Signaling under uncertainty
Brochhagen, T.S.

Citation for published version (APA):

General rights
It is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), other than for strictly personal, individual use, unless the work is under an open content license (like Creative Commons).

Disclaimer/Complaints regulations
If you believe that digital publication of certain material infringes any of your rights or (privacy) interests, please let the Library know, stating your reasons. In case of a legitimate complaint, the Library will make the material inaccessible and/or remove it from the website. Please Ask the Library: http://uba.uva.nl/en/contact, or a letter to: Library of the University of Amsterdam, Secretariat, Singel 425, 1012 WP Amsterdam, The Netherlands. You will be contacted as soon as possible.


Thomas Brochhagen, Michael Franke, and Robert van Rooij. Co-evolution of lexical meaning and pragmatic use, manuscript.


Steven T. Piantadosi, Joshua B. Tenenbaum, and Noah D. Goodman. Modeling the acquisition of quantifier semantics: a case study in function word learnability, under review.


Wat wordt overgebracht gaat vaak verder dan wat er wordt gezegd. In plaats van het te vermijden, floreert alledaagse communicatie in het impliciete; in het onuitgesprokene; in het contextueel bepaalde. Dit onderzoek concentreert zich op deze kwestie door te vragen waarom, en onder welke voorwaarden, taal(gebruik) het onuitgesprokene ter hand neemt terwijl de zaken ook explicieter overgebracht hadden kunnen worden. Preciezer gezegd proberen we op een fundamenteel niveau te begrijpen waarom het werk verdeeld wordt tussen semantiek en pragmatiek. Dit doen we door te kijken naar de voorwaarden waaronder eigenschappen die van deze werkverdeling gebruik maken voortkomen. We analyseren deze voorwaarden door speltheoretische modellen van rationeel taalgebruik, *reinforcement learning*, (geîtereerd) Bayesiaans leren, en populatiedynamiek zoals de replicaerder-muteerderdynamiek op nieuwe manieren te combineren.

Onze analyse traceert taalverandering zowel op het niveau van geîtereerde interacties als op het populatieniveau. Beide niveaus brengen hun eigen perspectief mee en schijnen daarmee hun eigen licht op een gegeven eigenschap van taal. Dit maakt het mogelijk om verschillende, doch verweven, antwoorden op vragen zoals waarom alledaagse communicatie doorspekt is met semantische ambiguïteit; onder welke voorwaarden pragmatische inferenties mogelijk (niet) lexicalizeren; en, meer algemeen, wat voor werkverdelingen tussen semantiek en pragmatiek we kunnen verwachten voort te zien komen uit het krachtenveld en omgevingsfactoren die taal vormgeven te verkennen.

Op het niveau van geîtereerde interacties, analyseren we het opzettelijk gebruik van ambigue uitdrukkingen in dialoog. Aan de hand van eerdere verklaringen van ambiguité beargumenteren we dat context een belangrijke rol speelt in het mogelijk maken van de risicoloze uitbuiting van ambiguité. We slaan echter wat gaten in deze uitleg door de aanname dat dialoogpartners toegang hebben tot dezelfde contextuele informatie te betwijfelen en uiteindelijk op te geven. Deze kwestie ontvouwt zich in een grotere, waar het samenspel tussen context, de gesprekspartners’ subjectieve contextuele verwachtingen, en hun opvattingen
over elkaars verwachtingen een belangrijke rol spelen. We beredeneren dat de gezamenlijke uitkomst van deze factoren de voorwaarden bepaalt waaronder een functioneel voordeel voor ambiguïteit kristaliseert. Om deze ideeën tastbaar te maken stellen we een model van rationeel taalgebruik voor en koppelen het model aan simpele adaptieve dynamieken. We laten zien dat het model empirisch onderbouwde patronen van ambigu taalgebruik met succes voorspelt.

