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**Special Section: Methods for the Analysis of  
Communication**



**METHODS FOR THE ANALYSIS OF COMMUNICATION SPECIAL SECTION**

**Nancy J. Cooke, Andrew Duchon, Jamie C. Gorman, Joann Keyton, and Anne Miller. *Preface to the Special Section on Methods for the Analysis of Communication.* S. 485-488.**

**Ronald H. Stevens, Trysha L. Galloway, Peter Wang and Chris Berka. *Cognitive Neurophysiologic Synchronies: What Can They Contribute to the Study of Teamwork?* S. 489-502.**

**Objective:** Cognitive neurophysiologic synchronies (NS) are low-level data streams derived from electroencephalography (EEG) measurements that can be collected and analyzed in near real time and in realistic settings. The objective of this study was to relate the expression of NS for engagement to the frequency of conversation between team members during Submarine Piloting and Navigation (SPAN) simulations.

**Background:** If the expression of different NS patterns is sensitive to changes in the behavior of teams, they may be a useful tool for studying team cognition. **Method:** EEG-derived measures of engagement (EEG-E) from SPAN team members were normalized and pattern classified by self-organizing artificial neural networks and hidden Markov models. The temporal expression of these patterns was mapped onto team events and related to the frequency of team members' speech. Standardized models were created with pooled data from multiple teams to facilitate comparisons across teams and levels of expertise and to provide a framework for rapid monitoring of team performance.

**Results:** The NS expression for engagement shifted across task segments and internal and external task changes. These changes occurred within seconds and were affected more by changes in the task than by the person speaking. Shannon entropy measures of the NS data stream showed decreases associated with periods when the team was stressed and speaker entropy was high. **Conclusion:** These studies indicate that expression of neurophysiologic indicators measured by EEG may complement rather than duplicate communication metrics as measures of team cognition. **Application:** Neurophysiologic approaches may facilitate the rapid determination of the cognitive status of a team and support the development of novel adaptive approaches to optimize team function.

- **Keywords:** team neurodynamics, neurophysiologic synchrony, artificial neural networks, EEG

**Jamie C. Gorman, Nancy J. Cooke, Polemnia G. Amazeen and Shannon Fouse. *Measuring Patterns in Team Interaction Sequences Using a Discrete Recurrence Approach*. S. 503-517.**

**Objective:** Recurrence-based measures of communication determinism and pattern information are described and validated using previously collected team interaction data.

**Background:** Team coordination dynamics has revealed that "mixing" team membership can lead to flexible interaction processes, but keeping a team "intact" can lead to rigid interaction processes. We hypothesized that communication of intact teams would have greater determinism and higher pattern information compared to that of mixed teams.

**Method:** Determinism and pattern information were measured from three-person Uninhabited Air Vehicle team communication sequences over a series of 40-minute missions. Because team members communicated using push-to-talk buttons, communication sequences were automatically generated during each mission.

**Results:** The Composition  $\times$  Mission determinism effect was significant. Intact teams' determinism increased over missions, whereas mixed teams' determinism did not change. Intact teams had significantly higher maximum pattern information than mixed teams.

**Conclusion:** Results from these new communication analysis methods converge with content-based methods and support our hypotheses. **Application:** Because they are not content based, and because they are automatic and fast, these new methods may be amenable to real-time communication pattern analysis.

- **Keywords:** communication analysis, interaction analysis, pattern analysis, recurrence analysis, teamwork

**M. Asif Khawaja, Fang Chen and Nadine Marcus. *Analysis of Collaborative Communication for Linguistic Cues of Cognitive Load*. S. 518-529.**

**Objective:** Analyses of novel linguistic and grammatical features, extracted from transcribed speech of people working in a collaborative environment, were performed for cognitive load measurement. **Background:** Prior studies have attempted to assess users' cognitive load with several measures, but most of them are intrusive and disrupt normal task flow. An effective measurement of people's cognitive load can help improve their performance by deploying appropriate output and support strategies accordingly.

**Methods:** The authors studied 33 members of bushfire management teams working collaboratively in computerized incident control rooms and involved in complex bushfire management tasks. The participants' communication was analyzed for some novel linguistic features as potential indices of cognitive load, which included sentence length, use of agreement and disagreement phrases, and use of personal pronouns, including both singular and plural pronoun types. **Results:** Results showed users' different linguistic and grammatical patterns with various cognitive load levels. Specifically, with high load, people spoke more and used longer sentences, used more words that indicated disagreement with other team members, and exhibited increased use of plural personal pronouns and decreased use of singular pronouns.

