Effect of visual condition on writing own name task in patients with unilateral neglect

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Effect of visual condition on writing own name task in patients with unilateral neglect

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ABSTRACT

Information processing of is two-folded; perceptual-cognitive processing and motor performance processing. On the unilateral neglect patients that they have defect mainly in the perceptual-cognitive processing, the effect of visual information on motor performance was studied using the assessment method that can easily separate improvement type and non-improvement type based on the presence of visual information. Another purpose of this study was to verify that the indices of the assessment method correlate with the level of independence in ADL. The subjects were unilateral neglect patients (n=10) and the healthy control (n=10). The tasks given were spontaneous writing of their own names under two conditions, with eyes open and closed. Comparison was made in length of written names, spatial distribution of the written name in the paper and the length ratio under two conditions. The results are: length of written names was significantly shorter in the neglect patients than the control with wider margin from the left end of the paper. Most of the neglect patients showed extension in the length with the eyes closed. This extension group tended to have better ADL independence than the shortening group. The subtype classification seemed to be useful in selecting therapeutic intervention strategies of controlling feedback of visual and motor information.

KEY WORDS

Unilateral neglect, Visual condition, Writing own name task

I. Introduction

Unilateral spatial neglect (the inability to respond to the left side of the space) is the best single predictor of poor recovery from stroke, yet it is very difficult to rehabilitate[1-3]. Various strategies have been used to treat these problems but evidence of their benefits has been lacking[4,5]. It is also well recognized that the disorder is heterogeneous and has numerous subtypes and that different subtypes of neglect may respond differently to treatments. Moreover, there have been numerous reports that failed to document duration of treatment effects or to generalize them into daily activities[5]. Though diverse treatments may all be effective, the efficacy is not clearly demonstrated yet. It is, therefore, necessary to study assessment methods to evaluate well-characterized patients/-subtypes and their index to reflect the levels of independence in activities of daily living (ADL).

There are many reported methods to test unilateral spatial neglect. But most of the methods that seem effective for subtype classification have been developed through researches on hypothetical mechanisms or treatment/intervention studies. There is little verification made in the relationship between single index of the test methods and the level of independence in ADL. The authors reported on "perceptual type and performance type", paying attention to skewed attention in the theory of attention disorder in terms of discrepancy between visuoperceptual cognition and motor performance in order to develop assessment

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Table 1. Clinical details and test performances of patients with unilateral neglect

Patients	Lesion location	Post stroke (days)	Barthel Index	Line bisection*	cancellation**	%line Type***
1	R thalamus	57	25	10.5	5/40	I
2	R front, parietal, temporo-occipital	242	60	-8.7	0/40	II
3	R thalamus	287	20	-16.6	0/40	II
4	R front, parietal, temporo-occipital	144	20	53.7	0/40	II
5	R temporal, occipital, thalamus	302	40	51.9	0/40	II
6	R thalamus	62	65	94.9	2/40	III
7	R corona radiata	79	80	-3.4	0/40	III
8	R front, parietal, temporo-occipital	128	60	-2.2	35/40	III
9	R basal ganglia	133	35	-4.8	0/40	III
10	R temporal	187	80	28.9	0/40	III

* : Deviations from the true midpoint were expressed in percentages, as in method of Schenkenberg (Schenkenberg et al.[19]), 0% denoting the true midpoint, +100% the right end of the line and −100% the left end of the line.

** : The number of non-marked targets / the total number of targets

*** %line type: 3-type of % line length

method to detect subtypes clinically[6]. However, we used mental rotation task that produced many problems in that investigation and could not test acute patients with consciousness disorders and patients with severe extended lesions. It was also difficult to quantify classification criteria. It was unable to confirm correlation between the subtypes and the level of ADL independence. In this study, we introduced simple task that most of the stroke patients in Japan had mastered before stroke, writing their own names, to testing. The test was performed under two conditions, with eyes open and closed. The results were compared to identify effective indices for classification and to verify their relationship with the level of ADL independence.

