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Reduced sensitivity to prosodic attitudes in adults with focal right hemisphere brain damage

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Abstract

Although there is a strong link between the right hemisphere and understanding emotional prosody in speech, there are few data on how the right hemisphere is implicated for understanding the emotive "attitudes" of a speaker from prosody. This report describes two experiments which compared how listeners with and without focal right hemisphere damage (RHD) rate speaker attitudes of "confidence" and "politeness" which are signalled in large part by prosodic features of an utterance. The RHD listeners displayed abnormal sensitivity to both the expressed confidence and politeness of speakers, underscoring a major role for the right hemisphere in the processing of emotions *and* speaker attitudes from prosody, although the source of these deficits may sometimes vary.

Keywords: Speech; Language processing; Prosody; Vocal expression; Emotion; Interpersonal communication; Right hemisphere; Brain-damaged; Social cognition; Non-literal language; Group study

1. Introduction

It is commonly observed that the processing of vocal expressions of human emotions such as "anger" or "sadness" in speech shows a distinct right-sided bias in lesion and neuroimaging studies (Gandour et al., 2003; Pell, 1998, 2006; Wildgruber, Pihan, Ackermann, Erb, & Grodd, 2002). However, a closer look at the prosody research promotes the idea that understanding speech prosody engages broadly distributed and bilateral networks in the brain (Gandour et al., 2004; Mitchell, Elliott, Barry, Cruttenden, & Woodruff, 2003; Pell & Leonard, 2003) and that asymmetries in network functioning, when detected, reflect differential sensitivity of the two hemispheres to behavioural, stimulus, and/or task-related variables (Kotz et al., 2003; Pell, 2006; Tong et al., 2005; Wildgruber et al., 2002). In particular, evidence that hemispheric sensitivities for prosody are dictated by the functional significance of prosodic cues in speech is strong (Baum & Pell, 1999; Gandour et al., 2004). In large part, these findings may reflect the *relative* dominance of the right hemisphere at stages for evaluating the emotional significance of prosodic events (Schirmer & Kotz, 2006; Wildgruber et al., 2004; cf. Poeppel, 2003 for a different perspective). These conclusions emphasize the critical importance of how prosody functions in language for understanding prosody-brain relationships as was cogently described by Van Lancker (1980) who underscored the operation of pitch in prosodic communication.

However, as characterized by Van Lancker's (1980) functional laterality continuum, prosody fulfils a wider array of functions than is currently being investigated in the neuro-cognitive research. Of main interest here, little is known about how the cerebral hemispheres respond to prosodic events that serve an interpersonal or *attitudinal* function in speech ("prosodic attitudes"). For example, prosody assumes a key role in communicating the likely veracity of a statement being uttered, the extent to which a speaker affiliates with ideas or individuals under discussion, or the speaker's intended politeness toward the hearer when making a request; these cues are routinely understood by

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listeners as the attitudes held by a speaker (Brown, Strong, & Rencher, 1974; Ladd, Silverman, Tolkmitt, Bergmann, & Scherer, 1985; Uldall, 1960). The attitudinal functions of prosody may be considered 'emotive'—as opposed to emotional or linguistic—in nature because they encode various *relational* meanings which are socially relevant to the speaker—hearer in the interpersonal context in which they appear (Caffi & Janney, 1994). The ability to infer the mental states and attitudes of a speaker and integrate these details with other sources of information represents a vital area of pragmatic competence which guides interpersonal communication (Pakosz, 1983).

In contrast to emotional prosody which can at times be understood in the absence of language content (Pell, 2005; Scherer, Koivumaki, & Rosenthal, 1972), the ability to understand speaker attitudes from prosody is typically intertwined with functional properties of language such as speech acts. Thus, when studying "prosodic attitudes," one must bear in mind that prosodic cues tend to coincide with specific linguistic strategies or devices which mark these attitudes, and the ability to correctly infer the emotive position of the speaker is often the product of *comparative relations* in the significance of prosody and concurrent language features (as well as other interpersonal variables such as existing knowledge of the speaker–hearer, situational cues, etc.). In fact, many speaker attitudes are achieved when speakers intentionally violate highly conventionalized, cross-channel associations in the use of prosody and linguistic strategies which acquire emotive meanings through their association over time (Burgoon, 1993; Wichmann, 2002).

According to social-pragmatic descriptions of emotive communication (Caffi & Janney, 1994), prosody and other speech-related cues serve as various 'emotive devices' for signalling the attitudes held by a speaker along such dimensions as *evaluation* (positive/negative), *evidentiality* (confident/doubtful), and *volitionality* (self-assertive/unassertive), among others. Other pragmatic frameworks emphasize how communicative strategies, such as changes in prosody or linguistic structure, serve to attenuate versus boost the illocutionary force of speech acts which may be inherently positive or negative toward the listener; these choices thus serve to communicate the degree of belief, commitment, or strength of feeling of the speaker's intentions (Holmes, 1984). These concepts supply a principled basis for investigating how prosody and adjacent language features are understood by healthy and *brain-damaged* listeners when these features operate as emotive markers of a speaker's attitudes during spoken language processing. Given the privileged role of the right hemisphere at stages of processing the emotional significance of prosody (Schirmer & Kotz, 2006), one might reasonably predict that the right hemisphere is also centrally implicated when drawing conclusions about the emotive or attitudinal characteristics of prosody. However, as noted earlier, there are few data to support this supposition.

In a recent study of emotional prosody, Pell (2006) evaluated three groups of adults who had focal right-hemisphere-damage (RHD, $n = 9$), focal left-hemisphere-damage (LHD, $n = 11$), or no brain damage (healthy control, HC, $n = 12$). Each participant was required to discriminate, identify, and rate expressions of five basic emotions based on the prosodic features of "pseudo-utterances" which contained no emotionally-relevant language cues (e.g., *Someone migged the pazing* spoken in a "happy" or "sad" tone) and to identify emotions from utterances with semantically-biasing language content (e.g., *I didn't make the team* spoken in a congruent "sad" tone). The data established that both the RHD and LHD patients exhibited impairments when only prosody signalled the emotional interpretation (Cancelliere & Kertesz, 1990; Pell, 1998; Ross, Thompson, & Yenkosky, 1997; Starkstein, Federoff, Price, Leiguarda, & Robinson, 1994), although closer inspection of the group and individual data implied that the RHD patients displayed a more pervasive insensitivity to the emotional features of prosody, whereas LHD patients had greater problems interpreting prosody in the context of concurrent language cues. One can argue that these findings reiterate the central role of the right hemisphere in retrieving the emotional details represented by prosodic cues in speech prior to integrating this information with the meanings of language (Friederici & Alter, 2004; Pell, 2006).

The goal of the present study was to evaluate these same RHD individuals (Pell, 2006) further to determine whether their difficulties extend to problems recognizing speaker attitudes under similar testing conditions. In an initial experiment, the processing of speaker confidence which signals the reliability or correctness of an assertive speech act (along a continuum of confident/doubtful) was studied, and in a second experiment the processing of speaker politeness which encodes levels of speaker self-identification or self-assertiveness toward the listener (along a continuum of assertive/unassertive or polite/impolite) was investigated. Both the emotive value of prosody and language content were manipulated to achieve a fine-grained analysis of whether RHD listeners are insensitive to speaker attitudes based on a potential misuse of prosodic information, linguistic cues, or both.

2. Experiment 1: Understanding prosody as a cue to speaker confidence

The relative commitment of a speaker to the propositional content of their utterances, or its probable 'truth value' to the listener, is communicated through prosodic and verbal choices, although prosody is likely to play a dominant role in how these attributions are made in the auditory modality (Blanc & Dominey, 2003; Brennan & Williams, 1995). Research involving young, healthy listeners indicates that alterations in loudness, pitch (rising or falling intonation contour), and the temporal patterning of speech (e.g., pauses, speaking rate) are all important for inferring the degree of speaker confidence in an assertion being made. High speaker confidence is identified through increased loudness of voice, rapid rate of speech, short and infrequent pauses, and a terminal fall in the intonation contour (Barr, 2003; Kimble & Seidel, 1991; Scherer, London, & Wolf, 1973), whereas low speaker confidence (i.e., doubt) corresponds with longer pre-speech delay, (filled) pauses, and a higher probability of rising intonation or raised pitch (Boltz, 2005; Brennan & Williams, 1995; Smith & Clark, 1993). Verbal "hedges" (e.g., *I think…, Probably…*) also play a role in judging speaker confidence by attenuating or boosting the perceived truth value of the utterance content (Caffi & Janney, 1994; Holmes, 1984), although it is unclear how much weight these verbal cues impose on listeners relative to prosody.