**Conclusion:** The article provides encouraging evidence for the use of linguistic and grammatical analysis for measuring users' cognitive load and proposes some novel features as cognitive load indices. **Application:** The proposed approach may be applied to many data-intense and safety-critical task scenarios, such as emergency management departments, for example, bushfire or traffic incident management centers; air traffic control rooms; and call centers, where speech is used as part of everyday tasks.

- **Keywords:** cognitive load measurement, collaborative communication, language analysis, bushfire management, adaptive interaction and support

**Ricardo A. Calix, Leili Javadpour and Gerald M. Knapp. *Detection of Affective States From Text and Speech for Real-Time Human-Computer Interaction*. S. 530-545.**

**Objective:** The goal of this work is to develop and test an automated system methodology that can detect emotion from text and speech features. **Background:** Affective human-computer interaction will be critical for the success of new systems that will be prevalent in the 21st century. Such systems will need to properly deduce human emotional state before they can determine how to best interact with people. **Method:** Corpora and machine learning classification models are used to train and test a methodology for emotion detection. The methodology uses a stepwise approach to detect sentiment in sentences by first filtering out neutral sentences, then distinguishing among positive, negative, and five emotion classes. **Results:** Results of the classification between emotion and neutral sentences achieved recall accuracies as high as 77% in the University of Illinois at Urbana-Champaign (UIUC) corpus and 61% in the Louisiana State University medical drama (LSU-MD) corpus for emotion samples. Once neutral sentences were filtered out, the methodology achieved accuracy scores for detecting negative sentences as high as 92.3%. **Conclusion:** Results of the feature analysis indicate that speech spectral features are better than speech prosodic features for emotion detection. Accumulated sentiment composition text features appear to be very important as well. This work contributes to the study of human communication by providing a better understanding of how language factors help to best convey human emotion and how to best automate this process. **Application:** Results of this study can be used to develop better automated assistive systems that interpret human language and respond to emotions through 3-D computer graphics.

- **Keywords:** knowledge representation, cognitive processes, language, human-computer interaction

**Federica Cavicchio and Massimo Poesio. *(Non)cooperative Dialogues: The Role of Emotions*. S. 546-559.**

**Objective:** The effect of emotion on (non)co-operation in unscripted, ecological communication is investigated. **Background:** The participants in an interaction are generally cooperative in that, for instance, they tend to reduce the chance of misunderstandings in communication. However, it is also clear that cooperation is not complete. Positive and negative emotional states also appear to be connected to the participants' commitment to cooperate or not, respectively. So far, however, it has proven remarkably difficult to test this because of the lack of entirely objective measurements of both cooperation levels and emotional responses. **Method:** In this article, the authors present behavioral methods and coding schemes for analyzing cooperation and (surface) indicators of emotions in face-to-face interactions and show that they can be used to study the correlation between emotions and cooperation effectively. **Results:** The authors observed large negative correlations between heart rate and cooperation, and a group of facial expressions was found to be predictive of the level of cooperation of the speakers. **Conclusion:** It is possible to develop reliable methods to code for cooperation, and with such coding schemes it is possible to confirm the commonsense prediction that noncooperative behavior by a conversational participant affects the other participant in ways that can be measured quantitatively. **Application:** These results shed light on an aspect of interaction that is crucial to building adaptive systems able to measure cooperation and to respond to the user's affective states. The authors expect their methods to be applicable to building and testing such interaction systems.

- **Keywords:** multimodal communication, face-to-face interaction, multimodal coding scheme, coding scheme validation, pragmatics, facial expressions of emotions

**Mark S. Pfaff. *Negative Affect Reduces Team Awareness: The Effects of Mood and Stress on Computer-Mediated Team Communication*. S. 560-571.**

**Objective:** This article presents research on the effects of varying mood and stress states on within-team communication in a simulated crisis management environment, with a focus on the relationship between communication behaviors and team awareness.

**Background:** Communication plays a critical role in team cognition along with cognitive factors such as attention, memory, and decision-making speed. Mood and stress are known to have interrelated effects on cognition at the individual level, but there is relatively little joint exploration of these factors in team communication in technologically complex environments. **Method:** Dyadic communication behaviors in a distributed six-person crisis management simulation were analyzed in a factorial design for effects of two levels of mood (happy, sad) and the presence or absence of a time pressure stressor. **Results:** Time pressure and mood showed several specific impacts on communication behaviors. Communication quantity and efficiency increased under time pressure, though frequent requests for information were associated with poor performance. Teams in happy moods showed enhanced team awareness, as revealed by more anticipatory communication patterns and more detailed verbal responses to teammates than those in sad moods. **Conclusion:** Results show that the attention-narrowing effects of mood and stress associated with individual cognitive functions demonstrate analogous impacts on team awareness and information-sharing behaviors and reveal a richer understanding of how team dynamics change under adverse conditions. **Application:** Disentangling stress from mood affords the opportunity to target more specific interventions that better support team awareness and task performance.

