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## Special Issue: Interpersonal Synchronization

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**Stephen J. Guastello**, Marquette University, Milwaukee, WI

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#### **Movement Coordination in Psychotherapy: Synchrony of Hand Movements is Associated with Session Outcome. A Single-Case Study**

**Fabian Ramseyer**, and **Wolfgang Tschacher**, University of Bern, Switzerland

**Abstract:** Previous work has shown that nonverbal behavior was associated with both session-level outcome and global outcome in psychotherapy. Nonverbal synchrony – here the coordination between patient's and psychotherapist's movement behavior – is a facet of nonverbal behavior that has recently been studied with video-based motion energy analysis (MEA). The present study aimed to replicate and extend these findings by using direct acquisition of movement data. In a single-case analysis, we monitored patient's and therapist's hand movements with a high-resolution accelerometric measurement system (Vitaport (r)). In addition to these behavioral data, both patient and therapist provided session-level ratings of various factors relevant to the psychotherapy process, which were assessed with post-session questionnaires. The patient-therapist coordination of hand movements, i.e. nonverbal synchrony, in ( $N = 27$ ) sessions of this dyadic psychotherapy was positively associated with progress reported in post-session questionnaires. Sessions with good evaluations concerning the quality of therapeutic alliance were characterized by high movement coordination. Thus, accelerometric data of this therapy dyad confirmed previous findings gained through video analyses: The coordination of nonverbal behavior shown by patient and therapist was an indicator of beneficial processes occurring within sessions. This replication study showed that nonverbal synchrony embodies important aspects of the alliance. Its assessment and quantification may provide therapists important additional information on processes that usually occur outside conscious awareness, but that nevertheless influence core aspects of the therapy.

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## **Synchronization Analysis of Language and Physiology in Human Dyads**

**Franco F. Orsucci**, University College London, UK, **Nicolò Musmeci**, King's College London, UK, **Benjamin Aas**, **Günter Schiepek**, Paracelsus Medical University Salzburg, Austria, **Mario A. Reda**, **Luca Canestri**, University of Siena, Italy, **Alessandro Giuliani**, Istituto Superiore di Sanità, Rome, Italy, and **Giulio de Felice**, University of Siena, Italy

**Abstract:** We studied the synchronization dynamics of a therapist and patient during a psychotherapy session. This investigation was developed in order to explore a new possible perspective and methodology for studying the expression of emotions. More specifically, literature concerning synchronization of in-session non-verbal variables emphasises its positive correlation with empathy and therapeutic outcomes. We compared the dynamics of galvanic skin response (GSR) and linguistic prosody, chosen as indicators of emotional expression in different domains. We studied their synchronization through complementary methodologies: Recurrence Quantification Analysis (RQA) and Principal Component Analysis (PCA), Markov Transition Matrix (MTM) and Cross-Recurrence Quantification Analysis (CRQA). We investigated the nonlinearity of GSR in terms of self-similarity and power-law, as emerged in autocorrelation functions and signal variations. We considered time-lagged correlations as a measure of dynamical systems' memory. This article concludes by highlighting the importance of a deeper study of all variables related to the psychotherapeutic process and their synchronization in order to extend our knowledge of general human dynamics.

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## **Top-down (Prior Knowledge) and Bottom-up (Perceptual Modality) Influences on Spontaneous Interpersonal Synchronization**

**Christina L. Gipson**, **Jamie C. Gorman**, Georgia Institute of Technology, Atlanta, GA, and **Eric E. Hessler**, University of Minnesota Duluth, Duluth, MN

**Abstract:** Coordination with others is such a fundamental part of human activity that it can happen unintentionally. This unintentional coordination can manifest as synchronization and is observed in physical and human systems alike. We investigated the role of top-down influences (prior knowledge of the perceptual modality their partner is using) and bottom-up factors (perceptual modality combination) on spontaneous interpersonal synchronization. We examine this phenomena with respect to two different theoretical perspectives that differently emphasize top-down and bottom-up factors in interpersonal synchronization: joint-action/shared cognition theories and ecological-interactive theories. In an empirical study twelve dyads performed a finger oscillation task while attending to each other's movements through either visual, auditory, or visual and auditory perceptual modalities. Half of the participants were given prior knowledge of their partner's perceptual capabilities for coordinating across these different perceptual modality combinations. We found that the effect of top-down influence depends on the perceptual modality combination between two individuals. When people used the same perceptual modalities, top-down influence resulted in less synchronization and when people used different perceptual modalities, top-down influence resulted in more synchronization. Furthermore, persistence in the change in behavior as a result of having perceptual information about each other ("social memory") was stronger when this top-down influence was present.

pp. 223-270.