II. Method

1. Subjects

The subjects (hereinafter called neglect group) were 10 CVA patients with damage in their right hemisphere (6 males and 4 females ; mean age : 63, SD.: 9.3) that had suffered from unilateral neglect for at least 1 month. They were assessed and trained between March and September 2000 in Kanagawa, Japan. The control group was ten healthy participants (5 males and 5 females; mean age: 48, S.D. : 7.8) with no appreciable medical, neurological or psychiatric history.

Table 1 shows details of the clinical characteristics of the neglect group. Barthel Index (BI)[7], which is the index for ADL independence, was studied using the medical record at the time of assessment.

2. Experiment and Procedure

The name writing task was performed under two conditions with eyes open and closed. Writing one's own name, unlike copying words and sentences, requires no samples and can be tested either with eyes open or closed. When the eyes are open, both motor performance and visual cognition are involved, whereas motor performance is the major mechanism of processing when the eyes are closed. The difference in task performance under two conditions reflects influence of visual cognition. The result when the eyes are open is the product of motor performance processing affected by visual information and

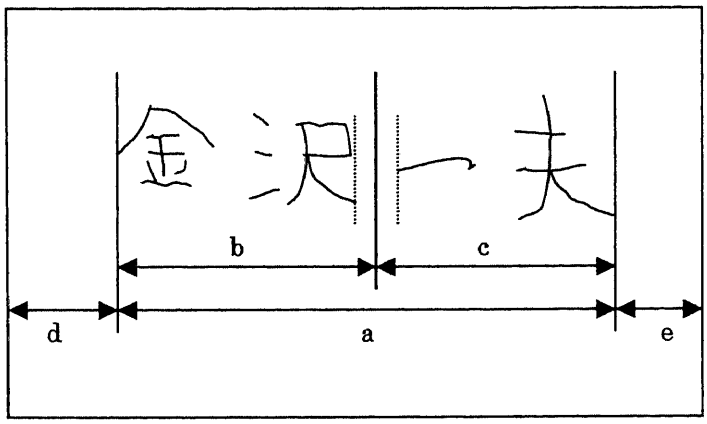

Fig 1. Model of line length measurement

that when the eyes are closed is the product of only motor performance processing without any effects of visual information.

The assessment was performed in a quiet room and the subjects were asked to sit on a chair. An A4 sized paper (19.9cm x 29.7cm) was placed on the desk at the midline of the subject's body. The subjects held a felt pen in their dominant hand and wrote their own name both with eyes open and closed. Only one assessment was performed in one condition. The verbal instructions given and the experimental settings are as shown below.

With eyes open: The verbal instruction, "Write your own name horizontally and legibly in the center of this paper" was given and the subjects wrote their full name in Japanese.

With eyes closed : After the above task, the patients were asked to close their eyes (using an eye mask) and the starting point of writing was set by the examiner by moving the paper 3cm up parallel (so that the produced letters height will be the space between the matched name lines of open and closed eye conditions) and by guiding the hand of the subjects to the same position as before. Verbal instruction, "Write your own name horizontally as big as before" was given then. When the subjects started writing their names off the guided position, no correction was made before completing the task.

The line bisection task, Albert's line cancellation task, and reading task were added to the neglect group so that we could confirm unilateral neglect.

3. Data processing and statistical methods

The names written on both conditions without going out of the paper were subjected for analysis. Data was processed as shown in Figure 1. A line vertical to the bottom of the paper was drawn on the left of the first letter and on the right of the last letter (hereinafter called the start line and the end line, respectively). The distance of the two lines was measured for total name line length. The third line was drawn vertical to the bottom of the paper in the middle of the end of the family name and the beginning of the first name (hereinafter called last name-first name division line) and the distance between the start line and the third line was measured for family name line length and the distance between the third line and the end line was measured for first name line length. The distance between the start lines to the left end of the paper was considered to be left space distance and that between the end line to the right end of the paper to be right space distance. The ratios of line lengths of the two conditions was calculated by dividing the lengths with eyes closed by those with eyes open to obtain %total name line length, %family name line length and %first name line length. The ratios for the left space distance and the right space distance were obtained similarly for %left space distance and %right space distance.

