Dialogical Reasoning in Patients with Schizophrenia 2 (DRiPS)

1 Purpose and aims

One of the most debilitating features of schizophrenia is patients' difficulty interacting with others. An important part of successful interaction is the ability to reason – not only about the relation between the discourse and the world, but also about the reasoning of other dialogue participants. This project aims to investigate and model how people reason in natural language dialogue, using the notion of *enthymemes* (see section 2), and how this reasoning ability is different in patients with schizophrenia.

We hypothesise that the social cognition impairments seen in patients with schizophrenia are underpinned by difficulties associated with the resources used in reasoning as it occurs in everyday interaction.

Through access to a unique corpus of patients' triadic interactions (see section 3.1.1) we have the opportunity to explore reasoning in patients' face-to-face dialogues to investigate this theory. Furthermore, we will identify and analyse verbal and nonverbal markers of social impairments during reasoning, using state of the art methods from computational linguistics and gesture research.

Specifically, this project will address the following questions:

1. In terms of natural language reasoning, how do patients with schizophrenia differ from their healthy interlocutors (patients' partners) and how do both of these groups differ from participants in dialogues without a patient (controls)?
   (a) How do the participants reason – are there differences between the groups in terms of the arguments they use and how they express them?
   (b) Are there differences between the groups during reasoning sequences in terms of verbal dialogue behaviour (e.g. the use of repair, specific words and expressions)?
   (c) Does the use of head and hand gesture during reasoning sequences differ between patients, patients' partners and controls?
2. How do these factors interact and can we give a precise account of any differences?

2 Survey of the Field

Traditional theories of linguistic communication rely on a separation between speaker and hearer, with the speaker encoding and transmitting a message, and the hearer decoding it. However, these simplifications are inadequate when we consider dialogue (see e.g. (1), taken from our corpus (see section 3.1.1)). Meaning is co-created incrementally by multiple participants using incomplete utterances (e.g. line 6), cross-person compound contributions (where one person continues another's utterance, as in lines 1 & 2), repairs (e.g. the clarification request, line 3), overlapping speech (shown in square brackets, e.g. lines 6 and 7) and disfluencies

(e.g. the restarts and reformulations in line 9), not to mention the nonverbal behaviours such as nodding and gesture that have not been transcribed here.

In order to understand this extract, where participants are discussing a hypothetical moral dilemma about who should jump from a hot air balloon to save the other passengers (see section 3.1.1) we must consider the context and shared reasoning the participants are engaged in, as well as the content of their talk. For example, line 2 only makes sense as a continuation of line 1 if we understand that one criteria for deciding who should jump might be based on weight and the participants believe that the pregnant lady may be heaviest.

(1)
1. **B:** If you're looking to lose weight
2. **A:** The pregnant lady would have to go
3. **C:** The pregnant [lady]?
4. **A:** [But]
5. **B:** Yeah
6. **A:** [that's that's not a good]
7. **C:** [Just dash her]
8. **B:** [haha]
9. **C:** Well you could say a child and mother tha- that counts so you cou- jus- could get rid of the little girl 'cause that's another child that we're saving (GP10 40–48)

2.1 Communication and reasoning in patients with schizophrenia

Dialogue, the primary mode of communication and interaction (Linell, 2009) involves linguistic, social and cognitive skills, areas that have all been found to have deficits in patients with schizophrenia. However, these have typically been studied independently in non-dialogue contexts. This project aims to bridge the gaps between these studies to show how impairments in patients' reasoning, linguistic and social abilities are manifested in dialogue.

A large body of research has been carried out on the language of patients with schizophrenia, with deficits in semantic priming and discourse cohesion particularly well documented (see e.g. Covington et al., 2005, for a review of the literature on language in schizophrenia since the 19th century). These studies show, for example, that patients' speech is less predictable and organised than that of healthy controls, and that patients are less sensitive to discourse context (Ditman and Kuperberg, 2010).

There is also a wealth of evidence demonstrating that patients with schizophrenia perform poorly on reasoning tasks (Hooker et al., 2000; Zajenkowski et al., 2011; Contreras et al., 2016) and social cognitive tests (Green et al., 2011) which assess the processes underlying an individual's ability to perceive and interpret social cues, share experiences, infer other people's thoughts and respond appropriately.

