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# Peripatetic Conference

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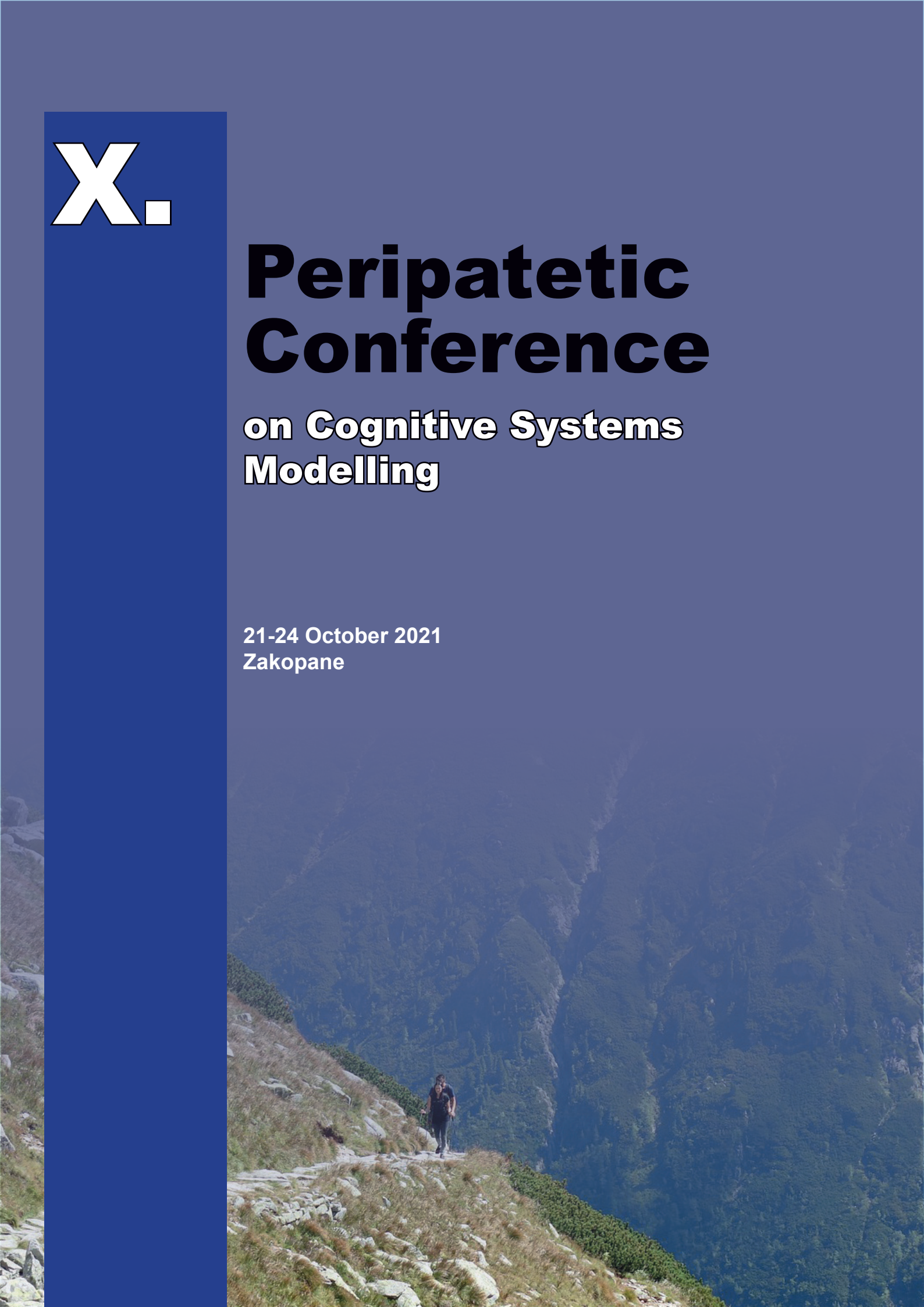

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# Contents

## Keynotes



## Presentations

# Keynotes

Łukasz Dębowski (Institute of Computer Science, PAS)

# A Refutation of Finite-State Language Models through Zipf's Law for Factual Knowledge

We present a hypothetical argument against finite-state processes in statistical language modelling which is based on semantics rather than syntax. In this theoretical model, we suppose that semantic properties of texts in natural language could be approximately captured by a recently introduced concept of a perigraphic process. Perigraphic processes are a class of stochastic processes that satisfy a Zipf-law accumulation of a subset of factual knowledge which is time-independent, compressed, and effectively inferrable from the process. We show that the classes of finite-state processes and of perigraphic processes are disjoint. The disjointness result makes use of the Hilberg condition, i.e., the almost sure power-law growth of algorithmic mutual information. Using a strongly consistent estimator of the number of hidden states, we show that finite-state processes do not satisfy the Hilberg condition, whereas perigraphic processes satisfy the Hilberg condition by the data-processing inequality. We discuss relevance of these mathematical results for theoretical and computational linguistics.

**Literature**

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Ł. Dębowski, (2018). Is Natural Language a Perigraphic Process? The Theorem about Facts and Words Revisited. Entropy, vol. 20(2), pp. 85.

