INTRODUCTION

Humans obtain a particularly large amount of information for adapting to their environment visually as opposed to other types of sensory input. Specific information is selected from a wide variety of visual stimuli, and then processed to guide behavior. Affection and emotion are critical elements of human relationships: generally, negative emotions impair quality of life, while positive emotions make life pleasurable. Affective stimuli have been shown to influence event-related potentials such as P300 components [1,2] and potentials related to eye movements [3-5]. The relationship between mother and baby, in particular, is of fundamental importance in the development of cognitive function and emotion [6].

Schwartz et al. [7] compared responses of healthy adults between emotional and non-motional figure photographs of a mother and baby (crying or smiling faces) and other stimuli (neutral mother or baby faces) on visual cognitive function in schizophrenic patients. We recorded exploratory eye movements in 22 healthy controls and 22 age-matched schizophrenic patients. Total number of right and left field gaze points (right TNGP, left TNGP) in the visual fields were determined using an eye-mark recorder as subjects viewed affectively charged or neutral photographs (crying, smiling or neutral faces). Left TNGP for all mother photographs (crying, smiling or neutral) were significantly larger in controls than patients, and right TNGP for neutral mother photographs were significantly larger in controls than in patients. Right TNGP for photographs of smiling babies were significantly larger in controls than patients, and left TNGP for photographs of both smiling and crying babies were significantly larger in controls than patients. Within the patient group, right TNGP were significantly larger than left TNGP for all mother photographs (crying, smiling or neutral). Left TNGP for photographs of mothers and babies correlated negatively with negative symptom scores. These results suggest that exploratory eye movements when viewing emotionally laded twin stimuli such as photographs of a mother and baby are a useful marker of visual cognitive function in both healthy controls and schizophrenic patients.

Key words exploratory eye movements, healthy control, schizophrenia, affective photograph, laterality, visual recognition

Effects of Emotionally Affect Adult and Baby’ Photographs in Healthy Controls and Schizophrenic Patients Evaluating by Exploratory Eye Movements

CHIZUKO KAWABE*, KIICHIRO MORITA*,**, YOSHIHISA SHOJI**, RYO FUJIKI*,**, ATSUSHI YAMAMOTO*, YASUE ASAUMI* AND NAOHISA UCHIMURA**

*Cognitive and Molecular Research Institute of Brain diseases, Kurume University,
**Department of Neuropsychiatry, Kurume University School of Medicine, Kurume 830-0011, Japan

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Summary: The relationship between mother and baby is of fundamental importance in the development of cognitive function and emotion. In this study we investigated the effects of affective photographs of a mother and baby (crying or smiling faces) and other stimuli (neutral mother or baby faces) on visual cognitive function in schizophrenic patients. We recorded exploratory eye movements in 22 healthy controls and 22 age-matched schizophrenic patients. Total number of right and left field gaze points (right TNGP, left TNGP) in the visual fields were determined using an eye-mark recorder as subjects viewed affectively charged or neutral photographs (crying, smiling or neutral faces). Left TNGP for all mother photographs (crying, smiling or neutral) were significantly larger in controls than patients, and right TNGP for neutral mother photographs were significantly larger in controls than in patients. Right TNGP for photographs of smiling babies were significantly larger in controls than patients, and left TNGP for photographs of both smiling and crying babies were significantly larger in controls than patients. Within the patient group, right TNGP were significantly larger than left TNGP for all mother photographs (crying, smiling or neutral). Left TNGP for photographs of mothers and babies correlated negatively with negative symptom scores. These results suggest that exploratory eye movements when viewing emotionally laded twin stimuli such as photographs of a mother and baby are a useful marker of visual cognitive function in both healthy controls and schizophrenic patients.

Key words exploratory eye movements, healthy control, schizophrenia, affective photograph, laterality, visual recognition

Original Contribution

Corresponding author: Kichiro Morita, MD, Cognitive and Molecular Research Institute of Brain diseases, Kurume University, 67 Asahi-machi, Kurume 830-0011, Japan. Tel: 0942-31-7581 Fax: 0942-31-7911 E-mail: kichiro@med.kurume-u.ac.jp

Abbreviations: ANOVA, analysis of variance; EMR, eye-mark recorder; PANSS, Positive and Negative Symptom Scale; RSS, responsive search score; TNGP, total number of gaze points.
recognition tasks, noting that the eyes more often moved to the left during the emotional tasks. Turning the eyes to the left suggests activity of mechanisms tending supply visual information to the right cerebral hemisphere, indicating a relationship between the right brain and emotion [7,8]. Furthermore, in terms of brain function, one study of emotional perception used eye movements across a screen to demonstrate that the right hemisphere plays a dominant role in retention and recall of emotionally related facial expressions, with a higher frequency of eye movements to the left during such tasks [9]. Since leftward shift of gaze fixation suggests direction visual information to the right cerebral hemisphere, that hemisphere appears to be concerned with emotional visual processing. Indeed, responsive search score (RSS) measured by exploratory eye movements was related to the right brain function [9].

