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THE ROLE OF PERCEPTION IN *SITUATED* SPATIAL REFERENCE

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1. Research Perspective

My research is inspired by exploring the interface between language and perception, and spatial reference in situated dialog is a natural area of study for this topic of research. My PhD [20] studied spatial reference in situated dialogue. Part of this research focused on modelling visual attention as a mechanism to help resolve underspecified references [11, 9]. Another theme of this research, informed by the Logan and Sadler's *spatial template* concept [25], involved designing and running psycholinguistic experiments to study the spatial templates of projective prepositions and the impact of frame of reference ambiguity on these spatial templates [10]. Using the results of these experiments a computational model was developed that modelled the geometric semantics of projective prepositions and that was able to accommodate the impact of frame of reference ambiguity [18].

My Post-doctoral research at DFKI (Saarbruecken) was on the CoSy project (`http://cognitivesystems.org/`) where I worked in the area of Human-Robot Interaction and Dialogue Systems. Continuing the theme of spatial language in situated dialogue and the role of perception on linguistic reference I did work on computational models of multi-modal information fusion, including the integration of spatial information as expressed through spatial linguistic references and visual perceptual information [23, 24]. Questions relating to the grounding of spatial reference in perception were at the core of this work and for the CoSy project a key task was to develop computational models that would enable the qualitative information expressed in linguistic spatial references to be grounded within the quantitative representations of the environment that a computational agents, such as a robot, would construct through its through the information it received through its (perceptual) sensors [1]. During this research I became more interested in exploring the spatial semantics of topological prepositions. For me a key problem with previous computational models of the spatial semantics of topological prepositions had been the relatively arbitrary mechanisms used to define the maximum extent of the spatial template of these

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prepositions. This led me to consider the impact of *distractor* objects[1] defining the extent of the spatial templates of these topological prepositions. To explore the impact of these distractor objects I (and my co-authors) designed and ran some psycholingustic experiments [2]. The results of these experiments indicated that distractor objects did impact on the spatial templates of topological prepositions. Building on these results I developed a computational model of proximity that was sensitive to distractors objects [14, 12]. In my opinion one of the most interesting aspects of my work on distractor objects and locative expressions is that it provides another illustration of how perceptual information affects the semantics of the spatial reference; in this case the perceptual information related to objects that are in the context but which are not mentioned in the spatial references. Integrating the computational models of the semantics of projective prepositions that I developed during my PhD with the computational models of topological prepositions that I developed during my Post-doctoral research I developed an algorithm for generating locative expressions [13, 21]. This algorithm extended Incremental Algorithm of Dale and Reiter[2] in 2 ways: (1) it defined a preference order over spatial relationships based on Cognitive Load; (2) it integrated a mechanism for utilising visual attention to help generate linguistically underspecified but contextual clear spatial references. Again, this work illustrated the role of a perception, in this case an attention mechanism, on spatial reference.

In my more recent research I have explored a number of other aspects of spatial reference. For example, semantics of topological prepositions in spatial reference [19]; the impact of the topological prepositions on the semantics of composite spatial terms (e.g., the difference between *at the front of* versus *on the front of* etc.) [15]; the role of analogical reasoning in spatial reference [6]; resolving frame of reference ambiguity [28, 5]; and using corpus based analytics to explore the functional and geometric semantics of prepositions in visually situated spatial reference [4]. However, throughout this time I have continued to explore perceptual factors on spatial reference. Indeed, some of my most recent work has explored the impact of perceptual errors on spatial reference and the mechanisms people use in dialogue to repair these communication breakdowns [29]. Other examples of recent research on perception and spatial reference include experiments that examined the the role of perspective on the semantics of projective prepositions [16] and the preposition *between* [27] and, also, the role of perceptual occlusion on the semantics of projective terms [17].

In conclusion, I believe that an interesting avenue of exploration on universals and variation in spatial reference is to address this topic in terms of the universals in human perception and attention and to explore how these universals impact on spatial reference across cultures and languages.

[1]By the term distractor objects I am denoting the set of objects that are in the perceptual frame of an agent but which are neither the landmark nor the located object in a locative expression the agent in currently resolving)

[2]The Incremental Algorithm is a well known algorithm in Natural Language Generation research that generates referring expressions.

2. Bio for John D. Kelleher

Dr. John D. Kelleher graduated with a BSc. in Computer Science from Dublin City University (DCU) in 1997 and was awarded his PhD in Artificial Intelligence in 2003 from DCU. He then worked as a post-doctoral researcher in Media Lab Europe (Dublin) and at DFKI (Saarbruecken). He joined the School of Computing at the Dublin Institute of Technology (DIT) as a lecturer in 2005. John is the Manager of the Applied Intelligence Research Centre at DIT, he is also the Project Lead at DIT for the ADAPT Research Centre (`http://adaptcentre.ie/`). John has been involved in the organisation of a number of workshops and conference, examples relevant to the theme of spatial reference include: the 4^{th} ACL-SIGSEM Workshop on Prepositions at ACL-2007 [3] and the CoSLI series of workshops on Computational Models of Spatial Language Interpretation and Generation [26, 7, 8]. John has reviewed for a number (> 40) of journals and conferences. Examples of journals that John has reviewed for include: Spatial Cognition and Computation (Taylor & Francis), Topics in Cognitive Science (Wiley), Language and Linguistic Compass (Blackwell), Discourse Processes (Taylor & Francis), Natural Language Engineering (Cambridge). Examples of international conferences that John has reviewed for include: ACL, IJCAI, Coling, NAACL-HLT, CogSci, SigDial. In 2015 John was the Track Chair for Language and Vision at the 53^{rd} Annual Meeting of the Association for Computational Linguistics. Also in 2015, John published a textbook with MIT Press on machine learning [22].

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