Tactile Extinction and Functional Status After Stroke
A Preliminary Investigation

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Background and Purpose  Research has identified a number of factors associated with poststroke recovery, but the prediction of long-term functional outcome remains an uncertain endeavor. In previous work, extinction to tactile, double-simultaneous stimulation has been shown to have short-term predictive utility. The present study was designed to examine its long-term prognostic value and to determine the relative importance of tactile extinction, cognitive functioning, and visual neglect as predictors of poststroke functional status.

Methods  Successive admissions to an acute-care facility (n = 26) were assessed three times: 1 month, 3.5 months, and 6 months after stroke. Hierarchical multiple regression, a procedure that maximizes the effect of the variables first entered, was used to predict functional status. Cognitive functioning and visual neglect were forced into the equation on the first step; tactile extinction was entered on the second step. Multivariate analysis of variance was used to compare the functional status of subjects with no extinction versus those who demonstrated extinction at the first assessment and later improved and those who continued to manifest the deficit.

Results  Tactile extinction on the left-hand side of the body was the most important predictor of functional outcome. A significant group-by-time interaction implied that the course of improvement in functional status differed between the groups.

Conclusions  Tactile extinction shows promise as a predictor of poststroke functional status, but further work is required to substantiate the present findings.

Key Words  • cerebrovascular disorders • rehabilitation • treatment outcome

The incidence of stroke has declined in recent years, but advances in medical care have resulted in an increasing number of survivors. Stroke is currently a leading cause of disability among the elderly, and estimates suggest that up to 75% of all survivors may be left with some degree of residual impairment. The sequelae of stroke can result in reduced mobility, self-care dependence, and disruptions in the areas of communication and social cognition. Rehabilitation services, therefore, direct their efforts toward the restoration of function in these and other domains.

The literature documents a number of physical and neuropsychological factors that are related to functional recovery after stroke. Among the former are site and extent of lesion and comorbid medical conditions such as diabetes, high blood pressure, or cardiovascular disease. Impaired balance, weakness, sensory loss, and loss of bowel/bladder control are also adverse prognostic signs. Neuropsychological deficits found to influence the reacquisition of self-care skills include perceptual difficulties, apraxia, aphasia, memory dysfunction, and unilateral spatial neglect.

Although research has identified many variables that are associated with recovery, prediction of poststroke functional status continues to be an uncertain endeavor. There remains the need for a predictor of function that is easily assessed with a standardized instrument, has long-term prognostic value, and is relevant to the skills required in everyday life. A recent study has suggested that extinction to tactile, double-simultaneous stimulation (DSS) may prove useful in this regard.

Extinction to DSS is said to occur when a patient able to detect a stimulus presented in isolation fails to report one of a pair of like stimuli presented simultaneously. It is a common observation in the early poststroke period and may be demonstrated in the visual and auditory modalities as well as in the tactile domain. Among stroke patients, extinction is typically manifested on the side of the body contralateral to the lesion; it occurs more rarely on the ipsilateral side. Extinction was originally conceptualized as a purely sensory deficit, but the role of attention in producing the phenomenon is increasingly recognized. In the normal brain, when stimuli are presented simultaneously, each hemisphere is responsible for processing information coming from the opposite side of the body. In a lesioned brain, the attentional capacity of the intact hemisphere may be sufficient to process incoming information from either the right or the left side but cannot fully compensate for the damaged area when information from both sides of the body is presented simultaneously. Because the right hemisphere is held to be chiefly responsible for the distribution of

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attention, right-brain lesions may more readily produce both contralateral and ipsilateral extinction.\textsuperscript{14}

Tactile extinction reflects a failure to bring into conscious awareness signals from one side of the body. As such, it may have a direct bearing on some aspects of functional status. Competent performance of self-care activities demands the efficient processing, organizing, and interpreting of incoming tactile stimuli as well as the ability to take appropriate action based on the information received. Functional status may thus be compromised if information from one side of the body is not fully processed.

Tactile extinction has previously been shown to be predictive of poststroke functional status. Campbell and his associates\textsuperscript{13} looked at the relation between performance on the Michigan Neuropsychological Battery (MNB) and self-care independence in a small sample of patients with unilateral left or right cerebrovascular lesions. The MNB consists of measures of various cognitive functions, for example, memory, verbal and nonverbal reasoning, as well as somatosensory and motor skills. Predictors and outcome were assessed at approximately the same point in time. Extinction to single stimulation and DSS on the left-hand side of the body emerged as a strong predictor irrespective of lesion location, leading the authors to conclude that the presence or absence of tactile extinction could predict functional status at that point in the patient’s recovery. No long-term data were collected, however, making it impossible to determine the relation of tactile extinction to eventual functional status.

