Focal ventromedial prefrontal cortex damage impairs convergence in discourse

Abstract
Conversational partners tend to converge (become more similar) on various speech and discourse characteristics, enhancing social affiliation. We examined convergence in the discourse of eight participants with bilateral ventromedial prefrontal cortex (VMPC) damage and eight healthy comparison participants (NC) each interacting with a clinician. Changes in total words, words/turn, and backchannels were assessed across the interaction by comparing the first ¼ and last ¼ of the session. Preliminary results suggest that convergence was displayed in NC interactions as conversational partners become more similar to one another across variables. In striking contrast, VMPC interactions did not display convergence across any variables.

Introduction
Conversation is interactive. The contributions of each interactant are tightly intertwined with those of their partner, requiring considerable coordination of speech and other behaviors. This coordination is considered critical for mutual understanding and the development of rapport (Clark, 1992, 1996; Garrod & Pickering, 2009). For example, over the course of a conversation, partners have a tendency to converge (or become more similar) on certain speech characteristics such as speaking time, pauses durations, and speech rate (Cappella, 1981; Cappella & Panalp, 1981; Giles et al., 1991). Convergence of behaviors in conversation enhances social affiliation (Cappella, 1981; Giles et al., 1991).

Impairments in conversational discourse, including coordinating speech and other behaviors with a partner have been noted in traumatic brain injury (TBI). Patients with TBI have deficits in turn taking, (e.g., excessive talking) (Snow et al., 1997) and their conversations are rated as less interesting, less rewarding, and less appropriate compared to those of non-brain injured participants (Bond & Godfrey, 1997). The current study examines the role ventromedial prefrontal cortex (VMPC) in discourse convergence in conversation. While the ventromedial prefrontal cortex (VMPC) is particularly susceptible to injury following TBI (Adams et al., 1985) and VMPC damage has been associated with impairments in social behavior, the effects of focal VMPC damage on conversational discourse are not understood. This study may advance our understanding of brain-behavior relationships and provide insight into more complex cognitive communication disorders such as TBI.

Methods
Participants and Data Set
Participants included 8 individuals with bilateral ventromedial prefrontal cortex (VMPC) damage (average age=61.0; education=14.6) and 8 age-, sex-, and education-matched healthy comparison participants (see Table 1).

Data were collected using the mediated discourse elicitation protocol (MDEP) (Duff et al., 2008; Hengst & Duff, 2007). The MDEP was designed to elicit conversationally produced discourse samples in a clinical setting with a skilled clinician across four discourse types (e.g., conversation, narrative, picture description, procedural). For the current study, the analysis was restricted to the ~10 minute conversational samples. The experimental advantages of this

protocol include: 1) the MDEP was developed and data collected without the intent of analyzing convergence, improving the ecological validity of the findings, 2) although participants are interacting with a clinician, this protocol was specifically developed so the clinician is an equal communication partner and does not restrict their contributions.

Data Analysis

Sessions were videotaped and transcribed (see Duff et al., 2008). *Interactional turns*, or utterances produced by one individual before a change in speaker, were counted. *Words* were counted and included standard words (e.g., *dog*), fillers (e.g., *uh*), contractions (e.g., *don't*), and false starts (e.g., *I I love apples). Backchannels*, both verbal (e.g., *mhm*) and nonverbal (e.g., nods), were counted. Healthy participant and VMPC sessions were comparable in mean lengths (13:04 and 11:46 (min:sec) respectively; p=0.50), number of words (2448.6 and 2236.4 respectively; p=0.52) and backchannels (145 and 124.8 respectively; p=0.50).

Sessions were parsed into segments of approximately 60 second bins, while respecting turn boundaries, and the frequency of target behaviors (see below) were calculated and adjusted for the length of the segment. In order to assess changes across the interaction, the average frequency of target behaviors for the first ¼ of the session (typically 2-3 minutes) were compared to last ¼.

1.*Total words:* Percent differences between the number of words spoken by the participant and clinician.
2.*Backchannels:* Percent differences between the number of backchannels produced by the participant and clinician, corrected for words.
3.*Words per turn:* Percent differences between the number of words per turn produced by the participant and clinician.
4.*Speech rate:* Calculated by dividing the total number of words produced in each conversational turn by the duration of that turn in seconds, and multiplying by 60 to produce words per minute.

Results/Discussion

Currently 3 of the 4 analyses are complete for 7 VMPC participants and 5 comparison participants, and full analysis will be completed by March. Preliminary results, discussed below, suggest that in healthy participant interactions, convergence is displayed across the interaction as conversational partners become more similar to one another on total words spoken, words per turn, and number of backchannels. In striking contrast, in VMPC interactions, convergence is not displayed on any of these variables.