- **Keywords:** stress, mood, communication, team awareness, team cognition, computer-supported cooperative work

**Joann Keyton. *Commentary: How Can Technology Help Us Understand the Communication Process?* S. 572-576.**

In this commentary, the author reflects on the articles chosen for the special section on communications analysis. These articles problematize communication and raise an interesting set of questions for both human factors and communication scholars to ponder. In the end, both sets of scholars seek the same goal: How do we better examine communication to improve it? Problematizing communication requires scholars to challenge their fundamental assumptions about the phenomenon as well as to tease out the distinctions of methodological approaches typically used by both human factors and communication scholars. Human factors scholars tend to favor forms of communication in which technology or task roles control who can communicate and how. Communication scholars tend to favor contexts in which information flows more freely with fewer explicit restrictions. Creating opportunities to collaborate in research on the communication process may create the best understanding of technology that can better serve our understanding of communication.

- **Keywords:** communication, communication analysis, decision making, naturalistic decision making, mental models

## ACCIDENTS, SAFETY, AND HUMAN ERROR

### **James E. Driskell, Eduardo Salas and Tripp Driskell. *Social Indicators of Deception*. S. 577-588.**

**Objective:** This study addresses a practical homeland security issue of considerable current concern: In a situation in which the opportunity exists to question or interview concurrently two or more suspects, how does one determine truth or deception at a social level? **Background:** Recent world events have led to an increased emphasis on the capacity to detect deception, especially in military, security, and law enforcement settings. In many screening or checkpoint situations, the opportunity exists to question two or more suspects regarding their involvement in some activity, yet investigators know very little regarding characteristics of speech or behavior that are exhibited between two suspects that indicate truth or deception. **Method:** We conducted an empirical study in which pairs of police officers and firefighters who had served together as partners took part. In the "truth" conditions, each dyad described a recent event in which they had actually taken part, and in the "deceptive" conditions, each dyad fabricated a story that did not take place. We expected that the officers in the truth-telling dyads would be able to draw on shared or transactive memory of the actual event they had participated in and would describe this event in a more interactive manner than would those in deceptive dyads. **Results:** Results indicated greater evidence of synchrony of behavior as well as more interactive behaviors, such as mutual gaze and speech transitions, in truthful dyads than in deceptive dyads. **Conclusion:** This research provides a unique perspective on detecting deception in a social context, and the results have both theoretical and practical value. **Application:** These results can inform training programs and refine strategies used by screeners in field settings.

- **Keywords:** deception, transactive memory, interviewing, homeland security, group processes

## AEROSPACE SYSTEMS

### **William Rodes and Leo Gugerty. *Effects of Electronic Map Displays and Individual Differences in Ability on Navigation Performance*. S. 589-599.**

**Objective:** The aim of this study was to determine how strongly the performance of navigation tasks is affected by changing electronic map interfaces and by individual differences in spatial ability. **Background:** Electronic map interfaces have two common configurations, north up and track up. Research suggests that north-up maps benefit some navigational tasks and track-up maps benefit others. However, little research has investigated how map configuration affects the important navigation task of judging cardinal direction or how individual differences in spatial ability interact with map configuration in affecting navigation performance. **Method:** In an aerial reconnaissance task, 16 participants completed route-following, cardinal direction, and map reconstruction tasks. Participants also completed three spatial ability tests. **Results:** The track-up map led to better performance on the cardinal direction and route-following tasks. The north-up map led to better performance on the map reconstruction task. Effects of map configuration showed small to medium effect sizes. Spatial ability correlated positively with performance of each navigation task, showing medium to large effect sizes. For some tasks, a helpful map interface compensated for low ability. For

other tasks, ability facilitated the performance of the helpful interface; optimal performance required a helpful interface and high ability. **Conclusion:** Achieving high performance at particular navigation subtasks requires two things: using the map configuration that optimizes subtask performance and having high spatial ability. **Application:** Some aspects of navigation performance can be improved primarily by using the optimal map configuration; other aspects require using the optimal configuration and having better spatial ability.