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Ramon Ferrer-i-Cancho (U. Politecnica de Catalunya)

# Trekking on the pyramid of (linguistic) theory construction

For a long time, statistical patterns of language have been considered to be secondary or irrelevant for theory construction. Research on linguistic laws and other patterns of communication typically falls into one of four levels of a pyramid that has been presented recently. ‘Exploratory and descriptive statistics’ (Level 1) is the most basic level, involving studies that test for conformity to linguistic laws in real world biological systems. ‘Descriptive mathematical modelling’ (Level 2) involves work that describes processes that reproduce these laws. ‘Inferential and predictive modelling’ (Level 3) involves research that uses computational approaches to explain possible functions of these laws and develops testable predictions. ‘General theory’ (Level 4) involves work to build scientific theory by integrating a set of interconnected principles that are independent from the observable phenomena.

In this talk, I will trek on that pyramid focusing on some recent research on Levels 3 and 4 in the domain of popular linguistic laws and word order patterns. For these levels, I will distinguish 1st order from 2nd order predictions. This pyramid can help as a guide for one’s current and future research.

Xavier Hinaut (Inria, Bordeaux)

# Sensorimotor and Hierarchical Models of Vocal and Language Learning: Songbirds, Humans, Robots

Birds, humans and monkeys produce sensorimotor sequences such as songs, speech utterances and complex motor actions. Could the processing and production of such sensorimotor sequences be performed by common emerging neural mechanisms? Such symbols imply neural substrates that should both perceive and produce them: this is the mirror neurons idea. From the interaction with the environment, common perceptuo-motor representations emerge. One big challenge is to understand how birds and humans learn to imitate such vocal symbols (and their ordering into sequences) while having to deal with hierarchical chunks of symbols at different timescales (from tens of milliseconds to seconds).

One of our goals is to model sensorimotor sequences learning using the same generic artificial neural substrates. We mainly use artificial random neural networks, known as reservoirs, as such substrates. In this talk, we will explore 1. a vocal sensorimotor model learning to produce realistic canary sounds, 2. a human syntax learning model working in several languages, 3. an application of such syntax model for robot language acquisition, and 4. a hierarchical model parsing sentences from speech.

Garret Roberts (University of Pennsylvania)

# Information, interaction, and inference: The emergence of organisation in experimental communication games

There is increasing evidence that a great deal of the organisational structure of languages is not simply baked into Universal Grammar but emerges via a cultural evolutionary process in which language is shaped by biases acting on language users. Much attention has been paid to biases operating during language learning, but work has also focused on the role of communicative interaction. One approach to investigating this is to conduct experiments in which participants play communicative games in which they are not permitted to use established forms of communication but must make use of novel media. Here I present results from more than one experiment of this kind, in which participants communicated with grids or changing colours, shedding light on the emergence of information structure and phonological organisation in language.

Katharina Rohlfing (University of Paderborn)

# Let’s think in frames

Early words are used for specific action goals. Departing from the theory summarized in Rohlfing et al., (2016) under the conception of Pragmatic Frames, I will present new data on how multimodal communicative behaviors differ when compared across frames and how frames raise different cognitive and linguistic demands. This view affords not only a change in theoretically conceptualizing word learning but also a change in methods.

Marieke Schouwstra (University of Amsterdam)

# Semantic reversibility and the noisy channel account of word order variation: a new analysis + evidence

How do cognitive biases and mechanisms from learning and use interact when a system of language conventions emerges? We investigate this question by focusing on how reversible events are conveyed in silent gesture production and interaction. Silent gesture experiments (in which participants improvise to use gesture but no speech) have been used to investigate cognitive biases that shape utterances produced in the absence of a conventional language system. In this mode of communication, participants do not follow the dominant order of their native language (e.g. Subject-Verb-Object), and instead condition the structure of their gesture strings on the semantic properties of the events they are conveying. An important source of variability in structure in silent gesture is the property of reversibility. Reversible events are a category of events in which conventions for word order become especially important, because they typically have two animate participants whose roles can be reversed ("a girl kicks a boy"). Without a syntactic/conventional means of conveying who does what to whom, there is inherent unclarity about the agent and patient roles in the event (by contrast, this is less pressing for non-reversible events like "a girl kicks a ball"). In experiment 1 we test a novel, fine-grained analysis of reversibility. Presenting a silent gesture production experiment, we show that the variability in word order depends on two factors (properties of the verb, and properties of the direct object) that together determine how reversible an event is. We relate our experimental results to principles from information theory, showing that our data supports the ‚noisy channel' account of constituent order.

In experiment 2, we focus on the influence of interaction on word order variability for reversible and non-reversible events. We show that when participants use silent gesture for communicative interaction, they initially use word order variably, depending on the reversibility of the event, but they gradually become more systematic in their usage of word order. We conclude that even though in improvisation there is a preference to reflect fine grained properties of the event in the structure of the utterance, this preference disappears when silent gesture is used for communicative interaction, reflecting a need for consistency in word order as a communicative system emerges.

# Presentations

Bibianna Bałaj (Nicolaus Copernicus University in Toruń)

# How to communicate mental images?

Communicating with the use of language is natural in the application. However, it seems to be a very complex process and the reception of the message often differs from the sender's intention. However, when it comes to imagination, sending and receiving a message is even more difficult. Not all of us can paint or express in words the visions that appear in our minds. The difficulty level increases when these visions are dynamic. Getting a one-to-one message about your ideas seems to be a miracle.