In statistical analyses, Pearson's correlation coefficients and Spearman's correlation coefficients were used to evaluate whether each line length was correlated with % line length and to examine the

Table 2. Mean values of Line length and % Line length in patients and control groups

	Unilateral neglect	Control	P value
Line length (cm)			
Open-eye condition			
Total name	7.3(SD=1.8463)	15.4(SD=3.1851)	0.001**
Family name	4.0(SD=0.8837)	8.2(SD=1.3937)	0.001**
First name	3.3(SD=1.2255)	7.2(SD=2.6465)	0.001**
Left space distance	12.1(SD=4.5955)	5.8(SD=2.0371)	0.002**
Right space distance	10.2(SD=4.5085)	8.4(SD=3.6990)	0.280
Closed-eye condition			
Total name	6.8(SD=1.9620)	13.2 (SD=3.9823)	0.001**
Family name	4.0(SD=1.4916)	7.1 (SD=1.9057)	0.003**
First name	2.9(SD=0.7466)	6.1 (SD=2.5828)	0.001**
Left space distance	12.2(SD=5.0506)	6.0 (SD=2.3230)	0.004**
Right space distance	10.5(SD=4.5588)	10.4 (SD=4.5155)	0.971
% Line length (%)			
Total name	98.9(SD=35.4054)	84.4(SD=11.7007)	0.821
Family name	101.4(SD=36.1083)	85.2(SD=12.4820)	0.762
First name	100.0(SD=39.0204)	84.0(SD=12.5040)	0.364
Left space distance	101.0(SD=19.3071)	103.7(SD=10.6126)	0.821
Right space distance	136.2(SD=121.862)	128.2 (SD=39.891)	0.450

**p<0.01(The Mann-Whitney U test was used for group comparisons.)

relationship between indicators of line length and BI. Differences in responses between the groups were compared using the Mann-Whitney test. The computer analyses were conducted with SPSS for Windows version SPSS 11. 0. J.

Ⅲ. Results

1. Results and correlation between the neglect group and the control group

The number of letters (Kanji/Hiragana) was average 3.9 (SD=0.738) for the neglect group (n=10), whereas 4.0 (SD=0.667) for the control group (n=10). There was no significant difference between the groups in terms of the number of letters in their names.

The result is tabulated in Table 2. And the correlation coefficients are shown in Tables 3-1 and 3-2. The high correlation between the two conditions was observed in all parameters, total name line length, family name line length, left space distance and right space distance, for the control group. For the neglect group, no correlation was observed in terms of the three separate line lengths. Correlations were found between left and right space distances. The control group also presented correlation between the right and the left space distances irrespective of the visual conditions.

BI was correlated with % family name line length (Spearman, r=0.648, n=10, p<0.05) but showed only a trend for % total name length (Spearman r=0.575, n=10, p=0.082) in the neglect group. The right deviation rate in line bisection task and the number of non-marked line Albert's line cancellation task were not showed correlation with BI (Spearman, r=0.153 and r=-0.079).

2. Comparison of line lengths and % line lengths under two conditions (Table 2)

Comparison of total name line length, family name line length and first name line length of the neglect group and the control group in two conditions showed greater lengths in the control group than in the neglect group in all parameters (U test, p<0.01). The left space distance was larger in the control group (U

Table 3-1. The relation between continuous variables of Neglect G.

