

# Informational content and unilateral neglect: a longitudinal investigation of five subjects with right hemisphere damage

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## Abstract

The relationship between unilateral visual neglect and production of narrative discourse in five patients with right hemisphere damage (RHD) was examined longitudinally. Initially, all subjects demonstrated a left unilateral neglect on the Behavioural Inattention Test (Wilson *et al.* 1987a). During subsequent testing at 6-8 months and 12-16 months post-onset, subjects with a persistent unilateral neglect produced less concise discourse with reductions in the percentage of meaningful content units as compared to a group of control subjects. Subjects with a transient unilateral neglect produced informational content that was comparable to the normal subjects. Results support the notion that the presence and persistence of a unilateral visual neglect might assist in delineating more homogeneous groups of RHD subjects.

## Introduction

Discourse production problems, particularly reductions in informational content, are often present in individuals with right hemisphere damage (RHD) (Bloom *et al.* 1992, Cherney 1990, Cherney and Canter 1993, Joannette *et al.* 1986, Myers and Brookshire 1994, 1996, Sheratt and Penn 1990, Trupe and Hillis 1985). Some of these studies have suggested that there may be subgroups of RHD subjects. For example, Joannette and colleagues (1986) identified two subgroups of RHD subjects on the basis of their informative content, while Trupe and Hillis (1985) classified RHD subjects into five groups based on the content units produced and an efficiency ratio of syllables per content unit. In both studies there also was a subset of RHD subjects who performed similarly to a normal group of individuals. These results illustrate the heterogeneity of the RHD population.

Therefore, the presence of a right hemisphere lesion alone is not sufficient to obtain a homogenous group (Joannette and Goulet 1994), and inclusion criteria should address other defining characteristics of the sample. One of the most salient characteristics of RHD is the presence of a unilateral or hemispatial neglect. This is a complex disorder in which patients ignore, or do not respond or orient to, stimuli on the contralateral side to the lesion, despite the motor and sensory capacity to do so (Heilman *et al.* 1983). Neglect may occur in any modality, but it is most common in the visual modality. Myers and Brookshire (1994, 1996) have

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suggested that the presence and severity of a unilateral visual neglect might assist in delineating more homogeneous groups of RHD subjects. They found a moderate to strong correlation between subjects' neglect scores and the number of major concepts produced on a picture description task, suggesting that the production of concepts may be associated with the severity of the RHD subject's neglect.

While most researchers agree that unilateral neglect is most profound in the initial phase of acute right-sided lesions, there is conflicting information about its course of recovery. According to Hier *et al.* (1983), neglect typically resolves over time, with a median duration to recovery of 2 months. However, other studies have demonstrated that the neglect still may be detectable many months after onset of the RHD (Colombo *et al.* 1982).

Most theories of neglect suggest that it is a deficit in attention, although its precise nature is not yet understood. For example, neglect may reflect a general deficit in attention and arousal (Coslett *et al.* 1987, Heilman *et al.* 1978, 1984), or it may be conceptualized as a deficit in attentional capture for stimuli located on the contralesional side of the current focus of attention (Arguin and Bub 1993), or a deficit in attentional disengagement (Posner *et al.* 1984, 1987). Mesulam (1981) considers unilateral neglect to be a problem in directed and selective attention, so that patients with neglect may have difficulty selecting relevant stimuli or filtering out distractors. As the selective attention demands of tasks increase, the signs of neglect may increase and performance decrease (Rapcsak *et al.* 1989).

In an attempt to relate the unilateral neglect and discourse production problems, Cherney (1990) has suggested that both unilateral neglect and deficits in verbal output may reflect involvement of a common substrate in the right hemisphere. Just as the right hemisphere is crucial for attending to space, it also may have an important role in attention to ideational associations. In response to a stimulus, RHD subjects, like normal individuals, may activate many related associations that may not necessarily be related to the original stimulus. To produce discourse that is meaningful, relevant, and on-topic, relevant associations must be selectively attended to, while irrelevant ones must be ignored. Cherney (1990) has postulated that, because of difficulties in selectively attending to meaningful concepts, the discourse of RHD may be impaired and characterized by irrelevancies, off-topic utterances and incorrect information.

In this preliminary study the relationship between discourse production and unilateral neglect in five patients with RHD was examined longitudinally. If both unilateral neglect and discourse impairments result from the same underlying attentional disorder, regardless of the specific theoretical bias, some relationship between these two variables would be anticipated. The purposes of the study were to: (a) assess the presence, severity, and change over time of unilateral neglect; (b) describe changes over time in informational content of narrative discourse; and (c) examine the relationship between informational content in narrative discourse and unilateral neglect.