For years, scientists have been trying to determine if we actually create images in mind and how we do it. For a time, they were so skeptical that they considered the subjectivity of imagery an insurmountable problem and doubted the feasibility of researching this area. However, on the one hand, the ingenuity of researchers (e.g. Shepard & Metzler, 1971), on the other, the development of tools (Gardony et al., 2017; Slotnick et al.,2005), turned out to be of help. In many aspects, the analogy of the processes of perception and imagery opened up a new way of getting to know this hidden part of our mind. Brain imaging techniques have shown how many similarities there are but also revealed fascinating differences (Dentico et al., 2014). The measurement of eye movements (the only moving part of the brain) also indicates the mental operations' course, stages, and strategies (Xue et al., 2017).

**Literature**

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Maria Bancerek (University of Warsaw)

# Domain-specific text generation

Text generation with language models is a crucial aspect of Artificial Intelligence. Fine-tuning a GTP-2 model enables us to design models that are sensitive to the generation context and exhibit high fluency in the task. Moreover, the fluency control measures enable us to reduce the fluency bias experienced by GTP-2 models. Natural language generation (NLG) tasks demand large amounts of highly descriptive texts, which requires a large amount of computational power, as well as high complexity to run. Specific datasets are often complex and the task of automatically generating end--to-end fluent utterances for a wide range of tasks is immense. Analyses on NLG data are useful for understanding the neural architecture of models and for evaluating the performance of encoders. Text evaluation for NLG systems has been extensively studied and evaluated. I discuss the shortcomings of NLG evaluation and highlight proposed solutions to these challenges.

**Literature**

Evani Radiya-Dixit, Xin Wang How fine can fine-tuning be? Learning efficient language models, Proceedings of the Twenty Third International Conference on Artificial Intelligence and Statistics, PMLR 108:2435-2443, 2020

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Anna Boros (University of Warsaw)

# Exaplainable AI paired with qualitative analysis – outcomes for effective climate communication

As the most advanced species when it comes to both polluting the planet and reflecting upon it, humans produce vast amounts of carbon dioxide and numerous texts.

Recent popularity of social media facilitates presenting them to broader audiences. My analysis concerns over 300 000 articles published on Facebook profiles of English-language press with EU, UK and Russian origin. Climate-related articles were extracted by topic modelling(Blei i in., 2003) and inter-divided into subtopics. Information on likes, comments and shares were recorded and used as dependent variables to model various attributes' impact on interactivity of content. With use of optimized random forest models, accuracy of around 75% on the validation set was reached when predicting engagement with the post. Explainable AI techniques were employed to unveil the mechanisms behind influence exempted by specific attributes. Additionally, qualitative methods were used to enrich analysis and compare the 100 most and least successful posts. During the analysis questions on climate change communication consistency and evolution as well as ways of portraying energy sources were raised and answered to the extent data allows.

After site popularity (quantified with number of observers), lexical features take prominent place in predicting interactivity of content. Raising particular topics and enhancing readability of the text might be the second most important factor for creating engaging climate-related contents. Importance of predictors differs when comparing forms of engagement expression (likes, comments and shares) generally confirming existing psychological theories on main drivers of those behaviours(Kim & Yang, 2017). However, causal relations should only be hypothesized with caution.

Lack of consistency in climate change communication policies is exemplified with The Guardian failing to follow own recommendations. Many uncertainty markers which might fuel the climate change denialism are discovered in the qualitative analysis within most interactive contents.

**Literature**

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Zofia Cieślińska (University of Warsaw)

# Online communication and psychological crises

As larger and larger parts of our lives are taking place in online spaces, a need emerges to detect psychological problems and provide help also in the virtual world, using different communication tools – which requires a multidisciplinary cooperation between specialists in vastly different fields of expertise. Not only toxic or alarming trends in one's communication can be detected by natural language processing specialists, but a well-designed way to approach a person in a crisis is also needed. A perfectly user-friendly and engaging app is not useful unless its meritorical content is reviewed by psychologists and its influence is confirmed experimentally.

In my presentation I will go through the main ways of dealing with this situation, as well as the difficulties encountered in the existing and potential tools.

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Krystian Dereziński (Nicolaus Copernicus University in Toruń)

# In search of new methods to predict the progression of cognitive impairment based on neural activity

Mild Cognitive Impairment (MCI) and dementia are problems of old age that are associated with irreversible changes in the cognitive sphere, and the only form of prevention is an early diagnosis and a possibly associated with it behavioral therapy. Cognitive disorders can manifest themselves in various domains of cognition – including language functions. The current situation, in which the increasing life expectancy and the growing demographic decline, causes the society to increasingly become a society of older people, which means that the problem discussed here will concern a rising part of the population and its consequences will have an impact on the socio-economic condition of entire nations.

The scientific goal of the project is to develop techniques allowing early prediction and monitoring of Mild Cognitive Impairment's (MCI) progression. Based on the characteristics of the neural signal, we are planning to collect measurements during the resting state and performance in a behavioral task from the subjects while acquiring the signal using an electroencephalograph (EEG).

