaction is known not to effective at the sub-second time scale that will be the main focus of
our research. As such, many of the methods of the more mature field of psycholinguistics are useful for future contributors in this area to acquire. Specifically, the experimental methods, statistical methods, and model-building aspects of cognitive psycholinguistics are of great value here. Second, application of these results across languages, across dialects, and across cultural groups, will be greatly facilitated to the extent that we can model both the universal and specific aspects of these types of interaction. Here again, the theoretical models, basic findings, and techniques of work on the cognitive aspects of bilingualism can be very useful to work in this area. Our graduate training in cognitive research on bilingualism emphasizes carefully designed experiments with large samples of human participants, meticulous control procedures, precise timing, and sophisticated statistical analysis. Our most frequently used dependent variables include error rates, error types, response times, and eye movement patterns/timing. Such variables are relatively easy to quantify and are conducive to computational and mathematical modeling and simulation. While there are ample opportunities to learn statistical techniques and mathematical modeling in the Psychology Department, Ph.D. students interested in cognition do not currently have mentors with appropriate expertise to build computational models and implement simulations of cognitive processes. The proposed program will make this training available. Computational models and simulations have played an important role in the field of cognitive science and in language and memory more specifically. We have a unique opportunity to apply such models to questions about bilingual memory and language with an available population of bilingual participants to confirm or falsify the predictions of the models. Comparing and contrasting simulated and human data are essential to developing, constraining and revising models of human cognition, including bilingual language processing.

New means—at least for us—of integrated doctoral training will be introduced into the project through new joint educational structures and activities. The difficulties of interdisciplinary research also present an opportunity for doctoral education to go beyond the model of one-on-one apprenticeship toward a model of systematic training arising from a community of scholars. The project will have common training for Ph.D. students through joint organizational structures such as research groups, reading groups, seminars, and, of course, laboratories. We do not expect students to become completely proficient in each other’s discipline. Rather, we expect that the students will learn to be synthetic (Klein, 1996; Lattuca, 2001) in their research through their observation of and participation in group activities. We will also offer joint courses in research methods, courses in advanced, project-specific topics such as natural-language processing and computational models of cognition. We plan to work with the Ph.D. students as a group to develop explicitly the common skills that they will need in academic careers, such as:

- Being able to develop a coherent research program that integrates (as opposed to simply agglomerating) individual research projects.
- Being able to articulate one's research area and program in a way that non-specialists will see why it's interesting and important and that specialists will understand the research's technical merit.
- Being able to team with other researchers in ways that all members of the team can advance knowledge in their own field.
- Being able to identify one's research community (conferences, journals, associations) and to participate meaningfully in that community.
- Being able to mentor junior researchers and research students.
5. Management, Assessment and Institutional Commitment

The project’s strategies for management include both top-down and bottom-up approaches. Administrative leadership, institutional commitment to the project’s success, and a perspective on integrating the project’s lessons university-wide will come from Novick, UTEP’s associate vice president responsible for interdisciplinarity, serving as principal investigator. Programmatic leadership of the project will be faculty-driven, with monthly management meetings of the principle investigators and regular periodic meetings with our assessment team. The project, building on the Department of Computer Science’s experience with its advisory board of both local and national participants, will form an external advisory board of nationally recognized scholars in computer science and psychology. Members of the board would be asked to agree to serve as part of the process of developing the full proposal.

For assessment, the project would include both formative measures, largely internal, and summative measures, largely external. The internal expertise would come from the Center for Institutional Evaluation, Research and Planning (CIERP). CIERP’s professional staff provides technical assistance to faculty, administrators, and staff in evaluating the effectiveness of their programs and activities. The external expertise would come from the project’s external advisory board, which would meet annually to assess the state of the project and to provide guidance to the principal investigators. All assessment would be outcomes-based, relating directly to the project’s main goals, so examples of measurable outcomes would include:

- The number of Ph.D. students and graduates who have interdisciplinary training and experience in computer science and psychology as an integral part of their education.
- The extent to which the project serves as a model for UTEP in developing new interdisciplinary initiatives at the doctoral level.
- The number of publications and additional awards relating to the project’s research themes of cognition, language and human-computer interaction, with particular emphasis on bilingualism.
- The extent to which the program’s students receive cross-disciplinary professional training for doctoral students, and that these approaches are adopted by other UTEP programs.