The present study was designed to further investigate the association between extinction to tactile DSS and poststroke functional status. Specifically, it was intended to examine whether left- and/or right-sided tactile extinction, measured at 1 month and 3.5 months after stroke, predicted functional status 6 months after onset. Also of interest was the relative importance of tactile extinction to the prediction of functional status and the question of whether tactile extinction represents a specific deficit or is a marker for more global impairment. Cognitive status and visual neglect were therefore assessed because it has been suggested that these variables are related to eventual functional status\textsuperscript{10,11,13} and, moreover, that extinction may reflect cognitive impairment\textsuperscript{20,21} or is a more subtle manifestation of hemispheric neglect.\textsuperscript{14}

Subjects and Methods

Subjects

Twenty-six patients who had been living independently before the stroke were enlisted on the basis of consecutive admissions to an acute-care facility. All had suffered stroke less than 3 weeks before initial contact was made and had adequate basic touch sensation as indexed by their ability to perceive a tactile stimulus when none was presented to the other side. Patients were excluded from the study if they had a history of previous stroke, alcohol and/or substance abuse, dementia, or psychosis or if they were extremely frail or visually impaired. Permission to approach the patient was obtained from the attending physician before formal consent was sought. The 12 male and 14 female subjects were between 59 and 90 years of age (mean, 73.64). Clinical and neurological evidence indicated that 54% of the sample had suffered right-hemisphere strokes, 19% had left-hemisphere strokes, 19% had bilateral involvement, and 8% had brain stem infarcts. Sixty-nine percent of the subjects received inpatient rehabilitation training before discharge; of the remainder, 19% were discharged home from the acute-care unit, whereas 12% went to an extended-care placement. At the time of the 6-month follow-up, 54% were at home, 27% were in nursing homes, and 19% were rehabilitation inpatients.

Procedure

Patients were assessed at three time points: 1 month, 3.5 months, and 6 months after stroke onset. Functional status was rated with the Functional Independence Measure (FIM),\textsuperscript{22} an instrument that yields scores in six separate areas: self-care, sphincter control, mobility, locomotion, social cognition, and communication. Scores from each area were summed to produce a global estimate of function. Tactile integration was measured by the Face-Hand Test,\textsuperscript{23} a standardized instrument that is quickly and easily administered.\textsuperscript{24} Patients unable to report single stimulation are not tested. The examiner touches various combinations of a blindfolded subject’s left and right cheek and hand. The score is the number of stimulations correctly reported. Cognitive status was assessed by means of the Raven’s Coloured Progressive Matrices,\textsuperscript{24} a general measure of intellectual functioning that has previously been found to be related to stroke outcome,\textsuperscript{6} and by the delayed recall score on the Paired Visual Associates subtest of the Weschler Memory Scale (revised).\textsuperscript{25} A test of visual memory was selected in preference to verbal memory to facilitate the inclusion of patients with expressive aphasia and because the literature documents an association between visual memory and functional status.\textsuperscript{8} The Line Bisection Test\textsuperscript{23} was used as a measure of visuospatial neglect.

The functional status and neuropsychological assessments took place in separate sessions no more than 7 days apart. The FIM rating was made by an occupational therapist with 14 years’ experience who was blinded to the results of the neuropsychological testing. A graduate student blinded to the results of the functional status assessment administered the neuropsychological tests.

Data Analysis

Data were analyzed with SPSS (version 4.0). The dependent variable for all analyses was the FIM global score at 6 months after stroke. Hierarchical multiple regression was used to predict functional status. Scores on the Line Bisection Test, Raven’s Coloured Progressive Matrices, and the memory scale were forced into the equation before tactile integration was allowed to enter. The hierarchical approach to multiple regression allows determination of whether the final predictor or set of predictors entered into the regression equation can explain a significant proportion of the variance in the dependent variable over and above that which is attributable to earlier sets. It thus represents a conservative test of the effect of the variable(s) of interest in that the contribution of the variables first entered is maximized.\textsuperscript{26} Multivariate analysis of variance was used to compare subjects with no extinction versus those who demonstrated extinction at the first assessment and later improved and those who continued to manifest extinction in terms of their functional status.