Finding the characteristic biomarkers for MCI is a modern and interdisciplinary approach involving the latest machine learning models and signal analysis, capturing individual differences in cognitive functions in relation to existing classification methods. Pathological changes in dementia or Alzheimer's disease have also been found to begin many years before the onset of cognitive decline and clinical diagnosis of dementia. Thus, there is an urgent need to identify disease in the early clinical stages such as MCI. Referring to physiological measurements, we would like to find specific markers in their characteristics that may help diagnosing and tracking disease progress or response to therapy. The planned use of artificial intelligence will also provide us with the possibility of early diagnosis of cognitive deficits and their subsequent monitoring. Our project can help older people to identify upcoming language problems in advance

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Agnieszka Dębska (Nencki Institute of Experimental Biology)

# The neural basis of the multimodal integration in the reading acquisition

The region of the left ventral occipitotemporal cortex (VOTc) encompassing Visual Word Form Area is considered to host orthographic representations of words. Even though this area was studied in visual word processing, there is evidence of multimodal engagement of the left VOTc in spoken language. It is supposed to facilitate the integration of phonology and orthography needed for an effective decoding skill crucial for reading acquisition.

To investigate the development of the left VOTc involvement in spoken language processing and its relations to the lexical and sublexical reading ability we tested 60 Polish beginning readers (6-7.3 y.o., 35 boys). In fMRI tasks children had to decide whether two auditory words or pseudowords start with the same sound (phoneme matching), if they rhyme (rhyming) or if they are identical (word matching).

We found that the reading skill was positively associated with accuracy in the phoneme matching task. On the neural level we found a posterior (but not anterior) VOTc effect related to phoneme matching of pseudowords (but not words): the activity of the posterior VOTc in the phoneme matching task was positively correlated with the word and pseudoword reading level. Moreover, in the same task, whole-brain analysis showed a significant correlation between the activity of the left lingual gyrus and the pseudoword reading level.

We showed that the effective acquisition of reading at the beginning of literacy instruction enhances orthography and phonology integration mostly on the sub-lexical level. Our results imply that better reading skills are associated with the integration of orthographic representations of letters and the phonological processing of single phonemes. Since children were still on the alphabetic (sub-lexical) stage of reading, we did not observe evidence for the VOTc engagement in processing whole-word (lexical) representations, which can be expected when children move to the orthographic stage.

**Literature**

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Krzysztof Główka (University of Warsaw)

# Ecologising the referential model of language emergence: agentivity and the protocol's ecological value

Some lines of research in language sciences have abandoned the divide between the information-processing approaches to language and the dynamics of processes spanning the cognitive system and the environment. This shift, as yet, has not been strongly reflected in the computational models of language emergence, which often share the underlying assumption that the dynamics of the simulated agent can be abstracted away. I will present an attempt to transfer those developments to the realm of modelling by extending the classical referential model of language emergence; first, towards dynamics including agent's agentive navigation across the available items; second, towards ecological value by an investigation into how the agent's fitness unfolds in time with respect to the properties of the communication protocol.

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Borys Jastrzębski (University of Warsaw)

# Protophones in the coregulation of human and non-human dyads: a study design

One of the great gaps in our understanding of how language emerges on multiple timescales is the question of how the first meanings are attached to conventional signs, i.e. symbols. In order to better model it in the evolutionary perspective, we need more evidence about this transition from early development and infants' interactions with their caregivers. Protophone vocalization is an especially promising stage to study due to its experimental character and an early structure of the vocalizations.

Protophones remain an understudied phase of infant vocalization since their introduction into language emergence research by Oller et al. (2000, 2005). The baseline data was gathered in human infants (Oller et al. 2013) and first interspecies comparison studies found interesting differences in patterns of dyadic communication at this stage (Oller et al. 2019). However, no study to date addressed the role of protophones in symbol grounding and semiosis in general.

In my talk, I will discuss a study design meant to fill this research gap with particular focus on the connection between protophone production, attention guiding and early symbolic relations emerging in child-caregiver interactions.

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Agata Kochańska (University of Warsaw)

# A note on the grammar of interpersonal distance in Polish

The paper is devoted to an analysis of selected uses of Polish distance--regulating structures in direct directive constructions employed in a specific type of context, that is, in interactions between members of the personnel and patients of a nursing home for physically and mentally disabled people. An illustrative example of utterances under analysis is offered in (1) below:

(1) Pokaż, pani Alu. (the nurse is looking for a PVC on Ms. Alicja's hand).
Show 2 SG. PERF. IMP. Ms. Ala DIM. VOC.

Zjadać, pani Alu.
Eat INF. Ms. Ala DIM. VOC.

'Show [this to me], Ms. Ala. Eat [some more], Ms. Ala.'

The utterances under consideration do not seem to be fully standard in Polish at large, as they employ apparently incompatible combinations of distance-maintaining address forms (such as pani Alu 'Ms. AlaDIM. VOC.') with the distance-reducing 2 SG. imperative construction, as well as combinations of structures involving explicit reference to the hearer (the 2 SG. imperative construction, address forms) with structures in which reference to the hearer is made only implicitly (the directive infinitive construction).

A characteristic property of the specific context under consideration is that in a context of this kind factors shaping the speaker-hearer distance regulation may easily be in conflict with one another. In the paper, it will be argued that the non-standard combinations under consideration are a means of flexibly responding, via the use of conventionalized linguistic resources, to the specific pressures of the contextual niche in which the combinations under analysis are used, including the conflicting factors pertaining to distance-regulation.

