Group study of an "undercover" test for visuospatial neglect: invisible cancellation can reveal more neglect than standard cancellation

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SHORT REPORT

Group study of an ''undercover'' test for visuospatial neglect: invisible cancellation can reveal more neglect than standard cancellation

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Visual neglect is a relatively common deficit after brain damage, particularly strokes. Cancellation tests provide standard clinical measures of neglect severity and deficits in daily life. A recent single-case study introduced a new variation on standard cancellation. Instead of making a visible mark on each target found, the patient made invisible marks (recorded with carbon paper underneath, for later scoring). Such invisible cancellation was found to reveal more neglect than cancellation with visible marks. Here we test the generality of this. Twenty three successive cases with suspected neglect each performed cancellation with visible or invisible marks. Neglect of contralesional targets was more pronounced with invisible marks. Indeed, about half of the patients only showed neglect in this version. For cases showing more neglect with invisible marks, stronger neglect of contralesional targets correlated with more revisits to ipsilesional targets for making additional invisible marks upon them. These results indicate that cancellation with invisible marks can reveal more neglect than standard cancellation with visible marks, while still providing a practical bedside test. Our observations may be consistent with recent proposals that demands on spatial working memory (required to keep track of previously found items only when marked invisibly) can exacerbate spatial neglect.

Spatial neglect is a common and disabling deficit following unilateral brain damage, particularly strokes, in which patients fail to orient or respond towards contralesional stimuli, even if primary sensory or motor areas remain intact.[1] In the severe and long-lasting form, neglect has been particularly associated with right perisylvian lesions,[2] but it can also be seen acutely in some left-hemisphere cases.[3] Several pen-and-paper tasks are commonly used as clinical tests for neglect, including line bisection, drawing tasks, and cancellation. Recent studies report that cancellation measures relate to the clinical severity of neglect and to impairments in daily living.[4 5]

A recent single-case study[6] introduced a new version of cancellation, in which the patient's marks on cancelled targets could either be made visibly with a pen (as in standard testing) or invisibly (with the other (ink-less) end of the pen), with marks now recorded by carbon paper beneath the cancellation sheet; hence our reference to this as an ''undercover'' test. This visible/invisible manipulation was introduced to distinguish two contrasting predictions. On the one hand, visible marks made on targets towards the ipsilesional side of the paper might increase the tendency for patients' attention to lock onto salient stimuli on that side,[7] thus exacerbating neglect compared with invisible marks. On the other hand, visible marks should provide a permanent record of locations that the patient has already explored, whereas with invisible marks the patient must remember these. Given recent proposals that spatial working memory deficits might contribute to neglect in some patients,[6 8] neglect might then be more severe with invisible than with visible marks. The results from a single stroke case with right frontal and subcortical damage[6] accorded with the latter prediction.

Regardless of the exact explanation for more severe neglect on invisible than visible cancellation when this is found, the main aim of the present study was to test whether invisible cancellation would reveal more neglect than visible cancellation across a larger group of patients, or whether instead the single case previously reported[6] was unusual in showing this outcome.

METHOD

Patients

A total of 23 successive patients with suspected contralesional neglect were tested after giving informed consent in accordance with local ethics. They were included if they passed any of the following criteria, which are fairly typical for patient groups in whom neglect is investigated in practice: major perisylvian stroke; and/or the presence of neglect on a standard cancellation test; and/or the presence of unilateral inattention mentioned by ward clinicians in notes. Lesions were confirmed by CT or MRI; three cases had left-hemisphere damage, while the remaining 20 were right-hemisphere cases, with these laterality proportions being fairly typical of neglect populations.[1–3] Lesion sites were heterogeneous, but again typical of previous neglect findings.[1–3] Two patients were post-surgical rather than stroke cases, but exclusion of this pair does not change the pattern of results. Table 1 lists clinical details.

Stimulus sheets for experimental measure of cancellation

Each sheet comprised 32 targets (Os) and 32 distractors (16 Qs and 16 Cs) pseudorandomly arranged into eight columns, each with small random horizontal displacements to make the columnar structure less apparent. Each column contained four targets and four distractors. Importantly, identical sheets were used across visible and invisible cancellation tasks.