However, both sets of findings are typically based on assessments that patients complete in isolation, far removed from dynamic on-line social interactions and it is unclear if patients' performance on such tasks reflects their ability to interpret and respond to others during their real world social interactions.

Investigations of patient behaviour in dialogue are often based on patient/psychiatrist consultations (Howes et al., 2013; Angus et al., 2012). While understandable, as much of this work is focussed on clinically relevant outcomes (e.g. improving clinicians' communication strategies McCabe et al., 2013), this means that differences in communication, such as lower levels of repair (Howes et al., 2012b) could be due to the context of the conversation and not to the

patient's condition. Context is known to affect the amount of repair in studies on the general population (Colman and Healey, 2011).

The few studies that have investigated patients' social interactions directly, with a control condition, reveal that patients display atypical patterns of participation (Lavelle et al., 2014) and gesture use (Lavelle et al., 2012), which predict patients' poorer social success (Lavelle et al., 2015). Patients' social difficulties contribute to their difficulty developing relationships and their high rates of social exclusion (Norman et al., 2005) and unemployment (Marwaha and Johnson, 2004).

Furthermore, the presence of a patient with schizophrenia in an interaction influences the nonverbal behavior of their interacting partners, both in clinical contexts (Lavelle et al., 2015) and during first meetings with healthy controls, when the patient's diagnosis is undisclosed (Lavelle et al., 2012, 2014). Pilot studies (Breitholtz et al., 2015; Howes et al., 2016) indicate that this is also true for reasoning in dialogue and the relationship between self-repair and gesture.

2.2 Reasoning in dialogue

As discussed in section 2.1 patients with schizophrenia have impairments at the level of discourse and reasoning. Reasoning is essential in dialogue since interacting with others frequently involves making non-logical common-sense inferences linking context, background knowledge and beliefs to utterances in the dialogue in order to understand one another.

Following Breitholtz and Cooper (2011); Breitholtz (2011, 2014a), we will use the Aristotelian term *enthymeme* in connection with such inferences. An enthymeme is an argument which appeals to what is in the listener's mind, i.e. an interlocutor must draw on background knowledge or contextual information to correctly interpret the argument. If a dialogue participant presents the argument P therefore Q, an interlocutor must supply a warrant that P is a valid reason for Q in order for the argument to be successful. These warrants are often referred to as *topoi* (Aristotle, 2007).

When we interact we expect topoi to be common ground, or to be accommodated (adopted by dialogue participants) during the course of the interaction. In (2), **A** wants to know which instrument the girl plays, and after being informed that she is the next Mozart, concludes that she plays the piano.

(2) 1. **A:** I wanna wanna know what she plays but [you know what I mean]
2. **B:** [apparently she's the next Mozart]
3. **A:** the next Mozart so piano (GP13 47–50)

(2.2) conveys the enthymeme *she is the next Mozart* therefore *she plays the piano*. For this enthymeme to be valid, we must assume a commonly accepted principle of inference – a topos – that makes this true. In this case such a topos would be something like "If someone is a Mozart, they play the piano". There may, in principle, be other topoi warranting this enthymeme.

In many contexts there might be several acceptable topoi, and misunderstandings and disagreement can arise if interlocutors assume different topoi (Jackson and Jacobs, 1980). As language users we have access to a vast set of topoi which may be used to invent and interpret arguments. Breitholtz and Cooper (2011) refer to these as our rhetorical resources, parallel to the other linguistic resources available to a language user. There are many suggestions as to how topoi may be categorised in terms of argument type and subject matter, for example the model recently developed by Walton et al. (2008); Walton (2013).

Though complex, the rhetorical competence needed to use and interpret enthymemes exists in most adult language users, and the ability to reason about interlocutors' intentions and the rhetorical resources they have access to is an important component of theory of mind. Research shows that theory of mind is specifically impaired in schizophrenia (Brne, 2005; Penn et al., 2008). Moreover, it has been suggested that these impairments may be underpinned by deficits in reasoning (Corcoran and Frith, 2005).