In the first experiment, it was evaluated whether healthy and RHD adults who participated in our study of emotional prosody (Pell, 2006) are able to rate the extent of confidence expressed by a speaker in the context of a simple declarative utterance which asserts the location of an object. In an attempt to delineate the specificity of potential deficits to a misuse of prosodic cues to this attitude, subjects were evaluated in two separate conditions in which utterances either contained both prosodic and lexical choices for understanding speaker confidence or only representative prosodic cues (i.e., encoded in "pseudo-utterances"). Given the instrumental role of prosody for understanding speaker confidence in young, healthy listeners, it was expected that the RHD group would demonstrate a reduced sensitivity to speaker confidence when compared to healthy adults, particularly when lexical cues supplied no information about the confidence level of the speaker (Bowers, Coslett, Bauer, Speedie, & Heilman, 1987; Pell, 2006; Pell & Baum, 1997).

2.1. Method

2.1.1. Subjects

Two groups of right-handed, English-speaking participants were studied as a follow-up to Pell (2006). Nine right-hemisphere-damaged (RHD) participants who had suffered a single, thromboembolic event with anatomical lesion of the right cerebral hemisphere affecting different regions of the middle cerebral artery distribution were recruited from Montreal-area rehabilitation centres (see Table 1 of Pell, 2006). Eleven normally-aging healthy control (HC) participants were recruited from the community through local advertisements; all but one of these individuals took part in our previous study of emotional prosody. Participants in the two groups resembled each other in the ratio of male to female participants (RHD = 4:5; HC = 5:6), mean age in years (RHD = 64.2 ± 16.6; HC = 63.4 ± 16.4), and mean years of formal education (RHD = 11.9 ± 1.5; HC = 13.4 ± 2.2).

Major clinical features of the RHD patients described by Pell (2006) are summarized as follows. The presence of unilateral right hemispheric lesion was confirmed by a neurologist based on evidence from CT or MRI and corresponding neurologic signs (contralateral hemiparesis, neglect). Details about lesion site and size, when available, were obtained by the researchers from medical records at the rehabilitation centre. All RHD patients were then tested during the chronic stage of their stroke (minimum one year post-onset, $M = 6.3$ years ± 2.7, *Range* = 2.0-11.9). Multifocal damage, damage involving the brainstem/cerebellum, the existence of past or concurrent neurological conditions (including psychiatric illness), and history of substance abuse served as exclusion criteria during recruitment. Left-sided visual neglect was detected in two RHD participants (R5, R6) as indicated by the Behavioral Inattention Test (Wilson, Cockburn, & Halligan, 1987). Participants in the control group were also surveyed to rule out major neurologic or psychiatric disease before testing. The hearing of individuals in both groups was formally assessed in both ears to establish acceptable hearing (puretone) thresholds for studies involving speech (minimum 35 db HL at 0.5, 1, and 2 kHz for the better ear). Each RHD and HC participant also completed a battery of neuropsychological tests which characterized overall cognitive status, perception, memory, and emotional functioning for these individuals.

Table 1
Neuropsychological performance for members of the right hemisphere damaged (RHD) and healthy control (HC) group, including data on the ability to identify basic emotions from prosody (Pell, 2006) (M ± *SD*, converted to percent correct)

Measure	Group		
	HC ($n = 11$)	RHD ($n = 9$)	Sig. (HC > RHD)
Mini-mental state exam (/30)	—	90.7 ± 7.2	—
Benton phoneme discrimination (/30)	92.1 ± 6.7	82.6 ± 10.1	$p < .05$
Benton face discrimination (/54)	87.2 ± 7.1	77.8 ± 6.5	$p < .05$
Auditory working memory—words recalled (/42)[a]	—	51.4 ± 11.1	—
Identifying emotion from faces (/40)	86.3 ± 9.1	68.6 ± 27.3	$p < .05$
Identifying emotion from verbal scenarios (/10)	86.0 ± 12.0	64.0 ± 25.5	$p < .05$
Discriminating emotional prosody (/30)[b]	79.0 ± 9.6	68.5 ± 11.8	$p < .05$
Identifying emotion prosody from pseudo-utterances ('pure prosody, /40)[c]	68.8 ± 24.0	43.9 ± 27.1	$p < .01$
Identifying emotional prosody with semantic cues (/40)[d]	79.5 ± 24.1	65.0 ± 25.9	$p < .05$

[a] Four RHD patients (R3, R7, R8, and R9) were unable to complete this task.
[b] As reported by Pell (2006), patients R2, R5, and R6 performed below the HC group range on the Emotion discrimination task.
[c] Patients R3, R5, and R6 performed below the HC group range on the "Pure prosody" Emotion identification task.
[d] Patients R4, R5, R6, and R8 performed below the HC group range on the "Semantic-prosody" Emotion identification task.

A summary of these findings, together with data on how the groups compared on tasks of processing emotional prosody (Pell, 2006), is furnished in Table 1. It should be noted that four of the RHD patients (R3, R7, R8, and R9) were unable or unwilling to complete the auditory working memory (listening span) task, although these individuals completed all other neuropsychological tasks listed in Table 1.

2.1.2. Experimental tasks/materials

Stimuli were canonical English sentences of 6–11 syllables in length. Each sentence was phrased as a declarative that could be modulated by prosody, and in some conditions lexical cues, to convey different levels of speaker confidence in the assertion. All stimuli were digitally recorded in a sound-attenuated booth by four male actors and then transferred to a PC for editing using Praat software (saved in wav format, 24 kHz, 16 bit, mono). Sentences were constructed to fit two distinct conditions for inferring speaker confidence. In the *linguistic* task, stimuli were semantically informative statements (e.g., *You turn left at the lights*) which began with linguistic phrases such as *for sure, most likely*, or *perhaps* to convey a relatively high, moderate, or low degree of speaker confidence through linguistic and prosodic cues of these utterances. During recording, actors were read a series of scenarios to help elicit target utterances with the desired level of high, moderate, or low confidence features. For the linguistic condition, this resulted in a set of stimuli for which prosody *and* lexical markers were available to guide listeners' interpretations of three levels of speaker confidence.

In the *prosody* task, comparable pseudo-utterances were constructed to resemble stimuli representing each confidence level in the linguistic condition (e.g., *You turn left at the lights → You rint mig at the flugs*). Each pseudo-utterance was produced to communicate a high, moderate, and low degree of confidence by manipulating prosodic features alone. To facilitate naturalistic productions in the prosody condition, actors always produced pseudo-utterances for a particular confidence level immediately after producing the corresponding stimulus in the linguistic condition, allowing them to mimic appropriate prosodic patterns across conditions to a considerable extent.

Stimulus validation procedure—To ensure that recorded stimuli reliably communicated different levels of speaker confidence in each condition; a pilot study was run to gather perceptual ratings for selecting only the best stimuli for each task. Independently for the linguistic (semantically-meaningful) and prosody (semantically-anomalous) stimuli, ten young adults (five male, five female) judged the utterances produced by the four actors which were played in a randomized sequence. Pilot subjects judged "how confident the speaker sounds" when producing each utterance along a five-point (1–5) scale, where "one" represented "not at all confident" and "five" represented "very confident". Based on the mean rating and standard deviation assigned by the pilot group to each token,[1] the most reliable exemplars of high, moderate and low confidence utterances were selected for entry into a corresponding linguistic or prosody rating task for presentation to RHD patients. In total, 45 stimuli (3 confidence levels × 15 tokens) were selected for each experimental task. A one-way repeated-measures ANOVA established that the mean ratings assigned to high, moderate, and low confidence exemplars robustly differentiated these three categories in the predicted manner for both the linguistic [$F(2,28) = 301.00$, $p < .001$] and the prosody [$F(2,28) = 113.76$, $p < .001$] stimuli.

Basic acoustic analyses of the 15 tokens representing each confidence level were undertaken for both task conditions. The linguistic stimuli were characterized by changes in mean fundamental frequency (high = 110 Hz; moderate = 130 Hz; low = 133 Hz), f0 range (high = 58 Hz, moderate = 86 Hz, low = 87 Hz), and speech rate in syllables per second (high = 5.26, moderate = 4.50, low = 3.93). The prosody (pseudo) stimuli displayed comparable changes in mean f0 (high = 116 Hz, moderate = 127 Hz, low = 136 Hz), f0 range (high = 62 Hz, moderate = 56 Hz, low = 103 Hz), and speaking rate (high = 4.46, moderate = 4.30, low = 3.18). A series of one-way ANOVAs confirmed that the three confidence levels differed significantly with respect to each of the three acoustic parameters, with only slight variations in these patterns for stimuli entered into the linguistic versus the prosody condition.[2]

2.1.3. Procedure

The RHD patients were tested in a quiet room in their home whereas HC subjects were tested in a laboratory room. The linguistic and prosody tasks were presented during a single session using SuperLab presentation software (Cedrus, USA). The presentation order of the rating tasks was alternated, so that approximately half of the participants in each group heard the prosody stimuli first and half heard the linguistic stimuli first. Individual trials within each task were pseudo-randomly distributed into two

[1] In both conditions, "high" confidence utterances had obtained mean perceptual ratings between 4.33 and 5.00 ($SD \leqslant 0.83$), "moderate" confidence utterances were rated between 2.7 and 3.6 ($SD \leqslant 0.94$), and "low" confidence utterances were rated between 1.11 and 1.78 ($SD \leqslant 0.97$).