It was hypothesized that at least two subgroups of subjects might be identified, based on the severity of the unilateral left neglect. Greater reductions in the informational content of narrative discourse might be expected in subjects with a severe neglect as compared to those with a mild neglect. In addition, as neglect improves over time, concomitant improvements might be anticipated in the informational content of the narrative discourse.

## Methodology

### *Subjects*

Five subjects with a single unilateral right hemisphere infarct and 25 control subjects participated. All subjects were right-handed, native speakers of English, with no prior history of neurological or psychiatric disorders and drug or alcohol abuse. All subjects passed a pure-tone audiometric screening at 30 dB HL in their better ear; corrected visual acuity was sufficient for newspaper print.

Table 1 includes specific demographic information about each subject with RHD. In four subjects the location of the infarct was confirmed by CT scan or MRI. In one subject the CT scan was within normal limits; however the patient demonstrated clinical signs of unilateral right hemisphere stroke such as the sudden onset of a left hemiplegia and unilateral neglect. Each subject was followed longitudinally. Three test sessions were conducted: in the acute phase (less than 6 weeks post-onset); at 6–8 months post-onset; and at 12 months or more post-onset. All subjects were receiving speech and language therapy in the acute phase, but treatment was discontinued at least 2 months prior to the second test session.

The larger group of 25 healthy older adults served as control subjects on the discourse task. All of these subjects were living independently in the community, and each scored within normal limits on the Mini-Mental State Examination (Folstein *et al.* 1975). Their mean age was 72.55 years (range 61.6–92.2 years, standard deviation 7.15 years) with a mean education level of 13.96 years (range 8–20 years, standard deviation 3.42 years).

### *Procedures*

The procedures were administered as part of a larger battery of tests that included four discourse tasks, the Behavioural Inattention Test (BIT) (Wilson *et al.* 1987a), and other tests of cognitive functioning. In all cases the discourse tasks were administered first, followed by the BIT. The tests were conducted within the same test session. This paper presents the results of the narrative discourse task and the BIT.

### *Unilateral visual neglect*

To assess the presence and severity of unilateral neglect, the Behavioural Inattention Test (BIT) (Wilson *et al.* 1987a, b), a comprehensive standardized test of unilateral visual neglect, was administered. The test includes six 'conventional' pencil-and-paper measures of neglect (line crossing, letter cancellation, star cancellation, figure and shape copying, line bisection, and representational drawing) which are used to diagnose the presence or absence of unilateral visual neglect. In addition, there are nine behavioural subjects reflecting aspects of daily life (e.g. telephone dialling, coin sorting, and map navigation), which are used to indicate the types of everyday problems likely to result from the unilateral visual neglect.

For each of the 16 subtests the normal range of performance is provided, as well as cut-off scores below which problems in unilateral visual neglect are suspected. The scores achieved on each subtest are summed to provide a score for the total

Table 1. Subject characteristics

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5
Age	83-5 years	83-8 years	66-6 years	51-6 years	58-1 years
Sex	Female	Female	Male	Male	Female
Education	12 years	12 years	16 years	16 years	12 years
Site of lesion	Unknown	Frontal- parietal	Frontal- parietal	Temporal- parietal	Frontal- parietal
Test Session 1, time post-onset	4 weeks	2 weeks	4 weeks	5 weeks	3 weeks
Test Session 2, time post-onset	7 months	7.5 months	6 months	7.5 months	6.5 months
Test Session 3, time post-onset	13 months	16 months	16.5 months	12 months	13 months

test, as well as overall scores for the conventional and for the behavioural groups of subtests. The test developers suggest that a unilateral visual neglect is present when the aggregate score on the six conventional subtests falls below the cut-off score of 129 (Wilson *et al.* 1987a, b). Cut-off scores or ranges of performance for different severity levels are not provided. However, lower scores would indicate more severe neglect than higher scores.

#### *Informational content*

Narrative discourse was elicited using an auditory stimulus. A visual task such as a picture description task was considered potentially difficult for individuals with unilateral visual neglect who might ignore a portion of the stimulus, thereby affecting the ability to describe the picture. The Story Retelling Task—Immediate of the Arizona Battery for Communication Disorders of Dementia (Bayles and Tomoeda 1991) was used. This 72-word short story was read aloud to the subjects (see Appendix A); immediately afterwards the subjects were asked to retell it. The developers of the test have identified 17 key elements of information in the story. In a group of normal older control subjects they found that the mean number of elements included in the retelling was 14.0 (SD = 2.8). In addition, among normal subjects the number of key elements recalled was found to be unaffected by age and education (Bayles and Tomoeda 1991).

