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Exploring the Cognitive Basis of Right-Hemisphere Pragmatic Language Disorders

Skye McDonald

University of New South Wales, Sydney, Australia

Despite considerable interest in the linguistic dimensions of right-hemisphere (RH) pragmatic language disorders, the cognitive bases for these are rarely examined. This study investigated two alternative explanations. First, RH pragmatic language disorders may reflect failure of the RH to synthesise incoming and preexisting information, verbal and visuospatial. In this case language and visuospatial performance should covary. Alternatively such disorders may reflect damage to executive control of all cognitive processing secondary to frontal system failure. In this case language and executive function would be associated. Further, in the former case, subjects should be insensitive to the plausibility of information, whereas in the latter they would be fixated by the literal meaning of information and therefore highly sensitive to plausibility. Eighteen patients with RH damage were compared to 20 matched controls on a range of language and neuropsychological tasks. Pragmatic performance was generally correlated to RH (visuospatial) function, not to executive function. Nonetheless RH patients were found to have problems ignoring plausibility. Thus the specific RH hypothesis described needs to be reconsidered. © 2000 Academic Press

INTRODUCTION

The nature of communication disorders following right-hemisphere brain lesions has attracted a great deal of interest from researchers since the 1970s, when evidence of disturbed linguistic function after RH damage first began to emerge. While not aphasic, RH patients have been observed to be tangential, verbose, and inefficient in their expressive language (Diggs and Basili, 1987; Gardner, 1975; Hecaen, 1978; Hillis, Trupe, & Hillis, 1985; Joanette, Goulet, Ska, & Nespoulous, 1986; Mackisack, Myers, & Duffy, 1987; Rivers & Love, 1980; Roman, Brownell, Potter, Seibold, & Gardner, 1987; Wapner,

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Address correspondence and reprint requests to Skye McDonald, School of Psychology, University of NSW, 2052, Sydney, Australia. E-mail: s.mcdonald@unsw.edu.au.

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Hamby, & Gardner, 1981; Weinstein, 1971) and to have difficulty comprehending nonliteral aspects of phrases such as metaphor (Winner & Gardner, 1977), proverbs (Hier & Kaplan, 1986), idioms (Van Lancker & Kempler, 1987), and jokes (Bihrle, Brownell, Powelson, & Gardner, 1986; Brownell, Michel, Powelson, & Gardner, 1983; Gardner, Ling, Flamm, & Silverman, 1975; Wapner et al., 1981).

More recently, efforts to characterize RH language impairment have been guided by consideration of the pragmatic dimensions of discourse. For example, studies have focused upon RH patients' knowledge of story structure (Hough, 1990; Rehak, Kaplan, Weylman, Kelly, Brownell, & Gardner, 1992; Roman et al., 1987), their ability to comprehend and utilize requests (Foldi, 1987; Hirst, Le Doux, & Stein, 1984; Weylman, Brownell, Roman, & Gardner, 1989; Stemmer, Giroux, & Joanette, 1994), and to understand sarcasm (Kaplan, Brownell, Jacobs, & Gardner, 1990; Tompkins and Mateer, 1985; Weylman et al., 1989; Winner, Brownell, Happe, Blum, & Pincus, 1998). The results of such studies have been variable, partly related to differing task requirements, but each suggests, at a quantitative or qualitative level, that deficits in language useage are present.

Efforts to characterize the dimension of pragmatic processing that is disturbed in RH patients have also been variable but suggest that RH patients retain their knowledge of basic discourse forms when provided with structured tasks using common exemplars of language. For example, RH patients have been found to be capable of imposing order on short stories when these are presented as individual sentences in a scrambled order (Huber & Gleber, 1982) and predicting the endings to familiar-type stories on the basis of what has gone before (Rehak et al., 1992). They have also proven capable of producing direct and conventionally indirect requests normally (Semmer et al., 1994). In terms of comprehension RH subjects have shown they are sensitive to the presence of pronoun anaphora to connect information within a text (Brownell, Carroll, Rehak, & Wingfield, 1992), can generate simple inferences in short stories (Brookshire & Nicholas, 1984; Brownell, Potter, Bihrle, & Gardner, 1986; McDonald & Wales, 1986), and can interpret comments as sarcastic in a forced-choice format (Kaplan et al., 1990).

On the other hand, problems appear when RH patients are required to make more complex or open-ended judgements about discourse such as inferring motives of actors in complex narratives (Wapner et al., 1981), predicting plausible story outcomes in the absence of explicit clues (Rehak et al., 1992), comprehending and producing nonconventional indirect speech acts (Stemmer et al., 1994), or using interpersonal relations or inferences about mental state to understand communicative intention between speakers (Kaplan et al., 1990, Winner et al., 1998).

RH language research has been characterized by a growing sophistication of the application of linguistic theory in general and pragmatic theories in particular to examining communication abilities in this clinical population.

Correspondingly, contemporary studies provide an increasingly detailed analysis of the level of discourse and pragmatic impairments experienced by RH subjects. However, very little interest has been generated in examining the neuropsychological mechanisms underlying the discourse failures reported. This is a serious limitation. By developing a clearer understanding of the causes for language impairment in the RH population, it will be a simpler task to discover generalities underlying various pragmatic impairments. Improved knowledge of the neuropsychological mechanisms involved will also facilitate the development of normal psycholinguistic theory. In this study, two cognitive explanations for RH pragmatic language failure were investigated.

Right-Hemisphere Specialization in the Construction of Mental Models

One explanation that has been tentatively proposed to explain RH language impairments is that, just as the RH has a bias for visuospatial mental constructions and synthesis (Corbalis, 1997; Nebes, 1974), it has responsibility for the synthesis of verbal information including the integration of new verbal information with prior knowledge and other extralinguistic information (Brownell et al., 1992; Schneiderman et al., 1992; Weylman et al., 1989, 1989). More specifically, it has been argued that the RH has a specialized role in the processing of discourse as it relates to mental models of the world (Grzybek, 1993; Moya, Benowitz, Levine, & Finklestein, 1986; Wapner et al., 1981). Such a conceptualization sits well with theories of text comprehension that promote a process of comprehension that relies upon the construction of mental models of (a) the information contained within the text and (b) the world at large to which the text refers (Johnson-Laird, 1983; Mandler & Johnson, 1977; Kintsch & van Dijk, 1983). By relating discourse to world knowledge, a text can be given a rapid prototypical interpretation, representing the most plausible meaning available. In the case of RH damage, this ability is impaired; there is a failure to relate textual information to knowledge of the world and this results in failure to make accurate plausibility judgements and general indifference to the implausibility of language.

Indeed, a number of studies have suggested that RH patients do have trouble evaluating plausibility, as evidenced by their preference for nonsequiter endings to jokes (Brownell et al., 1983; Wapner et al., 1981); nonplausible endings for stories (Rehak et al., 1992); and reduced sensitivity to the real-world plausibility of sentences, story elements, and conversational remarks compared to matched controls (Brownell et al., 1992; Picard, Joulet, & Joanette, 1995; Wapner et al., 1981). Additional support for the notion that the RH is responsible for plausibility stems from a series of experiments conducted on patients undergoing unilateral ECT (Cernigovskaja & Deglin, 1986, as cited in Grzybek, 1993). In this series, non-brain-damaged patients were required to interpret both plausible and nonplausible syllogisms, as exemplified in Examples 1–3.

Example 1: *1. Fish can be found in all rivers where fishermen throw out nets*
2. Nets are thrown out in the river Neva
3. Are there fish in the river Neva or not?
Example 2: *1. All states have flags*
2. Zambia is a state
3. Does Zambia have a flag or doesn't it?
Example 3. *1. Apes can jump through trees*
2. Porcupines are apes
3. Can porcupines jump through trees or not?

In Example 1, the syllogisms could be solved with reference to either the subjects' personal world knowledge (including knowledge of the local river Neva) or, alternatively, by forming a logical conclusion based upon the premises. In Example 2 the state of Zambia is fictional so the solution was only possible by forming a logical conclusion based upon the premises and in Example 3 the premises were implausible and thus the logical conclusion contradicted the subject's world knowledge. It was found that patients with LH ECT (presumably intact RH function) could not adhere to the logic of Example 3 being overly focused with the lack of plausibility of the premises and even found Example 2 difficult to accept because their world knowledge told them there was no state ''Zambia.'' It was assumed in these cases that LH impairment reduced the patients' capacity to follow the formal semantic and logical properties of the syllogism. In contrast, patients with RH ECT (presumably impaired RH function) were unconcerned by the lack of plausibility of Examples 2 or 3 and focused on the logical relations instead.