2.3 Theoretical approaches

As far as we know, few attempts have been made to account for semantic and pragmatic irregularities in speech by patients with schizophrenia using methods from formal and computational linguistics. One exception is work by Rebuschi et al. (2014); Amblard et al. (2011). However, the framework used (SDRT; Asher and Lascarides, 2003) employs a standard logic where contradictions cannot occur. Moreover, the acceptability of an enthymematic argument would, on an SDRT account, depend on the inferential relationship being true. We believe instead that it depends on it being acceptable to the interlocutors. As we see it, inference patterns are dynamic in that they can be presupposed, accommodated, elicited and themselves discussed. The SDRT account is not amenable to such flexibility, so SDRT analyses have to assume different kinds of mental states for dialogue participants affected and unaffected by schizophrenia.

An analysis using topoi and enthymemes rather than the discourse relations of SDRT, avoids these problems as the topoi accessible to one individual do not constitute a monolithic logical system. In contrast to, for example, a representation of world knowledge, a set of topoi may contain contradictions or principles of inference which lead to contradiction. Thus one individual may entertain several topoi leading to different conclusions in any given context (Breitholtz, 2014b).

Following Breitholtz and Cooper (2011); Breitholtz (2014a,b) we propose modelling reasoning contributions in Type Theory with Records (TTR; Cooper, 2005, 2012; Cooper and Ginzburg, 2015) using topoi and enthymemes. TTR has been successfully used for formal dialogue models (Ginzburg, 2012; Cooper, 2013), as it can be used to model problems tackled by traditional formal semantics in the Montague tradition (Cooper, 2005), but also has the advantage of modelling both utterance events and utterance types. This is crucial for analysing meta-communicative aspects of interaction such as reasoning about interlocutors' contributions, intentions and rhetorical resources. The TTR based framework KOS (Ginzburg, 2012) uses information state models (Ginzburg, 2012; Traum and Larsson, 2003), which show how coordination of the dialogue gameboard (DGB) progresses with successive utterances. The DGB provides a structured characterisation of the information available to dialogue participants and divides it into public (what is taken to be common ground) and private, offering a principled way in which asymmetries in shared knowledge can be represented.

3 Project Description

3.1 Methods

3.1.1 Data

The main source of data for this project is the anonymised transcriptions of triadic face-to-face video recorded and motion-captured dialogues from 19 patient (1 patient, 2 healthy participants) and 18 control (3 healthy participants) interactions (Lavelle et al., 2012). Participants discussed

the balloon task – an ethical dilemma requiring agreement on which of four passengers should be thrown out of a hot air balloon that will crash, killing all the passengers, if one is not sacrificed.

Data collection procedures were approved by an NHS Research Ethics Committee in the UK (07/H0711/90). Patients were recruited at routine psychiatric outpatient clinics under supervision of their psychiatrist, on the basis of a diagnosis of schizophrenia. All participants gave written informed consent and were free to withdraw at any time.

This corpus is unique in a number of ways. Unlike previous corpora that involve schizophrenia patients' dyadic interactions with people who are familiar to them such as clinicians or family members (e.g. McCabe et al., 2002; Cretchley et al., 2010), this corpus involves patients' unscripted behaviour during first meetings with two unfamiliar healthy participants who are unaware of their diagnosis.

This has the benefit of removing the potentially confounding factors of familiarity and stigma, through knowledge of the diagnosis. The triadic nature of the interactions offers a unique opportunity to explore patterns of communication under complex, yet commonly encountered, social interaction conditions. It also enables investigation of the impact of the presence of the patient on the interaction of their conversational partners.

This study is timely as the ethical approval for analysis of this unique corpus expires in 2020, meaning it cannot be analysed after this time.

3.2 Analysis

We will focus on the portions of the dialogue that involve overt reasoning, however we will not consider rhetorical phenomena in isolation, but also how rhetorical structure interacts with dialogue phenomena such as gesture, feedback and repair, which are areas that involve challenges for patients with schizophrenia, as discussed in section 2.1.

We will use a number of annotation and analytic techniques to investigate differences between the clinical and healthy populations in the ways in which this reasoning is instigated in dialogue. These are described below.

3.2.1 Topoi annotation

For our initial annotation – to identify the conversational turns involving reasoning – we will use a version of the classification for argument schemas in Walton et al. (2008). In order to validate the schema, we will first classify the turns in a test corpus consisting of text-based balloon task dialogues (the control group in Concannon et al., 2015) and make any modifications necessary to allow us to capture the reasoning sequences in the dialogues. When any necessary adjustments have been made, we will annotate our data set for the number and types of arguments used.