[2] For stimuli presented in the linguistic task, the three confidence levels differed significantly according to mean f0 [$F(2,42) = 6.61$, $p < .01$], f0 range [$F(2,42) = 4.05$, $p < .05$], and speech rate [$F(2,42) = 7.37$, $p < .01$]. Posthoc Tukey's comparisons ($p < .05$) indicated that "high" confidence utterances displayed a lower mean f0 and smaller f0 range than both "moderate" and "low" confidence utterances, which did not differ; moreover, all three confidence levels were significantly distinct in speech rate (high > moderate > low confidence, which was expressed most slowly). For the utterances presented in the prosody task, the three confidence levels were again defined by significant acoustic differences for all three measures [mean f0: $F(2,42) = 4.38$, $p = .02$; f0 range: $F(2,42) = 5.40$, $p < .01$; speech rate: $F(2,42) = 11.38$, $p < .001$]. High confidence was expressed with a lower mean f0 than low confidence, and both high and moderate confidence utterances displayed a reduced f0 range when compared to low confidence utterances. Finally, high confidence was expressed with a faster speech rate than both moderate and low confidence for the prosody stimuli.

separate blocks containing an approximately equal number of high, moderate, and low confidence exemplars, as well as tokens produced by different speakers.

All stimuli were played by a portable computer over high quality, volume adjustable headphones. Participants were instructed to listen closely to each sentence and, while viewing a five-point Likert scale on the computer screen, to tell the examiner which rating on the scale corresponded with the degree of confidence expressed by the speaker when producing the utterance (responses were entered by the examiner using the keyboard). For the prosody task, participants were informed that sentences would not "make sense" but that they should judge the extent of speaker confidence in the same manner. Each task always began with instructions and a practice session of 12 trials which did not appear in the actual experiment (i.e., high, moderate, and low confidence utterances that had not been selected following the validation procedure). The practice session familiarized listeners with the nature of the stimuli presented in that task, the speakers' voices, and the response procedure. No time limitations were imposed during testing. Subjects received a nominal fee for their participation (CAD $10/h).

2.2. Results

Table 2 displays the mean ratings (and standard deviations) assigned to stimuli encoding each level of speaker confidence, by group and condition. First, a 2×3 ANOVA involving condition (linguistic, prosody) and confidence level (high, moderate, low) was performed for each group separately to clarify how these factors may have affected their mean confidence ratings. For the *HC group*, there was a main effect of confidence level [$F(2, 20) = 135.58$, $p < .001$]; as expected, healthy listeners assigned significantly higher ratings to exemplars in the high versus moderate versus low confidence category (Tukey's HSD comparisons, $p < .05$). There was no impact of condition on confidence ratings for the HC group (both F's < 0.99, p's > .34). For the *RHD group,* the effect of confidence level was again significant [$F(2, 16) = 11.74$, $p < .001$], explained by the fact that the patients also differentiated the categories of high, moderate, and low confidence utterances between each level. In addition, a main effect was observed for condition [$F(1, 8) = 5.31$, $p = .05$]. Overall, the RHD listeners assigned higher ratings of speaker confidence when prosody *and* linguistic cues signalled this attitude as opposed to prosody alone.

To compare the two groups, a series of χ^2 analyses considered whether the frequency *distribution* of ratings assigned by the RHD and the HC groups were statistically independent when judging exemplars representing each confidence level, independently by condition. In the *linguistic* task, the confidence ratings assigned by RHD patients were distinct from those of the HC group when prosody and linguistic cues signified a high [χ^2 (4) = 24.88 $p < .001$], moderate [$\chi^2(4) = 39.19$, $p < .001$], and low [$\chi^2(4) = 42.36$ $p < .001$] degree of speaker confidence in the verbal message. In the *prosody* task, the distribution of responses assigned by RHD and HC participants was again distinct when rating the category of high [$\chi^2(4) = 50.72$, $p < .001$], moderate [$\chi^2(4) = 31.12$, $p < .001$], and low [$\chi^2(4) = 14.06$ $p < .01$] confidence exemplars. Evaluation of these patterns in Fig. 1 reveals that, unlike controls, the RHD group poorly differentiated the three confidence levels at most intervals of the rating scale, which seemed to be especially pronounced when listening to the prosody stimuli.

A final analysis considered the overall impact of manipulating lexical and prosodic cues in speech on how the two groups rated speaker confidence. A χ^2 analysis considered each group's distribution of ratings summed across the three confidence levels in the linguistic versus the prosody condition (these analyses were based on 495 responses for the HC group and 405 responses for the RHD group, per condition). For the HC group, confidence ratings showed a similar distribution between the two cue conditions [$\chi^2(4) = 7.79$, $p > .05$, *n.s.*] whereas the rating distribution for the RHD group was significantly biased by the cue manipulation [$\chi^2(4) = 26.02$, $p < .001$]. Review of Fig. 1 implies that, contrary to healthy listeners, the RHD patients relied more on lexical markers for inferring the extent of speaker confidence, and exhibited a tendency for judging speakers as less or "not at all" confident when exposed to prosodic cues alone.

Table 2
Mean ratings of speaker confidence (with standard deviations) assigned by the right-hemisphere damaged (RHD) and healthy control (HC) groups by condition and confidence level

	HC participants ($n = 11$)	RHD participants($n = 9$)
Confidence level*	Linguistic condition	
High	4.57 (0.71)	4.01 (1.42)
Moderate	3.03 (0.94)	2.92 (1.39)
Low	1.68 (0.83)	2.40 (1.36)
	Prosody condition	
High	4.37 (0.76)	3.47 (1.35)
Moderate	3.01 (1.01)	2.47 (1.27)
Low	1.61 (0.78)	1.90 (1.17)

* Note: Fifteen items contributed to the mean rating for each confidence level, per participant.

2.3. Discussion

Results of Experiment 1 establish that adults with focal right-hemisphere lesions do not show the normal capacity to judge the relative confidence of a speaker who is issuing a statement, such as clarifying the probable location of an object. The RHD group exhibited significant differences from healthy, aging participants in the ability to evaluate speaker confidence in both cue conditions tested, one in which only prosodic attributes conveyed this attitude and one in which prosody and lexical markers biased the intended interpretation. These findings underscore that many RHD patients who exhibit impairments for recognizing basic emotions from the prosodic features of utterances