Total Words

During the first 1/4 of the conversation sample, in both healthy comparison (NC) and VMPC interactions, the participant spoke more words than the clinician (on average NCs produced 53% more words; VMPC spoke 31% more; Figure 1). However, by the last 1/4 of the NC sessions, the NCs and the clinician were speaking approximately the same amount (NCs speaking on average only 1% more words). That is, across the conversation, the speaking amounts of the NCs and the clinician converged. However, the VMPC participants continued to speak more than the clinician across the interaction (final 1/4 of the session VMPC spoke on average 32% more words). Because the VMPC and NC sessions were so similar in length and total words, there was

no main effect for group F(1,10)=.12 p=.73). The critical analyses here are the significant change in words across the session (i.e., a main effect for time, first ¼ vs. last ¼) (F(1, 10)=10.4 p=.009) and the significant interaction between time and group (F(1,10)=11.3 p=.007).

Backchannels

Similar to the previous analysis, during the first 1/4 of both NC and VMPC interactions, the clinician produced more backchannels (e.g., uh huh, nod) (corrected for words) than the participant (on average the clinician produced 77% more backchannels than the NCs; 69% more than the VMPCs; Figure 2). By the last 1/4 of the sessions, the NCs and the clinician were backchanneling approximately the same amount (clinician backchanneling on average only 7% more than NCs). However, because the VMPC participants tended to dominate the conversation, the clinician continued backchanneling on average 45% more than VMPC participants. Similar to the previous results, no main effect for group was found (F(1,10)=.88 p=.36), a significant main effect for time was found (F(1, 10)=15.8 p=.003) and the interaction between time and group trended towards significance (F(1,10)=3.8 p=.07).

Words per turn

During the first 1/4 of the interaction, both NC and VMPC participants produce more words per turn than the clinician (percent difference=78% and 66% respectively; Figure 3). However, by the last 1/4 of the conversation, NC participants and the clinician produce similar amounts of words per turn (percent difference=22%), suggesting that they are having a back-and-forth conversation, where each person speaks not only equal total amounts (Figure 1), but in each *turn* they speak nearly equal amounts. However, VMPC participants do not show this change, and continue to produce 62% more words per turn than the clinician. While no main effect for group was found (F(1,10)=1.3 p=.27),there was a significant main effect for time (F(1, 10)=10.9 p=.008) and critically a significant interaction between time and group (F(1,10)=8.3 p=.016).

In sum, the preliminary evidence shows that healthy participants demonstrate convergence with a clinician partner on number of words, backchannels, and words/turn. Second, we find deficits in speech convergence in the VMPC sessions; participants continue to produce more words total, more words per turn, and less backchannels than their partner across the interaction. These results suggest that VMPC is critical for speech and discourse convergence and may contribute to discourse impairments in TBI.

References

Adams, J. H., Doyle, D., Graham, D. I., Lawrence, A. E., McLellan, D. R., Gennarelli, T. A., et al. (1985). The contusion index: a reappraisal in human and experimental non-missile head injury. *Neuropathol Appl Neurobiol, 11*(4), 299-308.

Bond, F., & Godfrey, H. P. (1997). Conversation with traumatically brain-injured individuals: a controlled study of behavioural changes and their impact. *Brain Inj, 11*(5), 319-329.

Clark, H. H. (1992). *Arenas of Language Use*. Chicago: University of Chicago Press.

Clark, H. H. (1996). *Using language*. Cambridge: Cambridge University Press.

Cappella, J. N. (1981). Mutual Influence in Expressive Behavior - Adult-Adult and Infant-Adult Dyadic Interaction. *Psychological Bulletin, 89*(1), 101-132.

Cappella, J. N., & Panalp, S. (1981). Talk and silence sequences in informal conversations: III Interspeaker influence. *Human Communication Research, 7*, 117–132.

Duff, M. C., Hengst, J. A., Tengshe, C., Krema, A., Tranel, D., & Cohen, N. J. (2008). Hippocampal amnesia disrupts the flexible use of procedural discourse in social interaction. *Aphasiology, 22*(7-8), 866-880.

Garrod, S., & Pickering, M. J. (2009). Joint Action, Interactive Alignment, and Dialog. *Topics in Cognitive Science, 1*(2), 292-304.

Giles, H., Coupland, J., & Coupland, N. (1991). *Contexts of Accomodation*. New York: Cambridge University Press.

Hengst, J., & Duff, M. C. (2007). Clinicians as Communication Partners: Developing a Mediated Discourse Elicitation Protocol. *Top Lang Disorders 27*(1), 37-49.