All responses were tape-recorded, transcribed verbatim, and scored. Categories used to analyse informational content included essential units, elaborations, irrelevancies, redundancies, off-topic information, and incorrect information units (Cannito *et al.* 1988, Ulatowska *et al.* 1988, Cherney and Canter 1993). Essential units are relevant pieces of information that are consistent with the major details and have been selected *a priori* for the particular task. For the story-retelling task the essential units were the 17 units of information identified as key elements by Bayles and Tomoeda (1991). These are listed in Appendix B. Elaborations are informational units that provide additional relevant information beyond that which was established *a priori*. Essential and elaborative units are considered to be content loaded because they contain relevant, non-redundant and correct information.

In contrast, irrelevancies, redundancies, off-topic information, and incorrect information units are considered to be non-meaningful because they do not add

relevant and novel information, and therefore do not enhance the communication. Irrelevancies are content units that are related to the topic but are inconsistent with the task requirements, such as describing a personal experience of losing a wallet rather than relating the story that was heard. Irrelevancies also include interpretations and judgements, and comments either about the task or to the examiner. Redundancies are content units that do not add any new information, but repeat information that has been given previously. Off-topic information units are digressions that are completely unrelated to the topic or task. Incorrect information refers to content units that are inconsistent with the original story stimulus provided. Examples of each type of content unit are included in Appendix C.

### *Reliability*

Inter-scorer reliability between the first and second authors was established on 20% of the transcripts. Point-to-point reliability was 93.82%, indicating a satisfactory level of consistency between raters. Breakdown for each category of informational unit was as follows: 100% for essential units of information; 78.13% for elaborations; 75.47% for irrelevancies; and 90% for redundancies, off-topic units and incorrect units combined. The latter category was combined because of the relatively few instances of these categories. Most discrepancies regarding the elaborations and irrelevancies resulted from disagreements about the length of the content unit, so that if units were judged to be longer, there were fewer units in a particular category. When discrepancies arose they were discussed and resolved.

## **Results**

### *Unilateral visual neglect*

Table 2 shows each subject's performance on the BIT at each test period. The final column indicates the cut-off scores for each subtest, below which problems in unilateral neglect are suggested (Wilson *et al.* 1987a). At initial testing, all subjects performed below the total cut-off scores of 129 for the conventional subtests and 67 for the behavioural subtests, indicating the presence of unilateral neglect. A qualitative error analysis confirmed that the error patterns were consistent with that of a *left* unilateral neglect. Neglect was most severe in Subjects 1 and 4, who achieved total test scores of 52 and 76 respectively.

Two patterns of performance emerged when the subjects' BIT scores were examined longitudinally. One pattern was characterized by continued reductions in performance, with scores at both the second and third test sessions that were below the cut-off score for normal performance. For these patients the unilateral neglect was described as *persistent*. The other pattern of performance was characterized by improved performance so that the scores achieved at test sessions 2 and 3 were maintained above the cut-off score for normal performance. For these patients the unilateral neglect was described as *transient*. Therefore Subjects 1 and 2 presented with a persistent unilateral neglect, while Subjects 4 and 5 presented with a transient unilateral neglect. It is of particular interest to note that initial severity was not a determining factor for persistence of unilateral neglect. For example, Subject 4, who initially presented with very low scores on the BIT, no longer displayed a unilateral neglect by 7.5 months post-onset.

Table 2. Behavioural Inattention Test scores at each test session

Test session	Subject 1			Subject 2			Subject 3			Subject 4			Subject 5			Cut-off
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
Total-conventional	44	76	82	110	116	128	117	129	105	62	131	136	120	131	133	129
Total-behavioural	8	33	29	60	58	61	40	67	66	14	66	66	58	69	77	67
Total	52	109	111	170	174	189	157	196	171	76	197	202	178	200	210	196

The pattern of performance on the BIT differed for Subject 3. Although test scores improved at the second test session to 196, the cut-off point for normal performance, performance decreased to below normal at the final test sessions. Rather than a change in visual neglect *per se*, clinically it appeared that this subject was able to use compensatory strategies learned in treatment at the second test session. For example, he would begin scanning at the extreme left side of the page, slowly move his pen across the page, and then carefully search for and return to the left side of the page before scanning the next line. However, he was unable to maintain use of these strategies, and he achieved scores that were below normal performance at the final test session. Therefore, his neglect was characterized as persistent.