	onset(day)	age	BI	line bisection	O-total line	C-total line	% total line	O-family line	C-family line	% family line	O-proper line	C-proper line	% proper line	O-paper left	C-paper left	% paper left	O-paper right	C-paper right	% paper right
onset(day)	1	-0.198	-0.197	-0.201	*0.688	-0.130	-0.482	0.619	-0.282	-0.573	0.586	0.219	-0.365	-0.278	-0.139	0.158	0.003	0.21	-0.263
age		1	0.585	*0.713	-0.085	-0.285	-0.220	-0.106	-0.328	-0.289	-0.078	-0.081	0.046	0.223	0.414	0.481	-0.192	-0.337	0.124
BI			1	0.001	-0.195	0.554	*0.645	-0.141	0.519	*0.649	-0.157	0.427	0.427	-0.023	-0.175	-0.341	0.104	-0.045	-0.344
line bisection				1	-0.199	0.221	0.258	-0.013	0.218	0.195	-0.244	0.160	0.288	0.272	0.472	0.471	-0.196	-0.618	-0.215
O-total line					1	0.017	-0.592	**0.824	-0.089	-0.533	**0.931	0.223	*-0.894	-0.248	-0.209	0.037	-0.157	0.224	0.119
C-total line						1	**0.785	0.236	**0.946	**0.801	-0.125	*0.745	0.518	-0.517	-0.433	0.086	0.520	0.049	-0.576
% total line							1	-0.337	**0.782	**0.964	*-0.648	0.508	**0.863	-0.268	-0.244	-0.003	0.515	-0.068	-0.558
O-family line								1	0.215	-0.338	0.574	0.188	-0.45	-0.371	-0.168	0.299	0.041	0.085	-0.293
C-family line									1	**0.838	-0.246	0.489	0.439	-0.367	-0.291	0.103	0.41	-0.085	-0.492
% family line										1	-0.549	0.434	*0.716	-0.198	-0.248	-0.114	0.419	-0.07	-0.375
O-proper line											1	0.164	**-0.765	-0.034	-0.128	-0.165	-0.348	0.198	0.397
C-proper line												1	0.492	-0.630	-0.562	0.012	0.55	0.303	-0.536
% proper line													1	-0.336	-0.214	0.161	0.627	0.014	*-0.661
O-paper left														1	**0.880	-0.010	**-0.918	*-0.753	0.623
C-paper left															1	0.458	**-0.812	**-0.922	0.346
% paper left																1	-0.005	-0.544	-0.345
O-paper right																	1	*0.676	*-.684
C-paper right																		1	-0.136
% paper right																			1

Table 3-2. The relation between continuous variables of Control G.

	age	O-total line	C-total line	% total line	O-family line	C-family line	% family line	O-proper line	C-proper line	% proper line	O-paper left	C-paper left	% paper left	O-paper right	C-paper right	% paper right
age	1	0.066	0.122	0.158	-0.363	-0.15	0.109	0.27	0.298	0.186	0.238	0.114	-0.501	-0.188	-0.166	0.04
O-total line		1	**0.925	0.602	0.573	*0.688	*0.671	**0.902	**0.919	0.455	-0.047	-0.199	-0.506	**-0.835	*-0.713	0.311
C-total line			1	**0.850	0.629	**0.845	**0.877	**0.782	**0.919	*0.709	0.062	-0.047	-0.379	**-0.831	**-0.858	-0.043
% total line				1	0.618	**0.877	**0.946	0.398	*0.664	**0.920	0.309	0.281	-0.115	*-0.688	**-0.894	-0.466
O-family line					1	**0.884	0.590	0.162	0.317	0.597	-0.062	-0.115	-0.185	-0.459	-0.495	-0.116
C-family line						1	**0.894	0.363	0.564	*0.748	0.117	0.052	-0.224	*-0.657	**-0.772	-0.277
% family line							1	0.497	*0.692	*0.744	0.340	0.276	-0.211	**-0.765	**-0.915	-0.326
O-proper line								1	**0.938	0.233	-0.024	-0.179	-0.512	*-0.763	-0.598	0.435
C-proper line									1	0.542	0.009	-0.111	-0.419	**-0.796	*-0.753	0.138
% proper line										1	0.214	0.223	-0.014	-0.509	*-0.740	-0.538
O-paper left											1	*0.953	-0.068	-0.510	-0.545	0.031
C-paper left												1	0.234	-0.353	-0.473	-0.165
% paper left													1	0.473	0.214	-0.582
O-paper right														1	**0.914	-0.285
C-paper right															1	0.123
% paper right																1

