# Project proposals

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## 1 Alternative-dependent interpretation of probability expressions

Recent linguistic theories of verbal probability expressions like *probably*, *certainly* or *possibly* have postulated that their meaning is given by a threshold-semantics (e.g. Yalcin, 2010). For example, *It will probably rain* is true iff the probability of rain according to the speaker is higher than some contextually specified $\theta_{\text{probably}}$. A few studies have looked at the different interpretations of probability expressions (e.g. Windschitl and Wells, 1996), i.e., trying to determine where exactly a threshold like $\theta_{\text{probably}}$ should be. One case has gained some recent coverage in the online media:

- `https://www.vedrashko.com/thisisbig/how-likely-is-probably`
- `https://github.com/zonination/perceptions`

Building on the latter, it would be interesting to see if/how people's judgements depend on the alternative expressions they encounter in the environment. For example, recent studies from psycholinguistics have shown that which alternative descriptions are present in an experiment can influence the interpretation of certain words (e.g. Degen and Tanenhaus, 2015; Franke, 2016). This project would experimentally investigate the interpretation of various probability expressions and manipulate the alternative expressions offered to different subjects. This would help to come to understand if the thresholds postulated in the literature are better thought of as pragmatic or semantic.

[experimental, non-technical, course project, BSc thesis]

## 2 Speed-accuracy tradeoffs: diffusion drift or similar models

There are a number of models which predict choice probalities and reaction times in 2-alternative forced choice tasks, e.g., in perceptual decision making or cardinality estimation tasks. Examples include the diffusion drift model (e.g. Ratcliff and McKoon, 2008) or variants of ACT-R (Anderson et al., 2004). This project would gather data or use an existing data set and explore model predictions or compare different models against each other, e.g., using existing packages in R (e.g., `https://www.biorxiv.org/content/10.1101/570184v1`).

[experimental, modeling, technical, BSc or MSc thesis]

## 3 Conduct a mouse-tracking study

Mouse-tracking is a behavioral method which gives very insightful data concerning a participants online decision making processes. This project would try to realize a mouse-tracking study (e.g., for language interpretation (Roettger and Stoeber, 2017; Tomlinson Jr., Bailey, and Bott, 2013)).

## 4 Modeling politeness in language use

Building on recent models of polite language use (Tessler & Yoon), this project would try to incorporate the dimensions of politeness outlined in the seminal work by Brown & Levinson, namely *face threats* and *rate of imposition*, into a Rational Speech Act model of polite language use.

[modeling, linguistics, sociolinguistics, BSc or MSc thesis]

## 5 Reference games with topic choice

Reference games are a widely studied experimental paradigm. In the production part of these experiments, participants are told to select a description of a referent which is highlighted as the topic of conversation in each experimental trial. This project collects data on a related event, namely where the speaker is allowed to freely choose which referent to talk about first, and will then produce a description to communicate to the listener. The hypothesis is that this topic choice is affected by factors such as visual salience, but might also lead to a strategic choice of topic, namely that participants choose expressions for which they have an efficient utterance to communicate it. Finally, it is interesting to compare choices of topics with the results from listener prior elicitation conditions.

[experimental (easy), project or BSc thesis]

## 6 Evolution of semantic meaning via pragmatic language use

Many (agent-based) models of the evolution of semantic meaning do not have a particularly sophisticated vision of how agents use and interpret language when they interact. In response, Brochhagen and Franke (2017) have used the Rational Speech Act model to look at simulations addressing the question: which semantic meaning would evolve if agents used language as described by the Rational Speech Act model. In this project, this approach could be applied, for example, to studying the evolution of meaning of gradable adjective, color terms, spatial expressions or a similar interesting domain. This could also use reference games with obects from a multi-dimensional feature space.