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Tomasz Korbak (University of Sussex)

# Imposing symbolic constraints on large language models

Large language models, such as GPT-3, were recently found to be able to generate natural language text of unprecedented fluency. Similarly, when trained on large corpora of source code, language models can provide uncannily thoughtful code completions. However, their training objective – predicting the next word in a sequence – overlooks important global features that are present in the training data such as syntactic correctness or compilability of a piece of code. In this talk, I'll present recent work done with my colleagues on fine-tuning large language models to generate compilable Python code. We pose generating compilable code as a constraint satisfaction problem, defining an Energy-Based Model (EBM) representing a pre-trained language model with an imposed constraint of generating only compilable sequences. We use the distributional policy gradients algorithm to train a new language model approximating the EBM. Unlike standard reinforcement learning, this approach improves compilability rate without sacrificing diversity or complexity of generated samples. Our results illustrate the potential of using EBMs as a way of injecting our structured, symbolic knowledge into large language models without breaking them down or sacrificing their uncanny abilities.

**Literature**

Tomasz Korbak, Hady Elsahar, Marc Dymetman, Germán Kruszewski. Energy-Based Models for Code Generation under Compilability Constraints. 1st Workshop on Natural Language Processing for Programming, ACL 2021

Mateusz Kostecki (Nencki Institute of Experimental Biology)

# At the beginning there was learning – on the canalization of behaviour

The idea of scala naturae – according to which living organisms form a hierarchical structure, with humans as a pinnacle of creation – is a textbook example of a concept overturned by the formulation of the theory of evolution. But while it is condemned in every text regarding evolution of species, this hierarchical way of thinking about the living world in general and animals in particular is still deeply ingrained in the way people think about animal behaviour.

It is often assumed that the behaviour of “lower” animals is mostly simple, stereotypic and instinctive and more flexible and learned behaviours evolved only later - evolution thus progression from instincts to flexibility. The same hierarchical way of thinking is visible in the way vertebrate brain is described – with “lower” brain regions, like hypothalamus, governing instinctive behaviours (like mating or fighting) and higher cognitive centers in cortex responsible for more flexible forms of behaviour.

While this view aligns with our intuitive view of evolution, we have now enough data on the evolution of behaviour to question its validity. Plasticity is a core property of the nervous system (and probably of the cell in general) and was present from its beginning. Flexible, adaptive behaviours can be observed in all animal taxa and a big part of invertebrates’ behavioural repertoire is learned – even in behaviours that are fundamental to survival. What is more, vertebrate brain do not form a hierarchy of structures, and even behaviours such as drinking or mating rely on learned mechanisms.

The goal of my presentation is to show that learned and flexible behaviours were present in animal evolution from the beginning and that instead of thinking how instincts evolved into more plastic forms, we should ask ourselves a question why some aspects of behaviour were canalized during the evolution and why others remained flexible. I will use bird’s behaviour as an example of a behavioural system in which learned and canalized aspects coexist and change in different species depending on environmental needs.

I will also consider what are the mechanisms that could allow for the canalization of behaviour, with the Baldwin effect being the most important of them.

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Agnieszka Kulesza (University of Warsaw, Nencki Institute)

# Longitudinal neuroimaging study on Tactile Braille Learning: insights from the implicit perception

Large language models, such as GPT-3, were recently found to be able to generate natural language text of unprecedented fluency. Similarly, when trained on large corpora of source code, language models can provide uncannily thoughtful code completions. However, their training objective – predicting the next word in a sequence – overlooks important global features that are present in the training data such as syntactic correctness or compilability of a piece of code. In this talk, I'll present recent work done with my colleagues on fine-tuning large language models to generate compilable Python code. We pose generating compilable code as a constraint satisfaction problem, defining an Energy-Based Model (EBM) representing a pre-trained language model with an imposed constraint of generating only compilable sequences. We use the distributional policy gradients algorithm to train a new language model approximating the EBM. Unlike standard reinforcement learning, this approach improves compilability rate without sacrificing diversity or complexity of generated samples. Our results illustrate the potential of using EBMs as a way of injecting our structured, symbolic knowledge into large language models without breaking them down or sacrificing their uncanny abilities.

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Ľudmila Lacková, Tyler Bennett (Palacký University in Olomouc)

# Proteins as minimal agents for modeling AI

Alongside the challenge to create artificial intelligent life there is a need to distinguish the living from the non-living, particularly in online communication, as bots and automated messaging systems become more sophisticated. It is already known that high processing power is not sufficient for the creation of life, but the minimal features of life remain ambiguous. The position of biosemiotics is that the minimal conditions for the emergence of life coincide with those of the sign, including code duality (Hoffmeyer 1993) and logical incompatibility (Kull 2015): even the simplest organism is a reader and interpreter in a more than metaphorical sense. In the first part of the presentation, these ideas from biosemiotics will be given a brief summary. We live in a post-genomic era in biology, but in their understanding of life and evolution the humanities remain where genetic research stopped in the 1970s. It is still common to hear statements like: it is written in his DNA, etc. What is neglected is that DNA is only a storage place of instructions for protein manufacturing. Genetic texts are only scripts which have to be interpreted, and in contrast to DNA, proteins are analog and not digital (Markoš 2002). Many factors influence how the genetic script is interpreted (Markoš-Švorcová 2019). With the presupposition that intelligence is originally a biological phenomena, but not strictly located in the brain, we propose to study AI on the basis of the smallest biological agents, which are proteins, and the language metaphor of life (DNA as language) should be expanded to include semantics/pragmatics when it comes to protein folding (Lacková-Faltýnek 2021). In the second part of the presentation, protein-as-agent and the language metaphor of life will be given fuller explanation. In general, the injection of concepts from biosemiotics to this discussion does not presume to challenge computational approaches to artificial intelligence, but only to steer them away from outdated mechanistic models of life. We hope that the benefit of this theorization for the 10th Peripatetic Conference will be that, if simple forms of life are understood with proper depth, this new comprehension of what makes them alive can furnish basic criteria for identifying bots and other primitive AIs online, if not also help generate instructions for creating genuine AIs some time in the future.