It has been observed that schizophrenic patients have deficient positive emotion perception. However, little direct evidence regarding the effects of affection on eye movements has been reported [3,4]. Thus, the effect of positive emotion on cognitive function linked to exploratory eye movements is an important new area of study. Loughland et al. [5] suggested that this deficit might reflect a failure to integrate visual information. Nishiura et al. [10] also reported that viewing images with positive affective content, such as smiling photographs, reduced exploratory eye movements in schizophrenic patients. Moreover, this impairment particularly involves scanning of the left field of the screen. The authors suggested that eye movements increase in distance and frequency as a result of an increased allocation of mental resources for maintenance of attention. We previously suggested that exploratory eye movements in schizophrenic patients have a more limited scanning range than in healthy controls [11], with longer maintenance of gaze when viewing simple figures such as a circle, similar to the findings of Kojima et al. [12]. Schizophrenic patients may gaze aimlessly at an inappropriate part of a picture rather than focusing attention on a more appropriate part. This finding suggests the possibility of impaired visual information processing in schizophrenic patients, especially concerning positive emotion presented to the left visual field of sight [10].

In the present study, we investigated the effects of emotionally laden photographs, such as a mother and child smiling or crying, and other photographs unrelated to emotion, upon exploratory eye movements, comparing healthy subjects and schizophrenic patients using an eye-mark recorder (EMR). A second aim was to determine whether any particular eye movement response was related to the ability to form human relationships.

METHODS

Subjects

Healthy paid volunteers (n=22; mean ±SD, 26.9±5.7), as well as age-matched schizophrenic patients (n=22; mean±SD, 27.9±5.7) were enrolled. Schizophrenia was of the paranoid type in 16 patients, and non paranoid in 6 patients. All healthy controls and patients were right handed and had normal visual and auditory ability. Controls had no history of psychiatric or neurological disease or of drug addiction. All subjects gave written informed consent for study participation. The Ethics Committee of Kurume University approved the present study.

Eye movement recording

Eye movements were recorded using an eye-mark recorder (Mac, EMR-8, Tokyo, Japan). Infrared light sources (850 nm) were positioned in front of each lower eyelid. The camera on the top of the cap recorded the pictures shown on the screen. After a camera controller superimposed these recordings with a 0.01 sec electronic timer, the combined recording was stored on a compact disc. Movement of more than 1° with duration greater than 0.1 sec was scored as an eye movement. In the present study, exploratory eye movements were analyzed in terms of one parameter, total number of gaze points (TNGP), as reported previously [13,14]. We also recorded two versions: Version 1 used photographs showing the mother in the left half of the screen, and version 2 showed the mother on the right side, and we recorded left TNGP and right TNGP, respectively [10]. Central, lateral (20° visual angle), and vertical (12° visual angle) positions were confirmed beforehand. Lateral differences in gaze points were analyzed based on data with confirmed positions [10].

Eye movement recording procedure

Subjects were instructed to identify each photograph exactly as it was presented. All subjects also were instructed to view and fixate upon several corner points to check their eye movements for neurological deficits and low-level eye movement disturbances such as reflex organic saccades. Deficits were not found in any subjects. Exploratory eye movements and fixation points were recorded during viewing. Photographs were projected onto a screen to form images 120 cm
wide and 90 cm high. Maximum angle of sight lines were 40˚ horizontally and 24˚ vertically. Each block consisted of a series of four photographs, each presented for 15 sec [11,12]. Six kinds of photographs were used (Fig. 1 and 2).

**Version 1:** Picture 1 showed a smiling mother on the left and smiling baby on the right to study the effect of positive affect. Picture 2 showed a crying mother on the left and crying baby on the right to study the effect of negative affect. Photograph 3 showed a neutral mother on the left and neutral baby on the right to study the effect of nonemotional content.

**Version 2:** The mother and baby were transposed from right to left and vice versa. Versions 1 and 2 were presented in a counterbalanced manner and two recordings were carried at one-week intervals.