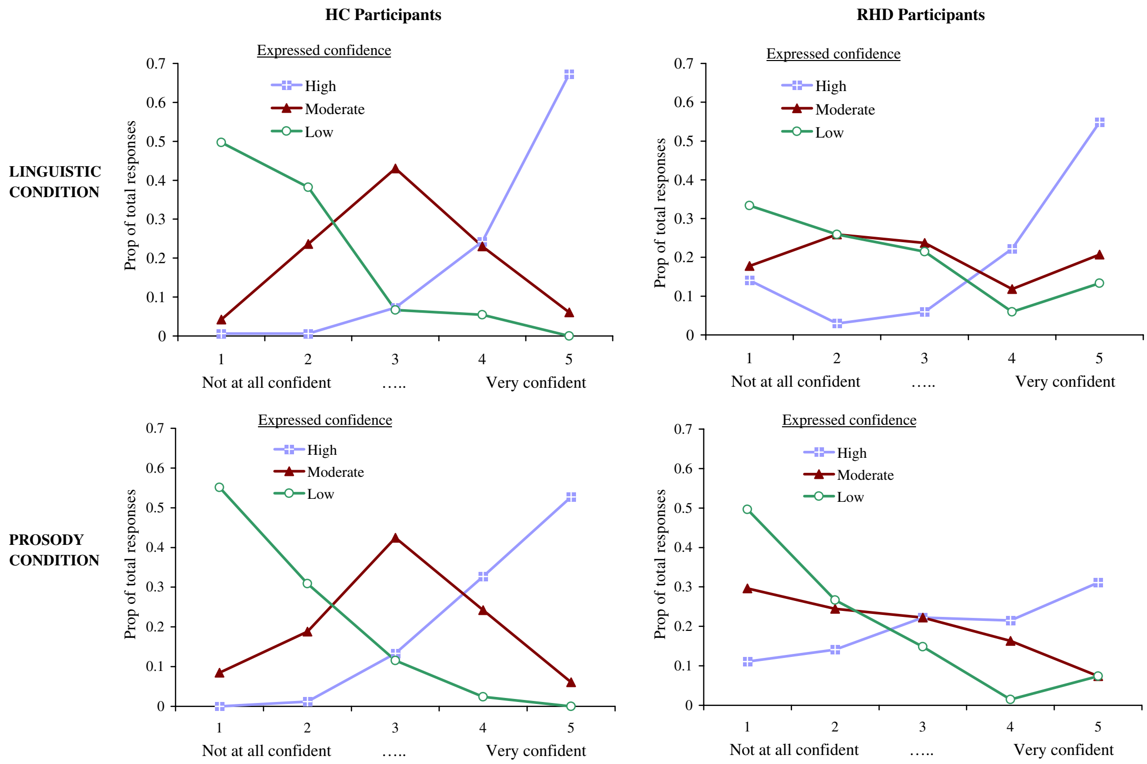

Fig. 1. The proportion of confidence ratings assigned at each interval of the 5-point scale in the linguistic and prosody tasks by participants with right hemisphere damage (RHD) and healthy controls (HC), according to the level of expressed confidence.

(Pell, 2006) are also likely to present with deficits for recognizing speaker "attitudes" such as confidence which revolve in a major way around an analysis of prosody.

Although attitudinal judgements rendered by the RHD patients were clearly atypical of those rendered by healthy adults, both listener groups showed a similar capacity to differentiate utterances constructed to convey "high," "moderate," or "low" speaker confidence by using the rating scale in the expected manner (i.e., mean ratings were greater for the category of "high" than "moderate" than "low" confidence exemplars). However, the ability of the RHD patients to detect graded differences among the three confidence levels tended to be less precise than for the HC group, yielding fewer distinctions among the response distributions pertaining to the three confidence levels. Evidence that RHD patients were less sensitive to meaningful distinctions in speaker confidence was found in both our "linguistic" and "prosody" tasks, although closer inspection of the data emanating from each cue condition argues strongly that interpreting speaker confidence from prosodic cues alone was especially problematic for the RHD group (review Fig. 1a and b). In the prosody only task, there were marked qualitative differences between the groups which imply that RHD patients frequently did not detect overt prosodic indicators of "speaking with confidence," such as speaking with a lower f0 and faster speaking rate (Kimble & Seidel, 1991; Scherer et al., 1973). This was most obvious for "high" confidence utterances in the prosody task which were highly salient to healthy listeners, although the RHD listeners displayed a highly aberrant response pattern in this context.

One issue which informs the group patterns pertains to the role and ultimate importance of lexical features of our stimuli for signalling reliable differences in speaker confidence to listeners. Interestingly, the ratings assigned by the HC group displayed almost no differences in how speaker confidence was judged from pseudo-utterances containing only prosodic indicators of this attitude when compared to "real" utterances containing prosody and *lexical* phrases indicative of speaker confidence. Given the major overlap in how healthy participants interpreted speaker confidence between our cue conditions, it is likely that lexical hedges in our stimuli such as "*I'm sure," "probably*", or "*likely*" assumed very little weight when making attributions about speaker confidence for these listeners. Rather, one must assume that prosodic features were the decisive factor in both conditions, leading to minimal differences in the rating distributions assigned by the control group in the linguistic and prosody tasks. This argument fits with previous data indicating the paramount importance of prosody for how normal listeners infer confidence or a "feeling-of-another's-knowing" from spoken language devoid of visual cues (Barr, 2003; Brennan & Williams, 1995; Kimble & Seidel, 1991).

Unlike healthy listeners, speaker confidence ratings assigned by the RHD group did not closely approximate each other across the two cue conditions; in particular, utterances recognized as very confident by healthy listeners were seldom recognized by RHD patients based on prosody alone, although these interpretations were facilitated somewhat when lexical phrases biased a high confidence meaning. These comparative results imply that listeners in the RHD group were more attuned to lexical features when judging attitudes of confidence, despite the fact that lexical cues were shown to be less informative to healthy listeners when inferring this particular attitude. The idea that RHD patients accord greater weight to the value of linguistic-verbal cues over prosody—perhaps as a compensatory attempt to understand attitudinal meanings which are encoded to a large extent through prosody—has been described previously when RHD patients are engaged in relatively complex interpretive language tasks (Bowers et al., 1987; Brownell, Carroll, Rehak, & Wingfield, 1992; Pell & Baum, 1997; Tompkins & Mateer, 1985). Given the central importance of prosody for deriving meanings in both of our tasks, in the current study this abnormal tendency to focus on the language channel (to the extent possible) may have been dictated by subtle impairments for processing the prosodic underpinnings of confident attitudes following damage to the 'emotive' right hemisphere.

3. Experiment 2: Understanding prosody as a cue to speaker politeness

Emotive features of speech which reflect the self-assertiveness of the speaker *vis-à-vis* the listener are strongly associated with the notion of 'politeness principles'(Caffi & Janney, 1994). In the language channel, relative politeness is marked through word selection (e.g., *please*) and through choices in sentence structure; in the latter case, perceived politeness tends to increase in the face of 'conventional indirectness', for example, when a command is framed as an optional request posed to the listener (Blum-Kulka, 1987; Brown & Levinson, 1987; Clark & Schunk, 1980). In the prosodic channel, politeness is communicated in large part through conventionalized choices in intonational phrasing; utterances with high/rising pitch tend to be perceived as more polite than those with a terminal falling contour (Culpeper, Bousfield, & Wichmann, 2003; Loveday, 1981; Wichmann, 2002), as are utterances produced with decreased loudness (Culpeper et al., 2003; Trees & Manusov, 1998). Most typically, differences in prosody and utterance type *combine* to signal the intended politeness of the speaker, for example, by attenuating or boosting the negative, illocutionary force of a request which places an imposition on the listener (LaPlante & Ambady, 2003; Trees & Manusov, 1998; Wichmann, 2002).

Although research has examined how RHD patients process the meaning of direct versus indirect requests (Hirst, LeDous, & Stein, 1984; Stemmer, Giroux, & Joanette, 1994; Weylman, Brownell, Roman, & Gardner, 1989), the specific role of prosody in judging the politeness of requests following RHD has not been carefully explored (Foldi, 1987). In the second experiment, the same RHD and HC listeners were evaluated to determine their sensitivity to speaker politeness based on the more complicated interplay of linguistic and prosodic strategies for communicating this attitude (and from prosody alone, by presenting pseudo-utterances comparable to those constructed in Experiment 1). It was anticipated that the RHD listeners would continue to exhibit differences in how they used prosodic information to recognize speaker politeness, but that impairments would be most pronounced in conditions where shifts in this attitude are marked by discrepant features in the prosody and language channels.

3.1. Method

3.1.1. Subjects

Participants were six of the RHD patients and ten of the HC subjects evaluated in Experiment 1 and by Pell (2006). Patients R2, R4, and R5 were unavailable for further testing when Experiment 2 was administered, approximately 2.5 years after Experiment 1. The RHD (age: $M = 62.8$; education: $M = 12.7$) and HC (age: $M = 65.6$; education: $M = 13.8$) groups were composed of an equal number of male and female participants.

3.1.2. Experimental tasks/materials

Stimuli were English sentences ranging from 3 to 15 syllables in duration, phrased as a command/request for a simple action to be performed by the listener. As in Experiment 1, an independent set of stimuli were prepared for eliciting politeness judgements based on combined prosody and lexical-semantic cues ("linguistic" condition) or prosodic features alone ("prosody" condition). Stimuli in the *linguistic* task were eight "stem" commands (e.g., *Do the dishes*) which were modified at the beginning of the utterance to change the emotive force of the command in four distinct ways: "direct" utterances contained initial phrases which linguistically boosted the intent of the command (*You must do the dishes*); "indirect" (*Can you do the dishes*) and "very indirect" (*Could I bother you todo the dishes?*) utterances used conventional indirectness to attenuate the negative force of the command; and "please" utterances (*Pleasedo the dishes*) contained an explicit lexical marker of politeness in English to attenuate the command. The influence of prosody on politeness judgements was assessed by requiring two female actors to produce all items for each linguistic construction in two prosodic modes: with a high/rising tone which tends to attenuate the imposition of requests (i.e., be interpreted as polite); and a falling tone which tends to boost the negativity of the request (i.e., less polite). Exhaustive combinations of linguistic (stem, direct, indirect, indirect+, please) and prosodic (rise, fall) factors for the eight items yielded 80 utterances recorded for each actor in the linguistic condition. Note that for some of these cue combinations, the emotive function of linguistic and prosodic conventions for understanding speaker politeness was opposed (e.g., indirect language spoken with a low prosody).