Op het populatieniveau staan eigenschappen emergent aan interacties aan de semantiek-pragmatiek interface voor uitdagingen die niet alleen taalgebruik, maar ook hun getrouwe overdracht over generaties omvatten. Nog semantiek nog pragmatiek zijn direct observeerbaar. In plaats daarvan zien leerlingen alleen het gedrag waarin de combinatie van semantiek en pragmatiek resulteert. Dit levert een probleem op omdat verschillende combinaties kunnen resulteren in (bijna) niet te onderscheiden zichtbare gedrag. In precieze zin vragen we wanneer en waarom reguliere pragmatische inferenties wel (of niet) lexicalizeren, en wanneer semantische onderspecificatie ofwel wordt behouden ofwel plaatsmaakt voor precieze uitdrukkingen. Om deze vragen aan te pakken formuleren we een model van de (co)evolutie van semantiek en pragmatiek. Het model houdt de effecten bij van functionele druk richting efficiënte informatieoverdracht en de effecten van druk richting leerbaarheid op zowel aparte als gecombineerde evolutionaire trajecten. We combineren dit model met modellen van pragmatisch taalgebruik op het niveau van het individu en dompelen het model onder in verschillende taalgebruik- en leeromgevingen.
Abstract

What is conveyed often goes beyond what is said. Rather than avoiding it, natural communication seems to thrive in the implicit; in the unsaid; in the contextually determined. This investigation centers around this issue by asking why and under which conditions language (use) may come to leverage or accommodate the unsaid when matters could be conveyed more explicitly. More precisely, at a fundamental level, we seek to better understand why there is a division of labor between semantics and pragmatics. We do so by looking at the conditions under which properties that draw from this division arise, which we analyze by combining, in novel ways, game-theoretic models of rational language use, reinforcement learning, (iterated) Bayesian learning, and population dynamics such as the replicator-mutator dynamic.

Our analysis traces linguistic change at the level of iterated interactions as well as at that of populations. Both levels come with their own perspective and thereby shed their own light on a given linguistic property. This allows us to explore different yet connected answers to questions such as why natural communication is rife with semantic ambiguity; under which conditions systematic pragmatic inferences may (fail to) lexicalize; and, more generally, what kinds of divisions of labor between semantics and pragmatics we can expect to arise from pressures and environmental factors that shape language.

At the level of iterated interactions, we analyze the deliberate use of ambiguous expressions in dialog. With previous explanations of ambiguity, we argue that context plays an important role in allowing for the safe exploitation of ambiguity. However, we inject some wrinkles into this explanation by calling into question and giving up the assumption that interlocutors have access to the same contextual information. This issue unravels into a larger one, where the interplay between context, interlocutors’ subjective contextual expectations, and their beliefs about each other’s expectations play an important role. We argue that the joint outcome of these factors determines the conditions under which a functional advantage for ambiguity crystallizes. We propose a model of rational language
use and couple it with simple adaptive dynamics to capture these ideas, and show that it succeeds in predicting empirically attested patterns of ambiguous language use.

At the population level, properties that draw from interactions at the semantics-pragmatics interface face challenges not only in language use, but also in their faithful transmission across generations. Neither semantics nor pragmatics are directly observable. Learners instead only witness the behavior in which their combination results. This raises an issue because different divisions could result in (almost) indistinguishable overt linguistic behavior. More precisely, we ask why and when regular pragmatic inferences do (not) lexicalize, and when semantic underspecification is either maintained or gives way to more precise expressions. To address these questions, we formulate a model of the (co-)evolution of semantics and pragmatics. This model tracks the effects of functional pressure toward efficient information transfer and the effects of pressure for learnability on separate as well as on combined evolutionary trajectories. We combine this model with individual-level models of pragmatic language use, and couch it in different environments of language use and learning.
Titles in the ILLC Dissertation Series:

ILLC DS-2009-01: Jakub Szymanik
Quantifiers in TIME and SPACE. Computational Complexity of Generalized Quantifiers in Natural Language

ILLC DS-2009-02: Hartmut Fitz
Neural Syntax

ILLC DS-2009-03: Brian Thomas Semmes
A Game for the Borel Functions

ILLC DS-2009-04: Sara L. Uckelman
Modalities in Medieval Logic

ILLC DS-2009-05: Andreas Witzel
Knowledge and Games: Theory and Implementation

ILLC DS-2009-06: Chantal Bax
Subjectivity after Wittgenstein. Wittgenstein’s embodied and embedded subject and the debate about the death of man.

ILLC DS-2009-07: Kata Balogh
Theme with Variations. A Context-based Analysis of Focus

ILLC DS-2009-08: Tomohiro Hoshi
Epistemic Dynamics and Protocol Information

ILLC DS-2009-09: Olivia Ladinig
Temporal expectations and their violations

ILLC DS-2009-10: Tikitu de Jager
“Now that you mention it, I wonder...”: Awareness, Attention, Assumption

ILLC DS-2009-11: Michael Franke
Signal to Act: Game Theory in Pragmatics

ILLC DS-2009-12: Joel Uckelman
More Than the Sum of Its Parts: Compact Preference Representation Over Combinatorial Domains

ILLC DS-2009-13: Stefan Bold
Cardinals as Ultrapowers. A Canonical Measure Analysis under the Axiom of Determinacy.