This notion that the RH plays a central role in the synthesis of verbal information has been primarily evoked to explain problems in language comprehension. However, production deficits have also been documented in RH subjects and the nature of these, i.e., tangentiality, confabulation, and implausibility, may equally be accounted for by a lack of ability to regulate language choices in accordance with mental formulations of the relevant communicative context. The coherence and effectiveness of discourse relies upon the speaker's ability to select verbal utterances that are related to their knowledge of the world and specific contextual demands.

The theoretical role that the RH plays in synthesizing language has been developed from similar views regarding the manner in which it processes visuospatial information (e.g., Levy, Trevarthen, & Sperry, 1972; Piercy, Hecaen, & Ajuriaguerra, 1963), thus implying that the RH performs a generic, analog function in this regard (e.g., Moya et al., 1986). However, there are few studies that have specifically investigated the coexistence of visuospatial and language problems and these have produced contradictory results. For example, Stemmer et al (1994) found very few associations between request performance and measures of RH function (i.e., spatial neglect) or more general measures of attention/concentration. On the other hand, Benowitz, Moya, and Levine (1990) and Moya et al. (1986) found specific associations between memory for information inferred in verbal passages and spatial skills (memory, construction, and neglect) that remained after effects of lesion size, premorbid brain injury, education, and age were statistically controlled.

Executive Dysfunction in RH Patients

An alternative explanation to the many difficulties in communication that are reported in RH patients is that these reflect a loss of executive control secondary to damage to the frontal systems of the brain or their connections. Executive function is conceptualized as a superordinate cognitive system that mediates and regulates all other cognitive activity in a goal-directed fashion. Executive dysfunction leads to a breakdown in the regulation of cognitive activity such that the individual no longer responds adaptively to internal and external stimuli but rather reacts in a piecemeal and habit-driven manner (Shallice & Burgess, 1991). Executive dysfunction is particularly apparent when the individual is faced with novel or unfamiliar tasks because habitual responses are inappropriate. Typical features of executive dysfunction include rigidity of thought processes; concrete responses including the tendency to respond to the most superficial aspects of information; failure to think at an abstract level; and poor regulation of behavior, in particular, poor response inhibition (Lezak, 1995).

Communication disorders are commonly reported following damage to the frontal lobes of the brain and bear a striking similarity to those reported in RH studies (see McDonald, 1993a for review) with little evidence for lateralization of language disturbances within the frontal lobes (Alexander, Benson & Stuss, 1989; Novoa & Ardila, 1987; Stuss, Alexander, & Leiberman, 1978). The possibility that many of the language impairments seen after RH damage reflect damage to the anterior aspects of the RH (the frontal lobe) therefore warrants serious consideration. Certain characteristics of RH language impairment disorders are consistent with damage to executive systems. For example, it has been found that RH patients are rigid in their interpretation of information, finding it difficult to revise initial interpretations to encompass subsequent information (Brownell, Potter, Birhle, & Gardner, 1986; Molloy, Brownell, & Gardner, 1990; Hough, 1990; Schneiderman and Saddy, 1988). They also have trouble using conceptual ''themes'' to organize stories (Delis, Wapner, Gardner, & Moses, 1983; Schneiderman et al., 1992) and tend to be uncritical of their responses (McDonald & Wales, 1986).

The right middle cerebral artery, the source of the majority of cerebrovascular accidents in the RH, spans both frontal and more posterior areas, making it difficult to attribute dysfunction in many RH patients to one system over the other. Nevertheless, in a few studies authors have been able to remark upon different patterns of performances subsequent to anterior versus posterior lesions. In these there is suggestion that failure to ignore the concrete attributes of verbal information, failure to derive verbal inferences, and loss of verbal control are more severe in patients with anterior lesions compared to damage restricted to the temporal-parietal areas (Benowitz et al., 1990; Foldi, 1987; Hirst et al., 1984; Hough, 1990; Wapner et al., 1981; Weylman et al., 1989). There have been no studies specifically investigating the association between pragmatic language skills and conventional, executive-type neuropsychological tests in RH patients.

In sum, there are at least two possible cognitive explanations for RH language disorders. On the one hand, these may reflect impairment in the synthesizing function of the RH, leading to a failure to relate incoming and outgoing information to mental models of relevant world knowledge. On the other, they may reflect a loss in the executive regulation of goal-directed activity, leading to habit-driven, piecemeal verbal responses.

In the following study the nature of pragmatic language disturbances and their cognitive correlates were examined in patients suffering from a single CVA in the RH. Subjects were given a battery of neuropsychological tests to assess both visuospatial and executive function. In addition, the cognitive basis of their pragmatic language abilities were scrutinized in two convergent studies.

First, they were assessed for their general level of pragmatic competence in both the production of pragmatically appropriate language and the comprehension of pragmatic inference. Several tasks were chosen to examine both facets in order to provide a comprehensive overview of their abilities in these areas. All tasks were selected on the basis that they have been demonstrated to be sensitive to right-hemisphere disorders and/or executive dysfunction in previously published, independent studies. Production was examined via tasks that required the subjects to produce a simple, coherent connected narrative as well as a variety of well-formed novel (i.e., nonconventional) speech acts in the form of direct and indirect requests. Comprehension was assessed by examining the capacity of subjects to interpret nonconventional direct and indirect speech acts.

Research into pragmatic language skills in both RH and executive populations make generally similar predictions about this range of tasks, i.e., both RH subjects and subjects with executive dysfunction perform these less effectively than their non-brain-damaged counterparts. However, the two models predict different relationships between these tasks and the other neuropsychological tests. The ‘‘mental model’’ theory predicts that pragmatic language competence would be associated with visuospatial scores. The executive dysfunction explanation predicts an association between performance on the pragmatic tasks and conventional, executive test scores.

As a second approach, the *nature* of pragmatic errors RH subjects make was examined using the plausible and implausible syllogism task. Unlike the tasks that comprise the pragmatic battery, the two theories predict contrasting performance profiles when confronted with absurd, logical syllogisms. If patients have poor plausibility judgement due to an impaired capacity to relate information to a mental model of relevant knowledge, they will be restricted to an understanding of the syllogisms based upon their logical properties and will be unperturbed by the presence of implausible propositions. Their responses to absurd, logical syllogisms, such as Example 3 above, should be based upon their logic, presumably in much the same way as non-brain-injured subjects respond. This pattern of performance might be expected to be positively associated with measures of visuospatial dysfunction. If, on the other hand, they suffer from executive dysfunction, they will be riveted to the concrete, salient, and familiar attributes of the information given and will be unable to ignore such attributes in order to attend to the underlying, logical relationships between propositions. They will thus answer the absurd logical syllogisms according to their lack of plausibility, a pattern of performance that is the reverse to that described above. This should be associated with independent measures of executive dysfunction.

METHODS

Subjects

Eighteen clinical subjects took part in the study, each having suffered a single right-hemisphere CVA infarction or hemorrhage between 3 and 70 days beforehand (mean 37 days). The clinical details of this group are provided in Table 1.

There were 11 males and 7 females, ages ranging from 25 to 86 (mean = 59.6) and years of education ranging from 8 to 15 years (mean = 11.1). The RH group were tested on the WAIS-R Vocabulary test to obtain a measure of premorbid intelligence and this indicated their intellectual level to be in the average range (mean SS = 9.56; percentile rank = 44%). A group of 20 non-brain-damaged control subjects were selected from the community to match RH subjects on the basis of age and education. The control group comprised 13 males and 7 females, ages ranging from 27 to 75 years (mean = 59.7) and education ranging from 9 to 15 years (mean = 12.5). Their intellectual level as indicated by the WAIS-R Vocabulary subtest was in the high average range (mean SS = 13.5; percentile rank = 88%). There were no significant differences between the clinical and control groups on the basis of age or educational level. There was, however, a significant difference between the groups in terms of estimated intellectual level, with the control group being significantly higher than the RH subjects. Therefore, all subsequent analyses were conducted using WAIS-R Vocabulary scores as a covariate in order to statistically control for this difference.

Tasks and Procedures

Subjects were examined on the battery of neuropsychological and pragmatic language tasks over a period spanning 2 to 3 hours. All assessments were completed within the same day or, if necessary, on the subsequent day.