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Robert Mirski (Nicolaus Copernicus University, Catholic University of Lublin)

# Action-based vs. cognitivist approaches to enculturated social cognition

In this paper, I will sketch out the action-based (interactivist) model of social cognition, highlight the place of language in it, and contrast the view with the cognitivist Theory of Mind tradition dominant in current research on social cognition. Interactivism models cognition as anticipation of potential interaction with the world (anticipatory processes and the relationships between them constitute mental content due to their implicit presuppositions about features of the world). Social cognition is a special case of such anticipatory knowing that interacts with what is termed situation convention: the interpersonal situation that is constituted jointly by the interacting agents' compatible anticipations. Language is modeled as a system that interacts with situation convention in a productive manner: Utterances have the function of systematic and detailed modulation of the situation convention occurring between the interacting agents' minds. Thus, representation of the possibilities of linguistic manipulation of social convention is a large part of what can be termed embodied or implicit social cognition. Explicit thought about other people (folk psychology) is modeled as a reflective convention that internally interacts with the already contentful implicit knowledge of how to interact with other people. The model contrasts starkly with the dominant Theory of Mind approaches to social cognition where (1) anticipation is the result of prior mental-state attribution (it is not intrinsic to cognition itself), (2) language is seen as a separate system that serves only as a source of information for the stipulated ToM mechanism, and (3) the relationship between implicit (unconscious) socio-cognitive mechanisms and explicit, folk psychological reflection is ambiguous (varies across particular approaches and in many cases remains unclear). Finally, I offer a quick review of the arguments for why the interactivist (or some similar anticipatory framework) is preferable over the ToM view.

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Subba Reddy Oota (Inria-Research, Bordeaux)

# Cross-Situational Learning: Sentence Parsing using Different Word Embeddings Towards Robot Grounding

How do children acquire language through unsupervised or noisy supervision? In particular, how do children understand homonyms in grounded language learning? We take this perspective to machine learning and robotics, where a part of the problem is to understand how language models can perform grounded language acquisition through noisy supervision. Prior works have either tracked the co-occurrence between word forms and referents (objects) to model how infants could learn or model word-referent mappings with repeated trails. In this study, we experiment with cross-situational learning (CSL) to understand the mechanism which enables children to learn one-to-one mappings between words and their meanings from full sentences in early word learning. Further, we investigate the CSL task on fewer training examples with three sequence-based models: (i) Echo State Networks (ESN), (ii) Long-Short Term Memory Networks (LSTM), and (iii) LSTM with Attention (LSTM_Attn). Most importantly, we explore the pretrained/fine-tuned BERT (contextual word embeddings) representations to perform the CSL task. We apply our approach to two datasets (Juven's and GoLD) and observe that (1) pretrained BERT representations are less efficient when compared to fine--tuned or one-hot encoding representations. (2) LSTM_Attn showcase higher performance by allowing the model to automatically look for parts of a sentence that are relevant to predict target concepts. (3) For increasingly large vocabularies, ESNs demonstrate better generalization than LSTM models. (4) Overall, even if trained with little data, these models are able to learn from scratch to link complex relations between words and their corresponding meaning concepts, handling polysemous and synonymous words. Importantly, this is done by giving full sentence input, not simple word utterances like in many CSL tasks. Further, such models are designed to be integrated into human-robot interaction studies on language grounding and help to understand children's developmental language acquisition.

Authors: Subba Reddy Oota, Frederic Alexandre, Xavier Hinaut

Wiktor Rorot (University of Warsaw)

# Compositionality in our heads, not in the world

Compositionality is undoubtedly an important feature of human language, responsible for its unbounded productivity. Studies of emergence of compositionality in communication almost uniformly make the assumption that it is, in fact, a hidden structural property of the world that gets approximated by a cognitive system during cognitive and communication events (this claim is explicitly formulated by e.g. Korbak, Zubek, and Rączaszek-Leonardi, 2020). Under this metaphysical assumption, it is natural to understand trivial and non-trivial compositionality (a distinction advanced by Steinert-Threlkeld, 2020) as picking out different natural kinds of relations in the world and so, to claim that identifying the sources of trivial compositionality does not give us any purchase on understanding the non-trivial version.

In my talk I would like to develop the following argument. We can in fact reject the initial assumption, namely that compositionality is a property of the world, and accept instead that it is a property imposed by the cognitive system on its perceptual and cognitive operations to reduce worldly complexity to a level more manageable for a finite being. This reduces the divide between the two types of compositionality and allows us to cast models of emergence of trivial compositionality as (false) models of emergence of the non-trivial variant. Under the model-based philosophy of science (see e.g. Cartwright, 1983; Wimsatt, 2007) false models play an important explanatory role. Following the approach proposed by Wimsatt, I will attempt to identify idealizations, heuristics, and misrepresentations that arise by viewing non--trvial compositionality through the lens of the trivial variant and will argue how to use this perspective for the development of a less false model of the emergence of compositionality. Finally, I will try to point out the implications of this view on the properties of cognitive systems required for compositionality to emerge.