[simulation, programming, modeling, language evolution, project, BSc or MSc thesis]

## 7 Web-app for (non-)cooperative MasterMind

We program a web-application that has a little AI and plays a variant of mastermind with our subjects (taking inspiration from Verbrugge and Mol, 2008). Subjects see, say, 3 colored objects from a pool of 3 shapes in 3 colors, no repetition possible, but order matters, so we have 504 possible "world states". The AI needs to guess the world state. Subjects give feedback on each guess of the AI. Feedback is given by constructing a sentence from a reasonable number of alternative expressions at different positions of the sentence, e.g.:

- quantifier: at least one of the, several of the, some of the, all of the, ... (some theoretically interesting ones)
- object: squares, blue squares, triangles, green circles, ... (all nine possibilities)
- predicate: is/are in the right place, has/have the right color, ...

This can be realized with simple dropdown menus. Feedback must be true (easy and fast to check with a precomputed lookup table). In the cooperative version subjects win if the AI correctly guesses the sequence after, say, 7 rounds. In the uncooperative version subjects win if the AI fails to guess the correct sequence for, say, 10 rounds (the precise numbers need to be chosen so that the game is fun to play, not too easy not too hard, which depends on how smart the AI is). We can measure the informativity of a feedback description quite simply in the program in terms of the number of contextually live possibilities ruled out by the given description at the current state of play. Cooperative language users should tend to choose more informative messages; uncooperative language users should ideally send maximally uninformative, yet true messages. It would be interesting to look at (i) differences in language use between cooperative and uncooperative plays, and possibly (ii) the amount of uncooperativity in choices (measured quantitatively (!) in terms of contextual informativity) as they develop over time.

[programming, web-app, group project or MSc thesis]

## 8 Inference of speaker competence

This project is about how different expressions might lead to different inferences about how knowledgeable the speaker is. For example, hearing Jones say *I ate all of the cake* will not usually have us believe that Jones is in any way uncertain about the amount of cake he ate. This gets more interesting when we come to comparing expressions like *up to 10* to *no more then 10* and *close to 10 but not more* etc. This project would try to collect data using web-based experiments.

[experimental, single project, possibly BSc thesis]

## 9 Argumentative language use

Much linguistic theories on language use assume that the speaker wants to ideally inform the listener, i.e., transfer a maximum of relevant and true information for the sake of the listener's knowledge. However, other forms of discourse exist. An example is *argumentative discourse* where interlocutors hold different opinions about some topic and give arguments in order to persuade one another of their own view (e.g. Anscombre and Ducrot, 1983; Glazer and Rubinstein, 2006; Merin, 1999). This project has two parts which can be independently executed or done in conjunction:

- In the **experimental part**, we implement an experiment in which a speaker chooses expressions to influence the hearer of a particular conclusion, e.g., report on the exam results of a class of students (using similar stimuli as Cummins, 2012).
- In the **modeling part**, we extend a model of goal-directed choice of expressions to incorporate a notion of argument strength (e.g., the notion of argumentative relevance of Merin, 1999).

[experimental and/or modeling, project BSc and MSc]

## 10 Bayesian data analysis for a model of hyperbolic language use

Kao et al. (2014) suggested an interesting model of how people can interpret non-literal language use. The model is intuitive and backed up by empirical data in the paper. However, the data analysis in the paper leaves some room for exploration. This project would take the data from the original study, and use an implementation of the model to practice a Bayesian data analysis. The goal of this project is to scrutinize the model, i.e., check which aspects of the data the model explains well, and which it might have trouble with.

[Bayesian data analysis, programming, cognitive modeling, individual project or BSc thesis]

## 11 Wason selection task and optimal data selection

The Wason selection task is a classic from the psychology of reasoning. Oaksford and Chater (1994) offer a rationalization of participants' choice behavior in terms of *optimal data selection*. This model makes some crucial assumptions which influence the predicted outcome. This project would explore the model by implementing it and changing a number of assumptions. For example, the original model assumes that participants' seek to distinguish between two hypotheses ($p$ and $q$ are probabilistically independent vs. $p$ makes $q$ likely). There are other possible hypotheses relevant to the interpretation of conditional sentences which arise if we interpret a conditional as an answer to a particular *question under discussion*, such as *What happens if p?* vs. *Under which circumstances q?*. The project could implement a model and check its predictions with these extended set of participant hypotheses. It could also gather data or use existing data to compare model variants.