In the present study, we used two similar pictures transposed left and right to examine differences in eye movement and to evaluate the perceived relationships between mother and baby. In a basic study, three kinds of photographs of mothers and babies were viewed by 100 healthy controls. All reported that the figures in picture 1 were crying and feeling sad, those in picture 2 were smiling and feeling pleasure, and those in photograph 3 were neither crying nor smiling and were feeling no emotion. Thus we utilized these photographs in the present study.

Recording was performed as follows. Session 1 (free task): All subjects were instructed, “Look at the photographs in front of you freely. After the task, I will ask you how the people shown were feeling, for example happy, sad or nothing.” Session 2 (memory task): All subjects were instructed, “Look at the photographs in front of you and try to remember carefully what you see. After the task, I will ask you what kind of pictures you saw.” Session 3 (confidence task): All subjects were instructed, “note any differences between the photographs you are seeing now and the ones you saw previously” to test confidence and attention. Data from right and left eyes were analyzed and found to be similar [11,15].

**Clinical evaluation and medication**

The clinical state of all patients was assessed using the Positive and Negative Symptom Scale (PANSS) [16] by two psychiatrists within 1 week after eye movement recording. The positive symptom score was $24.3 \pm 5.9$ and the negative symptom score $22.3 \pm 4.6$. When scores differed between the two psychiatrists, final scores were determined by negotiation before being analyzed as data. All patients were treated with neuroleptics (mean daily dose in chlorpromazine equivalent, $279.4 \pm 107.5$ (mg/day)) [13].

**Statistical analysis**

The present study considered only data obtained from the confidence task (session 3), since the confidence task has been reported to best reflect visual cognitive function [11]. First, three-way analysis of variance (ANOVA) (version, group, stimulus) was performed. Then two-way ANOVA was performed (group, stimuli) in version 1 and version 2. Finally, one-way ANOVA was performed, with or without interaction, for each version (version 1: mother on left, version 2: mother on right), group (patients or con-
trols) and stimuli (smiling, crying or neutral). Post hoc analyses were conducted using Scheffe tests. Pearson’s correlation coefficient was used to identify significant relationships between symptom scores, measures of eye movements, and dose of medication. A p value below 0.05 was taken to indicate statistical significance.

RESULTS

Representative sequences of exploratory eye movements from a healthy control and from a schizophrenic patient while viewing the three photographs in version 1 are shown in Figure 1, and eye movements from version 2 are shown in Figure 2. The control subject’s eye movements were coherent, focusing on the baby’s eyes and mouth in both the left and right visual fields (a double inverted triangle pattern). The patient’s eye movements appeared to be random, no organizing strategy was apparent, and they were relatively limited in aggregate length.

Mother (Table 1, Fig. 3).

Three-way ANOVA (group, version, stimulus) demonstrated significant group (F=113.3, p<0.0001) and version (F=6.00, p<0.05) differences. Significant interaction was observed between group and stimuli (F=25.9, p<0.0001). Two-way ANOVA (group, stimulus) demonstrated significant group differences in version 1 (F=133.2, p<0.0001) and in version 2 (F=14.4, p<0.0001).

By one-way ANOVA, TNGP in version 1 (left mother) differed between the two groups with regard to crying (F=42.55, p<0.0001), neutral photographs (F=75.5, p<0.0001) and smiling (F=25.3, p<0.0001).

In version 2, TNGP in controls (right mother) were significantly larger than in patients (neutral: F=11.48, p<0.001), but not for crying and smiling photographs. TNGP for version 1 in controls was significantly larger than for version 2 (F=4.99, p<0.05). In patients, TNGP for version 2 was significantly larger than for version 1 (crying: F=8.97, p<0.01, neutral: F=6.08, p<0.05, smiling: F=16.2, p<0.001) (not shown in figure).

Baby (Table 1, Fig. 4).

Three-way ANOVA (group, version, stimulus) demonstrated significant main group (F=9.57, p<0.01), version (F=7.8, p<0.01) differences. Significant interaction was observed between group and version (F=3.9, p<0.05). Two-way ANOVA (group, stimulus) in version 2 demonstrated group difference (F=8.79, p<0.01).

By one-way ANOVA, TNGP in patients (version 1: left mother) was significantly smaller than in controls (smiling: F=4.0, p<0.05), but not for crying and neutral photographs. TNGP in patients (version 2: right mother) was significantly smaller than that in controls (crying: F=5.9, p<0.05, smiling: F=4.77, p<0.05), but not for neutral photographs. In version 1, significant stimuli difference of TNGP was observed only in patients (F=4.2, p<0.05). TNGP for the neutral picture was significantly larger than for crying (p<0.05) and for smiling (p<0.05) photographs.