Procedure

Patients were instructed to cancel all Os, but importantly to cancel each O only once. A thick red marker pen was used for visible cancellation. Invisible cancellation was performed using the same pen, but with the cap now on (marks recorded in an ''undercover'' manner, via carbon paper under the sheet). Cancellation terminated for each sheet when a patient judged all Os had been cancelled. Each patient completed a minimum of one and a maximum of 10 sheets in each task (mean = 4 sheets, SD 2.4). A total of 87% of patients used at least four sheets. Different sheets were used for each successive pair of cancellation trials, but the same sheets were used across the two tasks overall (order of tasks being ABBA etc, or BAAB etc, for visible versus invisible).

RESULTS AND DISCUSSION

Across the whole group of patients, neglect was stronger for invisible than for visible cancellation. This applied when considering the total numbers of target Os that were missed by the patients ($F(1, 22) = 15.6$, $p<0.0007$). Importantly, it also applied when assessing spatially-specific neglect by considering the number of Os missed specifically in those columns that were further to the contralesional side (fig 1A). Thus the difference between visible and invisible cancellation, in terms of the additional targets missed for the latter, increased for columns that were further to the contralesional side (significant interaction between column (1 through 8), and cancellation task (visible versus invisible); $F(7, 154) = 2.45$, $p = 0.02$).

Of the 23 patients, 16 clearly showed a pattern of more neglect for cancellation with invisible marks. For these 16 patients, we examined whether neglect of contralesional targets was more severe in those cases who made more ''returns'' to ipsilesional targets in the invisible mark task (that is, making additional invisible marks on ipsilesional items that had already been found and invisibly marked). Such a positive correlation might be predicted from some recent accounts in terms of spatial working memory deficits,[6 8] on which ipsilesional returns should exacerbate contralesional neglect. Exactly such a correlation was observed ($r(14) = 0.74$, $p<0.005$).

In many patients, neglect only became apparent on the invisible version of the task. To illustrate this, fig 1B plots the results for just that half of the patient group (12 of the 23 patients) who showed the least neglect on the standard visible version of cancellation. These results indicate not only that invisible cancellation can produce somewhat stronger neglect, but also that it can reveal neglect in cases for whom this might otherwise be missed at the time of testing.

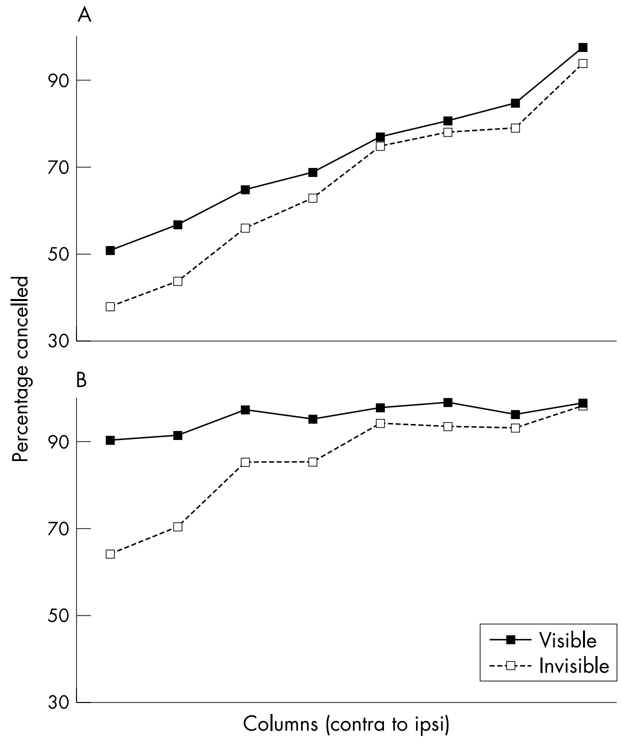

Figure 1 (A) Mean number of targets cancelled in each column on the test sheets (moving from column 1, at the extreme contralesional end, through to column 8, at the extreme ipsilesional end of the sheet) across the group of 23 patients. The solid line plots data for when visible marks were made; the dotted line plots data for when invisible marks were made instead (being recorded with carbon paper underneath the cancellation sheet). Note that fewer targets towards the contralesional side were cancelled when invisible marks were made. (B) This result is also found for that half of the patient group (12/23 cases) that showed little or no neglect when cancelling in the standard manner with visible marks. This demonstrates that cancellation with invisible marks can reveal neglect in patients for whom this might otherwise be missed.