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Ewa Sitarska (EMBL Heidelberg)

# Membrane patterning allows cellular adaptation upon interaction

Cellular movement is a hallmark out-of-equilibrium process in biology. In addition to persistent self-propelled motion [1,2,3], many cells display remarkable adaptive behaviors when they navigate complex environments and interact with inanimate objects or other cells [4,5]. To perform their function, many cells need to respond to changes in their surroundings in a timely and efficient manner. However, it is still not fully understood how they achieve it and what is the role of membrane patterning in this process. Combining theory and experiments, we find a membrane patterning mechanism underlying redirection of fast-moving cells upon interaction. We propose that the coupling between force-generating protein (actin) and cellular membrane dynamics leads to a mechanochemical instability that generates complex protrusive patterns at the cellular front. Adaptive motility thus arises from two simultaneous effects, the specific reduction of propulsion in regions where external objects deform the plasma membrane and the intrinsic patterning capacity due to the membrane-actin coupling that promotes spontaneous changes in the cell's protrusions. Our results show how cells utilize actin and plasma membrane biophysics to sense their environment, allowing them to adaptively decide if they should move ahead or turn away.

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Katarzyna Skowrońska (University of Warsaw)

# The pragmatic aspect of meaning in agent-based models of emergent communication

In linguistics there is a traditional division into the semantic aspect of meaning (what words mean out of context) and the pragmatic aspect (what speakers mean while using them in a particular situation). What can be concluded from applying this distinction to the communication systems that emerge in multi-agent simulations? In the vast majority of models the meaning of signals does not vary depending on the context – the simulation design entails that the optimal strategy for agents is to learn a stable and disambiguous one-to-one mapping from signals to objects or actions. This appears as a significant contrast with natural language units which are highly flexible and vague, and can convey different meanings relative to the speakers' and discourse history, current state of the environment and lexical context.

In this talk I will focus on two questions. First, to what extent the meaning of an utterance in natural language can be seen as a result of composition of the conventionalised, lexical meanings of its parts and to what extent it is determined by the non-linguistic context. There is no unified perspective on this issue in the literature on natural language. I will present briefly 1) the traditional view on the role of pragmatics within philosophy of language and linguistics; 2) the concept of the protean nature of the word meaning developed in cognitive linguistics; 3) and an information-theoretic argument demonstrating that in all efficient communication systems word meanings are ambiguous and context-dependent.

Second, I will discuss the implications for designing models of emergent communication and argue that current models inherit from the traditional linguistics the implicit assumption about the marginal role of pragmatics in meaning construction.

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Szymon Talaga (University of Warsaw)

# Effective information as a measure of complex coordination in informal communication networks

In complex systems such as societies or brains a significant degree of coordination between diverse elements is usually necessary for achieving their goals. In particular, human collaboration on complex tasks requires non-trivial patterns of communication. Frequently some parts of communication are organized within a formal framework (e.g. supervisor-subordinate relations within an organization) but others occur outside of such constraints. These kinds of informal communication are often instrumental for developing and maintaining cohesion and collective motivation necessary for effective group coordination. In particular, informal layers of communication are important in massive, volunteer-based collaborations without traditional financial incentives and associated command-and-control power structures.

In this presentation we argue that emergent coordination leaves a structural signature in communication networks which can be measured with information-theoretic methods. In particular, the interplay between local specialization and global integration of a network can be described and measured with a quantity known as effective information, which itself is motivated by seminal works of Edelman, Tononi and others on integrated information theory and structure of complex cognitive systems.

We first review and motivate the measure of effective information and discuss its connections to integrated information theory. We then show its practical utility based on an empirical study of hundreds of informal communication networks from a real-world complex system, that is, one of the largest volunteer-based collaborative efforts in human history which is Wikipedia. More concretely, we study the quality of output generated by groups of Wikipedia editors focused on specific topics known as Wikiprojects vis-à-vis the structure of networks of direct informal communication between the involved editors. We show that higher levels of effective information of the communication networks are associated with higher quality of curated articles.

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Krzysztof Tołpa (Nicolaus Copernicus University in Toruń)

# Multivariate multiscale sample entropy as a measure of complexity

Information theory defines the concept of entropy based on distribution of patterns which occur in the time series data. Regular signals with repetitive structures are characterized by low entropy values while unpredictable signals have high entropy. One of the methods used to quantify complexity in the biological systems is Sample Entropy. However, biological systems need to adapt to the dynamically changing environment. This fact is reflected in patterns on different temporal scales. Hence, the multiscale entropy (MSE) was introduced. Moreover, to account for multichannel correlated time-series data, the multivariate extension for MSE was developed.

The aim of the presentation will be to provide a general overview of MMSE analysis and show examples of its application with particular reference to EEG data.

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Natalia Valadzko (University of Warsaw)

# The interpretation of personal pronouns and dynamic meaning construction in tabletop role-playing games: a cognitive linguistic perspective

Using the self-compiled corpus of transcripts of recorded tabletop role--playing games and the framework of conceptual blending, this talk aims to explore the processes of the interpretation of personal pronouns and their "deictic shifts". Although the linguistic and literary scholars have long been interested in the interpretation of deixis, their main focus was the naturally occurring conversation or literary narratives. However, there is another medium that may present a challenge for description or analysis of deixis – tabletop role-playing games (TTRPGs). Due to the fact that TTRPGs are a combination of a narrative improvisation and a tabletop game, the participant has several roles: an individual, a player, a character. The "deictic shifts" (e.g., using "I" and "he"/"she" interchangeably to refer to the same entity) produce unique interaction instances that go beyond the conventions of natural language or literary narratives. Furthermore, character introductions, combat scenarios and flashbacks will be examined to illustrate how mental spaces – integral to the theory of conceptual blending – can be used as tools to facilitate the discussion of online meaning construction. The shifting of personal pronouns and spatial, temporal and epistemic dimensions further lead to the question of the role of multimodality. For example, gestures are examined to investigate their function as "anchors" to aid the shifting between mental spaces or as a way of visibly holding the floor for the character narration even while granting temporary interruption to the other participants of the discourse.