*p<0.05, **p<0.01 (Pearson's correlation conficient)

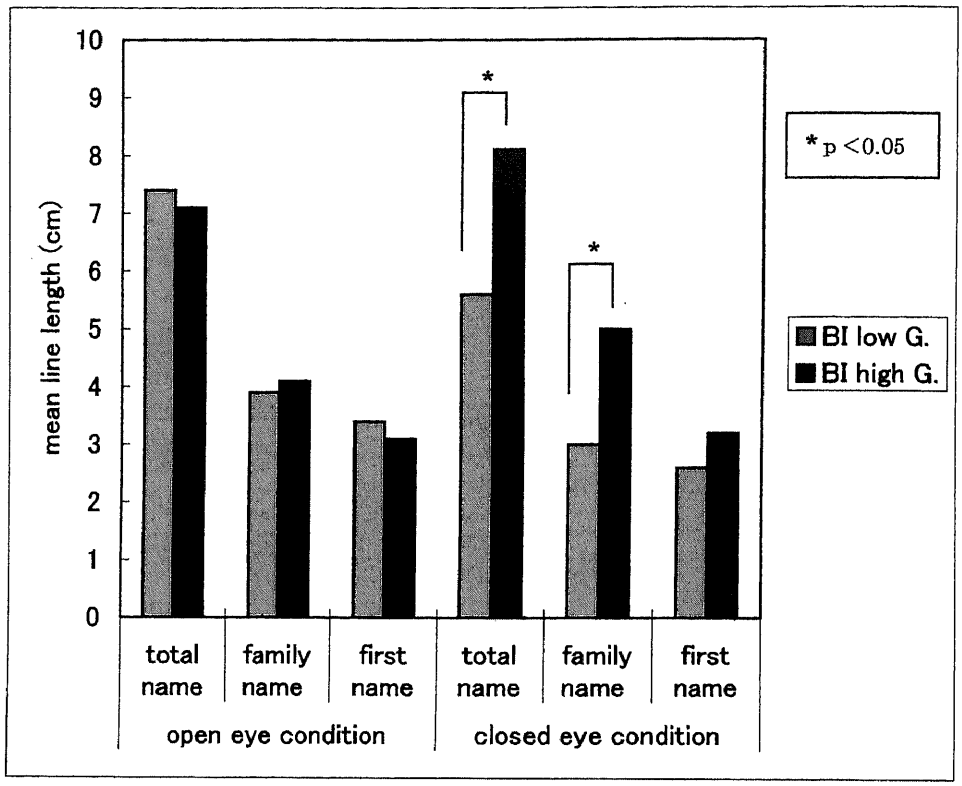

Fig 2. Comparison of mean line lengths between two BI groups in open and closed eye conditions

test, $p<0.01$). Bur there was no statistical difference in right space distance under any conditions.

The line length ratios of the two conditions (% total name line length, % family name line length and % first name line length) showed no significant difference between the groups.

3. Subtype classification and frequency observed with line length change under two conditions

To evaluate shortening/extension tendency of the total name line length under the two conditions, frequency analysis of %total name lengths below and above 100% was made for the neglect and the control groups. In the control group, nine belonged to shortening type, whereas the neglect group had 5 with shortening and 5 with extension. The neglect group showed the tendency for extension than the control group (Fisher's exact test, $p=0.007$).

Left hemiplegia group was further subcategorized with the average % total name length of the control group (84% ± 2SD). Type I is the abnormal shortening group (% length is shortened beyond 2SD of the control ; below 58.7%), Type II is the normal shortening/extension group (% length is within 2SD of the control group; 58.7~109.9%) and TypeIII is the abnormal extension group (% length is extended beyond 2SD of the control group ; 110% or higher). The numbers of the subtypes are 1 for Type 1, 4 for TypeII and 5 for TypeIII. All 10 control subjects belong to TypeII. Frequency analysis of the neglect group and the control group showed that there was one abnormal shortening in the neglect group and many were in the abnormal extension type (Fisher's exact test, $p<0.011$). The % line type was shown in Table 1.