We will examine a small number of these turns from both corpora in detail, to identify ways in which people "do" reasoning in dialogue using techniques from Conversation Analysis (CA) which have been previously applied to dialogues in the psychiatric domain (McCabe et al., 2004; Thompson et al., 2015).

This annotation and qualitative analysis will be carried out by Breitholtz and Howes in the first year of the project.

3.2.2 Nonverbal

In face-to-face interactions, nonverbal behaviour, including hand and head gestures, are powerful communicators; signalling partners' focus of attention, level of engagement, understanding and the choreography of turn exchange. Findings of cognitive tests suggest that patients with schizophrenia are less able to interpret such cues during interaction.

We will investigate use of, and responsiveness to, hand and head gestures used specifically to engage and address others during dialogue. This includes head nodding and interactive hand gesture, a type of gesture which is only displayed when an addressee is present (Bavelas et al., 1992).

We hypothesise that compared to control group participants (i) patients will display fewer gestures of interactional engagement and (ii) patients' partners will display more interactive gestures.

Lavelle will have sole access to the video data and will be responsible for annotation of gesture. Participants' reasoning sequences – identified in the transcripts in the topoi annotation task – will be aligned with the video footage. Participants' hand and head gestures will be annotated from video using the annotation software ELAN (Sloetjes and Wittenburg, 2008).

Head nodding: Nodding has been previously identified automatically for each individual in the corpus from the motion capture data (Lavelle et al., 2012).

Hand gesture: Using a standardised and reliable coding system (Bavelas et al., 1995) interactive gestures will be identified and categorised as delivery gestures, citing gestures, seeking gestures and turn gestures. Displacement behaviours indicating anxiety or stress (Troisi, 2002) will also be annotated.

Gesture annotation will take place between months 8 and 20.

3.2.3 Verbal

Repair: Successful social encounters require mutual understanding between interacting partners. To achieve this, conversational partners must monitor their own and their interlocutors' behaviour for potential misunderstandings, and attempt to address them as they arise. One way in which this is done in dialogue is through repair (Schegloff et al., 1977).

Investigations of patients' use of repair show that they use fewer self-repairs in non-interactive tasks (Leudar et al., 1992; Caplan et al., 1996). However, in therapy dialogues patients use more self-repair and less other repair (e.g. asking clarification questions) than in general dialogue (Howes et al., 2012a). These differences may be due to patients' increased difficulty in interaction, or to the clinical context. This corpus presents the opportunity to investigate patients' levels of repair as compared to both their interlocutors and control participants in an interactive, non-clinical setting.

During reasoning sequences, we hypothesise that (i) patients will produce fewer repairs and (ii) patients partners will produce more repairs than control group participants.

Howes will be responsible for annotation of repairs. Self-repairs will be automatically detected from the anonymised transcripts using STIR (Hough and Purver, 2014), which has previously been applied to therapy dialogues (Howes et al., 2014a). Other repair is harder to detect automatically (Purver et al., 2016), and a mixture of automatic methods to identify potential clarification requests and manual removal of those which are not instances of other repair will be used. Annotation and analysis of repair will be completed in year two.

Topic modelling: Recent work has used computational linguistic methods on topic modelling (see e.g. Blei, 2012) to identify incoherence in talk from patients with schizophrenia compared

to healthy controls (Elvevåg et al., 2007). However, in line with the majority of studies on schizophrenia this work relies on tasks undertaken individually (see section 2.1). As coherence is key in terms of both following and presenting reasons in dialogue, we are interested in whether patient differences in dialogue are also detectable using these measures.

Howes has previously applied topic modelling to clinical dialogues (Howes et al., 2013, 2014b), showing an association between topics and treatment outcomes. However, no direct comparison of patients' and healthy participants' interactive contributions to dialogue has hitherto been possible.

We hypothesise that there will be differences in the ways in which patients talk about the task when reasoning which can be probed using topic modelling. For example, we expect that patients will be more likely to produce a turn that is not topically linked to a prior turn. Their interlocutors will consequently do more work to integrate patients' turns into the dialogue and use more similar topics to patients' prior turns.

Howes will be responsible for this work, which will also be carried out in the second year of the project.

