Speech and hand movement coordination in schizophrenia

[1]Mary Lavelle, [2]Christine Howes, [2]Patrick G.T. Healey, [1]Rose McCabe
[1]Unit for Social and Community Psychiatry,
Queen Mary University of London.
[2]Cognitive Science Group, School of Electronic Engineering and Computer Science
Queen Mary University of London.

Abstract

Patients with schizophrenia have difficulties interacting with others, but the nature of this deficit is unclear. A critical feature of successful social interaction is coordination between speech and movement. The current study employed 3-D motion capture techniques to assess coordination between patients' hand movements and speech during live interaction. Compared to controls, patients displayed reduced coordination between their own speech and hand movement. Healthy participants interacting with the patient also appear to adopt this pattern but to a lesser extent. Patients' coordination deficits may underlie their social difficulties and contribute to their social exclusion.

Keywords: Schizophrenia; motion-capture; multiparty interaction.

Introduction

Patients with a diagnosis of schizophrenia have difficulty interacting with others. Patients' social deficits are a central and debilitating feature of schizophrenia that impair patients' occupational prospects, relationships with family and friends and involvement in their community (Addington, Penn, Woods, Addington, & Perkins, 2008). However, the nature of patients' deficit remains unclear.

Successful face-to-face interaction relies on the nonverbal exchange between interacting partners (Bavelas & Gerwing, 2007; Kendon, 1970; Ramseyer & Tschacher, 2010). Nonverbal behaviours, such as head, hand and body movements, convey critical information about the dynamics of the interaction including; when a speaker will start and end their turn, the role of each partner in the conversation, the level of engagement, shared understanding and affiliation between partners (Bavelas et al, 2007; Kendon, 1970). The ability to coordinate and communicate nonverbally is critical to successful interaction and associated with the development of better interpersonal relationships such as interpersonal rapport (Lakin et al, 2003; Miles et al, 2009).

Nonverbal communication is problematic in schizophrenia (Brüne et al., 2008; Penn, Sanna, & Roberts, 2007) Early psychiatrists described feeling a difficulty building rapport with patients during interaction, which was based on patients' nonverbal behaviour and termed the 'Praecox feeling' (Rümke, 1941). A recent study revealed that patients with schizophrenia display atypical patterns of hand movement when speaking and have difficulty coordinating their nonverbal behaviours with others during social interaction. Furthermore, both patients' increased hand movement when speaking and reduced coordination resulted in others experiencing poorer rapport with them (Lavelle, Healey, Frauenberger, & McCabe, under review; Lavelle, Healey, & McCabe, 2012).

Interpersonal coordination arises from interacting individuals displaying coordination between their own movements and speech (Condon & Ogston, 1966; Kendon, 1987). Perhaps patients' impaired coordination with others, and atypical hand movements when speaking, is due to an underlying difficulty coordinating their own movements and speech. Indeed, a small observational study demonstrated that patients with schizophrenia display reduced coordination between their facial expressions and speech during interaction, a pattern which is adopted by those interacting with them (Ellgring, 1986).

The aim of the current study is to investigate speech and hand movement coordination in patients with a diagnosis of schizophrenia during their interactions with others. The impact of the presence of the patient on the speech and hand movement coordination of their interacting partners will also be explored. The following hypotheses will be tested: Compared to controls, speech and hand movement coordination will be reduced in patients with a diagnosis of schizophrenia and their healthy participant partners.

Methods

This experimental study consisted of 40 triadic interactions, 20 involving a patient with schizophrenia and two healthy participants (patients' partners) and 20 involving only healthy participants (controls). The coordination between control participants' speech and hand movement was compared with (i) patients and (ii) patients' healthy participant partners.

Participants

Twenty patients with a diagnosis of schizophrenia (6 Male, 14 Female) and one hundred non-psychiatric healthy participants, forty in the patient condition (21 Male, 19 Female) and sixty in the control condition (34 Male, 26 Female), participated in the study.

Patients were recruited at routine psychiatric outpatient clinics, on the basis of a clinical diagnosis of schizophrenia. Of all patients approached, 25% agreed to participate. Diagnosis was confirmed using the Structured Clinical Interview for Diagnostic symptoms.(American Psychiatric Association, 2000) Patients presenting with motor side effects from anti-psychotic medication (e.g. muscle stiffness and involuntary muscle spasms) were excluded from the study based on clinicians' assessment. Non-fluent English speakers were also excluded.