ILLC DS-2010-01: Reut Tsarfaty
Relational-Realizational Parsing
ILLC DS-2010-02: Jonathan Zvesper
   Playing with Information

ILLC DS-2010-03: Cédric Dégremont
   The Temporal Mind. Observations on the logic of belief change in interactive systems

ILLC DS-2010-04: Daisuke Ikegami
   Games in Set Theory and Logic

ILLC DS-2010-05: Jarmo Kontinen
   Coherence and Complexity in Fragments of Dependence Logic

ILLC DS-2010-06: Yanjing Wang
   Epistemic Modelling and Protocol Dynamics

ILLC DS-2010-07: Marc Staudacher
   Use theories of meaning between conventions and social norms

ILLC DS-2010-08: Amélie Gheerbrant
   Fixed-Point Logics on Trees

ILLC DS-2010-09: Gaëlle Fontaine
   Modal Fixpoint Logic: Some Model Theoretic Questions

ILLC DS-2010-10: Jacob Vosmaer
   Logic, Algebra and Topology. Investigations into canonical extensions, duality theory and point-free topology.

ILLC DS-2010-11: Nina Gierasimczuk
   Knowing One’s Limits. Logical Analysis of Inductive Inference

ILLC DS-2010-12: Martin Mose Bentzen
   Stit, Iit, and Deontic Logic for Action Types

ILLC DS-2011-01: Wouter M. Koolen
   Combining Strategies Efficiently: High-Quality Decisions from Conflicting Advice

ILLC DS-2011-02: Fernando Raymundo Velazquez-Quesada
   Small steps in dynamics of information

ILLC DS-2011-03: Marijn Koolen
   The Meaning of Structure: the Value of Link Evidence for Information Retrieval

ILLC DS-2011-04: Junte Zhang
   System Evaluation of Archival Description and Access
ILLC DS-2011-05: **Lauri Keskinen**  
*Characterizing All Models in Infinite Cardinalities*

ILLC DS-2011-06: **Rianne Kaptein**  
*Effective Focused Retrieval by Exploiting Query Context and Document Structure*

ILLC DS-2011-07: **Jop Briët**  
*Grothendieck Inequalities, Nonlocal Games and Optimization*

ILLC DS-2011-08: **Stefan Minica**  
*Dynamic Logic of Questions*

ILLC DS-2011-09: **Raul Andres Leal**  
*Modalities Through the Looking Glass: A study on coalgebraic modal logic and their applications*

ILLC DS-2011-10: **Lena Kurzen**  
*Complexity in Interaction*

ILLC DS-2011-11: **Gideon Borensztajn**  
*The neural basis of structure in language*

ILLC DS-2012-01: **Federico Sangati**  
*Decomposing and Regenerating Syntactic Trees*

ILLC DS-2012-02: **Markos Mylonakis**  
*Learning the Latent Structure of Translation*

ILLC DS-2012-03: **Edgar José Andrade Lotero**  
*Models of Language: Towards a practice-based account of information in natural language*

ILLC DS-2012-04: **Yurii Khomskii**  
*Regularity Properties and Definability in the Real Number Continuum: idealized forcing, polarized partitions, Hausdorff gaps and mad families in the projective hierarchy.*

ILLC DS-2012-05: **David García Soriano**  
*Query-Efficient Computation in Property Testing and Learning Theory*

ILLC DS-2012-06: **Dimitris Gakis**  
*Contextual Metaphilosophy - The Case of Wittgenstein*

ILLC DS-2012-07: **Pietro Galliani**  
*The Dynamics of Imperfect Information*
ILLC DS-2012-08: **Umberto Grandi**

*Binary Aggregation with Integrity Constraints*

ILLC DS-2012-09: **Wesley Halcrow Holliday**

*Knowing What Follows: Epistemic Closure and Epistemic Logic*

ILLC DS-2012-10: **Jeremy Meyers**

*Locations, Bodies, and Sets: A model theoretic investigation into nominalistic mereologies*