[psychology of reasoning, conditionals, linguistics, cognitive modeling, BSc or MSc thesis]

## 12 Statistical model comparison for models of vague gradable expressions

The interpretation of gradable adjectives, like *tall* or *short*, but also of vague quantifiers like *many* and *few*, seems to depend on statistical world knowledge. At least three formal models of how a *prior expectation*, e.g., about the tallness of a person, can lead to choices of adequacy of a description like *John is tall*: a fixed-threshold hypothesis (Fernando and Kamp, 1996), an evolutionary account (Qing and Franke, 2014), and a pragmatic reasoning account (Lassiter and Goodman, 2017). This project would implement a (Bayesian) model comparison of these approaches based on existing experimental data.

[Bayesian data analysis, programming, linguistics, cognitive modeling, project or BSc/MSc thesis]

## 13 Preferences for objective meaning in referential expressions

Not every word's semantic meaning is equally uncontroversial. What the word *flat* means is less subjective than what *beautiful* means. Speakers of a language should know (at least roughly) which words are more subjective than others.

A theory of rational expression choice would predict that speakers would therefore preferably describe a given referent using words with a less subjective meaning (because that minimizes the chance of misunderstanding, when compared to the use of words that have a more subjective meaning; after all, the listener might not agree which of the dogs in front of us is *beautiful*). In this project, we will set up an experiment in which participants choose expressions to refer to objects, such that they choice options are more or less subjective. We will investigate whether the prediction that less subjective expressions are preferred is supported by the data.

[experimental, some modeling, project or BSc thesis (MSc thesis if extended)]

## 14 Goodness-of-fit & model comparison

There are many measures for a model's goodness-of-fit and several ways of comparing (cognitive) models. This project would use simulations (based on generating hypothetical empirical data) to compare different theoretical notions against each other. In particular, this project could compare correlation scores against likelihood-based criteria.

[statistics, simulation, theory; can be anything: project, thesis etc. depending on scope and depth]

## 15 Optimal stopping (secretary problem)

The *secretary problem* is a famous instance of a general class of optimal stopping problems: `https://en.wikipedia.org/wiki/Secretary_problem`. While optimal stopping problems are abstract puzzles which mostly concern theoretical computer science and theoretical economics, this project would explore optimal stopping from an experimental perspective, a topic for which substantial and very interesting literature also exists. We would try to cover novel ground, for instance by having participants learn implicitly the distribution of an attribute which needs to be maximized. For example, participants are shown 50 boxes with black and white marbles in sequence. For each box, they can choose it or inspect the next one. They can never go back but can only choose the current box. The goal is to select the box which contains with the highest number of marbles from the set of all 50 boxes. (Alternatively, the goal could be to choose a box with as large a number of marbles as possible.) To play optimally in this case, participants must screen a number of boxes in order to form beliefs about the distribution of the number of marbles in the offered boxes. We can model that as rational belief learning under uncertainty. We will compare such a rational belief learning + rational choice model to data from an experiment.

[experimental, cognitive modeling, rationality; BSc thesis (ambitious!) or MSc thesis]

## 16 Scalar implicatures with probability expressions

Extend the final model of the second chapter of `problang.org` to include also probability expressions, i.e., yielding complete utterances of the form "Possibly some of the apples are red." Additionally, experimental data could be collected to test the model's predictions.

[pragmatics, webppl, programming, experimental; project, possibly BSc thesis]

## 17 Imprecision (semantic slack) in RSA

Semantic slack is the phenomenon that we often interpret expressions which have a precise meaning as true even if they are, strictly speaking, false (e.g. Bach, 1994; Krifka, 2002, 2007; Lasersohn, 1999). This project would try to incorporate this phenomenon into a probabilistic pragmatics model. A first step into this direction has been made by Kao et al. (2014) where a model is presented that integrates the possibility of interpreting a number words as imprecisely used. This project could build on this model (which is also presented in Chapter III or `problang.org`) but include reasoning about multiple levels of precision.