The only significant difference was noted between version 1 and 2 viewing neutral photographs (F=4.36 p<0.05). TNGP for version 1 was significantly larger than for version 2 (p<0.05) (not shown in figure).

Symptom scores and eye measures (Table 2)

In version 1 (left mother), a significant correlation was obtained between negative symptom scores and TNGP for the crying baby (right) (r=−0.393, p<0.01),

| TABLE 1. Value of the measurements of the exploratory eye movements under confidence condition |
|---------------------------------------------------|------------------|------------------|------------------|------------------|
| TNGP of mother (n)                                |                  | TNGP of baby (n) |
|                                                  | Controls         | Patients         | Controls         | Patients         |
| Version 1                                        |                  |                  |                  |                  |
| Crying                                           | 15.4±6.1         | 7.9±4.0          | 12.7±4.6         | 12.0±5.5         |
| Neutral                                          | 16.8±3.1         | 8.0±5.5          | 12.9±4.5         | 14.3±6.0         |
| Smiling                                          | 14.8±5.5         | 9.2±4.5          | 13.6±4.4         | 11.9±3.1         |
| Crying                                           | 13.1±4.5         | 11.1±5.4         | 12.7±4.3         | 9.4±6.9          |
| Neutral                                          | 15.4±5.1         | 11.1±5.9         | 12.4±6.1         | 11.5±6.1         |
| Smiling                                          | 14.8±5.1         | 13.3±4.8         | 12.9±4.3         | 10.5±5.5         |

Data are given as mean±standard deviation.
a: p<0.001,vs.controls. b: p<0.01,vs.controls. c: p<0.05,vs.crying and smiling of patients. d: p<0.01,vs.controls.
EYE MOVEMENTS BETWEEN MOTHER AND BABY IN SCHIZOPHRENIA

for neutral mother (left) ($r= -0.521$, $p<0.001$), and for smiling mother (left) $r= -0.552$, $p<0.001$). In version 2 (right mother), a significant correlation was obtained between negative symptom scores and TNGP of neutral baby (left) ($r= -0.410$, $p<0.01$) and for smiling mother (right) ($r= -0.367$, $p<0.05$).

In version 1, a significant correlation was obtained between positive symptom scores and TNGP of crying baby (right) ($r= -0.475$, $p<0.01$), and in version 2 between positive symptom scores and TNGP of crying baby (left) ($r= -0.350$, $p<0.05$). No significant correlation was obtained for either negative or positive symptom scores and drug intake.

**TABLE 2.**

<table>
<thead>
<tr>
<th></th>
<th>TNGP of mother (n)</th>
<th>TNGP of baby (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left Mother</td>
<td>Right Mother</td>
</tr>
<tr>
<td>Version 1</td>
<td>Crying</td>
<td>-0.217</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>-0.521*</td>
</tr>
<tr>
<td></td>
<td>Smiling</td>
<td>-0.552*</td>
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<tr>
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<tr>
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<td>Neutral</td>
<td>0.070</td>
</tr>
<tr>
<td></td>
<td>Smiling</td>
<td>-0.367c</td>
</tr>
</tbody>
</table>

a: $p<0.001$.  b: $p<0.01$.  c: $p<0.05$

**DISCUSSION**

TNGP was significantly larger in controls than in the schizophrenic patients. In the patients, right TNGP were larger than left TNGP.

The most important finding of the present study was that emotionally charged adult (mother) and baby photographs proved to be a useful tool in investigating characteristics of exploratory eye movements in healthy subjects and also in patients with schizophrenia, most notably in eye scanning when viewing smiling and neutral pictures on the left side of the visual field.

The relationship between mother and baby should...
be the most important factor in enabling human beings to establish human relationships. An impairment of this relation may cause various dysfunctions in social relationships between humans [7]. However, no reports have concentrated on the role of affection in the mother-baby relationship on cognitive function as evaluated by physiological methods such as event related potential or eye movements. Kojima et al. [10,16] investigated exploratory eye movements using specially constructed S-shaped geometric figures, demonstrating exploratory eye movement to be a useful biologic marker of visual cognitive function in patients with schizophrenia. The present study examined effects of emotionally charged and non-emotional stimuli on gaze points in the left or the right scanning fields, and more particularly examined the scanning for a mother or baby.