Neuropsychological Test Battery

Visuospatial tasks. In order to provide a general indication of visuospatial function both RH and control subjects were given a range of tests that rely upon visuospatial perception, synthesis, rotation, construction, and learning. These included the Benton Facial Recognition

TABLE 1
Details of the Clinical Subjects

Subject	Age/sex	Education (years)	Time since CVA (days)	CT scan	Clinical notes
1	33/F	11	56	Hemorrhage R T lobe	Right T lobectomy 3 weeks later
2	65/M	10	21	Nil pathology Apparent	Pure motor weakness
3	62/M	8	28	Low density R TP area, slight mass effect extended to include BG Old infarct noted in L CN	L hemiplegia
4	77/M	10	56	Infarct of external capsule and thalamus. Slight compression of R LV	L hemiplegia
5	57/M	9	35	Not available	L hemiplegia
6	72/F	8	3	Low density in superior head of R CN. Periventricular changes	L hemiparesis
7	55/M	9	70	Intracerebral hemorrhage in R BG and IC	L hemiparesis
8	86/F	12	14	Not available	L hemiparesis, LHH
9	75/F	8	28	R anterior cerebral artery CVA, slight bilateral F lobe changes	L hemiplegia
10	69/M	15	28	Infarct in R insular with late hemorrhagic changes	L hemiplegia and LHH
11	65/M	10	28	Low density lesion (infarct) in L P lobe	L hemiparesis
12	69/M	15	42	Ischemia in the area of the R anterior cerebral artery	L hemiplegia, LHH
13	76/F	15	21	R T-P lacunar infarct	L hemiplegia and LHH
14	66/F	10	28	Hemorrhage in R IC	L hemiplegia, and LHH
15	56/M	15	28	Infarct in R P lobe	L hemiplegia, LHH
16	39/M	12	28	Infarct in R P and O lobes, low density area in cerebellum and slightly enlarged ventricles	L hemiplegia, LHH
17	28/F	11	63	Stroke in R P subcortical area	L hemiplegia
18	25/M	12	49	Intracerebral hemorrhage R F-P area	L hemiplegia

Abbreviations: R, right; L, left; HH, homonymous hemianopia; F, frontal; P, parietal; T, temporal; O, occipital; IC, internal capsule; LV, lateral ventricle; BG, basal ganglia; CN, caudate nucleus.

Test (BFRT) (Benton and Hamsher, 1968), the Visual Organisation Test (VOT) (Hooper, 1983), the Rey–Ostereith Complex Figure—copy (RF) (Corwin and Bylsma, 1993), the Wechsler Adult Intelligence Scale—Revised (WAIS-R) Block Design subtest (BD) (Wechsler, 1981) and the Wechsler Memory Scale—Revised (WMSR), and the Visual Reproduction subtest (VR) (Wechsler, 1987).

Executive tasks. Many tasks normally used to assess executive skills rely upon visuospatial skills and are unsuitable for RH patients. Therefore two verbal tests that are sensitive to executive dysfunction were used. The Controlled Oral Word Association Test (COWAT) (Benton, Hamsher, & de Sivan, 1994) demands both generativity and rule compliance (Walsh & Darby,

1999) and has proven, in the absence of aphasic conditions, to be sensitive to executive dysfunction secondary to focal frontal brain injury (Miller, 1984; Pendelton, Heaton, Lehman, & Hulihan, 1982). The WAIS-R Similarities subtest (WAISR-S) requires verbal conceptual abilities (Lezak, 1995) and has also been shown to be detrimentally affected by frontal lobe injury (McFie, 1975; Newcombe, 1969; Rao, 1990).

Memory and attention tasks. In order to confirm that poor performances on the various tasks was not due to poor memory or attention per se, the RH and control subjects were also tested on a sample of tests of attention and verbal new learning. These comprised the WMSR subtests: Information and Orientation (IO) and Mental Control (MC) (attention) and Verbal Paired Associates (VPA) and Logical Memory (LM) (new learning).

Pragmatic Competence Battery

The pragmatic battery represented a range of tasks assessing both pragmatic production and comprehension.

Production tasks. Pragmatic language measures were chosen to sample both the production of connected narrative discourse and conversational speech acts.

Procedural narrative. Procedural discourse production tasks have been used to elicit pragmatic language production deficits in a variety of groups including aphasic speakers (Ulatowska, North, & Maclaluso-Haynes, 1981; Ulatowska, Weiss-Doyell, Stern, & Macaluso-Haynes, 1983), nonaphasic traumatically brain injured subjects (Coppens, 1995; McDonald, 1992, McDonald & Pearce, 1995; Snow, Douglas, & Ponsford, 1997) and RH subjects (Roman et al., 1987). Procedural narratives are discrete examples of connected discourse that have the specific goal of informing the listener. To this end the speaker needs to be precise and explicit in their communication of information (Ulatowska, Allard, & Chapman, 1990). A variety of procedures have been used to elicit such narratives. These normally involve the speaker describing a familiar domestic routine such as mailing a letter (Ulatowska, Allard, Donnell, Bristow, Haynes, Flower, & North, 1988; Ulatowska, Hayashi, Cannito, & Fleming, 1986), changing a tire (Roman et al., 1987), or making a sandwich (Coppens, 1995; Ulatowska et al., 1981, 1983). Alternatively, a novel board game has been used as a stimulus in both developmental and brain-injury studies (Flavell, 1975; McDonald, 1993b; McDonald & Pearce, 1995). Of particular relevance to this study is the finding that deficits in procedural narratives have been seen in traumatically brain-injured speakers with circumscribed deficits in executive function (McDonald, 1992; McDonald and Pearce, 1995) and RH subjects (Roman et al., 1987). This task was therefore included as a means to assess ability to produce pragmatically appropriate, connected discourse. Subjects were asked to describe how they would make a cheese-and-tomato sandwich. The responses were taped, transcribed and analyzed for the total number of procedural steps produced and the number of essential steps produced (12 essential steps were identified as steps mentioned by at least 70% of the normal controls). The number of essential propositions produced has been found to be a sensitive measure of discourse impairments in a number of studies (McDonald, 1993b; McDonald & Pearce, 1995; North, Ulatowska, Macaluso-Haynes, & Bell, 1986, Snow et al., 1997). In addition the percentage of irrelevant steps (defined as steps not mentioned by any other subject) as a function of total text length was used as an index of tangentiality since this has been considered a characteristic of both executively impaired (McDonald, 1992; McDonald & Pearce, 1995) and RH subjects (Roman et al., 1987).

Production of nonconventional requests. Nonconventional requests are requests that are uniquely formulated to meet contextual demands. Such requests have been specifically investigated in RH patients and brain-injured patients with executive dysfunction and in both differences have been found between RH subjects and controls (McDonald & Pearce, 1998; McDonald & van Sommers, 1993; Stemmer et al., 1994). This type of task was therefore also included in this battery, focusing upon both direct and indirect nonconventional requests.

1. *Requests that overcome listener reluctance:* Subjects were asked to produce a request that would overcome some explicitly identified reluctance on the part of the listener to comply. For example, subjects were asked how they might ask a relative for the loan of her car when they knew that she needed it herself. Such requests require the subject to generate a direct request that is, by necessity, nonconventional because it needs to be formulated to meet specific, idiosyncratic contextual requirements. This task has not been trailed on RH patients before but has been shown to be poorly performed by patients with executive dysfunction (McDonald & Pearce, 1998). In the current study subjects listened to eight scenarios which described a situation such as the one above in which the speaker wanted to request something from the listener, who was reluctant to comply. In each case they were asked how they might make such a request. Each response was transcribed and given a score of 2 if it addressed the source of the listener's reluctance, 1 if it encompassed some form of inducement not directly related to the reluctance, and 0 if the request was unembellished.

2. *Production of nonconventional indirect requests (hints):* Nonconventional indirect requests require the speaker to produce a request that alludes to the required action in indirect terms; for example, hinting to a friend to remind them that they had borrowed $20 some time ago and should repay the debt. In order to successfully produce such requests, subjects need to consider the specific features of the situation and produce a request that is conceptually related to what is required and infers as much while refraining from stating this explicitly. Nonconventional indirect request production has been examined in both the RH population (Stemmer et al., 1994) and in the executive dysfunction population (McDonald & van Sommers, 1993) and was therefore considered a useful task for the current study. The subjects were read a brief description of eight request scenarios and asked to imagine themselves in that situation and describe how they might make a request in the form of a hint to the listener. Responses were transcribed and scored 1–5 according to how closely related they were to the actual request using criteria described in McDonald and van Sommers (1993). A high score (5) was gained if the hint was remote from the desired action being requested while a low score (1) was gained for requests that simply stated the action required.