Table 1 Clinical details and experimental results for each individual case

Patient	Mean visible	Mean invisible	Gender	Age	Vintage	Hemisphere	Lesion
1	0.95	0.66	M	78	3 months	R	PO and posterior F; Hr
2	0.67	0.48	F	–	2 weeks	R	SC(EC); Hr
3	0.97	0.81	M	56	6 weeks	R	P, SC; Inf
4	0.92	0.76	M	64	2 months	R	PF; Inf
5	0.89	0.73	M	59	10 months	R	SC (IC+BG)+inferior T; Hr
6	0.95	0.80	M	59	2 months	R	SC; Inf
7	0.95	0.81	F	40	>1 year	R	P (post-surgery for cyst)
8	0.77	0.66	M	62	>1 year	R	P (post-surgery for meningioma)
9	0.99	0.90	M	69	7 months	R	PF; Inf
10	1.00	0.94	M	76	3 weeks	R	P; Hr
11	0.14	0.07	M	71	3 months	R	PO; Inf
12	0.91	0.86	M	65	12 months	R	PO; Hr
13	0.43	0.39	M	67	4 months	R	SC (IC); Inf
14	0.61	0.59	F	46	2 weeks	R	SC; aneurysm (subarachnoid)
15	0.15	0.13	M	66	3 months	L	PFO; Inf
16	1.00	0.99	M	72	2 months	L	F; Inf
17	0.99	0.99	M	61	1 month	L	SC (thalamic lacunar); Inf
18	0.50	0.50	F	65	6 month	R	PF; Inf
19	0.14	0.14	M	78	3 weeks	R	PO; Hr
20	0.97	0.98	M	87	6 months	R	P; Hr
21	0.33	0.36	M	68	2 weeks	R	PFT; Hr
22	0.76	0.79	M	68	7 months	R	PT; Inf
23	0.78	0.81	M	78	7 months	R	PF; Inf

The following details are given: mean proportion of targets cancelled with visible or invisible marks; gender and age; approximate vintage (when known) of lesion, plus its laterality and site as revealed by CT or MRI.
BG, basal ganglia; EC, external capsule; F, frontal; IC, internal capsule; Inf, infarction; Hr, haemorrhage; O, occipital; P, parietal; SC, subcortical.
Cases are ordered here by experimental result, with case 1 showing the largest increase in neglect for invisible versus visible cancellation, case 2 next largest, and so on.

Table 1 orders the patients such that the increased neglect with invisible as compared with visible cancellation is largest for the patient at the top of table, with this effect reducing down the table. This ordering reveals no obvious relationship between lesion location (or vintage) and the increased neglect on invisible cancellation; but more detailed anatomical study of this issue might prove worthwhile in future research. No systematic practice effects were observed in our data, although this issue too (along with test–retest reliability) might be examined in further research with more extensive testing. For now, the present study shows that cancellation with invisible marks can reveal more visuospatial neglect than standard cancellation with visible marks, across a heterogeneous group of 23 patients. It also demonstrates that this new ''undercover'' test can uncover neglect that might otherwise be missed.

One theoretical interpretation of the greater neglect with invisible cancellation is that many patients may fail to remember which locations they have already visited when these are not visibly marked (perhaps due to associated deficits in spatial working memory, see Wojciulik *et al*[6] and Husain *et al*[8]). As a result the patient returns repeatedly during invisible cancellation to the ipsilesional items favoured by their spatial bias, to make additional marks there, consistent with the correlation we report. But whatever the theoretical interpretation, the present results show that invisible cancellation offers a practical bedside test that can reveal more neglect than standard cancellation.

While the present study should be considered a preliminary report of a potentially useful new assessment for neglect in stroke patients, it already shows that our new test can reveal neglect in patients for whom this might otherwise be missed. Future research should assess the validity, sensitivity, and reliability of our new test in more detail in larger patient groups, and in relation to measures of other deficits (perhaps including performance in spatial working memory tests[8]); to lesion anatomy; and to other components of the neglect syndrome.[1–3]

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