## **Physiological Synchronization in Emergency Response Teams: Subjective Workload, Drivers and Empaths**

**Stephen J. Guastello**, **David E. Marra**, **Claire Perna**, **Julian Castro**, **Maribeth Gomez**, and **Anthony F. Peressini**, Marquette University, Milwaukee, WI

**Abstract:** Behavioral and physiological synchronization have important implications for work teams with regard to workload management, coordinated behavior and overall functioning. This study extended previous work on the nonlinear statistical structure of GSR series in dyads to larger teams and included subjective ratings of workload and contributions to problem solving. Eleven teams of 3 or 4 people played a series of six emergency response (ER) games against a single opponent. Seven of the groups worked under a time pressure instruction at the beginning of the first game. The other four groups were not given that instruction until the beginning of the fourth game. The optimal lag length for the teams, which appeared to be phase-locked, was substantially shorter than that obtained previously for loosely-coupled dyads. There was a complex nonlinear effect from the time pressure manipulation on the

autocorrelation over time that reflected workload and fatigue dynamics that were operating. The  $R^2$  values for linear and nonlinear statistical models differed by less than .01. The average amount of influence from one ER team member to another was 4.5-4.7% of the variance in GSR readings. ER team members were classified as drivers and empaths, based on the autocorrelations and transfer influences to and from other players in the GSR time series. Empaths were rated by their peers as making more types of positive contributions to the problem solving discussions than others, and drivers received the lowest ratings. Larger Lyapunov exponents that were calculated from the GSR time series were positively correlated with individuals' ratings of subjective workload and were negatively correlated with leadership indicators. Several directions for further research are outlined.

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### **Tracing Neurodynamic Information Flows during Teamwork**

**Ronald Stevens** *The Learning Chameleon, Inc., IMMEX/UCLA* and **Trysha Galloway** *The Learning Chameleon, Inc.*

**Abstract:** *The goal of this study was to evaluate different neurodynamic representations for their ability to describe the interactions of team members with each other and with the changing task. Electroencephalography (EEG) data streams were collected from six crew members of a submarine piloting and navigation team while they performed a required training simulation. A representation of neurodynamic organization was first generated by creating symbols every second that showed the EEG power levels of each crew member. The second-by-second expression of these symbols continuously varied with the changing task, and the magnitude, duration and frequency of these variations could be quantitated using a moving window of Shannon entropy over the symbol stream. These changes in neurodynamic organization (i.e. entropy) were seen in the alpha, beta and gamma EEG frequency bands. A representation of team members' synchrony was created by measuring the mutual information in the EEG power levels for fourteen dyad combinations. Mutual information was present in the gamma EEG band, and elevated levels were distributed throughout the task. These discrete periods of synchrony were poorly correlated at zero lag with either changes in the team's neurodynamic organization, or speech patterns.*

pp. 293-317.

### **Synchronization, TIGoRS, and Information Flow in Complex Systems: Dispositional Cellular Automata**

**William H. Sulis**, *McMaster University, Hamilton, Ontario, Canada*

**Abstract:** *Synchronization has a long history in physics where it refers to the phase matching of two identical oscillators. This notion has been extensively studied in physics as well as in biology, where it has been applied to such widely varying phenomena as the flashing of fireflies and firing of neurons in the brain. Human behavior, however, may be recurrent but it is not oscillatory even though many physiological systems do exhibit oscillatory tendencies. Moreover, much of human behaviour is collaborative and cooperative, where the individual behaviours may be distinct yet contemporaneous (if not simultaneous) and taken collectively express some functionality. In the context of behaviour, the important aspect is the repeated co-occurrence in time of behaviours that facilitate the propagation of information or of functionality, regardless of whether or not these behaviours are similar or identical. An example of this weaker notion of synchronization is transient induced global response synchronization (TIGoRS). Previous work has shown that TIGoRS is a ubiquitous phenomenon among complex systems, enabling them to stably parse environmental transients into salient units to which they stably respond. This leads to the notion of Sulis machines, which emergently generate a primitive linguistic structure through their dynamics. This article reviews the notion of TIGoRS and its expression in several complex systems models including tempered neural networks, driven cellular automata and cocktail party automata. The emergent linguistics of Sulis machines are discussed. A new class of complex systems model, the dispositional cellular automaton is introduced. A new metric for TIGoRS, the excess synchronization, is introduced and applied to the study of TIGoRS in dispositional cellular automata. It is shown that these automata exhibit a nonlinear synchronization response to certain perturbing transients.*