Comprehension tasks. Two type of tasks assessing the capacity to process pragmatic inference were included.

Sarcasm. The ability to interpret sarcastic inference often requires the listener to reinterpret an utterance to derive a meaning that is the converse of that literally asserted. Comprehension of sarcastic inference has been explicitly examined in subjects with both RH and executive deficits (e.g., Kaplan et al., 1990; McDonald, 1992; McDonald & Pearce, 1996; Tompkins & Mateer, 1985; Weylman et al., 1989; Winner et al., 1998) using a variety of paradigms and producing variable results. In this study, the paradigm used by McDonald and Pearce (1996) was employed. This task encompassed two conditions.

1. *Literally consistent exchanges:* In this task subjects were read six brief exchanges between two people such as:

> Bob: ''What a great football game.''
> Pete: ''So you are glad I asked you?''

They were then asked to answer four questions concerning their understanding of the exchange e.g., ''Did Bob think the game was good?'', ''Did Bob think the game was poor?'', ''Is Pete glad he asked Bob to the game?'', and ''Is Pete sorry he asked Bob to the game? '' They were scored correct on each item if they responded to each question according to the literal meaning of the corresponding utterances.

2. *Literally inconsistent exchanges:* In the complementary set of items there were six sets of exchanges in which the literal meaning of the second utterance was reversed, such as:

> Bob: ''What a great football game.''
> Pete: ''Sorry I made you come.''

This type of exchange can make sense only if it is assumed that one or other of the speakers is being sarcastic and means the opposite to what they state. In this condition responses to each set of questions (as above) were considered correct if subjects responded as if *one or other* of the utterances was literally false. Thus two combinations of answers to this task were considered acceptable. Patients with executive dysfunction have been found to have difficulty with the second condition but not the first in two independent studies (McDonald, 1992; McDonald & Pearce, 1996).

Indirect nonconventional requests (hints). Counterfactual inferences such as generated by sarcasm are blatant because the literal meaning is clearly contradicted by the context. In order to provide an indication of their ability to deal with more obliquely generated inferences, the clinical subjects were also given a task in which they were required to interpret nonconventional indirect requests in the form of hints. In such requests, the inference being conveyed is frequently related to the literal assertion in a practically logical manner. For example, the hint may refer to some condition that is causally related to the request, e.g., ‘‘*I want to wear that blue shirt but its very creased*’’ as a hint that the speaker would like his wife to iron the shirt (Corcoran, Mercer, & Firth 1995). It has been demonstrated that RH patients have difficulty interpreting such requests (Stemmer et al., 1994) and while comprehension of hints has not been investigated in patients with acquired executive dysfunction, deficits in this kind of comprehension have been demonstrated in schizophrenic patients (Corcoran et al., 1995) and it has been frequently intimated that schizophrenic-type illness reflects a disturbance to executive function (Robbins, 1990; Frith, 1993). The task used in this study was adapted from Corcoran et al. (1995). Subjects were read brief scenarios ending in a hint by one of the participants. The subjects were asked what the hint meant. If they were incorrect in their interpretation they were provided with an additional clue as to the meaning. Responses were scored 2 for a correct interpretation on the first round, 1 for a correct response after the clue, and 0 for an incorrect response.

Syllogism Task

The syllogism task encompassed four different types of syllogisms (10 examples of each), which were based upon the exemplars described by Grzybek (1993): Sensible, semantic (SS) syllogisms were syllogisms which could be answered by reference to either general semantic knowledge or by following the logic of the preceding premises (e.g., ‘‘*Electricity is a form of power; microwaves use electricity to run; do microwaves use power to run?*’’). Sensible logical (SL) syllogisms contained semantically consistent premises but could, nonetheless, only be solved by following the logic of the preceding premises (e.g., ‘‘*Helen and Mike have a son called Tom; they also have a daughter called Nellie; does Tom have a sister?*’’). In both SS and SL syllogisms there were an equal number of true and false items. Absurd logical (AL) syllogisms contained semantically absurd (false) premises and would be answered in the affirmative if the subject ignored the truth value of the premises and adhered, instead, to the logic (e.g., ‘‘*Apes can climb trees; porcupines are apes; Can porcupines jump through trees?*’’). Finally, absurd illogical (AI) syllogisms contained both a semantically absurd proposition and did not adhere to a logical sequence and should therefore be answered in the negative (e.g., ‘‘*Bridges are made of steel; pedestrians cross bridges; are pedestrians made of steel?*’’).

Results

Neuropsychological Test Performance

The results of the clinical and control subjects’ test performance on the neuropsychological tests are detailed in Table 2.

As expected, the RH group performed significantly poorer than the con-

TABLE 2
Mean Neuropsychological Tests Scores (and Standard Deviations) for the RH and Control Subjects and Summary ANOVA Scores

	Group		ANOVA (*F* values)	
Neuropsychological measures	RH	Controls	Between groups	Covariate
Visuospatial tests				
Facial Recognition (FR)	39 (5.9)	48.8 (3.6)	$F(1, 34) = 22.7$*	$F(1, 34) = 0.07$
Rey Figure (RF)	22 (9.4)	32.2 (1.9)	$F(1, 33) = 27.8$*	$F(1, 33) = 4.1$
Visual Organization Test (VOT)	20.3 (7.4)	27.5 (1.8)	$F(1, 34) = 7.8$*	$F(1, 34) = 1.9$
WAIS-R Block Design (BD)	6.5 (4.0)	13.6 (2.6)	$F(1, 37) = 20.5$*	$F(1, 37) = 1.7$
WMSR Visual Reproduction (VR)	20.9 (11.5)	35.1 (2.8)	$F(1, 34) = 11.7$*	$F(1, 34) = 3.1$
Executive tests				
Controlled Oral Word Association (COWAT)	30.4 (15.4)	46.7 (8.5)	$F(1, 34) = 4.4$	$F(1, 34) = 6.2$
WAIS-R Similarities (S)	7.6 (3.2)	12 (2.6)	$F(1, 37) = 4.7$	$F(1, 37) = 12.7$*
Attention and memory				
WMSR Information/Orientation (IO)	10.5 (1.2)	11.0 (0)	$F(1, 36) = 0.16$	$F(1, 36) = 6.8$
WMSR Mental Control (MC)	7.1 (2.0)	8.8 (0.7)	$F(1, 36) = 3.8$	$F(1, 36) = 2.5$
WMSR Paired Associates (PA)	12.4 (3.7)	15.7 (3.3)	$F(1, 36) = 0.85$	$F(1, 36) = 6.2$
WMSR Prose Passages (PP)	26.7 (10.4)	41.1 (4.8)	$F(1, 37) = 8.2$*	$F(1, 37) = 19.6$*

* Significantly different from controls at $p < .05$ (controlling for WAIS-R Vocabulary scores and using Bonferroni adjustment to probability level to adjust for inflated error rate associated with multiple comparisons).

trols on all visuospatial tasks. They were no different to controls on the two tasks of executive function. Nor were they different on tasks of attention and memory with the exception of a prose-recall task (WMS Prose Passages). It should be noted, however, that although the *average* performance of the two groups was similar on executive and attention tasks, there was a larger standard deviation associated with the performance of the RH group on all measures compared to the control group, indicating much greater individual variation on these tasks across the clinical subjects.

Pragmatic Language Battery

The performances of the RH and control subjects on the pragmatic language tasks are detailed in Table 3.

Group differences were examined using ANOVA with WAIS-R Vocabulary scores entered as a covariate. The RH patients were, on average, similar to their non-brain-injured counterparts on the majority of the pragmatic language tasks given. They produced, on average, a similar number of essential procedural steps when describing how to make a sandwich and as many procedural steps overall. Furthermore, no greater proportion of these were tangential. They were as capable as controls at producing indirect nonconventional requests (hints) and were as capable as their non-brain-damaged counterparts when interpreting hints appropriately. Both groups performed similarly when asked to interpret literally inconsistent (sarcastic) exchanges. The RH group were significantly poorer than controls at interpreting literally consistent (sincere) exchanges, mainly because the control group produced a universally flawless performance while the RH subjects were, as on the majority of other tasks, more variable on this task. The RH group were significantly and, in this case, substantially less likely than controls to produce a request that addressed the specific concerns of the listener.