A parallel *prosody* task was created to examine the isolated effects of prosody on politeness judgements, consistent with our earlier methods. Linguistic stem sentences were altered to form comparable pseudo-utterances without semantic content. Given large differences in the length of the linguistic sentences, "short" (*Gub the mooshes*) and "long" (*Voriful yoza gub the mooshes*) pseudo-utterances were constructed for each stem command to avoid potential confounding effects of sentence length on politeness judgments in the prosody condition. All items were produced by the two actors in a "rising" and a "falling" tone like in the linguistic condition (again, actors first produced the linguistic stimulus and then echoed the prosodic pattern when producing the pseudo-utterance during the elicitation procedure). Thirty-two utterances were recorded for each actor in the prosody condition.

Stimulus validation procedure—To ensure that stimuli were valid for conveying the intended meanings, the "linguistic" and "prosody" utterances were judged by a group of eight young adults (3 male, 5 female) in separate pilot tasks. Participants listened to each sentence and indicated on a five-point (1–5) scale how "polite the speaker sounds," where "1" represented "not-at-all polite" and "5" represented "very polite". Based on the mean politeness ratings for the pilot group,[3] exemplars obtaining a high consensus about the meaning conveyed were retained for the main experiment and entered into a final corresponding "linguistic" (5 linguistic structures × 2 tones × 8 items) or "prosody" (2 tones × 2 sentence lengths × 8 items) rating task. For the selected linguistic stimuli, a 5 × 2 ANOVA showed that politeness ratings differed significantly according to Utterance type [$F(4,28) = 20.48$, $p < .001$], Prosody [$F(1,7) = 1399.58$, $p < .001$], and as an interaction of these factors [$F(4,28) = 11.25$, $p = .001$]. Posthoc examination of the interaction ($p < .05$) indicated that "rising" prosody was always perceived as significantly more polite than "falling" prosody irrespective of utterance type, although the effect of specific utterance types on ratings for each intonation contour differed to some extent.[4] For the selected prosody stimuli, a 2 × 2 ANOVA independently established that pseudo-utterances spoken with a rising versus falling intonation were rated as significantly more polite [Prosody main effect, $F(1,7) = 168.87$, $p < .001$], with no main or interactive effect of sentence Length on the ratings (both p's > .19).

Basic acoustic measures (mean f0, f0 range, speech rate) of the stimuli presented in the linguistic and prosody tasks are furnished in Table 3. Statistical analysis of each acoustic measure, by means of a two-way ANOVA involving prosody and relevant utterance distinctions for each stimulus set, revealed that the prosody manipulation (rise, fall) was strongly associated with multiple acoustic differences in each stimulus set, although the impact of utterance type or utterance length on the acoustic measures was comparatively minimal.[5]

3.1.3. Procedure

Testing procedures were largely identical to those of Experiment 1. All testing was completed during a single 45-min session, alternating the order of linguistic and prosody tasks within and between groups. Stimuli in the linguistic task were distributed into three separate blocks of 26–27 items each, whereas stimuli in the prosody task were presented in a single block of 32 items. Participants were instructed to listen closely to each utterance and to judge the politeness of the speaker by choosing a number on a five-point scale presented on the computer screen (where "5" = "very polite" and "1" = "not at all polite"). Again, listeners were cautioned at the beginning of the prosody task that sentences would not "make sense," and each task always began with a practice block of 10 trials (which did not appear in the experiment) to accustom participants to the nature of the stimuli and task requirements. Subjects indicated their response verbally to the examiner and the numerical rating assigned to stimuli in each condition were analyzed statistically.

3.2. Results

The mean politeness ratings assigned by each group (with standard deviations) are furnished in Table 4 for each

[3] In the linguistic condition, "stem commands" were assigned mean ratings of 1.25 ($SD = 0.48$) when spoken in a low tone and 3.36 ($SD = 0.68$) when spoken in a high/rising tone. "Direct" sentences received mean ratings of 1.34 ($SD = 0.51$) for a low tone and 3.21 ($SD = 0.75$) for a high tone. "Indirect" utterances had mean ratings of 1.64 ($SD = 0.64$) for low tone and 3.85 ($SD = 0.71$) for high tone. "Very indirect" utterances obtained a mean rating of 1.59 ($SD = 0.56$) for low tone and 4.47 ($SD = 0.62$) for high tone. "Please" utterances obtained mean ratings of 1.65 ($SD = 0.66$) for low tone and 3.92 ($SD = 1.02$) for high tone. In the prosody condition, the "short" and "long" sentences produced in a low tone had mean ratings of 1.42 ($SD = 0.57$) and 1.45 ($SD = 0.53$) and those in a high tone had mean ratings of 4.16 ($SD = 0.71$) and 4.29 ($SD = 0.83$), respectively.

[4] When utterances were spoken with a falling intonation, "direct" and "stem" commands were rated as significantly less polite than "indirect," "very indirect," and "please" utterances, which did not differ. When utterances were spoken in a rising intonation, direct and stem commands were again rated as the least polite, although there were more differences among the remaining utterance type levels in their perceived politeness: direct<indirect<please<very indirect.

[5] For the linguistic task, a 5 × 2 ANOVA involving Utterance Type and Prosody was performed on each acoustic parameter. The main effect for Prosody was significant for mean f0 [$F(1,31) = 39.51$, $p < .001$], f0 range [$F(1,31) = 13.61$, $p < .01$] and speech rate [$F(1,31) = 9.35$, $p < .01$]. Utterances with a "rising" prosody displayed a higher mean and range of f0 and a slower speech rate than "falling" utterances. A main effect of Utterance Type was observed for the measure of speech rate only [$F(4,31) = 4.37$, $p < .01$]. "Please" utterances were spoken significantly more quickly than both "indirect" and "very indirect" utterances. There was no interaction of Utterance Type and Prosody for any of the acoustic measures. For the prosody task, a 2 × 2 ANOVA involving Prosody and sentence Length revealed a significant effect of Prosody on mean f0 [$F(1,14) = 12.79$, $p < .01$] and f0 range [$F(1,14) = 4.64$, $p < .05$], although not for speech rate. Pseudo-utterances with a "rising" prosody were higher in both mean and range of f0 than "falling" utterances. There were no main or interactive effects of sentence Length on the three acoustic measures.

Table 3
Basic acoustic measures of the politeness stimuli entered into Experiment 2 by task, according to levels of utterance type and prosody

Utterance type*	Mean f0 (Hz)		f0 Range (Hz)		Speech rate (syllables/s)	
	Falling prosody	Rising prosody	Falling prosody	Rising prosody	Falling prosody	Rising prosody
Linguistic condition						
Stem	228	277	151	192	3.87	4.27
Direct	228	268	158	184	3.79	4.68
Indirect	216	258	139	221	4.63	4.74
Very Indirect	229	270	218	312	4.32	4.7
Please	218	257	165	180	2.93	3.95
Prosody condition						
Short	220	286	130	262	3.66	4.02
Long	232	250	219	245	3.95	4.08

* Note: Eight items contributed to each conditional mean value.

Table 4
Mean ratings of speaker politeness (with standard deviations) assigned by right-hemisphere damaged (RHD) and healthy control (HC) participants by condition, utterance type and prosody

Utterance type[a]	HC participants ($n = 10$)		RHD participants ($n = 6$)	
	Falling prosody	Rising prosody	Falling prosody	Rising prosody
	Linguistic condition			
Stem command	1.33 (0.21)	2.84 (0.51)	1.45 (0.34)	2.75 (0.45)
Direct	1.16 (0.14)	2.99 (0.45)	1.52 (0.27)	2.56 (0.29)
Indirect	1.89 (0.33)	3.61 (0.51)	2.46 (0.37)	3.45 (0.46)
Very indirect	1.65 (0.33)	4.07 (0.49)	2.15 (0.72)	3.98 (0.48)
Please	1.98 (0.37)	4.17 (0.34)	2.70 (0.90)	4.24 (0.44)
	Prosody condition			
Pseudo-short	1.76 (0.31)	4.11 (0.45)	2.03 (0.52)	3.96 (0.45)
Pseudo-long	1.70 (0.18)	4.29 (0.56)	2.23 (0.51)	4.00 (0.66)

[a] Note: Eight items contributed to the mean rating for each combined level of utterance type and prosody, per participant.

task according to manipulations in the stimulus parameters. For each task, analyses were first performed on each group separately (given differences in the size of our two groups) to establish how levels of utterance type and/or prosody influenced the mean politeness ratings assigned by each group. This was followed by analyses which compared the two groups directly by task.