- **Keywords:** track-up maps, north-up maps, spatial ability, navigation, cardinal directions

## AGING AND INDIVIDUAL DIFFERENCES

**Ari Z. Zivotofsky, Ehud Eldror, Roi Mandel and Tova Rosenboom. *Misjudging Their Own Steps: Why Elderly People Have Trouble Crossing the Road.* S. 600-607.**

**Objective:** The aim of this study was to test whether elderly individuals underestimate the time that it will take them to cross a street by comparing estimated with actual road-crossing time. **Background:** In many developed countries, elderly people are overrepresented among pedestrian fatalities from motor vehicle accidents. There is surely more than one contributing factor to this phenomenon, and many have been offered. We propose that one additional factor may be that although older people are consciously aware that they no longer walk at the same pace as they once did, they do not take this fact into consideration when planning a street crossing. **Method:** We compared the ability of young and old pedestrians to estimate the time that it will take them to cross a street, using both prospective and retrospective time estimation. **Results:** A significant interaction was found between age group and crossing time. Among elderly participants, actual crossing times were significantly longer than both their precrossing estimation and their postcrossing estimation, which did not significantly differ from each other. In contrast, the undergraduate group's crossing times did not display a significant difference across measurements. **Conclusion:** This study implies that even if older pedestrians correctly evaluate the road situation, they may nonetheless endanger themselves by underestimating the time that it will take them to cross the street. We suggest that minimizing this effect could be accomplished by educating seniors to the fact that they are not as fast as they once were and that this fact needs to be factored in to street-crossing decisions.

- **Keywords:** time estimation, aging, traffic safety, retrospective estimation, prospective estimation

## BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY

**Arun Garg and Jay M. Kapellusch. *Long-Term Efficacy of an Ergonomics Program That Includes Patient-Handling Devices on Reducing Musculoskeletal Injuries to Nursing Personnel.* S. 608-625.**

**Objective:** The aim of this study was to evaluate long-term efficacy of an ergonomics program that included patient-handling devices in six long-term care facilities (LTC) and one chronic care hospital (CCH). **Background:** Patient handling is recognized as a major source of musculoskeletal disorders (MSDs) among nursing personnel, and several studies have demonstrated effectiveness of patient-handling devices in reducing those

MSDs. However, most studies have been conducted in a single facility, for a short period, and/or without a comprehensive ergonomics program. **Method:** Patient-handling devices along with a comprehensive ergonomics program was implemented in six LTC facilities and one CCH. Pre- and post-intervention injury data were collected for 38.9 months (range = 29 to 54 months) and 51.2 months (range = 36 to 60 months), respectively. **Results:** Postintervention patient-handling injuries decreased by 59.8% (rate ratio [RR] = 0.36, 95% confidence interval [CI] [0.28, 0.49],  $p < .001$ ), lost workdays by 86.7% (RR = 0.16, 95% CI [0.13, 0.18],  $p < .001$ ), modified-duty days by 78.8% (RR = 0.25, 95% CI [0.22, 0.28],  $p < .001$ ), and workers' compensation costs by 90.6% (RR = 0.12, 95% CI [0.09, 0.15],  $p < .001$ ). Perceived stresses to low back and shoulders among nursing staff were fairly low. A vast majority of patients found the devices comfortable and safe. Longer transfer times with the use of devices was not an issue. **Conclusion:** Implementation of patient-handling devices along with a comprehensive program can be effective in reducing MSDs among nursing personnel. Strategies to expand usage of patient-handling devices in most health care settings should be explored.

- **Keywords:** patient transfer, musculoskeletal injuries, ergonomic intervention, nursing personnel, patient handling, injury reduction

### **Jing Qiu and Rolf Helbig. *Body Posture as an Indicator of Workload in Mental Work*. S. 626-635.**

**Objective:** For this article, the relationships between body posture and workload for four mental tasks simulated on a computer were studied. **Background:** Human behaviors are observable during work and are related to human mental activities. A novel supplementary method, based on human behavior but not directly related to task execution, is proposed to assess the workload in mental work situations. **Method:** Body posture was quantitatively analyzed with the use of a video-based analysis system. The distance between a participant's head and the display, the distance between the shoulder and the hip, and the trunk angle of the shoulder and the hip with respect to the gravitational field were calculated. **Results:** The various tasks affected the distance between the head and the display ( $p < .001$ ) and the trunk angle ( $p < .001$ ). The distance between the head and the display decreased with increasing workload ( $p = .007$ ). **Conclusion:** These results indicate that body posture can be used as an indicator for overall workload assessment. **Application:** The proposed method of workload may be useful for real-time observations or the monitoring of mental states in mental work environments (e.g., rail traffic dispatching, air traffic control).