Relationship between Language Tasks and Neuropsychological Function

The greater variance in the clinical group's performance on both neuropsychological and pragmatic language tasks compared to the controls suggests that the RH patients were not uniformly capable on these measures. While average group performances on many tasks were not significantly different, the RH group may well have encompassed a number of individuals who were, indeed, impaired. Scrutiny of individual cases revealed a number of subjects who were particularly poor on certain tasks. Interestingly, however, there was little consistency across subjects in this, i.e., at least half of the RH subjects were particularly poor on one or more tasks but no one subject performing consistently poorly across all tasks. It remains to be seen, however, whether incapacity on the pragmatic language measures is associated with either visuospatial or executive-type dysfunction. In order to examine this four mean z scores were calculated for each subject. Two were based

TABLE 3
Average Performance (and Standard Deviations) of RH and Control Subjects on the Pragmatic Language Tasks and Summary ANOVA Scores

	Group		ANOVA (F values)	
Pragmatic tasks	RH	Control	Between groups	Covariate
Procedural narrative				
Essential steps	8.2 (2.8)	10.6 (1.6)	$F(1, 37) = 3.8$	$F(1, 37) = 1.1$
Percentage tangential ideas	0.14 (0.15)	0.11 (0.14)	$F(1, 37) = 0.4$	$F(1, 37) = 0.04$
Total no. of propositions	12.7 (5.6)	16.2 (5.2)	$F(1, 37) = 1.6$	$F(1, 37) = 0.3$
Request production	5.3 (3.2)*	16.2 (5.2)	$F(1, 35) = 11.5$*	$F(1, 35) = 0.04$
Hint production	24.9 (6.5)	25.8 (5.6)	$F(1, 37) = 1.3$	$F(1, 37) = 1.7$
Hint comprehension	17.5 (2.5)	19.8 (0.4)	$F(1, 37) = 5.3$	$F(1, 37) = 3.6$
Sarcasm comprehension				
Sincere exchanges	4.8 (1.4)*	6.0 (0)	$F(1, 37) = 9.5$*	$F(1, 37) = 0.01$
Sarcastic exchanges	41.1 (1.6)	4.4 (1.8)	$F(1, 37) = 0.5$	$F(1, 37) = 0.01$

* $p < .05$ (controlling for WAIS-R vocabulary scores and using Bonferroni adjustment to probability level to adjust for inflated error rate associated with multiple comparisons).

TABLE 4

Pearson Partial Correlations between Mean *z* Scores for Pragmatic Production and Comprehension Tasks and Mean *z* Scores for Visuospatial and Executive-Type Neuropsychological Tasks (Controlling for WAIS-R Vocabulary)

Summary pragmatic score	Visuospatial function	Executive function
Pragmatic production	0.43*	0.35
Pragmatic comprehension	0.43*	0.24

* $p < .05$ (controlling for WAIS-R vocabulary scores and using Bonferroni adjustment to probability level to adjust for inflated error rate associated with multiple comparisons).

upon their performance on the five visuospatial tasks and two on the executive-type tasks respectively, producing a ''visuospatial'' score and an ''executive'' score. Similarly, two ''pragmatic scores'' were calculated. A mean *z* score for ''pragmatic production'' was calculated based upon the procedural narrative (number of essential steps minus the percentage of irrelevant propositions), request production, and hint production. A ''pragmatic comprehension'' mean *z* score reflected scores on the sincere and insincere (sarcastic) exchanges and hints. These two facets of pragmatic performance were correlated to visuospatial and executive function respectively using Pearson Partial Correlations covarying for WAIS-R Vocabulary scores. The results are detailed in Table 4. The probability level used as a criterion for significance was reduced to control for the inflated alpha error rate associated with multiple analyses using the Bonferroni procedure. The numbers with an * signify Pearson correlations that were significant ($p < .05$).

As is evident from Table 4, pragmatic production and comprehension were both correlated with visuospatial function. Neither aspect of pragmatic competence was correlated to executive function although the relationship between executive function and production was close ($p = .08$). A linear regression was performed to evaluate the independent contributions of visuospatial and executive function respectively while holding the other constant. This confirmed that visuospatial function made an independent contribution to pragmatic production and comprehension ($\beta = 0.38$, $t = 1.79$, $p = .04$ and $\beta = 0.49$, $t = 2.4$, $p = .01$ respectively) while executive function did not.

Syllogism Task

Performance on the syllogism task is detailed in Table 5. As can be seen from this table, RH subjects performed similarly to controls on the majority of the syllogisms, with the exception that they were significantly less capable of ignoring absurd propositions in the AL condition and therefore failed to respond on the basis of the logic of these unlike the controls.

This performance pattern suggests that the RH subjects were unable to

TABLE 5
Average Performance (and Standard Deviations) of RH Subjects and Controls on the Syllogism Task

Type of syllogism	RH patients	Control subjects
Syllogisms		
Sensible-semantic (SS)	9.5 (1.0)	9.9 (0.3)
Sensible-logical (SL)	8.8 (1.5)	9.9 (0.3)
Absurd-logical (AL)	1.1 (3.9)*	9.2 (1.6)
Absurd-illogical (AI)	8.7 (1.6)	9.7 (0.5)

* $p < .05$ (controlling for WAIS-R vocabulary scores and using Bonferroni adjustment to probability level to adjust for inflated error rate associated with multiple comparisons).

ignore superficial or irrelevant characteristics of stimuli. It should be noted, however, that in a similar pattern to other pragmatic performances, there were larger standard deviations associated with the RH subjects' performance compared to controls on *all* syllogism types, suggesting the clinical subjects were more variable on these than the control subjects. Correlations between the syllogism performances and indices of visuospatial function and executive dysfunction were performed using Pearson Partial Correlations controlling for WAIS-R Vocabulary scores. These are detailed in Table 6.

As can be seen, performance on three of the four syllogism types were associated with visuospatial function. Only the absurd but logical syllogisms were associated with executive function. This latter correlation is suggestive that failure on this task is due to executive type deficits rather than to more generic visuospatial dysfunction. Linear regressions were conducted on the four syllogism types to examine the independent contributions of visuospatial function and executive function respectively while holding the other constant. These confirmed that *all* syllogisms were predicted by visuospatial function (SS: $\beta = 0.59$, $t = 2.56$, $p = .008$, SL: $\beta = 0.72$, $t = 3.61$, $p = .001$, AL: $\beta = 0.31$, $t = 2.05$, $p = .024$, AI: $\beta = 0.56$, $t = 2.5$, $p = .008$).

TABLE 6
Pearson Partial Correlations between Syllogism Tasks and Mean *z* Scores for Visuospatial and Executive-Type Neuropsychological Tasks (Controlling for WAIS-R Vocabulary)

	Visuospatial function	Executive function
Syllogisms		
Sensible-semantic (SS)	0.45*	0.24
Sensible-logical (SL)	0.56*	0.26
Absurd-logical (AL)	0.64*	−0.05
Absurd-illogical (AI)	0.34	0.69*

* $p < .05$.

Executive function predicted the AL syllogisms alone ($\beta = 0.56$, $t = 3.7$, $p < .001$).

DISCUSSION

This group of RH subjects appeared to be typical in the sense that they showed specific impairment on a range of neuropsychological tasks routinely used to assess visuospatial abilities in clinical subjects. As a group they did *not* display significant impairments on the two tasks chosen to measure executive function, viz. the COWAT and the WAIS-R Similarities subtest. It is possible that this was, in part, due to the limited number and range of tasks used to measure this construct. Unfortunately, the fact that many tasks considered to be sensitive to executive function have visuoperceptual demands limits the range of such tasks that are suitable for use with RH subjects. A more extensive battery may have proven more sensitive. Nonetheless, the RH group contained a number of individuals who were less capable on these tasks, as evidenced by the larger standard deviations derived for the two scores compared to the control group. This pattern is consistent with the expectation that only a proportion of the RH group would have damage to the right frontal lobe or its connections.

The RH patients were also relatively well able to meet the range of pragmatic demands generated by the tasks in the pragmatic language battery. This is not completely surprising, given the variable and often subtle pragmatic language disturbances reported in this population on such tasks. For example, the performance on the procedural narrative task, mirrored the findings reported by Roman et al. in 1987. While these authors did not statistically analyze their results, they surmised that the RH subjects, as a group, were generally able to identify the essential (major) elements of a procedure but there was a greater amount of individual variation compared to the controls. Similarly, trivial and intrusive details were not dramatically dissimilar to the controls, although this again was characterized by individual variation. The RH subjects' ability to produce nonconventional indirect requests (hints) was comparable to controls and in keeping with one earlier study detailing RH performance on such tasks by Stemmer et al. (1994). These authors found hint production per se to be unimpaired but the RH subjects differed from control subjects regarding when they chose to use such hints. Interestingly, the RH subjects in the present study were reliably less able than control subjects to produce nonconventional requests that addressed a specific concern of the listener. When asked to formulate a request under these circumstances they were inclined to produce unembellished, conventional requests that did not take the listener's interests into account. This particular task has not been used before with RH patients. It may have yielded differentially poor performances compared to the hint task because the items encompassed specific, idiosyncratic obstacles to listener compliance and therefore required specifically tailored responses. In contrast, the hinting task referred to more general situations in which common forms of indirect requests could often suffice.