[pragmatics, webppl, programming, linguistics, philosophy of language; BSc/MSc thesis]

## 18 Efficient learning from good teachers

Csibra and Gergely (2011) argue that human children are born with a unique skill set which evolved to make them particularly good learners. Part of this package of skill is the ability to infer information about the intentions of a teacher who produces good examples (Shafto, Goodman, and Griffiths, 2014). This project could look at rational (probabilistically) learner models, either in iterated learning models Kirby, Griffith, and Smith (2014), or as models of word learning (Frank and Goodman, 2014).

## 19 Free-choice inferences in probabilistic pragmatics

Free-choice inferences are inferences associated, for example, with sentences like in (1a), which naturally obtain a reading like in (1b), even though this does not follow from their standard logical semantics Fox, 2007; Kamp, 1973, 1978; Zimmermann, 2000.

(1) a. You may have cake or ice-cream.

b. $\rightsquigarrow$ You may have a cake and you may have ice-cream (but possibly not both at the same time).

While a lot of work has been devoted to explaining free-choice inference in formal pragmatics, a convincing account in the tradition of Rational Speech Act models Frank and Goodman, 2012 is missing. The project would explore different possibilities (e.g., in terms of reasoning about lexical uncertainty Bergen, Levy, and Goodman, 2016) for explaining free-choice inferences in RSA.

## References


Anderson, John R. et al. (2004). "An Integrated Theory of the Mind". In: *Psychological Review* 111.4, pp. 1036–1060.

Anscombre, Jean-Claude and Oswald Ducrot (1983). *L'argumentation dans la langue*. Brussels: Mardaga.

Bach, Kent (1994). "Semantic Slack: What is Said and More". In: *Foundations of Speech Act Theory. Philosophical and Linguistic Perspectives*. Ed. by Savas L. Tsohatzidis. London and New York: Routledge, pp. 267–291.

Bergen, Leon, Roger Levy, and Noah D. Goodman (2016). "Pragmatic Reasoning through Semantic Inference". In: *Semantics & Pragmatics* 9.20.

Brochhagen, Thomas and Michael Franke (2017). "Effects of transmission perturbation in the cultural evolution of language". In: *Proceedings of CogSci 39*. Ed. by Glenn Gunzelmann et al. Austin, TX: Cognitive Science Society, pp. 1678–1683.

Csibra, Gergely and György Gergely (2011). "Natural Pedagogy as Evolutionary Adaptation". In: *Philosophical Transactions of The Royal Society B: Biological Science* 366.1567, pp. 1149–1157.

Cummins, Chris (2012). "Using embedded quantifiers". Talk held at the University of Konstanz, October 13 2012.

Degen, Judith and Michael K. Tanenhaus (2015). "Processing Scalar Implicatures: A Constraint-Based Approach". In: *Cognitive Science* 39, pp. 667–710.

Fernando, Tim and Hans Kamp (1996). "Expecting Many". In: *Proceedings of SALT 6*. Ed. by Teresa Galloway and Justin Spence. Ithaca, NY: Cornell University, pp. 53–68.

Fox, Danny (2007). "Free Choice and the Theory of Scalar Implicatures". In: *Presupposition and Implicature in Compositional Semantics*. Ed. by Uli Sauerland and Penka Stateva. Hampshire: Palgrave MacMillan, pp. 71–120.

Frank, Michael C. and Noah D. Goodman (2012). "Predicting Pragmatic Reasoning in Language Games". In: *Science* 336.6084, p. 998.

— (2014). "Inferring word meanings by assuming that speakers are informative". In: *Cognitive Psychology* 75, pp. 80–96.

Franke, Michael (2016). "Task types, link functions & probabilistic modeling in experimental pragmatics". In: *Proceedings of Trends in Experimental Pragmatics*. Ed. by Fabienne Salfner and Uli Sauerland, pp. 56–63.

Glazer, Jacob and Ariel Rubinstein (2006). "A Game Theoretic Approach to the Pragmatics of Debate". In: *Game Theory and Pragmatics*. Ed. by Anton Benz, Gerhard Jäger, and Robert van Rooij. Palgrave MacMillan, pp. 248–262.