ILLC DS-2012-11: **Floor Sietsma**

*Logics of Communication and Knowledge*

ILLC DS-2012-12: **Joris Dormans**

*Engineering emergence: applied theory for game design*

ILLC DS-2013-01: **Simon Pauw**

*Size Matters: Grounding Quantifiers in Spatial Perception*

ILLC DS-2013-02: **Virginie Fiutek**

*Playing with Knowledge and Belief*

ILLC DS-2013-03: **Giannicola Scarpa**

*Quantum entanglement in non-local games, graph parameters and zero-error information theory*

ILLC DS-2014-01: **Machiel Keestra**

*Sculpting the Space of Actions. Explaining Human Action by Integrating Intentions and Mechanisms*

ILLC DS-2014-02: **Thomas Icard**

*The Algorithmic Mind: A Study of Inference in Action*

ILLC DS-2014-03: **Harald A. Bastiaanse**

*Very, Many, Small, Penguins*

ILLC DS-2014-04: **Ben Rodenhäuser**

*A Matter of Trust: Dynamic Attitudes in Epistemic Logic*

ILLC DS-2015-01: **María Inés Crespo**

*Affecting Meaning. Subjectivity and evaluativity in gradable adjectives.***

ILLC DS-2015-02: **Mathias Winther Madsen**

*The Kid, the Clerk, and the Gambler - Critical Studies in Statistics and Cognitive Science*
ILLC DS-2015-03: Shengyang Zhong
Orthogonality and Quantum Geometry: Towards a Relational Reconstruction of Quantum Theory

ILLC DS-2015-04: Sumit Sourabh
Correspondence and Canonicity in Non-Classical Logic

ILLC DS-2015-05: Facundo Carreiro
Fragments of Fixpoint Logics: Automata and Expressiveness

ILLC DS-2016-01: Ivano A. Ciardelli
Questions in Logic

ILLC DS-2016-02: Zoé Christoff
Dynamic Logics of Networks: Information Flow and the Spread of Opinion

ILLC DS-2016-03: Fleur Leonie Bouwer
What do we need to hear a beat? The influence of attention, musical abilities, and accents on the perception of metrical rhythm

ILLC DS-2016-04: Johannes Marti
Interpreting Linguistic Behavior with Possible World Models

ILLC DS-2016-05: Phong Lê
Learning Vector Representations for Sentences - The Recursive Deep Learning Approach

ILLC DS-2016-06: Gideon Maillette de Buy Wenniger
Aligning the Foundations of Hierarchical Statistical Machine Translation

ILLC DS-2016-07: Andreas van Cranenburgh
Rich Statistical Parsing and Literary Language

ILLC DS-2016-08: Florian Speelman
Position-based Quantum Cryptography and Catalytic Computation

ILLC DS-2016-09: Teresa Piovesan
Quantum entanglement: insights via graph parameters and conic optimization

ILLC DS-2016-10: Paula Henk
Nonstandard Provability for Peano Arithmetic. A Modal Perspective

ILLC DS-2017-01: Paolo Galeazzi
Play Without Regret

ILLC DS-2017-02: Riccardo Pinosio
The Logic of Kant’s Temporal Continuum
ILLC DS-2017-03: Matthijs Westera  
Exhaustivity and intonation: a unified theory

ILLC DS-2017-04: Giovanni Cinà  
Categories for the working modal logician

ILLC DS-2017-05: Shane Noah Steinert-Threlkeld  
Communication and Computation: New Questions About Compositionality

ILLC DS-2017-06: Peter Hawke  
The Problem of Epistemic Relevance

ILLC DS-2017-07: Aybüke Ö zgün  
Evidence in Epistemic Logic: A Topological Perspective

ILLC DS-2017-08: Raquel Garrido Alhama  
Computational Modelling of Artificial Language Learning: Retention, Recognition & Recurrence

ILLC DS-2017-09: Miloš Stanojević  
Permutation Forests for Modeling Word Order in Machine Translation

ILLC DS-2018-01: Berit Janssen  
Retained or Lost in Transmission? Analyzing and Predicting Stability in Dutch Folk Songs

ILLC DS-2018-02: Hugo Huurdeman  
Supporting the Complex Dynamics of the Information Seeking Process

ILLC DS-2018-03: Corina Koolen  
Reading beyond the female: The relationship between perception of author gender and literary quality

ILLC DS-2018-04: Jelle Bruineberg  
Anticipating Affordances: Intentionality in self-organizing brain-body-environment systems

ILLC DS-2018-05: Joachim Daiber  
Typologically Robust Statistical Machine Translation: Understanding and Exploiting Differences and Similarities Between Languages in Machine Translation