Results

Descriptive Statistics

No subject with a brain stem infarct demonstrated tactile extinction. At 1 month after stroke, extinction was present in 50% of the sample. Of the subjects with extinction, 62% had suffered right-hemisphere strokes, 23% had left-hemisphere strokes, and 15% had bilateral involvement. Sixty-four percent of the subjects with extinction demonstrated this on the contralateral side only; in the remaining 46%, which included all of the left-hemisphere strokes, extinction occurred on the ip-
Functional Status Prediction

In the first analysis, the scores obtained at 1 month after stroke were used to predict performance on the FIM at the 6-month follow-up. Neglect and cognitive impairment together failed to account for a significant proportion of the variance in the dependent measure ($R^2$ (adj) = .12, NS). When tactile extinction was included in the predictive equation, the multiple regression coefficient was significant ($R = .71$, $P < .05$), and an additional 23% of the variance in FIM scores was explained ($R^2$ (adj) = .35). Moreover, extinction on the left-hand side of the body emerged as the only significant predictor of functional status ($\beta = 7.046, t = 2.656, P < .05$).

When the FIM scores were regressed on tactile extinction, cognitive functioning, and visual neglect assessed at 3.5 months after stroke, neglect and cognitive functioning together accounted for a significant proportion of the variance in the dependent measure ($R = .63$, $R^2$ (adj) = .40, $P < .005$). Tactile extinction explained an additional 20% of the variance in FIM scores ($R = .83$, $R^2$ (adj) = .60, $P < .0005$). Both left-sided tactile extinction ($\beta = 5.78$, $t = 3.449$, $P < .005$) and visual memory ($\beta = 2.871$, $t = 2.214$, $P < .05$) made significant individual contributions to the prediction of functional status at follow-up, with left-sided tactile extinction being the stronger predictor of the two.

Subjects were grouped according to whether extinction was absent (intact), was present at 1 month but absent at 3.5 months after stroke (improved), or present at both assessments (unimproved), and mean FIM scores for the groups at each time point were plotted (Figure). The intact group showed little change over time in terms of mean FIM scores; moreover, mean scores in this group were consistently higher than those of the improved or unimproved groups. Changes across time were apparent in the two extinction groups. Between 1 month and 3.5 months after stroke, the mean FIM scores of the improved and the unimproved groups increased. There was a further increase in the mean FIM score for the improved group at the 6-month follow-up, but the unimproved group made no comparable gain. Multivariate analysis of variance indicated a significant effect for groups [$F(2,22) = 12.99$, $P < .0001$] and time [$F(2,44) = 21.28$, $P < .0001$]. A significant groups-by-time interaction [$F(4,44) = 6.16$, $P < .001$] suggested that the course of improvement in functional status differed between the groups.

Discussion

These results, although preliminary and in need of cross-validation on a larger sample of stroke patients, are consistent with those of Campbell et al. They imply the involvement of right-hemisphere processes in the reacquisition of self-care skills and, moreover, suggest that left-sided tactile extinction warrants further investigation as a promising predictor of functional outcome in stroke patients. The present sample was heavily weighted with patients who had right-hemisphere lesions, therefore no firm conclusions regarding the applicability of these findings to patients with damage in other areas may be drawn. Because previous work with a small sample of patients has indicated that left-sided tactile extinction predicts functional status in subjects with lesions in the left hemisphere, there is a strong possibility that the association between extinction on the left side of the body and function will also hold for patients with left-brain damage. Additional research, however, is necessary to confirm this.

A further caveat in terms of the generalizability of the results is also in order. The sample was selected on the basis of fairly stringent exclusionary criteria; consequently, the subjects may not be typical stroke admissions. For example, it appears that older stroke patients often have a history of cognitive deficits resulting from conditions such as Alzheimer's or multi-infarct dementia, and the impact of stroke is frequently complicated by frailty due to previous ill health. Indeed, the heterogeneity of the stroke population is cited as a major limiting factor in the ability to predict functional outcomes. To establish the prognostic value of left-sided tactile extinction in the general population of stroke patients, any further work should be conducted on an unselected sample.

In the present study, left-sided tactile extinction was found to be more strongly associated with functional status than was either global cognitive impairment or visuospatial neglect. While the results cannot definitively rule out the possibility that tactile extinction is a nonspecific index of cognitive impairment or a marker for hemispheric neglect, the fact that it did emerge as a significant predictor of FIM scores in a fairly conservative test suggests that it may be tapping abilities that have a direct bearing on functional status. To better understand the phenomenon of tactile extinction and how it is associated with functional status, any future study should consider its predictive value with respect to each of the various domains of functioning covered by the FIM. In addition, the question...
of how tactile extinction relates to lesion size and location might profitably be addressed in future research, and a comparison of the neuroradiological characteristics and functional status of patients with extinction confined to the contralateral side versus those with both ipsilateral and contralateral extinction could also prove informative.

References
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doi: 10.1161/01.STR.25.10.1973

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