Non-psychiatric healthy participants were recruited through advertising on local community websites. Of those who responded to the advertisement, 40% participated. Participants with a diagnosis of psychosis or affective disorders in themselves or any first-degree relatives, and those who were not fluent English speakers were excluded.

Participants within each group had not met prior to the study. Healthy participants were informed that the study was an investigation of social interaction, and were not aware that there was a psychiatric patient present. All interactions were conducted outside of a psychiatric department, i.e. in a non-medical university department. All procedures were approved by a NHS Research Ethics Committee (07/H0711/90). All participants gave written informed consent.

Clinical Assessment: Patients' diagnosis of schizophrenia, was confirmed using the structured clinical interview for diagnostic symptoms (SCID-IV).(Michael, Spitzer, Gibbon, & Williams, 2002).

Executive functioning: The Brixton Spatial Anticipation Test and the Hayling Sentence Completion Test assessed participants executive functioning (Burgess & Shallice, 1997).

Procedure

Interactions were recorded in a human interaction laboratory fitted with an optical based Vicon motion-capture system, consisting of 12 infrared cameras and Vicon iQ software. Participants wore a top and a cap with 27 reflective markers attached (figure 1). Cameras detected the markers at 60 frames per second, resulting in a highly accurate 3D representation of participants' movements over time (figure 1). After participants were seated, participants were instructed to discuss a moral dilemma called 'The Balloon Task' (described elsewhere) (Purver, Healey, King, Ginzburg, & Mills, 2003). Participants were interviewed after the interaction to complete the rapport questionnaire. ML administered the PANSS and had a high inter-rater reliability score with her trainer RM (Cohen's Kappa =0.75).

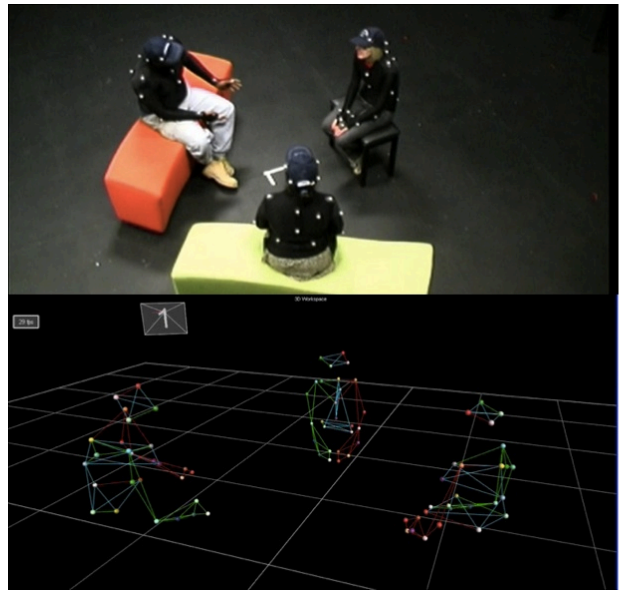

Figure 1: 2-D image and 3-D wire frame representation of a triadic interaction.

Data Analysis

Speech: For each interaction, speech was transcribed from the 2D video in the annotation tool ELAN (Wittenberg, Burgman, Russel, Klassmann, & Sloetjes, 2006).

Hand movement: The motion capture data was used to identify hand movement rate (mm/frame). This was defined as a change in any direction of the fastest moving hand marker frame-by-frame to give a hand movement rate (mm/frame).

Windowed lagged cross-correlation: The speech transcript was synchronized with the 3D motion capture data providing, for each individual, their speaking status (speaking/not speaking) and hand rate (mm/frame) at each frame of the interaction. Following Boker et al. (2002) windowed cross-correlations were used to determine the degree of coordination between individual's speech and hand movement. This method directly compares speech and hand movement on a lagged frame-by-frame basis within each 30-second window providing: (i) the correlation between an individual's speech and hand movement and (ii) the temporal offset at which they occur. Windows were overlapped by 50% to minimize the chance of significant correlations being undetected.

In order to identify if patients differed in their underlying rate of hand movement a mixed models analysis compared hand movement rate, in millimeters per frame, between patients and healthy participants in the control group adjusting for participants' age.

