Final Summary Report for the Project:
Multi-scale Dynamics in the Explanation of Linguistic Phenomena
(MULTISCALEDYNAMICS 256587)

This project's goals were specified on theoretical, empirical and organizational level. Their achievement was planned as steps towards developing a more encompassing, novel approach to study language, which is compatible with the embodied and distributed theories of cognition that have recently grown in popularity. Language is seen primarily as a social coordination system that sculpts existing interpersonal dynamics into functional wholes (see Vygotsky, 1971; Rączaszek-Leonardi & Kelso, 2008; Rączaszek-Leonardi, 2012; Fusaroli et al., in press).

1) On the theoretical level: In the earlier work of the Fellow (performed within the EIF MC Fellowship), on the basis of the approach to information in biological systems (Pattee, 1969, 1982) we developed a view of linguistic symbols as constraints on dynamics (in contrast to the dominant "symbols as containers for meaning" approach) (Rączaszek-Leonardi & Kelso, 2008 and Rączaszek-Leonardi, 2009). One of the main goals of ERG was to integrate this novel approach with the modern cognitive science, and especially with the new and promising trends of embodied cognition and distributed cognition. This involved propagating the original work by Howard Pattee and linking it to the theoretical and methodological developments in the cognitive sciences. **The goal was realized through a book co-authored by the fellow and Prof. Howard Pattee: "Laws, Languages & Life" (Springer Verlaag, 2012).** The book contains original papers by prof. Pattee, his contemporary commentary and an extensive chapter by the Fellow, relating the work of Pattee and his contemporaries to major theoretical problems in modern cognitive psychology, such as symbol grounding and contextual dependence of meaning. **It was shown that the view of symbolic structures as replicable constrains on dynamics is a viable third way that has a power to integrate the symbolically- and algorithmically-oriented information-processing approach with purely dynamical approach of the ecological psychology**. Both the book and the chapter received enthusiastic comments and currently three reviews are being prepared. The contents of the concluding chapter motivated several research institutions to invite the fellow as a keynote speaker (University of Aarhus, Denmark) or an opening-conference speaker (University of London, Goldsmith College). Besides the book, the above theoretical considerations were the topic of the **paper in *Interactive Studies* (IF=1.1), co-authored with Prof. Stephen Cowley (2012)** and a paper by the fellow **"Types of Integration in the theory of language" in *Psychology of Language and Communication* (2012)**. To propagate and develop further these ideas, the fellow organized a large international conference devoted to Language as Social Coordination (Warsaw, 2010), with 8 renowned key-note speakers from 6 countries and 40 other presentations from 16 countries.

2) On the empirical level the project consisted of studies motivated by the theory developed above. In such a theoretical framework, in which dynamical processes play a key role in determining linguistic behavior and emergence of language structures, it is crucial to carefully operationalize the theoretical concepts and find novel methods of gathering and analysis of time-dependent data. The first study was devoted to this. We recorded quasi-natural conversations in which topics were either neutral or emotionally engaging. At the end of each interaction participants rated their subjective feelings about the conversation. The aim was to find statistical and dynamic properties of conversations that could predict the subjective quality and comfort in interaction. We analyzed mainly the patterns of turn-taking. We estimated usefulness of the traditional descriptive methods as well as novel dynamical measures, such as: recurrence quantification analysis (RQA), cross-recurrence quantification (CRQ), Bayesian description of states dynamics, and entropy assessment methods.

The main results of the traditional statistical analyses showed that the amount of overlap is positively linked to the naturalness of interaction and positive mood change. In the dynamical analyses the most useful measure was the recurrence rate (RR) of the conversation as a whole, which reflects the recurring of a certain dialogical patterns (Webber & Zbilut, 1994). Surprisingly, it was this variable, which described the dyadic system globally that had the stronger relation to the subjective feelings about the conversation, and not the alignment measures (CRQ) that are usually implicated as predictors (e.g., Pickering & Garrod, 2004). Out of the various parameters of RQA it had

the best stationarity and showed significant correlations with both descriptive measures of conversation and the subjective questionnaire measures (r=-0,65; p<0, 001 with the perceived Sparsity, r=0,48; p<0,01 with safety and cooperation dimension of the subjective evaluation questionnaire and r=0,42; p<0,01 with the mood increase). Another RQA parameter, DET, which reflects the length of the recurring patterns in conversation, systematically correlated with measures of safety (r=0,5; p<0,02), and positive mood change after the conversation (r=0,49; p<0,02).