The RH and control group's mean accuracy scores were comparable on the hint-comprehension task, with the characteristic increase of subject variability within the RH group. The only previous study of this kind in RH subjects was performed by Stemmer et al., 1994, who examined the extent to which RH patients rated hints as indirect and polite. While they did find differences in these regards their results were not directly comparable to, or incompatible with, the findings of this study. Finally, the finding that RH subjects, as a group, processed sarcasm normally is also not unexpected given the subtle and often contradictory results yielded by a range of studies investigating sarcasm in RH subjects, some of which have reported overall loss of accuracy interpreting sarcasm (e.g., Tompkins & Mateer, 1985; Winner et al, 1998), while others have found either no differences (Tompkins & Flowers, 1987) or preserved capacity to distinguish between sarcasm and other forms of indirectness with only relative loss of efficiency using contextual cues (Brownell et al., 1992; Kaplan et al., 1990).

While the RH performance profile on the pragmatic battery is, on the whole, not dissimilar to other studies of RH subjects using similar tasks, they do diverge from expectations of performance in patients with explicitly documented deficits in executive processes. In the latter studies, more dramatic group differences have generally been reported when examining procedural narratives (McDonald, 1993b; McDonald & Pearce, 1995); hint production (McDonald & van Sommers, 1993); sarcasm comprehension (McDonald, 1992; McDonald & Pearce, 1996); and, in the schizophrenia population, hint comprehension (Corcoran et al, 1995). There are two explanations for this. First, it may be that the subtle and variable performance of the RH subjects on the pragmatic battery in this and other studies reflected the heterogenous nature of the group with respect to the inclusion of patients with executive dysfunction, i.e., only a few subjects within the group suffered executive deficits and it is their performances that were affecting the group's profile. This explanation is not convincing, however, because no individual subjects in this study showed consistently poor performances across the range of pragmatic tasks. More importantly, the derived index of executive function was not significantly associated with pragmatic competence in production or reception. The second explanation is the more generally assumed notion that the language disturbances seen in this and other RH studies reflects a peculiar contribution of the RH per se to higher level language processes. This explanation is supported by the finding of significant associations between indices of pragmatic competence and RH (visuospatial) function. Such a finding reinforces a previously reported association between verbal and visual abilities (Benowitz et al., 1990; Moya et al., 1986), although null associations have also been found (Stemmer et al., 1994).

The next question addressed in this study is related to the nature of the pragmatic impairments experienced. The syllogism task was included as a specific test of whether pragmatic failure in RH subjects is characterized by a failure to relate propositions to existing mental models of world knowledge (leading to a general lack of concern with implausibility) or alternatively to executive-type dysfunction reflected in a failure to see beyond the immediate, concrete meaning of individual propositions (leading to a fixation with implausibility). The RH group were, indeed, unable to solve absurd syllogisms logically and their performance on this particular type of syllogism was clearly inferior to the controls. Eight of the 18 subjects obtained a score of 0 out of 10 on this task. This pattern of performance contradicts predictions based upon the mental model explanation while being consistent with the executive dysfunction theory. Importantly, however, both executive dysfunction *and* visuospatial dysfunction made independent contributions to the variance in poor performance seen on this task.

What does this pattern suggest? First, the positive relationship between the absurd syllogisms and executive function may be an indication that executive dysfunction led to concrete thinking and behavior in the clinical group. However, given the general lack of association between executive function and pragmatic competence on the test battery, performance on the AL syllogism task cannot be taken as a broader indicator of the cognitive style with which RH subjects approached the pragmatic tasks. The reasons why executive dysfunction did not predict general pragmatic performance are unclear but may relate to the unilateral nature of the brain damage experienced. Most studies depicting the impact of executive dysfunction on communication skills focus upon subjects in whom bilateral frontal-lobe damage is implicated (e.g., traumatic brain injury or anterior communicating artery aneurysm). It is also true that even within this population, only a proportion experience pragmatic deficits (McDonald & Pearce, 1995). Thus executive impairments may need to be particularly pervasive, or of a particular kind, to disrupt pragmatic language skills. The fact that executive dysfunction was associated with the absurd syllogisms but not the pragmatic tasks in this battery suggests that the syllogisms presented either a greater cognitive demand on the subjects than the other language tasks or else a qualitatively different set of demands. Comparison between the syllogisms and the pragmatic comprehension tasks reveals both similarities and differences. The syllogisms, hints, and sarcasm tasks all required the subject to ignore literal meanings in order to appreciate underlying inference. On the other hand, the syllogisms task contained propositions that were, within themselves, clearly counterfactual while the hints and sarcasm contained premises that *could* be true in absolute terms but which were rendered unlikely by the particular context in which they occurred. Thus the syllogism task challenged the RH subjects' ability to ignore implausibility at a semantic rather than pragmatic level.

The failure of this study to attribute pragmatic dysfunction to executive-type cognitive disturbances leads us back to considering the relationship between RH (visuospatial) function and pragmatic competence. This appears to be a systematic relationship and yet the notion that both visuospatial skills and pragmatic skills are mediated by a common mechanism which enables mental models of incoming and existing information to be developed is not supported. RH subjects do appear, at least in this study, to be very cognizent of the plausibility of incoming information, suggesting they are capable of relating this to their view of the world. Fixation with plausibility could not simply be attributed to those in the group with executive dysfunction because poor performance on the absurd syllogisms was associated with visuospatial as well as executive dysfunction scores.

Given the very subtle and variable nature of the pragmatic deficits experienced in the RH subjects in this and other studies, an alternative explanation is that the RH compromises complex language function in a nonspecific manner. While somatosensory, perceptual, and basic language functions are relatively localized, more complex neuropsychological functions such as information processing, problem solving, and general intelligence appear to be supported by widespread cortical systems (Kertesz, 1996). The frontal lobes clearly make a particular contribution to the executive control and regulation of cognitive activity, but posterior association areas also contribute to complex cognitive activity as components of a highly interactive system (Sergent, 1988). The solving of difficult, complex, unfamiliar, and nonstandard communicative tasks presents a greater inferential load than the processing of simple, familiar communicative acts (Bara, Tirassa, & Zettin, 1997) and is more likely to rely upon such distributed networks. Group studies of subjects with lesions that vary in size and location within the RH would, in such a case, produce a picture of a loss of efficiency on complex pragmatic language tasks that reflects the relative extent of system disruption. The finding that general indices of pragmatic deficits in RH subjects are associated with visuospatial disturbances fits with this notion; the greater the extent of cognitive dysfunction, as indexed by these scores, the greater the likelihood of disruption to subtle language processes. This type of explanation would suggest that language disorders experienced by RH subjects reflect quantitative rather than qualitative differences compared to non-brain-damaged interlocuters. The variability seen may be a product of the inherent difficulty of the tasks used, the individual's premorbid competencies, and the extent of their dysfunction. Such an explanation of RH language impairment is not without value for the development of normal psycholinguistic models. The difficulty level of particular tasks can provide useful insights into the cognitive load required to process them (e.g., Bara et al., 1997). But the application of such a heurist is predicated upon the basis that it can be demonstrated that RH language disorders reflect a relative reduction of efficiency in normal language processes.

Alternatively, the RH may support a variety of modular functions other than, or in addition to, those investigated here. For example, the processing and identification of affective, familiar, and personally relevant information has been proposed to be a RH specialization (see Van Lancker, 1991 for review) that has implications for RH communication dysfunction (e.g., Brownell, Pincus, Blum, Rehak, & Winner, 1997). However, the variable and subtle results yielded by group studies using a plethora of linguistic approaches makes it difficult to perceive a systematic relationship here either. Group approaches to the investigation of RH language disorders may be doomed to yield heterogenous and therefore ambiguous results. *Qualitatively distinct* pragmatic disorders may only be apparent via intensive investigation of single cases. Similarly, the use of correlation in this study has gone some way to exclude possible contendors for a global cause for pragmatic language impairment following RH damage but does not exclude the possibility that damage to specific systems within the RH may, in select individuals, lead to a loss of the ‘‘plausibility metric’’ (Wapner et al., 1981) and in others a loss of control over goal-directed language behavior.