A Friedman's test will compare the speech and hand correlation distributions by participant type. A second mixed models analysis will compare the correlation between speech and hand movement at an offset of zero, accounting for clustering within interaction group and participants age.

Results

The distribution of gender in the patient condition (female =46·7%) and control condition (female=56·7%) did not significantly differ (X^2 (1)=1·20, p=·27). Healthy participants had a mean age of 31.10 (sd=9.60), whereas patients were significantly older with a mean age was 41.50 (sd=8.64) (*t* (199)=-4.51, p<.01).
Compared to healthy participants, patients displayed poorer verbal and spatial executive functioning (*t* (199)=3.65, p<.01), with patients displaying a mean score of 3.07 (sd=0.51) and healthy participants mean score of 5.10 (sd=.22). Patients did not differ from healthy participants on hand movement rate (ß = -.026, Chi^2=0.05, *p*=.83, CI: -.260 to .207).

Figure 2 displays the results of speech and hand movement rate cross-correlation analyses. Friedman's test revealed significant differences between distributions of all three participant types (Table 1).

Table 1: Friedman's pair-wise comparison of correlation distributions.

Pair-wise comparison		Test statistic Raw	Std.	*p*
Control	Patient	6358.91	254.27	<.01
Control	Patients' partner	3954.37	259.31	<.01
Patient	Patients' partners	2404.53	278.36	<.01

Table 2 displays the comparison of hand movement and speech correlation at an offset of zero, by participant type. This revealed that control participants display greater correlation between their speech and hand movements compared to patients or patients' healthy participant partners.

Table 2. Mixed models comparison of hand and speech movement correlation at an offset of zero.

	M (SD)	**ß**	**95% CI Low**	**Up**	**t**	***p***
2. Correlation of hand movement rate and speech (*r*)						
Patient	.134 (.15)	-.07	-.08	-.07	-65.22	<.01
Patients' partner	.161 (.13)	-.02	-.02	-.02	-21.70	<.01
Control	.196 (.14)					

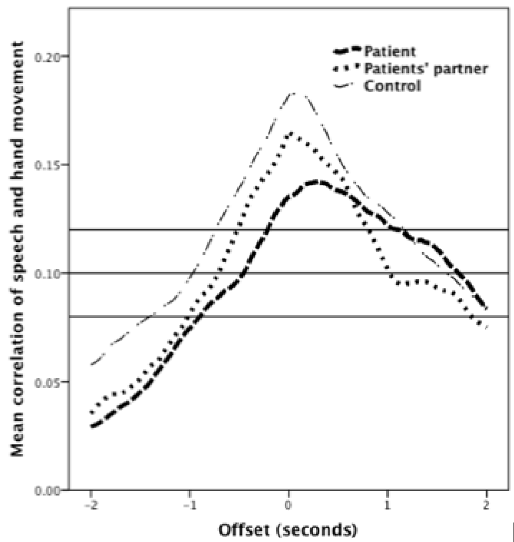

Figure 2: Cross-correlation of speech and hand movement rate by participant type

Discussion

Coordination between speech and hand movement during face-to-face interaction is reduced in patients with a diagnosis of schizophrenia and the healthy participants they are interacting with. This is seen even though patients' partners are unfamiliar and unaware they are interacting with a patient.

The results of this preliminary study suggest that individual level coordination, between speech and hand movement, is impaired in schizophrenia. Furthermore, the presence of a patient within an interaction impairs the speech and hand movement coordination displayed by others. These findings corroborate with the observations of Ellgring (1986), who found reduced coordination between speech and facial expressions in patients and those interacting with them.

The results of this study must be viewed in terms of its strengths and limitations. This is the first study to employ motion capture techniques to investigate patients' hand and speech coordination during live interaction. The automatic methods of movement detection were based on rate rather than observation. This method has the advantage of removing human judgement and the time and labour intensive hand coding required for traditional observational studies. A disadvantage is that you cannot presume that hand movements are those that would be classified as 'hand gestures' using traditional coding schemes. Future research should investigate if patients' coordination deficits persist for observationally coded co-speech hand gestures.

The current findings provide further evidence of a coordination deficit in schizophrenia (Lavelle et al., under review). However, the relationship between patients' individual coordination and their difficulty coordinating their movements with others remains unknown. Future research should investigate this relationship and its role in interpersonal rapport.