In the *linguistic* task, a 5×2 ANOVA with repeated levels of Utterance Type (stem, direct, indirect, indirect+, please) and Prosody (high, low) was performed on the mean ratings obtained for each group. For the HC group, significant main effects emerged for Utterance Type [$F(4, 36) = 64.18$, $p < .001$] and Prosody [$F(1, 9) = 240.69$, $p < .001$] and a significant Utterance Type × Prosody interaction was observed [$F(4, 36) = 10.01$ $p < .001$]. Posthoc (Tukey's HSD) comparisons of the conditional means ($p < .05$) indicated that sentences spoken in a high versus a low prosody had a marked influence on politeness ratings, with uniformly higher ratings corresponding to a high/rising contour irrespective of the linguistic content. For both prosody types, stem commands and requests with direct wording were always rated as relatively impolite and there were no differences between these two utterance types. When sentences were produced in a high (polite) tone, stem/direct utterances were both rated as less polite than indirect utterances (*Can you*...) which in turn were significantly less polite than very indirect utterances (*Could I bother you to*...) or those containing "please," which were both perceived as the most polite. Interestingly, when sentences were produced in a low (impolite) tone, stem/direct utterances were judged to be less polite than indirect and "please" utterances, whereas utterances containing very indirect language spoken in a low prosody were not rated as significantly more polite than stem commands spoken with the same tone. For the RHD group, the ANOVA uncovered significant main effects for Utterance Type [$F(4, 20) = 17.68$, $p < .001$] and Prosody [$F(1, 5) = 54.28$, $p < .001$].

The RHD patients judged utterances spoken in a high prosody to be significantly more polite than those spoken in a low prosody in the linguistic condition overall. Independently, the patients assigned significantly lower politeness ratings to stem commands and direct utterance types when compared to indirect, very indirect, and "please" constructions which did not differ in any case. The interaction of utterance type and prosody on politeness judgements was not significant for the RHD group [$F(4, 20) = 1.89$, $p = .20$, *n.s.*]. In the *prosody* task, separate 2×2 ANOVAs with repeated measures of Prosody (high, low) and sentence LENGTH (short, long) were performed for each group. For each group, a significant main effect of Prosody characterized the pattern of ratings assigned by the HC [$F(1, 9) = 174.76$, $p < .001$] and the RHD [$F(1, 5) = 37.31$, $p = .002$] participants. Sentences spoken with a high prosody were always judged to be more polite than those spoken in a low prosody, irrespective of the utterance length (all main and interactive effects involving LENGTH, $p > .05$).

Given the conjoint influences of utterance type and prosody for judging politeness for healthy listeners, a final analysis considered whether the performance of the two groups differed according to whether levels of Utterance Type and Prosody were operating as a device for "attenuating" or "boosting" the inherent negative force of the request. Previous research implies that unconventional associations of linguistic and prosodic cues which conflict in their emotive function are most likely to generate speaker attitudes, usually favouring a negative (impolite) evaluation of the utterance (LaPlante & Ambady, 2003). The frequency distribution of ratings recorded at each interval of the five-point politeness scale was compared between groups after summing responses assigned to the "stem" and "direct" utterances (boosters) and those for the "indirect," "very indirect," and "please" utterances (attenuators), separately in conditions of a low prosody (booster) or a high prosody (attenuator). χ^2 analyses examined the frequency distributions of the two groups in each of the four contexts to determine how language and prosodic strategies conjointly influenced the politeness ratings when defined in this manner (each analysis included 250 observations for the HC group and 150 observations for the RHD group).

The group rating distributions were significantly independent in two of the four conditions: when language boosted but prosody attenuated the request [$\chi^2(4) = 12.05$, $p < .025$] and when language attenuated but prosody boosted negative features of the request [$\chi^2(4) = 40.02$, $p < .001$]. Qualitative inspection of these patterns, illustrated in Fig. 2, underscored that group differences were most notable in the context in which speakers employed linguistic strategies to render the request more polite in conjunction with a disconfirming and impolite, low prosody (middle left panel of Fig. 2). In this context, RHD patients tended to rate these utterances as more polite than the HC listeners.

3.3. Discussion

The results of Experiment 2 must be interpreted with some caution due to attrition of the RHD group and reduced sample size, prohibiting strong conclusions to be made about speaker politeness. Nonetheless, data analyzed in Experiment 2 supply further evidence that the ability to judge speaker attitudes which revolve around prosody is adversely affected by damage to the right cerebral hemisphere—in this case, reducing the ability of many RHD patients to infer the intended politeness of a speaker toward the hearer. At the same time, by manipulating the combined function of prosody *and* language variables for signifying speaker attitudes in a more extensive manner than in Experiment 1, findings of the second experiment help to qualify some of our earlier conclusions about the possible nature of prosodic deficits in RHD patients.

As anticipated, the value of the utterance type, prosody, and the *interaction* of these factors were critical for determining how healthy listeners gauge the extent of a speaker's politeness when issuing a request (LaPlante & Ambady, 2003; Trees & Manusov, 1998). Utterance types which used conventional indirectness to mitigate the negative impact of the request (*Can you…, Would you mind…*) or the explicit politeness marker *please*, were systematically rated as more polite than linguistic strategies which boost the negative imposition of the request on the hearer, such as the imperative (stem) form or a direct obligation statement (*You must…*) (Clark & Schunk, 1980). Results indicated that healthy as well as RHD patients were broadly capable of interpreting whether highly conventionalized phrases were acting to attenuate or boost the negative attitude of the request as reflected in the distribution of their politeness ratings (Stemmer et al., 1994). However, the RHD group tended to recognize *fewer* distinctions among the five utterance types in certain conditions; for example, only healthy and not the RHD listeners recognized that "very indirect" utterances, which incorporated indirect strategies which highlight the imposition of the request, were more polite than indirect utterances, which highlight the listener's ability to perform the action. Differences in the perceived politeness of these two utterance types have been documented for healthy listeners in the past (Clark & Schunk, 1980) but were only recognized by our healthy listeners for the current study.

Independent of utterance type (or utterance length), prosodic attributes weighed potently on attributions of speaker politeness at all times: when speakers used a high/rising rather than a falling intonation contour, requests were invariably perceived as more polite by all participants in the study (Culpeper et al., 2003; Loveday, 1981). This marked influence of the prosody variable on listeners was relatively comparable between the two tasks, and importantly, was the only meaningful distinction in the prosody task which listeners could use to judge politeness from pseudo-utterances. These data are consistent with the idea that listeners use conventional and *categorical* choices in contour type to make decisions about speaker politeness (Scherer, Ladd, & Silverman, 1984; Wichmann, 2002). It has been suggested that when speakers adopt a relatively high register or a rising tone, these cues are recognized as the speaker's attempt to appear "small" or less dominant than the listener in the context of the request, rendering this prosodic category more polite (Brown & Levinson, 1987; Cosmides, 1983). Whatever the source of these attributions, the findings imply that most RHD listeners could meaningfully process these prosodic distinctions when judging speaker