#### *Analysis of informational content*

Table 3 shows the total number of words and content units produced by each subject, as well as a breakdown of the number of each type of content unit. The table also shows the percentage of the total number of content units that are meaningful (essential units and elaborations). This percentage was calculated to control for differences in the quantity of output elicited. Finally, an efficiency or conciseness ratio (modified from Hier *et al.* 1985) was computed as follows: (essential units/total number of words)  $\times$  100. A larger ratio indicates greater communicative efficiency. Results are provided for each subject at each test session. In addition, the final column indicates the normative data obtained on the 25 control subjects. The mean and standard deviation for each variable are given.

Examination of scores at initial testing indicates that the discourse of Subjects 4 and 5 was comparable to that of normal subjects for all variables. In contrast, the discourse of Subjects 1 and 2 differed from that of the control group of subjects. Subjects 1 and 2 produced more total content units, characterized by more elaborations, irrelevancies, and redundancies. As a consequence a smaller percentage of the total number of content units was meaningful, and the conciseness index was smaller. These results are consistent with the suggestion that there may be subgroups of RHD subjects, that can be differentiated on the basis of their discourse.

Examination of scores over time indicates relative stability within each of the two groups of subjects. Subjects 1 and 2 continued to produce discourse that differed, while Subjects 4 and 5 continued to produce discourse that was comparable to that of the control group of subjects. The one exception was the discourse produced by Subject 4 at the second test session. At this time Subject 4 produced an accurate retelling of the story, but added a larger number of irrelevancies and therefore more words. However, normal discourse production was maintained at the final test sessions.

The discourse characteristics of Subject 3 require separate discussion. At each test session the number of essential units produced was comparable to that of the control subjects. However, Subject 3 produced more elaborations, and therefore more words than the control subjects. In addition, at the third test session his discourse was characterized also by irrelevancies. These differences in discourse performance are captured in the conciseness index. With this variable the discourse performance of Subject 3 may be considered comparable to that of Subjects 1 and 2.

Table 3. Subject scores on the narrative discourse task at each test session

Test session	Subject 1			Subject 2			Subject 3			Subject 4			Subject 5			Controls: mean (SD)
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
Total content units	24	24	17	20	17	25	26	23	21	18	27	17	18	18	17	16.4 (3.32)
No. essential	12	13	11	11	11	11	15	16	13	17	15	15	17	17	15	13.56 (2.10)
No. elaborative	4	4	2	2	1	2	9	6	4	0	0	1	0	1	2	1.08 (1.53)
No. irrelevant	5	1	1	3	3	6	0	0	3	1	11	0	0	0	0	0.68 (1.07)
No. redundant	2	6	2	3	2	4	0	0	1	0	1	1	1	1	0	0.68 (1.35)
No. off-topic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 (0.00)
No. incorrect	1	0	1	1	0	2	2	1	0	0	0	0	0	0	0	0.36 (0.81)
Total no. of words	111	123	109	94	91	140	137	110	118	74	163	65	81	70	71	78.48 (19.07)
Conciseness index	10.8	10.6	10.1	11.7	12.1	7.9	11.0	14.6	11.0	23.0	9.2	23.1	21.0	24.3	21.1	17.89 (3.63)
Percentage meaningful units	66.7	70.8	76.5	65	70.6	52	92.3	95.7	81	94.4	55.6	94.1	94.4	100	100	90.2% (10.08)



*Relationship between informational content and unilateral neglect*

Because of the small number of subjects, statistical analyses were not performed and conclusions were drawn from visual inspection of the data. There did not appear to be a relationship between initial severity of neglect and reductions in informational content. In addition, concomitant changes over time in both unilateral visual neglect and informational content did not occur, since the discourse measures of informational content were relatively stable over time for all subjects.

Rather, the persistence or transience of the unilateral visual neglect appeared to be related to the informational content measures derived from the story-retelling task. As discussed previously, two subgroups of subjects appeared to emerge. The same two groups of subjects were differentiated, regardless of whether identification was based on the unilateral neglect or the informational content. Those subjects with a transient unilateral neglect (Subjects 4 and 5) produced discourse with informational content comparable to that of the normal subjects, even at the initial test session when a unilateral neglect was present. Those subjects with a persistent unilateral neglect (Subjects 1, 2 and 3) produced discourse with informational content that differed from that of the normal control subjects. In particular the conciseness index was a variable that was sensitive to the differentiation of the two groups. Subjects with a persistent left unilateral neglect displayed a smaller conciseness index than those subjects in which the unilateral neglect was transient.

**Discussion**

This preliminary investigation followed five subjects with RHD longitudinally to document concomitant changes in unilateral neglect and in informational content of narrative discourse over time. The trends demonstrated by these subjects support the notion that there may be subgroups of RHD individuals differentiated not only by the presence of unilateral neglect, but by the persistence or transience of the neglect. Initial severity of neglect may not predict the amount of improvement anticipated over time, or whether the neglect will be transient or persistent. For example, Subject 4, who had a transient neglect, presented with more severe deficits at initial testing but greater improvement in neglect over time. In contrast, Subject 2 demonstrated less severe reductions in neglect at initial testing, smaller improvements over time, and subsequently a neglect that was characterized as persistent.