4. Relationship between line length and level of ADL among the neglect group

Type I and II of the line length ratio of the neglect group was then regrouped as no abnormal extension group and TypeIII was regrouped as abnormal extension group. BI of the two groups were compared to show the tendency that the level of ADL was higher in the abnormal extension group than the other (U test, $p=0.076$).

Then 10 neglect patients were classified by

good/poor ADL (48 and higher/ 47 and lower in Barthel Index) and their total name line length, family name line length and first name line length under the two conditions were compared (Fig. 2). There was no significant difference in any of the measures under eye opening condition. However under eye closed condition, the total name line length and the family name line length of the good ADL group were longer than those of the poor ADL group ($p<0.05$). And there was the tendency that % total name line length and % family name line length were longer for the good ADL group ($p=0.076$).

Ⅳ. Discussion

All the subjects in the control group were assessable under two conditions. Some of the neglect group subjects, on the other hand, could not write with their eyes closed while they could write their names in Kanji or Kanji and Kana with their eyes opened. Inability to write with eyes closed may be the characteristic errors of the unilateral neglect patients in the language tasks where processing occurs in the dominant hemisphere as in the case of writing and reading. However, we observed such errors only in some of the patients and thus we did not study the phenomenon in detail. The task of writing their own names is the language task and some researchers already reported neglect dyslexia using tasks of word and systematic word arrangement[8-10]. In Japan there is a study on error analysis for neglect dyslexia[11]. They reported that severity of unilateral neglect and severity of neglect dyslexia in Japan are related since we have unique language system different from Indo-European language. In this study, we selected those subjects who could write without errors under both conditions. The products of name writing under both conditions were considered to reflect symptoms of unilateral neglect and the difference in space arrangement (left space distance) and product in space (name length) were analyzed.

In the control group, each name line length and space distance under the eyes opening condition was correlated with the matched line length and space distance under the eyes closed condition. Resulting in shortening of the names at certain ratio, disruption of visual information in writing names did not affect spatial arrangement of the names. Their total name line length and the left space distance did not show any correlation when eyes were open, with inverse correlation between the total length and the right space distance. There was no correlation observed between the left and the right space distances. In other words, though the starting points were varied, those with longer total name line length had shorter right space distance and those with shorter length had longer right space distance. When visual and kinaesthetic feedback in writing was blocked, the normal control made writing errors as frequent as the unilateral neglect patients. That is why monitoring visual and kinaesthetic feedbacks is said to be involved in writing performance[12]. When we think of name writing strategy of the healthy control, image of the size of the letters is determined by the size of the paper and the image of spatial balance of their names. Once they start writing their names on paper, the size of the first letter serves as the criteria for balance. The right space distance is grossly controlled by the first name length rather than the family name length. There is no strict adjustment made to make the right space distance same as the left space distance. Visual information, therefore, affects determination of the size of letters and where to start writing names. But performance of writing letters is under the control of mastered motion image or monitoring of kinaesthetic feedback in the memory. Visual feedback is considered to be involved in fine tuning the spatial arrangement of the letters and the distance between the letters under motor processing.

The line length of the unilateral neglect patients when eyes were open was significantly shorter than the control subjects in terms of total name line length, family name line length and first name line length with longer left space distance. The cause of longer left space distance or right deviation of the start point of the neglect group is expected to be either non-recognition of the left end of the paper during visual information processing or directional hypoactivity in the motor processing. In either case, writing start point would deviate rightwards, leaving smaller space for writing names and making shorter name line length. It is difficult to single out the effects of different processing when eyes are open. Two

effects may be overlapped in causing the phenomenon.