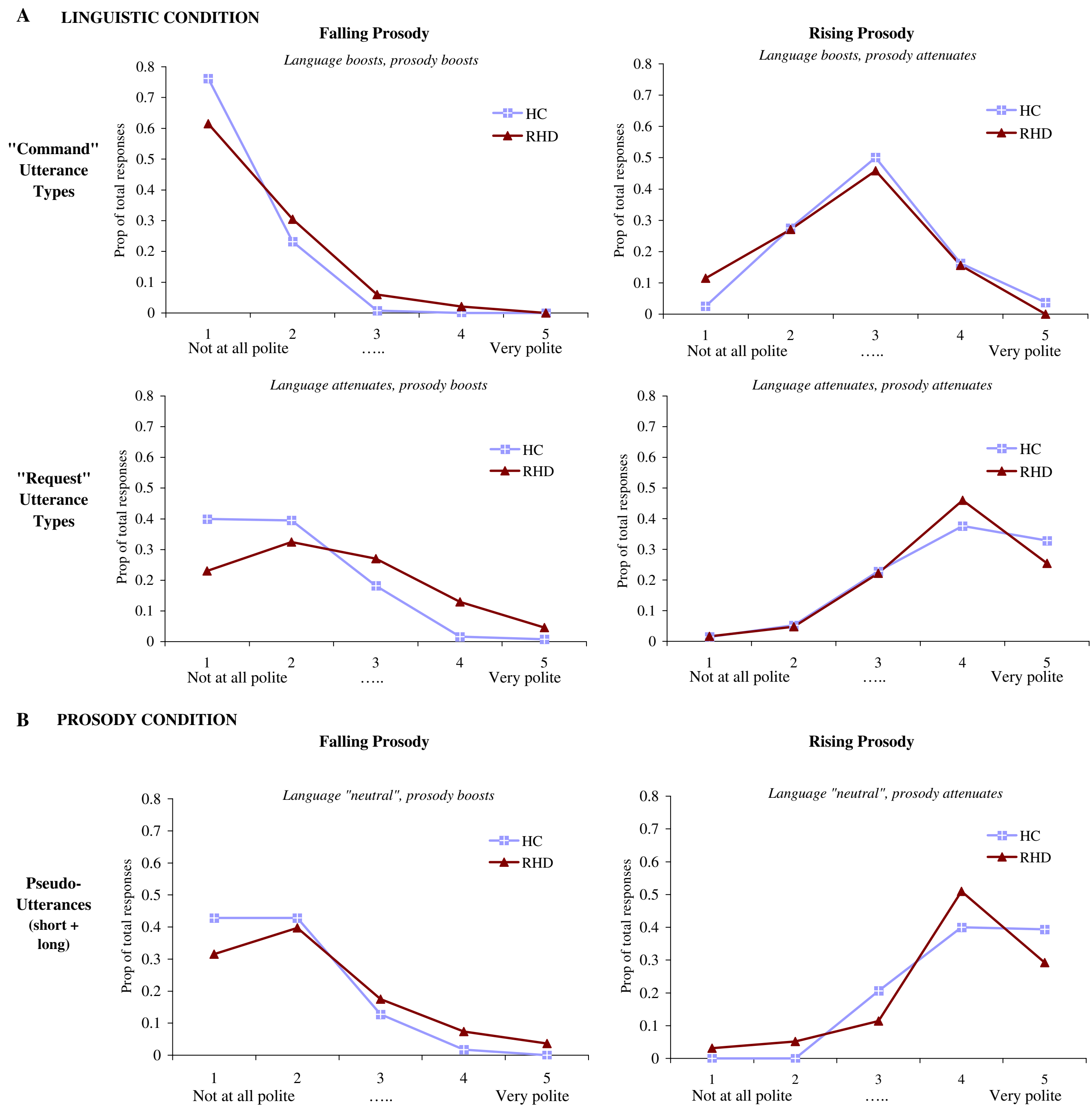

Fig. 2. The proportion of politeness ratings assigned at each interval of the 5-point scale in the linguistic and prosody tasks by participants with right hemisphere damage (RHD) and healthy controls (HC), according to differences in utterance type and prosody. In the linguistic condition (A), utterance types were grouped according to whether language content served to "boost" (stem + direct) or "attenuate" (indirect + very indirect + please) the negative intent of the request as a function of the prosody variable. In the prosody condition (B), short and long utterances were grouped as a function of the prosody variable.

politeness, at least when the impact of prosodic features alone is considered.

What appeared to pose marked difficulties for RHD listeners was the ability to detect the politeness of speakers when functional *discrepancies* existed in the emotive force of linguistic versus prosodic cues of the stimuli. When conventional linguistic strategies for attenuating the imposition of requests (e.g., *Would you mind*...) were conjoined with conventional prosodic choices which boost the impoliteness (i.e., perceived dominance) of the speaker, healthy listeners interpreted these utterances as being very impolite; in fact, these utterances were rated as similar in the degree of impoliteness to direct imperatives (stem commands) spoken with the same prosody. This evaluation by the HC group was expected because, for this example, this cue combination would naturally occur in an interpersonal context where the speaker criticises the hearer through "mock" or sarcastic politeness (Culpeper, 1996). However, pending more data, there was no comparable evidence here that RHD patients were sensitive to speaker attitudes which are signalled through the interaction of linguistic and prosodic cues. For example, the RHD patients did not seem to normally recognize that utterances produced with mock politeness (i.e., very indirect language + low prosody) reflect a negative/impolite attitude toward the listener (review Fig. 2, middle left panel). In this context, the RHD group showed a greater tendency to rate these utterances, which contained overt linguistic strategies for expressing politeness, as more "polite" than the HC group.

Since RHD adults were fundamentally aware of how prosody functions to signal politeness based on their rating of pseudo-utterances (prosody condition), it would appear that a major source of deficit in these patients was the ability to engage in a comparative analysis of relevant cues across the two speech channels (Foldi, 1987; Weylman et al., 1989). One can speculate that in the absence of detailed processing at this stage, violations in the emotive significance of language and prosody were not efficiently detected, precluding inferential processes which would highlight the intended (i.e., non-conventional) attitude of the speaker in these situations. This argument fits with an abundant literature indicating that RHD patients fail to fully integrate or *apply* social and affective cues which are relevant to understanding the intended meaning of communicative events (Brownell, Pincus, Blum, Rehak, & Winner, 1997; Brownell et al., 1992; Cheang & Pell, 2006).

Once again, our data from Experiment 2 hint that RHD patients may have assigned greater weight to the functional significance of language over prosodic content when judging speaker attitudes in these situations of comparative cues (Bowers et al., 1987; Pell & Baum, 1997; Tompkins & Mateer, 1985). However, contrary to our earlier claim that a deficit for prosody was contributing to difficulties for understanding speaker confidence, additional data on speaker politeness clarify that the apparent "language focus" of our RHD patients did not reflect an incapacity to process relevant prosodic distinctions to this attitude. Rather, one can speculate that these difficulties emerged at a *subsequent* stage of retrieving learned associations between utterance type and intonation contour which are routinely used by listeners to infer speaker politeness, particularly in instances when violations of these expectations occur and generate distinct attitudinal interpretations (Wichmann, 2002). Further research will be needed to verify these claims.

4. General discussion

The overarching goal of this study was to initiate empirical testing of how prosody is understood in different interpersonal or 'emotive' contexts of spoken language and to determine whether the right hemisphere is centrally implicated in these processes. By studying a group of RHD patients with known impairments for identifying vocal expressions of emotion (Pell, 2006), our new findings establish a firm platform for predicting that many RHD patients who fail to comprehend emotional prosody also fail to normally appreciate many of the emotive attitudes conveyed by speakers at the level of prosody. However, as emphasized by our research (Pell, 2006; Pell & Baum, 1997), not all RHD individuals display receptive impairments for emotional prosody and this was also true for the data on speaker attitudes. As a supplementary procedure, the performance of individual RHD patients was therefore inspected to compare the ability to recognize emotional prosody versus speaker attitudes.

For speaker confidence, there was important overlap in the ability of individual patients to judge speaker confidence and to judge emotional prosody from pseudo-utterances (i.e., "pure prosody" identification task from Pell, 2006). Based on the normal range of confidence ratings observed for the HC group (mean conditional ratings from 1.7 to 4.5, group range = 2.8), three RHD participants (R3, R5, and R6) were identified who were markedly "impaired" on the confidence task as defined by an individual range of confidence judgements less than half the expected HC range. Interestingly, these three RHD participants were also the most impaired for judging emotional prosody (Pell, 2006). Patient R5, who had a large temporoparietal lesion and whose deficits for emotional prosody were most pronounced, was also most severely impaired for judging speaker confidence with no demonstrable ability to differentiate low, moderate, and high confidence utterances (respective conditional means = 2.1, 2.2, 2.2). Although attrition of the RHD group, including participant R5[6], precludes extensive comparison of individual data for Experiment 2, it is noteworthy that only participant R3 demonstrated little ability to rate speak politeness based on prosodic cues alone (prosody condition). This finding suggests that certain RHD individuals exhibited consistent impairments for understanding both emotions and attitudes from prosody. In support of this idea, it is remarkable that two RHD patients who were clearly unimpaired on the emotional prosody tasks (R1, R7) also performed normally in both the confidence and politeness experiments based on qualitative analysis of their rating patterns in reference to the HC group. Thus, there is sufficient evidence here that emotional prosody deficits often correlate with deficits for understanding speaker confidence and perhaps other speaker attitudes for many individuals with RHD, pending future studies to investigate these issues in more detail.

[6] Of the three RHD patients who did not participate in Experiment 2 (R2, R4, R5), only R5 performed outside the normal range in Experiment 1.