CONCLUSION

This study explicitly attempted to examine competing theories for the nature of language dysfunction seen in RH damage, the visuospatial, synthesis processing hypothesis versus the executive function hypotheses. The variety of tasks used here, based on both RH and executive function–communication literature, produced comparable results to similar paradigms used in the RH literature, confirming that the phenomena reported are both subtle and variable. The finding that performance on these tests more closely mirrored other RH research rather than specifically executive deficit research gives weight to the thesis that RH language disorders are distinct from disorders seen after frontal lobe injury. The fact that these measures were uncorrelated to an index of executive dysfunction further supports this view. The finding of a correlation between pragmatic language measures and visuospatial measures can be taken to imply that there is a common substrate underlying both. However, the specific contention that the RH has a pivotal function in the synthesis of incoming information with existing cognitive schemas was not supported. The RH patients’ failure to ignore the implausibility of absurd logical syllogisms explicitly contradicted predictions based on the mental model theory. Their performance on the syllogism task was associated with executive function, as expected, but also with visuospatial function. The nature of RH language disturbances remains beyond simple explanation but does not appear to be accounted for by the global explanations tested in this study. Hopefully, however, this research has highlighted the need for more critical research into the neuropsychological basis for RH language disorders.

REFERENCES

Alexander, M. P., Benson, D. F., & Stuss, D. T. (1989). Frontal lobes and language. *Brain and Language,* **37,** 656–691.

Bara, B. G., Tirassa, M., & Zettin, M. (1997). Neuropragmatics: Neuropsychological constraints on formal theories of dialogue. *Brain and Language,* **59,** 7–14.

Benowitz, L. I., Moya, K. L., & Levine, D. N. (1990). Impaired verbal reasoning and constructional apraxia in subjects with right hemisphere damage. *Neuropsychologia,* **28,** 231–241.

Benton, A. L., & Hamsher, K. de S. (1989). *Multilingual Aphasia Examination.* Iowa City, IA: AJA Associates.

Benton, A. L., Hamsher, K., & de Sivan, A. B. (1994). *Multilingual Aphasia Examination.* Iowa City, IA: AJA Associates.

Bihrle, A. M., Brownell, H. H., Powelson, J. A., & Gardner, H. (1986). Comprehension of humorous and nonhumorous materials by left and right brain-damaged patients. *Brain and Cognition,* **5,** 399–411.

Brookshire, R. H., & Nicholas, L. E. (1984). Comprehension of directly and indirectly stated main ideas and details in discourse by brain damaged and non-brain-damaged listeners. *Brain and Language,* **21,** 21–36.

Brownell, H. H., Carroll, J. J., Rehak, A., & Wingfield, A. (1992). The use of pronoun anaphora and speaker mood in the interpretation of conversational utterances by right hemisphere brain damaged subjects. *Brain and Language,* **43,** 121–147.

Brownell, H. H., Michel, D., Powelson, J., & Gardner, H. (1983). Surprise but not sensitivity to verbal humour in right hemisphere patients. *Brain and Language,* **18,** 20–27.

Brownell, H. H., Potter, H. H., Bihrle, A. M., & Gardner, H. (1986). Inference deficits in right brain damaged patients. *Brain and Language,* **27,** 310–321.

Brownell, H., Pincus, D., Blum, A., Rehak, A., & Winner, E. (1997). The effects of right hemisphere brain damage on patients' use of terms of personal reference. *Brain and Language,* **57,** 60–79.

Coppens, P. (1995). Subpopulations in closed head injury: Preliminary results. *Brain Injury,* **9,** 195–208.

Corbalis, M. C. (1997). Mental rotation and the right hemisphere. *Brain and Language,* **57,** 100–121.

Corcoran, R., Mercer, G., & Frith, C. D. (1995). Schizophrenia, symptomatology and social inference: Investigating ''theory of mind'' in people with schizophrenia. *Schizophrenia Research,* **17,** 5–13.

Corwin, J., & Bylsma, F. W. (1993). Translations of excerpts from Andre Rey's *Psychological examination of traumatic encephalopathy* and P. A. Osterrieth's *The complex figure test. The Clinical Neuropsychologist,* **7,** 15–21.

Delis, D., Wapner, W., Gardner, H., & Moses, J. (1983). The contribution of the right hemisphere to the organisation of paragraphs. *Cortex,* **19,** 43–50.

Diggs, C. C. and Basali, A. (1987). Verbal expression of right cerebrovascular accident patients: Convergent and divergent language. *Brain and Language,* **30,** 130–146.

Flavell, J. H. (1975). *The development of role taking and communication skills in children.* New York: Krieger.

Foldi, N. S. (1987). Appreciation of pragmatic interpretations of indirect commands: Comparison of right- and left-hemisphere brain-damaged patients. *Brain and Language,* **31,** 88–108.

Frith, C. D. (1993). *The cognitive neuropsychology of schizophrenia* Hove, UK: Erlbaum.

Gardner, H. (1975). *The shattered mind: The person after brain damage.* London: Routeledge & Kegan Paul.

Gardner, H., Ling, K., Flamm, L., & Silverman, J. (1975). Comprehension and appreciation of humour in brain damaged patients. *Brain,* **98,** 399–412.

Grzybek, P. (1993). A neurosemiotic perspective on text processing In H. H. Brownell & Y. Joanette (Eds.), *Narrative discourse in neurologically impaired and normal aging adults.* San Diego: Singular.

Hecaen, H. (1978). Right hemisphere contribution to language. In P.A. Buser & A. Rouget-Buser (Eds.), *Cerebral correlates of conscious experience.* Amsterdam: North Holland.

Hier, D. B., & Kaplan, J. (1980). Verbal comprehension deficits after right hemisphere damage. *Applied Psycholinguistics,* **1,** 279–294.

Hillis Trupe, E., & Hillis, A. (1985). Paucity versus verbosity: Another analysis of right hemisphere communication deficits. In R.W. Brookshire (Ed.), *Clinical aphasiology* Minneapolis: BRK. Vol. 15, pp. 83–96.

Hirst, W., LeDoux, J, & Stein, S. (1984). Constraints of processing indirect speech acts: Evidence from aphasiology. *Brain and Language,* **23,** 26–33.

Hooper, H. E. (1983). *Hooper Visual Organisation Test (VOT)* Los Angeles: Western Psychological Services.

Hough, M. S. (1990). Narrative comprehension in adults with right and left hemisphere brain-damage: Theme organization. *Brain and Language,* **38,** 253–277.

Huber, W., & Gleber, J. (1982). Linguistic and nonlinguistic processing of narratives in aphasia. *Brain and Language,* **16,** 1–18.

Joanette, Y., Goulet, P., Ska, B., & Nespoulous, J. (1986). Informative content of narrative discourse in right-brain-damaged right-handers. *Brain and Language,* **29,** 81–105.

Johnson-Laird, P. N. (1983). Mental models. In *Towards a cognitive science of language, inference and consciousness.* Cambridge, MA: Cambridge Univ Press.

Kaplan, J. A., Brownell, H. H., Jacobs, J. R., & Gardner, H. (1990). The effects of right hemisphere damage on the pragmatic interpretation of conversational remarks. *Brain and Language*, **38,** 315–333.

Kertesz, A. (1996). Localisation. In J. G. Beaumont, P. M. Kenealy, & M. J. C. Rogers (Eds.), *The Blackwell dictionary of neuropsychology.* Cambridge, MA: Blackwell.

Kintsch, W., & vanDijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review,* **85,** 363–394.

Levy, J., Trevarthen, C. B., & Sperry, R. W. (1972). Perception of bilateral chimeric figures following hemisphere deconnexion. *Brain,* **95,** 61–78.

Lezak, M. D. (1995). *Neuropsychological assessment* (3rd ed.) New York: Oxford Univ. Press.

Mackisack, L. E., Myers, P. S., & Duffy, J. R. (1987). Verbosity and labelling behaviour: The performance of right hemisphere and non brain damaged adults on an inferential picture description task. In R. J. Brookshire, (Ed.), *Clinical aphasiology.* Minneapolis: BRK. Vol. 17, pp. 143–151.

Mandler, J. M., & Johnson, N. S. (1977). Remembrance of things parsed: Story structure and recall. *Cognitive Psychology,* **9,** 111–151.