Snow, P., Douglas, J., & Ponsford, J. (1997). Conversational assessment following traumatic brain injury: a comparison across two control groups. *Brain Inj, 11*(6), 409-429

Street Jr., R. L. (1988). Communication style: Considerations for measuring consistency, reciprocity, and compensation. In C. H. Tardy (Ed.), *A Handbook for the Study of Human Communication: Methods and Instruments for Observing, Measuring, and Assessing Communication Process*. Norwood, NJ: Ablex Publishing.

Table 1. Demographic and neuropsychological characteristics of the VMPC participants *(n=7; those included in preliminary data)*

Participant	Sex	Education (Years)	Age (Years)	WAIS-III FSIQ	BNT	Token Test	Acquired Personality Problems[1]	Social and Interpersonal Functioning[2]
318	M	14	69	143	60	44	Yes (3)	3
1983	F	13	46	108	58	44	Yes (3)	3
2352	F	14	60	106	54	44	Yes (3)	2
2391	F	13	63	109	57	43	Yes (2)	2
2577	M	12	69	84	55	44	Yes (3)	3
3349	F	13	66	101	53	44	Yes (1)	1
3350	M	18	57	118	52	n/a	Yes (1)	1
Mean	-	13.8	61.4	109.8			-	-

Note: M =male; F =female; WAIS-III =Wechsler Adult Intelligence Scale-III; FSIQ =Full Scale Intelligence Quotient; BNT=Boston Naming Test; n/a=not available

[1]Acquired Personality Problems refer to whether or not the participant had acquired problems in personality functioning, as derived from data on the Iowa Rating Scales of Personality Change. The numbers in parentheses denote degree of severity, where 1 = mild, 2 = moderate, and 3 = severe.

[2]The extent of post-lesion change or impairment in aspects of social conduct and interpersonal functioning was rated on a three-point scale, with 1 = no change or impairment, 2 = moderate change or impairment, 3 = severe change or impairment.

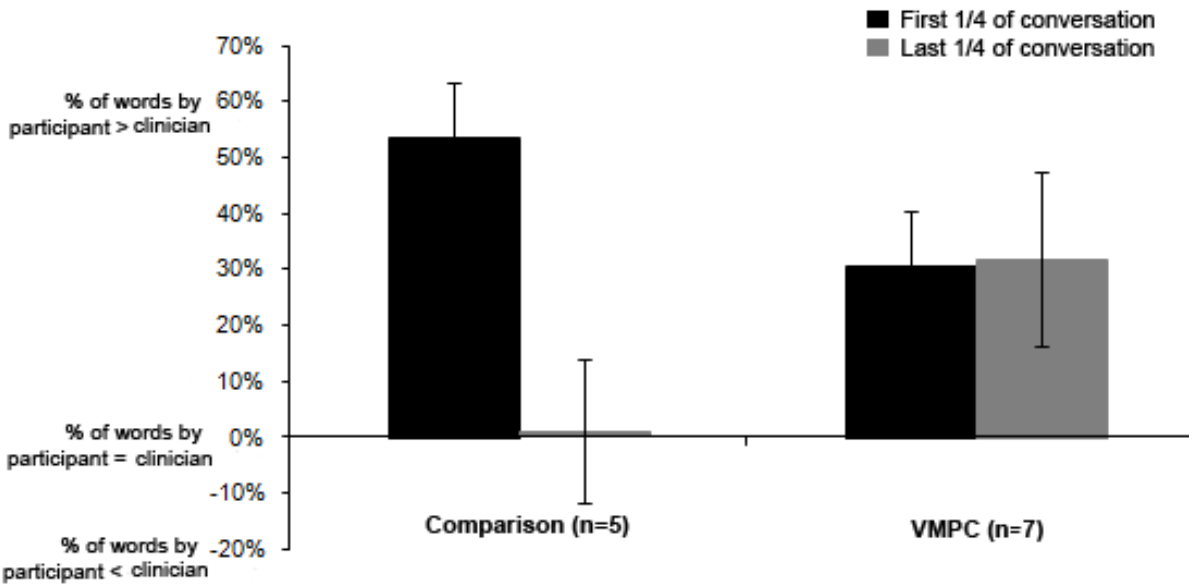

Figure 1. VMPC sessions display a lack of convergence in the number of words spoken by participant and clinician, as measured by percent difference in the number of words spoken by the partners. Note: Error bars represent S.E.M.