The project benefits from an inherent institutional commitment, both because the principal investigator is UTEP’s administrator responsible for promoting interdisciplinary research and education and because UTEP is placing interdisciplinarity at the core of the strategic plan associated with the university’s approaching centennial. UTEP is already creating administrative paths for facilitating interdisciplinary research and education. For example, Novick heads the university’s Research Collaboration Team (RCT), composed of the associate deans for research for the six disciplinary colleges.

The project will include collaboration with UTEP’s recruitment, retention and professional development programs. These include an NSF ADVANCE project, dedicated to the recruitment, retention, and advancement of women and underrepresented minorities employed in academic science and engineering disciplines. The UTEP NSF ADVANCE initiative includes:

1. A policy and recruitment process that formulates faculty support and retention policies, supports recruitment efforts, and provides research support.
2. A faculty development process that expands the existing faculty mentoring program for women and introduces a seminar series to help faculty develop integrated plans for career success.

3. A collaborative leadership process that facilitates productive and supportive departmental climates, identifies innovative leadership behaviors, and shares best practices for recruitment and promotion of a qualified faculty.

6. Other Resources and Connections

No other resources have been identified.

Three kinds of connections should play a role in achieving the project’s goals. The first set of connections arises from the network of universities collaborating with UTEP in its NSF MII project for promoting graduate study in Computer Science and Engineering among Hispanic students. Our Texas partners, from which some of our Ph.D. students have come, include The University of Texas—Pan American, The University of Texas—Permian Basin, Texas A&M Corpus Christi, and Angelo State University, all of which are Hispanic-serving institutions. Our “graduate” partners include Arizona State University and The University of Texas at Austin.

The second set of connections is with Mexican universities. UTEP also maintains strong connections with institutions of higher education in Mexico, including the Universidad Autonoma de Ciudad Juarez, the Universidad Autonoma de Guadalajara, the Universidad de las Americas (Puebla), and Monterrey Tech. With the project’s emphasis on bilingualism, we expect these connections to provide opportunities for student exchange and faculty collaboration that tie directly to project goals.

The third set of connections arises from UTEP’s interactions with the staff of the National Research Council. UTEP served as one of the “launch” universities for the NRC’s recent report on interdisciplinary. See http://www7.nationalacademies.org/interdisciplinary/index.html.

7. Recent Traineeship Experience and Results from Prior NSF Support

“Graduate Education for Minority Students in Computer Science and Engineering: Extending the Pipeline,” NSF EIA-0080940, $1.25 million over 60 months beginning September 15, 2000 (David Novick, Sergio Cabrera, Ann Gates, Mehdi Shadaram and Patricia Teller).

This grant, 2000-2005, is focused on increasing the number of Hispanic students who obtain graduate degrees in computer science and engineering. As a result of the grant, the number of Computer Science Ph.D. students has increased from 5 in 1999 to 17 in 2005. The number of Hispanic and Mexican Ph.D. students in Computer Science increased from 1 in 1999 to 8 in 2005. Research results from this support include work in all of the department’s research themes, principally high-assurance systems (software engineering, human-computer interaction, and theory motivated by applications) and high-productivity computing (performance evaluation, workload characterization and optimization, and self-organizing systems). Students and faculty supported by this award have published dozens of papers. See http://www.cs.utep.edu/DeptCS/research/ and http://www.cs.utep.edu/DeptCS/mii/. Recent outcomes of the award include:
• Two UTEP Hispanic CS master’s graduates have been accepted to doctoral programs at Rice University and Virginia Polytechnic Institute and State University for fall 2004
• Two MII recruited and supported doctoral students, Diana Villa and Ricardo Portillo, have been invited to attend the invitational conference, "Extreme Scale Computing - The 2003 Conference on High-Speed Computing" with their faculty mentor and advisor, Patricia Teller
• MII recruited and supported doctoral student, Diana Villa, has been awarded an IBM Ph.D. Fellowship, from IBM-CAS. The fellowship is one of only seven awarded nationally
• The UTEP Graduate School has received nine doctoral applications from computer science educators affiliated with Hispanic-serving institutions in Texas
• Enrollment in UTEP’s Computer Engineering doctoral program has risen to an all-time high of 29 students; this includes seven Hispanic students and one African-American student.


This project has just started. Building on prior work that detailed phonetics of non-lexical items in English and Japanese and compared the timing of back-channels in English and Japanese (e.g., Ward & Tsukahara, 2000), we are now looking at similar issues for speakers of Spanish. This includes building prototype systems using both the Nuance SLS builder and Wizard-of-Oz methods, comparing human-computer and human-human interaction to understand what accounts for the fluidity of natural interaction.