**Mother**

Significant differences of TNGP were noted between controls and patients for the smiling, neutral and crying photographs in the left field (version 1), but only for the neutral pictures in the right field (version 2). Indeed, in patients, TNGP in version 2 (right mother) were significantly larger than under version 1 (left mother) for smiling, neutral and crying pictures. This enhancement was not observed with the photographs of the baby (see below). This indicates that left field scanning in patients of the mother image tended to be inhibited, thus the left adult affective stimuli may generally be impaired without regard to stimuli differences. Moreover, the increases in TNGP under version 2 for neutral photographs were rather smaller than for the other stimuli.

**Baby**

Significant differences of TNGP were noted between controls and patients only for the smiling photographs in the left field (version 1), and for the crying and the smiling photographs in the right field (version 2). TNGP for neutral pictures both in version 1 and version 2 were about the same in both groups. Interestingly, TNGP for neutral photos among patients was larger than that for crying and smiling photographs in both version 1, and version 2, although the difference was not significant. These findings indicate that neutral photographs may enhance the attention and eye scanning in patients, especially in the left field of vision. Indeed, no significant difference between version 1 and version 2 for the crying and smiling pictures was noted. Significant differences were observed only for the neutral picture: TNGP for the neutral photo with the baby on the right side (version 1) was larger than that with the baby on the left. Photos with the neutral baby in the right field tended to attract enhanced attention in patients, but not in the left. Furthermore, TNGP in patients for smiling and crying pictures in the right field were somewhat higher than for those in the left. These indicate that the left scanning in patients was generally impaired, as was observed in the case of photos of a mother. However, the dysfunction when viewing a baby appeared to be weaker than when viewing a mother.

**Symptoms and eye movements**

Negative psychiatric symptoms have been reported to correlate negatively with exploratory eye movements [11]. In our study, a significant negative correlation was observed between the TNGP of version 1 (left mother) for the neutral and smiling picture and negative symptom scores, but not in version 2 (right mother). TNGP of right baby (version 1) for the crying and neutral photographs was negatively correlated with negative symptom scores. TNGP of left baby (version 2) for the neutral and smiling photographs correlated negatively with negative symptom scores. These results strongly indicate that the left TNGP for smiling or neutral pictures is the best index and revealed a fundamentally important dysfunction of the schizophrenic patients regardless of whether the photo viewed was a mother or baby. Our findings strongly suggest that exploratory eye movements may be a clinically useful prognostic indicator of negative symptoms. Correlations between scanning measurements and symptoms showed that negative symptoms were related to scanning measures such as fixation numbers, and total scan path length of face [14]. The authors suggest that visual organization impairments may be related to cognitive inflexibility and frontal dysfunction.

Positive symptom scores were negatively correlated to TNGP of right baby in version 1 (left mother) and TNGP of right mother in version 2 (left baby) only for crying photographs. These results indicate that negative affective stimuli may relate to positive symptoms only in the right field of vision. These results taken together suggested that negative symptoms might be related to right brain function and positive symptoms to left brain function.

**Conclusions and psychophysiological significance**

Phillips et al. [3] reported that schizophrenic patients had difficulty in redirection of focus of attention to left-field stimuli, proposing left-specific scan paths as a marker of attention processes in schizophrenic patients. Ishi et al. [17] reported that left TNGP...
was smaller in schizophrenia patients under positive affection with voice and suggested that left eye scanning function could be a trait marker of schizophrenia, similar to previous reports [10]. In the present study, left TNGP under both versions (version 1: left mother, version 2: left baby) differed between patients and controls, especially depending on the location (left or right) of the mother. These indicated the left scanning dysfunction should occur regardless of the stimulus. This function was seen also in when viewing neutral baby photograph. Thus, the left-sided ocular scanning may be a particularly good trait marker of visual cognitive dysfunction in schizophrenic patients.

We hypothesize that if patients see themselves in the baby photographs, the neutral mother face may tend to cause confusion, thus patients may avoid looking at the mother and prefer to look at the self (baby) on the right side [18]. This hyper activation of viewing in case of the neutral baby may be one of the characteristics of the cognitive function of schizophrenic patients.

From these reports, schizophrenic patients may have an impairment of the right frontal cortex especially under pleasurable and neutral conditions. Indeed, the RSS of exploratory eye movement viewing the letter “S” was reported to reflect right brain function [19]. This dysfunction should make human social relationships more difficult. Finally, exploratory eye movements while viewing certain pictures showed certain differences between schizophrenic patients and healthy controls in the left field of screen using adult or baby photographs. Thus, exploratory eye movements appear to include clinical and hemispheric functional markers that could be useful for exploring human visual cognition.

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