In conclusion, the findings of this preliminarily study highlight coordination deficits in schizophrenia as promising research avenue for specifying the nature of social deficits within this patient group and pinning down the factors that may contribute to their poor social functioning.

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References

Addington, J., Penn, D., Woods, S. W., Addington, D., & Perkins, D. O. (2008). Social functioning in individuals at clinical high risk for psychosis. *Schizophrenia Research*, *99*(1-3), 119-124. doi: 10.1016/j.schres.2007.10.001

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental health disorders* (Vol. 4th ed).

Bavelas, J. B., & Gerwing, J. (2007). Conversational hand gestures and facial displays in face-to-face dialogue. In K. Fiedler (Ed.), *Social Communication*. New York: Psychology Press.

Boker, S. M., Minquan, X., Rotondo, J. L., & King, K. (2002). Windowed Cross–Correlation and Peak Picking for the

Analysis of Variability in the Association Between Behavioral Time Series. *Psychological methods, 7*(1), 338–355.

Brüne, M., Sonntag, C., Adbel-Hamid, M., Lehmkämper, C., Juckel, G., & Troisi, A. (2008). Nonverbal behaviour during standardized interviews in patients with schizophrenia spectrum disorders. *Journal of Nervous and Mental Disease, 196*(4), 282-288.

Burgess, P., & Shallice, T. (1997). *The Hayling and Brixton Tests*. Bury St. Edmunds, UK: Thames Valley Test Company.

Condon, W. S., & Ogston, W. D. (1966). Sound film analysis of normal and pathological behaviour patterns. *Journal of Nervous and Mental Disease, 113*(4), 338-347.

Ellgring, H. (1986). Nonverbal Expression of Psychological States in Psychiatric Patients. *European Archives of Psychiatry and Clinical Neuroscience, 236*, 31-34.

Kendon, A. (1970). Movement coordination in social interaction: Some examples described. *Acta Psychologica, 32*, 101-125.

Kendon, A. (1987). On gesture: It's complementary relationship with speech. In A. W. Siegman & S. Feldstein (Eds.), *Nonverbal behavior and nonverbal communication* (2nd ed., pp. 65-97). Hillsdale, NJ: Lawrence Erlbaum.

Lavelle, M., Healey, P. G. T., Frauenberger, C., & McCabe, R. (under review). Nonverbal coordination in schizophrenia and its role in interpersonal rapport.

Lavelle, M., Healey, P. G. T., & McCabe, R. (2012). Is Nonverbal Communication Disrupted in Interactions Involving Patients With Schizophrenia? *Schizophrenia Bulletin*. doi: 10.1093/schbul/sbs091

Michael, B., Spitzer, R. L., Gibbon, M., & Williams, J. B. W. (2002). *Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version, Patient Edition. (SCID-I/P)*. New York: New York State Psychiatric Institute Biometrics Research.

Penn, D. L., Sanna, L. J., & Roberts, D. L. (2007). Social Cognition in Schizophrenia: An Overview. *Schizophrenia Bulletin, 34*(3), 408-411. doi: 10.1093/schbul/sbn014

Purver, M., Healey, P., King, J., Ginzburg, J., & Mills, G. (2003). *Answering Clarification Questions*. Paper presented at the In Proceedings of the 4th SIGdial Workshop on Discourse and Dialogue, Sapporo, Japan.

Ramseyer, F., & Tschacher, W. (2010). Nonverbal Synchrony or Random Coincidence? How to Tell the Difference Development of Multimodal Interfaces: Active Listening and Synchrony. In A. Esposito, N. Campbell, C. Vogel, A. Hussain & A. Nijholt (Eds.), (Vol. 5967, pp. 182-196): Springer Berlin / Heidelberg.

Rümke, H. C. (1941). Das Kernsyndrom der Schizophrenie und das 'Praecox-Gefühl'. *Zentralblatt gesamte Neurologie und Psychiatrie, 102*, 168-169.

Wittenberg, P., Burgman, H., Russel, A., Klassmann, A., & Sloetjes, H. (2006). *ELAN: A professional framework for multimodality research*. Paper presented at the Fifth International Conference on Language Resources and Evaluation (LREC), ELRA, Paris.