Another issue uncovered by our experiments is that for many RHD patients, the failure to appreciate speaker attitudes may reflect impairments at slightly different stages of processing depending on the manner in which prosody, language, and other key variables which define speaker attitudes are assigned meaning by the interpersonal context. In Experiment 1, it was concluded that prosody was always the dominant cue for inferring speaker confidence, justifying the hypothesis that difficulties relating specifically to *prosody* were responsible for the deficits of the RHD group in this context. Like basic emotions, the vocal features which communicate distinctions in confidence/doubt are likely represented by co-variation of multiple prosodic elements with continuous expression in speech (Scherer et al., 1984; Scherer et al., 1973). For this reason, an underlying defect for processing continuous prosodic features in our RHD patients may have contributed to difficulties on both the confidence and emotional prosody tasks (Pell, 1999).

In contrast, Experiment 2 emphasized the interdependence of prosody and language and strongly indicated that the same RHD patients could successfully interpret categorical distinctions in intonation contour for judging the polite or impolite attitude of speakers. At the level of prosody alone, an intact ability to recognize categorical or configural representations of prosody in RHD patients is often noted, for example, in tasks of recognizing phonological pitch categories in speech (Baum & Pell, 1999; Hsieh, Gandour, Wong, & Hutchins, 2001). This places the likely source of impairment for understanding certain attitudes such as politeness, not at the level of prosody *per se*, but in resolving these attitudinal meanings based on the comparative weight of prosody with other socially-relevant cues such as utterance type.

There is a well-established literature indicating that RHD patients do not consistently integrate all relevant sources of information during language processing when intended meanings are non-canonical or non-transparent in form (for a review, see Brownell et al., 1997). Along similar lines, our new data on speaker attitudes such as politeness imply that RHD patients do not always incorporate their evaluations of prosodic information with the significance of language content which was often the primary focus of these listeners. This particular bias meant that when prosodic cues were continuously encoded in speech and weighed heavily for assigning speaker attitudes (Experiment 1) or signalled a non-literal interpretation of the verbal message (Experiment 2), RHD patients failed to fully appreciate the attitude of the speaker in these situations. In many cases, one must assume that these problems are part of a wider array of "pragmatic language deficits" exhibited by RHD patients who show a number of difficulties inferring the intended meanings of socially- and emotionally-relevant information in speech (see Martin & McDonald, 2003 for a recent overview). The possibility that in Experiment 2, difficulties in the processing of formulaic expressions which signal politeness (*Could I bother you to…)* contributed to the RHD patients' impairments cannot be dismissed (see Van Lancker Sidtis, 2004; for a detailed discussion).

If one compares the conclusions derived for our two experiments, it would appear that the role of the right hemisphere in understanding prosodic attitudes is less dictated by the emotive context of these prosodic features, but rather, by the *manner* in which prosody encodes pragmatic and attitudinal information in speech (i.e., through continuous/co-variation versus categorical/configural representation of meaningful cues, Pell, 1999; Scherer et al., 1984). The possibility that features of the pseudo-utterances were simply distracting to many RHD listeners, especially those with difficulties in working memory or perhaps divided attention, seems unlikely in the context of these experiments given that the RHD group sometimes performed more like the healthy controls when rating the pseudo-stimuli (i.e., in the politeness study). It will be constructive to extend these findings to a broader array of interpersonal contexts that centre critically on prosody, to a larger sample of RHD participants, and to study these phenomena through convergent investigative approaches. In particular, our findings encourage researchers to explore how emotive features of prosody are interpreted by other brain-damaged populations who exhibit deficits for emotional prosody, such as patients with acquired left hemisphere lesions (Adolphs, Damasio, & Tranel, 2002; Cancelliere & Kertesz, 1990; Charbonneau, Scherzer, Aspirot, & Cohen, 2003; Pell, 1998, 2006; Van Lancker & Sidtis, 1992).

Although emotional *and* attitudinal meanings of prosody appear to implicate the right hemisphere in a mandatory way, perhaps at multiple processing levels, our findings are inconclusive regarding the probable input of the left hemisphere in these processes. Given indications of inter-hemispheric cooperation in how emotional prosody is processed from speech (Kotz et al., 2003; Schirmer & Kotz, 2006), one would predict that bilateral hemispheric mechanisms are also heavily engaged when processing speaker attitudes embedded in spoken language content (Pell, 2006). Through continued attempts to define the relationship of the prosodic message to conjoined linguistic, contextual, and other relational variables—and to isolate effects due to prosody whenever possible—future research will undoubtedly arrive at increasingly fine descriptions of how the mental and emotive states of a speaker are understood from speech.

Acknowledgments

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Appendix A

(1) Stimuli constructed for Experiment 1 (Speaker confidence)

Scenario 1

Linguistic condition:	
Stem:	You turn left at the lights
High confidence:	For sure, you turn left at the lights
Moderate confidence:	Most likely, you turn left at the lights
Low confidence:	Perhaps, you turn left at the lights
Prosody condition:	You rint mig at the flugs

Scenario 2

Linguistic condition:	
Stem:	The book is on the top shelf
High confidence:	I'm positive the book is on the top shelf
Moderate confidence:	Probably the book is on the top shelf
Low confidence:	There's a chance the book is on the top shelf
Prosody condition:	The derm is on the cindibal

Scenario 3

Linguistic condition:	
Stem:	I am the right person for the job
High confidence:	I know that I am the right person for the job
Moderate confidence:	I think that I am the right person for the job
Low confidence:	Maybe I am the right person for the job
Prosody condition:	I ming the paze mester for the yorn

Scenario 4

Linguistic condition:	
Stem:	It takes an hour to drive there
High confidence:	Definitely, it takes an hour to drive there
Moderate confidence:	Probably, it takes an hour to drive there
Low confidence:	Possibly, it takes an hour to drive there
Prosody condition:	It munds a zile to vorf there

Scenario 5

Linguistic condition:	
Stem:	I will be going to the Alps
High confidence:	For sure, I will be going to the Alps
Moderate confidence:	With any luck, I will be going to the Alps
Low confidence:	Hopefully, I will be going to the Alps
Prosody condition:	I krad ree zelling to the kelts

(2) Stimuli constructed for Experiment 2 (Speaker politeness)

Scenario 1:

Linguistic condition:	
Stem:	Pass the butter
Direct:	You should pass the butter
Indirect:	Can you pass the butter
Very Indirect:	Would you be able to pass the butter
Please:	Please pass the butter
Prosody condition:	
Short:	Mott the floober
Long:	Koo derma mott the floober

Scenario 2:

Linguistic condition:	
Stem:	Open the window
Direct:	You should open a window
Indirect:	It would be good if you open a window
Very Indirect:	Could I trouble you to open the window
Please:	Please open the window
Prosody condition:	
Short:	Oleff a zingo
Long:	Povity vester oleff a zingo

Scenario 3:

Linguistic condition:	
Stem:	Do the dishes

(2) Stimuli constructed for Experiment 2 (Speaker politeness)

Direct:	You must do the dishes
Indirect:	Can you do the dishes?
Very indirect:	Could I bother you to do the dishes?
Please:	Please do the dishes
Prosody condition:	
Short:	Gub the mooshes
Long:	Voriful yoza gub the mooshes

Scenario 4:

Linguistic condition:	
Stem:	Lock the door
Direct:	You should lock the door
Indirect:	It would help if you lock the door
Very indirect:	You couldn't possibly lock the door?
Please:	Please lock the door
Prosody condition:	
Short:	Paze the nure
Long:	Vire ballah wug paze the nure

Scenario 5:

Linguistic condition:	
Stem:	Lend me some money
Direct:	I want you to lend me some money
Indirect:	Can you lend me some money?
Very Indirect:	Would it be possible for you to lend me some money?
Please:	Please lend me some money
Prosody condition:	
Short:	Yorn me some malka
Long:	Zappa yorn me some malka

Scenario 6:

Linguistic condition:	
Stem:	Come back in the morning
Direct:	You have to come back in the morning
Indirect:	It would be best if you come back in the morning
Very indirect:	Could you kindly come back in the morning?
Please:	Please come back in the morning
Prosody condition:	
Short:	Mo gak in the wossel
Long:	Nester otto mo gak in the wossel

Scenario 7:

Linguistic condition:	
Stem:	Pour me some coffee
Direct:	I want you to pour me some coffee
Indirect:	Can you pour me some coffee?
Very Indirect:	Could I inconvenience you to pour me some coffee?
Please:	Please pour me some coffee
Prosody condition:	
Short:	Ni me some moder
Long:	Ora lamadee ni me some moder

Scenario 8:

Linguistic condition:	
Stem:	Give me some privacy
Direct:	I want you to give me some privacy
Indirect:	I was hoping you could give me some privacy
Very indirect:	Would it be possible for you to give me some privacy?
Please:	Please give me some privacy
Prosody condition:	
Short:	Wance me some cindibal
Long:	Nerry vapp vance me some cindibal

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