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Konrad Zieliński (University of Warsaw)

# Building intersubjective knowledge and inclusive narratives – together

Engaged empirical research conducted with, and co-led by, autistic (Williams 2020) or alaryngeal (Zieliński 2021) participants show that direct involvement of all people present in the particular interaction provides opportunities to study the situations in which truly "human knowing" manifests itself. "Take knowing what is going on with someone from seeing the way they lift their gaze, how to build workable cities, how to read, write, and listen. Take knowing how to make maple syrup, knowing how to tame a fox, how to make ideas felt in poetry, music, or dancing, or how to playfully move between experientially different worlds" (De Jaegher 2017). It is this concrete, risky, situated, and inherently ethical form of knowing (De Jaegher 2021) which is the most important and extremely interesting, also for me.

However, for some time I have been struggling with the question: HOW to build knowledge about laryngectomy experience in a way which would be inclusive, participatory and strive for the values I believe in as a person and as a researcher (e.g. justice, well-being, scientific rigour, richness of data, preserving real phenomena). The dominant narratives in the research on laryngectomy are developed by doctors and engineers (I refer to it as "biophysical perspective") and therefore lack the lived experience perspective of alaryngeal individuals. I claim that incorporation of embodied knowledge of larynx amputees – people directly involved in communicative situations in which at least one person is missing an organ responsible for voiced speech – could be beneficial for mainstream science.

I wish to discuss with you my preliminary ideas to tackle the aforementioned problem: 1) text, image or video-mediated narratives (see e.g. the use of ethnographic creative non-fiction by Williams, 2020), 2) teaching practical skills utilizing our bodily incorporeality to evoke directed evolution of embodied knowledge (see e.g. interpretation of sailors' behaviour by McLaren, 2002). 3) participatory workshop form of interaction investigation (see e.g. PRISMA framework, De Jaegher et al., 2017).

I am also open to discussing other ways of building intersubjective knowledge together and possible directions of work towards inclusive, participatory narratives on laryngectomy and other issues sharing similar methodological difficulties.

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Zieliński Konrad 2021, Integrating perspectives on perturbed communication: a case study of two alaryngeal speakers and their interactions, Master Thesis, University of Warsaw.

Karolina Ziembowicz (The Maria Grzegorzewska University)

# Interaction frame – intermittent context that determines local relationships between events in social interaction

Quantitative research on social interaction shows a wealth of statistically significant findings on how various interaction settings determine the probability of a studied behavior. However, studies of human communication, both qualitative and quantitative, indicate that events in interaction usually are not distributed randomly, but rather in bursts of similar activity. Thus, indexes such as “laughter per minute” or „participation rate” do not capture the sense of what is going on in the interaction.

In this presentation I argue that another layer of analysis is needed to capture sequential organization of events in social interaction. I build up on the concept which has been referred to in many ways – interaction frame (Goffman, 1974), sequential environment (Gibson, 2008), ephemeral emergent (Sawyer, 2005), conversation topic (Angus et al., 2013), or floor (Hayashi, 1991). I argue that this co-acknowledged „what’s going on here” (Goffman, 1974) serves as an intermittent context structuring the ongoings of a social interaction. I start a review of how „interaction frame” has been conceptualized in literature and end up with a sketch of own methodology of the multilevel analysis of the interaction flow.

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Julian Zubek, Joanna Rączaszek-Leonardi (University of Warsaw)

# Computational models of language emergence – what is still missing?

Last 10 years have seen a proliferation of computational models of language emergence (Lazaridou & Baroni, 2020). Despite their variety (in concerns and architectures) they still seem to cling to several key assumptions about the communication process. We try to identify those among the assumptions which may hinder progress and point to possible ways to substitute them with less-limiting ones. We discuss three key issues.

First, in the existing models environments tend to be extremely simplified, often reduced to a set of static stimuli presented to a passive agent. Agent's actions are limited to choosing the target stimulus from the set of distractors. There is no structure of agent's actions which could guide the structure of emerging communication.

Second, the function of communication is often limited to describing the properties of the environment. The communication is unidirectional: there are distinguished roles of speaker and listener. What is missing is the interactivity: there is no recognition that interaction itself is a meaning-making process (De Jaegher & Di Paolo, 2007). Communication can be about (regulating) the interaction, rather than about prespecified "meanings".

Third, signals are often cast as amodal, discrete symbols devoid of any physical properties. Signals are not a part of the environment in a meaningful way. Existence of discrete symbols with replicable form is presupposed rather than explained (Rączaszek-Leonardi, 2012). Such symbols can be composed in an arbitrary manner and assigned meanings equally arbitrary. There are no external constraints to guide their interpretation

Under such assumptions, the meaning of signals is reduced to static mapping from symbols to concepts. We propose to move away from this simplification, and orient towards dynamic and pragmatic aspects of communication. We discuss how this reorientation helps to conceptualize new models of language emergence.

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