On the other hand, there should be only motor processing affecting writing when the eyes are closed. All the name line lengths of the neglect group were significantly shorter when the eyes were closed. There was no correlation between the line lengths under two conditions but good correlation was observed between the left and the right space distances. It is, therefore, considered that writing with eyes closed is performed based on the motor memory of writing position and of the letter sizes when the eyes are open. The line length dependent on the visual information was thought to be different from that dependent on the motor information. The cause of line length discrepancy is considered based on the strategy used by the healthy control. Since the starting point of writing names when eyes were closed were made identical to that when eyes were open by guiding the subjects' hands to the position, visual information error in estimating paper size and the directional hypoactivity was considered to be similar to those when the eyes were open. These two factors, therefore, cannot be the cause of line length difference under the two conditions. Assuming visual information is involved in fine tuning the spatial arrangement of letters and space between letters even for the unilateral neglect group, the line length difference under the two conditions may be attributable either to negative feedback of the visual information or to the positive feedback of the visual information.

Taking severity of impairment of visual and motor processing into consideration, the extension type has blockade of abnormal visual information and write their names using relatively normal motor processing, leading to longer line length closer to tat of the normal control. The extension type has normal motor processing relative to the visual processing, whereas the shortening type has normal visual processing relative to the motor processing.

These feedback effects were studied against the total name length of the normal control. There are three types of the neglect group identified; the abnormal shortening group, the group within the normal range and the abnormal extension group. The sample number was not big enough in this study to directly compare levels of ADL among the three subtypes. Therefore the authors classified the error types into two; the type whose total name length does not extend when their eyes were closed and the type whose total name length extends. The latter was found to have higher level of ADL than the former. There is a report that monitoring visual and kinaesthetic feedback is a quasi-attentional function of the normal right parietal lobe which is not directly related to unilateral neglect, but which is likely to co-occur with aspects of unilateral neglect as a result of the anatomical proximity of the regions that mediate these functions[10]. Though it is not definitive that the feedback effect is directly related to the major symptoms of unilateral neglect, it is estimated that the extension and shortening of the line length ratio is related to the extreme shortening of the line length of the neglect group when their eyes are open. The conventional single assessment method (line bisection and line cancellation tasks) does not show any correlation, whereas the new and simple assessment method of line length ratio we introduced showed correlation with the level of ADL independence and provided qualitative indices for type classification. The method, therefore, seems to be effective in verifying the effectiveness of intervention in the future.

The subjects we tested this time were chronic neglect patients, 70% of them were more than 6 months after the onset of the disease. However, their disease durations were varied and we could not confirm whether the subtypes we saw were influenced by the duration of rehabilitation they received. It is not known whether the error types they presented at the time of assessment reflect those at onset. We would like to continue this research so that we can observe chronological changes in typing and the effects of intervention.

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半側空間無視患者における氏名書字課題成績に開閉眼条件の及ぼす影響

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要　旨

課題遂行について脳内処理過程は大きく２分すると知覚処理過程 perceptual-cognitive processing と運動遂行過程 motor performance processing に分けられるが，半側空間無視患者で障害が主に知覚認知過程にある場合の視覚情報が運動遂行に与える影響を，視覚情報の有無による改善タイプと非改善タイプのタイプ分類が簡便にできる検査法を用いて検討した．またその検査の指標が ADL 自立度を反映するものであるかを検証することを本研究の目的とした．方法は半側空間無視群（ｎ＝10）と健常コントロール群（ｎ＝10）を対象とし，開眼条件と閉眼条件の２条件で自己氏名を自発書字させる課題を実施し，両条件での氏名線分長，氏名の用紙空間配置距離および対応する長さの比率の群間比較を行った。結果は，いずれの条件でも健常群に比較し半側無視群の線分長は有意に短く，用紙左端からの距離は長かった。また２条件で対応する線分長比率でタイプ分類した結果，半側無視群では閉眼によって線分長が長くなる拡大タイプが多くを占め，この拡大タイプと反対の縮小タイプの ADL 自立度を比較したところ，拡大タイプの方が ADL 自立度は良好の傾向があった。視覚情報および運動情報の feedback を統制した治療的介入の方略を選択する手がかりとしてこのタイプ分類は有用と考えられた。