Kamp, Hans (1973). "Free Choice Permission". In: *Proceedings of the Aristotelian Society* 74, pp. 57–74.

— (1978). "Semantics versus Pragmatics". In: *Formal Semantics and Pragmatics for Natural Languages*. Ed. by Franz Guenthner and Siegfried Josef Schmidt. Dordrecht: Reidel, pp. 255–287.

Kao, Justine T. et al. (2014). "Nonliteral Understanding of Number Words". In: *PNAS* 111.33, pp. 12002–12007.
Kirby, Simon, Tom Griffith, and Kenny Smith (2014). "Iterated Learning and the Evolution of Language". In: *Current Opinion in Neurobiology* 28, pp. 108–114.
Krifka, Manfred (2002). "Be Brief and Vague! And How Bidirectional Optimality Theory Allows for Verbosity and Precision". In: *Sounds and Systems. Studies in Structure and Change. A Festschrift for Theo Vennemann*. Ed. by D. Restle and D. Zaefferer. Berlin: Mouton de Gruyter, pp. 439–458.
— (2007). "Approximate Interpretation of Number Words: A Case for Strategic Communication". In: *Cognitive Foundations of Interpretation*. Ed. by Gerlof Bouma, Irene Krämer, and Joost Zwarts. Amsterdam: KNAW, pp. 111–126.
Lasersohn, Peter (1999). "Pragmatic Halos". In: *Language* 75.3, pp. 522–551.
Lassiter, Daniel and Noah D. Goodman (2017). "Adjectival vagueness in a Bayesian model of interpretation". In: *Synthese* 194.10, pp. 3801–3836.
Merin, Arthur (1999). "Information, Relevance, and Social Decisionmaking: Some Principles and Results of Decision-Theoretic Semantics". In: *Logic, Language and Computation*. Ed. by Lawrence C. Moss, Jonathan Ginzburg, and Maarten de Rijke. Vol. 2. CSLI Publications, pp. 179–221.
Oaksford, Michael and Nick Chater (1994). "A Rational Analysis of the Selection Task as Optimal Data Selection". In: *Psychological Review* 101.4, pp. 608–631.
Qing, Ciyang and Michael Franke (2014). "Gradable Adjectives, Vagueness, and Optimal Language Use: A Speaker-Oriented Model". In: *Proceedings of SALT 44*. Ed. by Jessi Grieser et al. elanguage.net, pp. 23–41.
Ratcliff, Roger and Gail McKoon (2008). "The Diffusion Decision Model: Theory and Data for Two-Choice Decision Tasks". In: *Neural Computation* 20, pp. 873–922.
Roettger, Timo and Mathias Stoeber (2017). "Manual Response Dynamics Reflect Rapid Integration of Intonational Information during Reference Resolution". In: *Proceedings of CogSci 39*. Ed. by Glenn Gunzelmannn et al. Austin, TX: Cognitive Science Society, pp. 3010–3015.
Shafto, Patrick, Noah D. Goodman, and Thomas L. Griffiths (2014). "A rational account of pedagogial reasoning: Teaching by, and learning from, examples". In: *Cognitive Psychology* 71, pp. 55–89.
Tomlinson Jr., John M., Todd M. Bailey, and Lewis Bott (2013). "Possibly all of that and then some: Scalar implicatures are understood in two steps". In: *Journal of Memory and Language* 69.1, pp. 18–35.
Verbrugge, Rineke and Lisette Mol (2008). "Learning to Apply Theory of Mind". In: *Journal of Logic, Language and Information* 17, pp. 489–511.
Windschitl, P. D. and G. L. Wells (1996). "Measuring psychological uncertainty: Verbal versus numeric methods". In: *Journal of Experimental Psychology: Applied* 2.4, p. 343.
Yalcin, Seth (2010). "Probability Operators". In: *Philosophy Compass* 5.11, pp. 916–937.
Zimmermann, Thomas Ede (2000). "Free Choice Disjunction and Epistemic Possibility". In: *Natural Language Semantics* 8, pp. 255–290.