3.2.4 Verbal and nonverbal interplay

For non-clinical participants, the presence of repair can aid comprehension (Brennan and Schober, 2001), and when verbal difficulties are encountered people may compensate by using additional multimodal resources such as hand gesture (Seyfeddinipur and Kita, 2014; Healey et al., 2015) and head nods (Healey et al., 2013). The collaborative nature of interaction means that these multimodal resources are employed not only by the speaker, but also by their addressees Healey et al. (2015). Thus verbal and nonverbal streams are intrinsically coordinated both within and between interacting partners during conversation.

Preliminary analysis of our corpus suggests that although control groups display a positive association between hand movement speed and verbal disfluency, schizophrenia patients and their partners do not (Howes et al., 2016). This analysis does not provide details on the type of gesture or the verbal context, nor does it investigate the relationship between a speakers' repair and their partners' gesture use. However it does highlight this as a potentially promising area of research and suggests that collaborative multimodal coordination may be disrupted in schizophrenia patients' interactions.

This will be investigated by exploring the relationship between the use of repair and the specific types of gesture during reasoning sequences of dialogue. We hypothesise that (i) schizophrenia patients will employ fewer gestures both when using repair as a speaker, and when listening to others using repair, and (ii) patients' partners will employ fewer gestures when using repair as a speaker, but more gestures when listening to others using repair.

This work will be carried out by Howes and Lavelle from months 20 to 28 of the project.

3.2.5 Theoretical Development

We will develop the initial qualitative analysis using formal linguistic methods, focussing on sequences illustrating phenomena that the topoi annotation has shown to be significant. In order to give a precise account of the reasoning in patients and non-clinical populations, and to pinpoint divergence between the two, we will use techniques developed in formal semantics and pragmatics.

As discussed in section 2.3 we will model the interaction of reasoning sequences using a gameboard semantics cast in TTR. This approach allows us to do a fine grained analysis of the enthymematic arguments used and the topoi that underpin them. The fact that we model

the information state of each dialogue participant separately enables us to model mismatches in rhetorical resources that become apparent at points of repair. We will extend the analysis of reasoning in Breitholtz (2014a) – and other TTR-based analyses of dialogue (e.g. Cooper and Ginzburg, 2015) – by including gestures as a semantic component. This will enrich the analysis and enable us to draw conclusions regarding the interaction of gestures and reasoning.

We will also formulate update rules that describe how the dialogue develops. We expect these to differ between healthy participants and patients. We hypothesise that such differences are not due to patients reasoning less logically than healthy participants, but to them accessing their resources differently. Patients would thus produce reasoning that gives an impression of incoherence and "jumping to conclusions" (Dudley and Over, 2003). Potentially, we may find regularities in the reasoning of patients that have not been previously known simply because no study of this kind has been done. This parallels the way non-standard versions of English have been shown to be as regular as standard versions – just following different rules (Labov, 1972).

Breitholtz will be responsible for theoretical development, supported by Cooper. This work will be undertaken during years two and three.

4 Significance

The work proposed by this project will make a significant contribution to several different fields of research, most obviously in schizophrenia research and dialogue modelling.

Social impairments are one of the most debilitating features of schizophrenia. They contribute to problems such as high social exclusion and poor employment rates. However, at present there is no successful treatment that targets patients social impairment (Keefe et al., 2016), despite this being a clinical and research priority (Kahn and Keefe, 2013).

It has been hypothesised that deficits in reasoning underpin the social cognitive impairments that make it difficult for patients with schizophrenia to interact socially (Corcoran and Frith, 2005). However, as discussed in section 2.1 previous research relies on tests conducted in isolation, far removed from dynamic on-line social interactions and it is unclear which, if any, of patients' impairments remain during their real world interactions with others.

Access to our corpus of patients' triadic interactions means that we have a unique opportunity to explore reasoning in patients' face-to-face dialogues directly, and compared to two control conditions – patients' partners, and control groups without a patient. This means we can investigate not just how patients' impairments influence their own reasoning behaviour in dialogue, but also the effect on their interlocutors. This will progress the clinical understanding of patients' social deficits and have implications for the development of targeted social skills training. Furthermore, it will provide behavioural markers of patients' social deficits that can be assessed for improvement during dialogue, which overcomes a critical obstacle in advancing the treatment of this debilitating feature of schizophrenia (Keefe et al., 2016).

