

Statement of Purpose

I am a research fellow at Microsoft Research India and graduated from the Indian Institute of Technology Delhi with a bachelors and masters in computer science and engineering. I am interested in research that seeks theoretical explanations of observed phenomena from a computational standpoint, and the Ph.D. in Language and Information Technologies at Carnegie Mellon University provides the perfect opportunity to do so.

When my mother started her Ph.D., I was six and I would try to read some important-sounding words and diagrams from her drafts. As a child of professors of computer science, I had front-row seats to the life of an academic, and naturally, I wanted to be a part of the show. I chose to major in computer science because of the interest I had developed for the field by reading from the stack of CS books at home, and also for the rigour and promise of the field. It was here that the idea of a Ph.D. metamorphosed in my head, from a childish ambition to a principled path towards a career as an impactful researcher and independent thinker.

Besides an excellent learning environment and a firm foundation in computer science, IIT Delhi gave me ample exposure to pursue my curiosities in linguistics and psychology. As a computer science major with a keen interest in problems relating to these disciplines, I married my skills with my passion by applying data-driven methods to study human language and mind. I took courses that would equip me with the requisite knowledge to viably pursue my interests as projects. Starting with foundational courses in artificial intelligence, machine learning and behavioural psychology, I gravitated towards more specialized ones on computational linguistics, advanced natural language processing, computational cognition, neuroscience and cognitive psychology, each of which allowed me to undertake related hands-on research projects.

Computational models now enable novel and interdisciplinary ways to probe deeper into human language and cognition, often validating, augmenting or fine-tuning long-standing theories and upending others. This inspired several of my projects. I worked with [Sumeet Agarwal](#) in my fourth year in a project on the way humans learn structured categories after seeing examples of entities. We explored if Bayesian approaches of inductive reasoning, as described by [Kemp and Tenenbaum 2008 \(PNAS\)](#), can be augmented to also capture common simplifying biases found in human learning, such as availability and representativeness heuristics. Our method of reducing the dimensionality of structural representation while preserving subspaces indeed made for a more plausible cognitive representation of categories, as validated by a user study. By preserving information only around the category prototypes, we could explain the way the brain simplifies information before storing it.

I pursued another project that year with [Varsha Singh](#), on lateral differences within the brain between two kinds of visual perception - global (coarse-grained) and local (fine-grained). We conducted divided-visual-field studies that measured statistical differences in reaction times and accuracies between the two hemispheres, on a simple visual recognition task. A significant challenge in this behavioural task was avoiding confounding variables, and we assuaged that through multiple pre-trial rounds. Coming up with the end-to-end study design and analysis was particularly rewarding for the budding researcher in me. While testing the original hypothesis, we also found evidence informing the debated claim that such lateral specialization enables a performance advantage.

Another project in my final year was with [Mausam](#), on a neural generative model of natural language. Building upon work by [Jiwei Li et al \(2017\)](#), we used generative adversarial networks and trained on movie subtitles to generate conversational language for a chatbot. Even though dialog quality is notoriously hard to quantify because of a lack of metrics that correlate well with human judgment, we managed to improve the chatbot on response diversity, topical coherence, and length of conversation before breakdown. Apart from changes in the training curriculum and reward mechanisms, we found that even simpler modifications like performing a cleaner text preprocessing is beneficial for improving model output.

In my thesis research guided by Sumeet Agarwal and Rajakrishnan Rajkumar, we undertook a machine learning-aided study to understand the semantics of spontaneous conversational gestures. Being tasked with the formulation of a research problem, I spent two months simply studying the literature and related work. We were able to tackle the same problem from multiple perspectives besides computational paralinguistics: neurology (brain regions responsible for gesticulation), anthropology (primitive shared origins with language) and developmental psychology (gestures aiding language acquisition and comprehension in children). The spontaneity of these gestures makes them harder to be classified by communicative function, and annotation typologies are often noisy across cultures and individuals, contributing to paucity of usable data. Neural prediction from speech annotations revealed the subject of an utterance to be the best predictor of the accompanying gesture type. However, we found no clear evidence for other claims from literature, like the predictive power of individual words and parts of speech, which we observed to be low and less generalizable. Based on neurological production theories, we operationalized metrics of production rates of speech and gesture, and observed that interference of production between the two modalities was correlated with the semantic predictability of the gesture event. Less conventionalized gestures required more articulatory bandwidth. This long project taught me the importance of sustaining motivation through ups and downs, and to keep going even when one feels absolutely stuck. I learned that good results build over multiple iterations of bad ones, each of which provides new and deeper insights into the problem at hand.

After my masters, I joined the computational linguistics research group at Microsoft Research India for more research experience and mentorship. My work with [Monojit Choudhury](#) centers on incorporating socio-cultural awareness into language systems. I began with an extensive literature survey on computational pragmatics, discourse and computational sociolinguistics. To progress our collective understanding of these ideas, I run a reading group on the same topics. We devised a formal framework for modeling linguistic style, and how reasoning about style aspects like politeness and formality can inform a dialog system's response pipeline, which we are prototyping into an engineered system. This framework was inspired by a formalism for semi-autonomous vehicles, where an agent actively estimates another's hidden states based on observed trajectories. We are also looking at intrasentential mixing of language as a linguistic style dimension in multilingual conversations on Twitter and in Hindi-language movies. We formulated corpus metrics to capture how conversation participants accommodate each other using this dimension. Being an interdisciplinary environment, Microsoft Research enables dialogue with and feedback from experts in linguistics, HCI and theoretical machine learning. Communicating my work to this diverse audience has broadened my understanding and improved my presentation skills.

I am very passionate about teaching and loved being a teaching assistant for two courses in my final year, including a large undergraduate class on programming languages. Besides evaluating coding assignments and checking answer scripts, I went the extra mile to address doubts from students, and to design test-cases for other TAs to ensure consistency and fairness in grading across subgroups. For my initiative, the department rewarded me with an [outstanding TA award](#).

I am interested in work by **Louis-Philippe Morency**, **Justine Cassell** and **Eduard Hovy**. I will get to learn a great deal if I get the opportunity to work on social media analysis, distributional and lexical semantics under Ed Hovy's guidance. The work at MultiComp Lab on multimodal communication and human communication dynamics is quite pertinent to my interests. I am also enthusiastic about the work at the Articulation Lab in multimodal behavioural dynamics, dyadic rapport and virtual conversational agents.

A Ph.D. in Language and Information Technologies is the perfect avenue for me to not just tackle some of the challenging aforementioned research questions, but is also a step towards a lifelong career in academia, research and teaching. I believe my motivation, competence, and experience make me a worthy candidate for a Ph.D. at Carnegie Mellon University. I am excited to take up the challenges of graduate school and look forward to collaborating with the passionate researchers of the department. I would like to thank the admission committee for considering my application.