- **Keywords:** workload, workload assessment, mental work, body posture, human behavior

## **DISPLAYS AND CONTROLS**

### **Jacqueline Urakami. *Developing and Testing a Human-Based Gesture Vocabulary for Tabletop Systems*. S. 636-653.**

**Objective:** The goal was to study the natural and intuitive use of surface gestures for the development of a tabletop system. Furthermore, the effect of expertise on choice of gestures was examined. **Background:** It is still not well understood what kinds of gestures novice users choose when they interact with gesture recognition systems. **Method:** First, novices' and experts' choice of gestures for a tabletop system was compared in a quasiexperimental design. Second, memorability of novices' and experts' gesture sets derived from the first study was compared in an experimental study. Third,

memorization of hand shape and motion path was examined in a further experiment. **Results:** Data revealed user preferences for specific hand shapes and motion paths. Choice of gestures was affected by the size of the manipulated object, expertise, and nature of the command (direct manipulation of objects vs. assessment of abstract functions). Follow-up experiments revealed that the novices' gesture set was better memorized than were the experts' gesture set. Furthermore, the motion path of a gesture is better memorized than the specific hand shapes for a gesture. **Conclusion:** Expertise affects the choice of gesture to a certain degree. It is therefore essential to involve novice users in the development of gesture vocabularies. Gestures for technical systems should be simple and should involve distinctive motion patterns instead of focusing on specific hand shapes or number of fingers. Abstract or symbolic gestures should be avoided. **Application:** Results of the study can be applied to the development of surface gestures for tabletop systems.

- **Keywords:** ergonomic design, user study, surface gestures, expertise, hand shape, motion path

## SURFACE TRANSPORTATION SYSTEMS

**Jan-Erik Källhammer and Kip Smith. *Assessing Contextual Factors That Influence Acceptance of Pedestrian Alerts by a Night Vision System*. S. 654-662.**

**Objective:** We investigated five contextual variables that we hypothesized would influence driver acceptance of alerts to pedestrians issued by a night vision active safety system to inform the specification of the system's alerting strategies. **Background:** Driver acceptance of automotive active safety systems is a key factor to promote their use and implies a need to assess factors influencing driver acceptance. **Method:** In a field operational test, 10 drivers drove instrumented vehicles equipped with a preproduction night vision system with pedestrian detection software. In a follow-up experiment, the 10 drivers and 25 additional volunteers without experience with the system watched 57 clips with pedestrian encounters gathered during the field operational test. They rated the acceptance of an alert to each pedestrian encounter. **Results:** Levels of rating concordance were significant between drivers who experienced the encounters and participants who did not. Two contextual variables, pedestrian location and motion, were found to influence ratings. Alerts were more accepted when pedestrians were close to or moving toward the vehicle's path. **Conclusion:** The study demonstrates the utility of using subjective driver acceptance ratings to inform the design of active safety systems and to leverage expensive field operational test data within the confines of the laboratory. **Application:** The design of alerting strategies for active safety systems needs to heed the driver's contextual sensitivity to issued alerts.

- **Keywords:** alert acceptance, active safety systems, knowledge elicitation, driver behavior, automation

**Brian R. Ott, George D. Papandonatos, Jennifer D. Davis and Peggy P. Barco. *Naturalistic Validation of an On-Road Driving Test of Older Drivers*. S. 663-479.**

**Objective:** The objective was to compare a standardized road test to naturalistic driving by older people who may have cognitive impairment to define improvements that could potentially enhance the validity of road testing in this population. **Background:** Road testing has been widely adapted as a tool to assess driving competence of older people

who may be at risk for unsafe driving because of dementia; however, the validity of this approach has not been rigorously evaluated. **Method:** For 2 weeks, 80 older drivers (38 healthy elders and 42 with cognitive impairment) who passed a standardized road test were video recorded in their own vehicles. Using a standardized rating scale, 4 hr of video was rated by a driving instructor. The authors examine weighting of individual road test items to form global impressions and to compare road test and naturalistic driving using factor analyses of these two assessments. **Results:** The road test score was unidimensional, reflecting a major factor related to awareness of signage and traffic behavior. Naturalistic driving reflected two factors related to lane keeping as well as traffic behavior. **Conclusion:** Maintenance of proper lane is an important dimension of driving safety that appears to be relatively underemphasized during the highly supervised procedures of the standardized road test. **Application:** Road testing in this population could be improved by standardized designs that emphasize lane keeping and that include self-directed driving. Additional information should be sought from observers in the community as well as crash evidence when advising older drivers who may be cognitively impaired.

- **Keywords:** driving, aging, dementia, Alzheimer's disease, cognitive impairment