Using this data to investigate the theory that patients reasoning underpins their social deficits also requires us to come up with a precise account of how people reason in dialogue, including the verbal and nonverbal markers that people use during reasoning exchanges. The challenge of modelling dialogue including participants with divergent use of arguments and rhetorical resources will contribute to our understanding of how dialogue and reasoning works. We believe that many traits typically found in the reasoning of patients – such as seemingly incoherent utterances and contradictions – are also present in the dialogue contributions of non-clinical populations. Being able to extend our understanding of this reasoning – which is often considered irrational since it does not follow the rules of classical logic – will be an important contribution to foundational dialogue research.

This also has implications for artificial agents and interactive robots intended to have human-like behaviours, e.g. companion robots for the elderly. One of the reasons it is currently so difficult to produce human-like dialogue models is that we do not fully understand the ways in which we use all of the resources available to us in communication – this project will contribute to bridging this gap.

5 Publication strategy & other dissemination

Scientific results will be communicated to the scientific community through international peer reviewed conferences and journals (e.g. Dialogue and Discourse, Cognitive Science, Linguistics, Schizophrenia Bulletin, Schizophrenia Research, Journal of Language Modelling). All four researchers will be involved in writing up the work in the final year of the project. We will also submit papers to the most prestigious conferences in the area (e.g. SemDial, SigDial, Cognitive Science Conference, Schizophrenia International Research Society) with at least three conference contributions in each year of the project.

We will initiate a public-facing blog associated with DRiPS, which will be aimed at a non-academic audience, including those who may have an interest in the work from a clinical perspective. The themes covered in this blog will be foundational ones relating to our research, and more informal posts on issues that arise during the project. Updates will also be publicly announced through social media such as twitter.

6 Local Environment and International Collaboration

The project will be located within The Centre for Linguistic Theory and Studies in Probability (CLASP; led by Shalom Lappin; supported by the Swedish Research Council: E0003901) in our department at the University of Gothenburg. One of the centre's focus areas is dialogue and interaction.

We have links with internationally renowned researchers who we will discuss our research with. These include:

Patrick G.T. Healey, Professor of Human Interaction, Head of the Cognitive Science Group (`http://cogsci.eecs.qmul.ac.uk/`), Queen Mary University of London. Healey's programme of research applies models of human communication, drawn from psychology and sociology to testing and developing theories of social interaction.

Rosemarie McCabe, Professor of Clinical Communication, University of Exeter. McCabe's research employs verbal and nonverbal analytical techniques to explore clinicial communications, with a specific focus on psychiatric populations. This informs the development of novel interventions to improve clinical communication, therapeutic relationships and patient outcomes.

Matthew Purver, Reader in Computational Linguistics, Joint head of the Computational Linguistics Lab (`http://compling.eecs.qmul.ac.uk/`), Queen Mary University of London. Dr. Purver's main research interest is in the computational semantics and pragmatics of dialogue, and he has applied natural language processing techniques to clinical data.

Cooper and Breitholtz are members of NatLogProofSem (Natural Logic and Proof-theoretic Semantics), an international multidisciplinary network for researchers interested in natural logic, natural reasoning, and the semantics of natural language (http://www.nwo.nl/en/research-and-results/research-p The network is coordinated by Dr Reinhard Muskens, Tilburg Center for Logic and Philosophy of Science, and funded by The Netherlands Organisation for Scientific Research.

7 Participants

Ellen Breitholtz (780710-4943, PhD 2015): Postdoc in Linguistics at the University of Gothenburg. Her area of expertise is formal pragmatics and dialogue semantics, particularly reasoning in dialogue.

Christine Howes (780411-1040, PhD 2012): Postdoc in Linguistics at the University of Gothenburg. Howes' research focusses on all aspects of dialogue. She is an expert in qualitative and quantitative corpus methods, and has worked extensively with dialogue data from clinical populations.

Mary Lavelle (1978-12-03, PhD 2011): Research Fellow at King's College, London. She is an expert in interaction in patients with schizophrenia, specifically focussing on nonverbal behaviours.

Robin Cooper (471223-1697, PhD 1975): Senior Professor at the University of Gothenburg. His work on the semantics of natural language, both theoretical and computational, has focussed on dialogue and he is the developer of TTR.

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