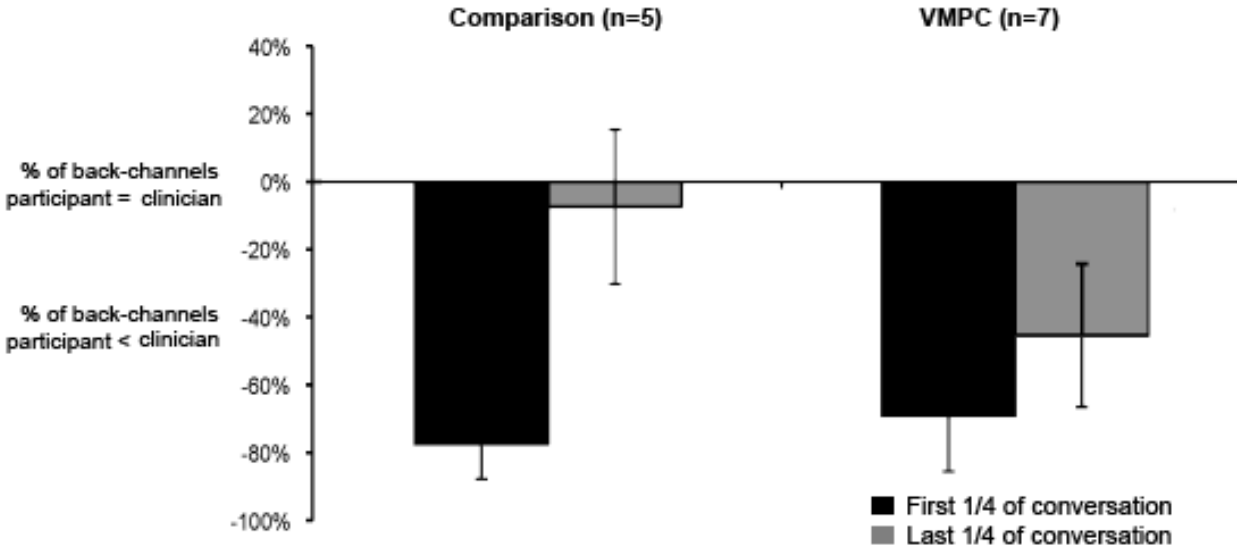

Figure 2. VMPC sessions display a lack of convergence in the number of backchannels produced by participant and clinician, as measured by percent difference in the number of backchannels produced by the partners. Note: Error bars represent S.E.M.

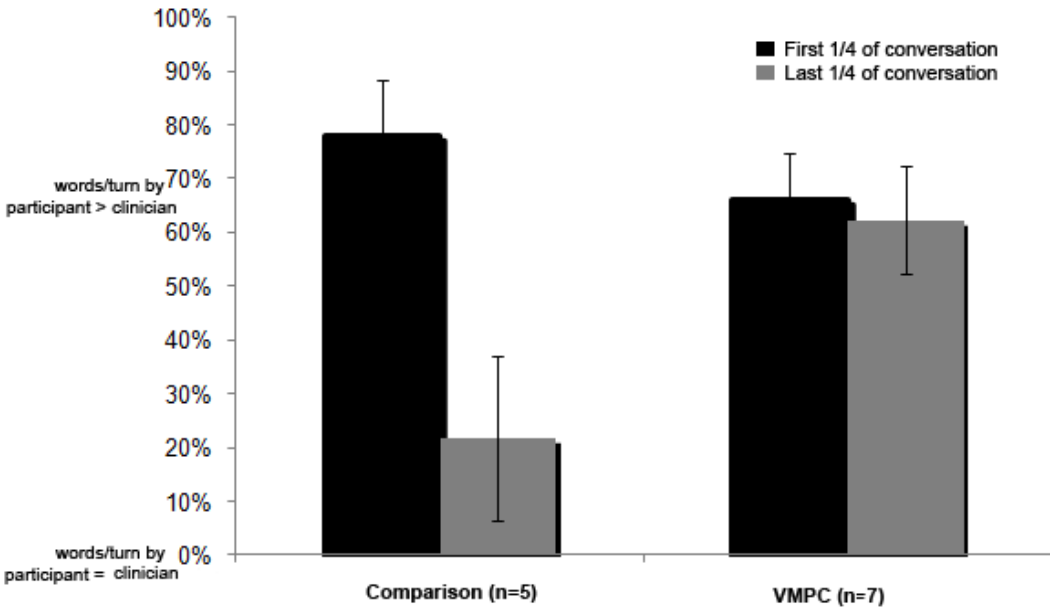

Figure 3. VMPC sessions display a lack of convergence in the number of words per turn produced by participant and clinician, as measured by percent difference in the number of words per turn produced by the partners. Note: Error bars represent S.E.M.