Another important result is a demonstration that while some dynamical measures of the interaction as a whole are stationary (thus it makes sense to correlate them with, e.g., subjective evaluation measures), others are not (see Fig. 1). In the latter case, it is the variance of measures that may be informative. Further studies are planned to establish if this is the case. Another direction of continuing this work is to perform the traditional and dynamical analyses of measures other than turn-taking (such as voice pitch and amplitude).

A)

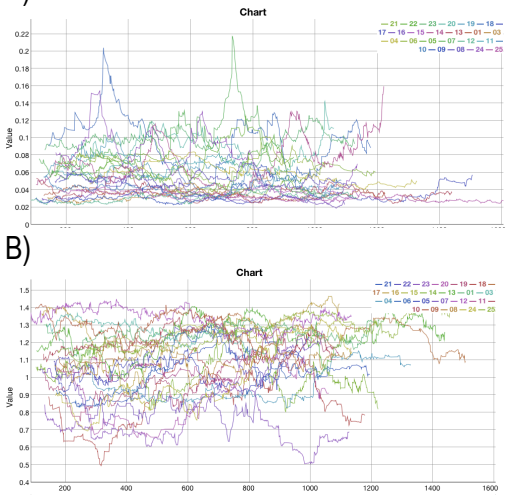

Figure 1. Dynamical measures for 24 conversations: A) relatively stationary measure (recurrence rate), where only few conversations show non-stationarity, and B) relatively non-stationary measure (Entropy). Visualization was made with the Stationarity Analysis Tool developed for this project.

This study led to the following deliverables: i) an on-line interactive Stationarity Analysis Tool: http://cogsyswaw.appspot.com/stationary.html was constructed and will be further developed into an interaction analysis open-source tool. The funding for this has already been secured. ii) **Paper based on the above results: „Linguistic interaction as a coordinative structure: Relationship between supra-individual and subjective measures“** has been written. Additional analyses are performed before the submission of the paper to PLoS ONE (an open source journal). iii). Both the theoretical work mentioned above and the experience gained in the empirical interaction analyses resulted in a new collaboration with Bielefield group involved in research on caretaker-infant interaction and the paper co-authored with this group: **Rączaszek-Leonardi, J., Nomikou, I., Rohlfing, K. “Young children’s dialogical actions: The beginnings of purposeful intersubjectivity”, accepted in IEEE Transactions in Autonomous Mental Development (IF=2.3),** to be printed this year**.**

3) On the career-development level the project led to i) publication of the **habilitation book “United in Speech”, Scholar (2011)** and **awarding the habilitation degree to the Fellow**, ii) foundation of the **Cognitive Systems Warsaw research group (**http://cognitivesystems.pl) , which already has secured next funding (Project DRUST from ESF), and iii) employment of the Fellow as a **full professor at the University of Warsaw**, where the Fellow formed a research group consisting of 3 PhD and 5 MA students, iv) establishing the Human Interactivity and Language Lab which will integrate the research potential of the groups (http://psych.uw.edu.pl/humaninteractivity).

Summarizing: The project led to the integration of the Fellow as a full professor at Warsaw University with her own research group at the Faculty of Psychology and an interdepartmental research group comprising Dept. of Physics and Interdisciplinary Centre of Mathematical Modeling. The research performed leads to a better understanding of factors regulating linguistic communication, which has wide societal impact. Results include a novel theoretical framework for the study linguistic interaction as well as new tools for interaction analysis. The latter will be of use in the following settings: developmental (diagnosing of early social interaction dysfunctions), educational, patient-doctor interaction, common problem solving and

negotiation (some of the applications are already in course). Funding for further work has been secured. Deliverables and dissemination activities within the 36 months period include 2 published books, three papers published or in press, one paper in preparation, 8 organized workshops and conferences, 3 invited and key-note conference participations, and 12 regular conference and workshop participations (10 of them as a sole or first author). Open seminars and radio interviews were also realized as part of the dissemination plan.

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