For those subjects with a persistent unilateral visual neglect, the reduced performance on the discourse task is consistent with the notion that neglect and deficits in verbal output may reflect an underlying attentional impairment and involvement of a common substrate in the right hemisphere. Results do not help delineate the precise nature of the attentional impairment. However, they suggest the possibility that unilateral neglect is not a unitary phenomenon; rather, different mechanisms may underlie the attention deficits, depending on whether the neglect is transient or persistent.

Although subgroups for RHD subjects were identified from the informational content of their story-telling, it is possible that these subgroups may be an artifact of the specific discourse measures taken or the discourse task used. For instance,

Subject 3 more closely matched the profile of Subjects 4 and 5 when the proportion of meaningful content units was used, but more closely matched the profile of Subjects 1 and 2 when the conciseness index was used. Further research with other types of discourse analyses (e.g. cohesion) and other discourse tasks is needed to corroborate the existence of these subgroups.

In addition, the performance of Subject 3 may not be consistent with the identification of only two subgroups of RHD subjects. In view of the great variability in the discourse of RHD subjects, the search for subgroups may be an artificial endeavour, with subgroups occurring only because of the need to impose order on this variability. Rather than a dichotomy, there may be several subgroups, or the discourse behaviours may be characterized on a continuum.

The effects of several other variables on differentiation of subgroups in this study also remain unanswered. For example, age rather than persistence of neglect may be the defining characteristic of the subgroups. Clearly, subjects 1 and 2 are much older than Subjects 4 and 5. Other factors such as lesion location and size should be considered also. Although there appears to be involvement of the parietal lobe in most of the subjects, more precise anatomical localization within the parietal area should be considered. In particular, lesions of the inferior parietal lobule have been implicated as crucial for unilateral neglect (Vallar and Perani 1986, 1987). Information was not available on the subjects in this study about where, precisely, in the parietal lobe, the damage occurred. The influence of treatment also has not been addressed. All subjects had been enrolled in speech and language treatment, but treatment had been terminated at least 2 months prior to the second test session. No data were available on the amount and frequency of treatment, and to what extent patients learned compensatory strategies for the neglect.

Replication of the study with larger numbers of individuals, using a variety of different discourse tasks and a variety of different analysis procedures, is warranted. A better understanding of possible subgroups of RHD patients, and the types of discourse deficits associated with each, has important implications for differential diagnosis within the RHD population. Such information might help in developing treatment techniques to better manage RHD communication problems. Therefore, we are continuing to examine a broad range of discourse skills in large numbers of RHD subjects with and without unilateral neglect.

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### Appendix A: Story Retelling Task (Bayles and Tomoeda 1991)

While a lady was shopping, her wallet fell out of her purse, but she did not see it fall. When she got to the check-out counter, she had no way to pay for her groceries. So she put the groceries away and went home. Just as she opened the door to her house, the phone rang and a little girl told her that she had found her wallet. The lady was very relieved.

### Appendix B: Story retelling task—essential information units (Bayles and Tomoeda 1991)

Lady  
 Was shopping  
 Her wallet  
 Wallet fell  
 Out of her purse  
 She did not see it fall  
 At the check-out counter  
 No way to pay  
 Put the groceries away  
 Went home/to her house  
 As she opened the door  
 Phone rang  
 little  
 Girl  
 Told her  
 She found wallet  
 Lady relieved

*Note:* Alternative acceptable words and phrases are provided on the Response Record Form of the Arizona Battery for Communication Disorders of Dementia (Bayles and Tomoeda 1991).

### Appendix C: Examples of informational content units

*Essential content units:* see Appendix B.

#### *Elaborations*

When she got to the check-out counter, *She opened her purse*, and found she did not have her wallet  
 She put the groceries back, *put them on the shelves presumably*  
 The phone rang *and she answered the phone*

#### *Irrelevancies*

I once lost my wallet, credit cards and all  
 She lost her wallet, *that was a stupid thing to do*

She was a very honest child  
She should have given her a reward  
I would have been relieved too  
I think I missed something about the groceries

*Redundancies*

When she got to the check-out counter, *at the check-out counter*  
She found out she lost her wallet, *she didn't have her wallet*

*Off-topic content units*

Digressions unrelated to the topic or task were not present in the discourse of either the RHD or the normal control subjects.