McDonald, S. (1992). Differential pragmatic language loss following closed head injury: Ability to comprehend conversational implicature. *Applied Psycholinguistics,* **13**(3), 295–312.

McDonald, S. (1993a). Viewing the brain sideways? Right hemisphere versus anterior models of non-aphasic language disorders. *Aphasiology,* **7,** 535–549.

McDonald, S. (1993b). Pragmatic language loss following closed head injury: Inability to meet the informational needs of the listener. *Brain and Language,* **44,** 28–46.

McDonald, S., & Pearce, S. (1995). The Dice game: A new test of organisational skills in language. *Brain Injury,* **9,** 255–271.

McDonald, S., & Pearce, S. (1996). Clinical insights into pragmatic language theory: The case of sarcasm. *Brain and Language,* **53,** 81–104.

McDonald, S., & Pearce, S. (1998). Requests that overcome listener reluctance: Impairment associated with executive dysfunction in brain injury. *Brain and Language,* **61,** 88–104.

McDonald, S., & van Sommers, P. (1993). Differential pragmatic language loss following closed head injury: Ability to negotiate requests. *Cognitive Neuropsychology,* **10,** 297–315.

McDonald, S., & Wales, R. (1986). An investigation of the ability to process inferences in language following right hemisphere brain damage. *Brain and Language,* **29,** 68–80.

McFie, J. (1975). *Assessment of organic intellectual impairment.* London: Academic Press.

Miller, E. (1984). Verbal fluency as a function of a measure of verbal intelligence and in relation to different types of cerebral pathology, *British Journal of Clinical Psychology,* **23,** 53–57.

Molloy, R, Brownell, H. H., & Gardner, H. (1990). Discourse comprehension by right hemisphere stroke patients: Deficits of prediction and revision. In Y. Joanette and H. H. Brownell (Eds.), *Discourse ability and brain damage: Theoretical and empirical perspectives.* New York: Springer-Verlag.

Nebes, R. D. (1974). Dominance of the minor hemisphere for the perception of part–whole relationships. In M. Kinsbourne & W. Lynn Smith (Eds.), *Hemispheric disconnection and cerebral function.* Ch X. Springfield, IL: Thomas.

Newcombe, F. (1969). *Missile wounds of the brain.* London: Oxford Univ. Press.

North, A. J., Ulatowska, H. K., Macaluso-Haynes, S., & Bell, H. (1986). Discourse impairments in older adults. *International Journal of Aging and Human Development,* **23,** 267–286.

Novoa, O. P., & Ardila, A. (1987). Linguistic abilities in patients with prefrontal damage. *Brain and Language,* **30,** 206–225.

Pendleton, M. G., Heaton, R. K., Lehman, R. A. W., & Hulihan, D. (1982). Diagnostic utility of the Thurston Word Fluency Test in neuropsychological evaluation. *Journal of Clinical Neuropsychology,* **4,** 307–317.

Picard, C., Goulet, P., & Joanette, Y. (1995). Plausibility judgement in right-brain-damaged patients: Poster presented at the European INS, 1994. *Journal of the International Neuropsychological Society,* **1,** 205.

Piercy, M., Hecaen, H., & Ajuriaguerra, J. (1960). Constructional apraxia associated with unilateral cerebral lesions—Left and right side cases compared. *Brain,* **83,** 225–242.

Rao, S. M. (1990). Neuroimaging correlates of cognitive dysfunction. In S. M. Rao (Ed.), *Neurobehavioural aspects of multiple sclerosis.* New York: Oxford Univ. Press.

Rehak, A., Kaplan, J. A., Weylman, S. T., Kelly, B., Brownell, H. H., & Gardner, H. (1992). Story processing in right-hemisphere brain-damaged subjects. *Brain and Language,* **42,** 320–336.

Rivers, D. L., & Love, R. J. (1980). Language performance on visual processing tasks in right-hemisphere-lesion cases. *Brain and Language,* **10,** 348–366.

Robbins, T. W. (1990). The case for a frontostriatal dysfunction in schizophrenia. *Schizophrenia Bulletin,* **16,** 391–342.

Roman, M., Brownell, H. H., Potter, H. H., Seibold, M. S., & Gardner, H. (1987). Script knowledge in right hemisphere damaged and in normal elderly adults. *Brain and Language,* **31,** 151–170.

Schneiderman, E. I., Murasugi, K. G., & Saddy, J. D. (1992). Story arrangement ability in right-brain-damaged patients. *Brain and Language,* **43,** 107–120.

Schneiderman, E. I., & Saddy, J. D. (1988). A linguistic deficit resulting from right hemisphere damage. *Brain and Language,* **34,** 38–53.

Sergent, J. (1988). Some theoretical and methodlogical issues in neuropsychological research. In F. Boller & J. Grafman (Eds.), *Handbook of neuropsychology, volume 1.* Amsterdam: Elsevier.

Shallice, T., & Burgess, P. W. (1991). Deficits in strategy application following frontal damage in man. *Brain,* **114,** 727–741.

Snow, P., Douglas, J., & Ponsford, J. (1997). Procedural discourse following traumatic brain injury. *Aphasiology,* **11,** 947–967.

Stemmer, B., Giroux, F., & Joanette, Y. (1994). Production and evaluation of requests by right hemisphere brain damaged individuals. *Brain and Language,* **47,** 1–31.

Stuss, D. T., & Benson, D. F. (1986). *The frontal lobes.* New York: Raven.

Stuss, D. T., Alexander, M. P., Leiberman, A., & Levine, H. (1978). An extraordinary form of confabulation. *Neurology,* **28,** 1166–1172.

Tompkins, C. A., & Flowers, C. R. (1987). Contextual mood priming following left- and right-hemisphere damage. *Brain and Cognition,* **6,** 361–376.

Tompkins, C. A., & Mateer, C. A. (1985). Right-hemisphere appreciation of prosodic and linguistic indications of implicit attitude. *Brain and Language,* **24,** 185–203.

Ulatowska, H. K., Allard, L. & Chapman, S. B. (1990). Narrative and procedural discourse in aphasia. In Y. Joanette & H. H. Brownell (Eds.), *Discourse ability and brain damage: Theoretical and empirical perspectives.* New York: Springer-Verlag.

Ulatowska, H. K., Allard, I., Donnell, A., Bristow, J., Haynes, S. M., Flower, A., & North, A. (1988). Discourse performance in subjects with dementia of the Alzheimer type. In H. A. Whitaker (Ed.), *Neuropsychological studies of non-focal brain damage.* New York: Springer-Verlag.

Ulatowska, H. K., Hayashi, M. M., Cannito, M. P., & Fleming, S. G. (1986). Disruption of referencing in aging. *Brain and Language,* **28,** 24–41.

Ulatowska, H. K., North, A. J., & Macaluso Haynes, S. M. (1981). Production of narrative and procedural discourse in aphasia. *Brain and Language,* **13,** 345–371.

Ulatowska, H. K., Weiss-Doyle, A., Freedman-Stern, R., Macaluso-Haynes, S., & North, A. J. (1983). Production of procedural discourse in aphasia. *Brain and Language,* **18,** 315–341.

Van Lancker, D. (1991). Personal relevance and the human right hemisphere. *Brain and Cognition,* **17,** 64–92.

Walsh, K. W., & Darby, D. (1999). *Neuropsychology: A clinical approach (4th ed.).* Edinburgh: Churchill Livingstone.

Wapner, W., Hamby, S., & Gardner, H. (1981). The role of the right hemisphere in the apprehension of complex linguistic materials. *Brain and Language,* **14,** 15–32.

Wechsler, D. (1981). *WAIS-R Manual.* San Antonio, TX: The Psychological Corporation.

Wechsler, D. (1987). *Wechsler Memory Scale—Revised Manual.* San Antonio, TX: The Psychological Corporation.

Weinstein, E. A. (1971). Linguistic aspects of amnesia and confabulation. *Journal of Psychiatric Research,* **8,** 1–8.

Weylman, S. T., Brownell, H. H., Roman, M., & Gardner, H. (1989). Appreciation of indirect requests by left and right damaged patients: The effects of verbal context and conventionality of wording. *Brain and Language,* **36,** 580–591.

Winner, E., & Gardner, H. (1977). Comprehension of metaphor in brain damaged patients. *Brain,* **100,** 719–727.

Winner, E., Brownell, H., Happe, F., Blum, A., & Pincus, D. (1998). Distinguishing lies from jokes: Theory of mind deficits and discourse interpretation in right hemisphere brain damaged patients. *Brain and Language,* **62,** 89–106.