Mentally Retarded Children Detection at an Early Ages using Social Reaction Test

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Results have shown that in the first three years of human life, the brain undergoes most of its growth. If mentally retarded children could be detected before the age of three, correct treatment could be prescribed at an early stage before the brain completely develops. Therefore, the possibility for the brain's recovery would be higher. In this study, we detect mentally retarded children at an early age merely by analyzing children's reactions while a feedback image is displayed for two minutes. Results showed that by Social Reaction Test, we verified that our system renders the same evaluation as the Enjoji method. Furthermore, detection of mental retardation in children under age three was possible.

Keywords: Mental Retardation, Social Test Experiment, Monitor Test, Mirror Test, Social Test Score

1. Introduction

Recently, various child intelligence development tests are used to detect mental retardation in children. However, persons qualified to detect them and testing locations are limited. Moreover, there are various problematical points including subject's wide range of age detection and the large burden on children during testing.

Investigation results for mentally retarded children and people in Japan in 2000 by the Ministry of Health and Welfare indicate that mentally retarded children and others in Japan are increasing year by year. Those mentally retarded people detected from birth to age three are only 25%; those after age three are approximately 75% [1]. That report emphasizes the difficulty of having a proper child intelligence development test for detecting mentally retarded children before they reach the age of three years or since they could be asked for doing something and answering the question.

However, many results show that between birth and the age of three, brain development is almost 80% completed, while it is almost 90% completed before the age of five. The human brain achieves maximum efficiency before ten years old. It is in the first three years of human life that the brain undergoes most growth [2]. If mentally retarded children could be detected before age three, correct treatment could be prescribed at an early stage before the brain completely develops. Thereby, the probability of brain recovery would be increased [2].

Conventional child intelligence development tests have many test items that require time; also, the burden concerning a child is large. Testing locations and examiners qualified to detect them are limited; also, test items cannot be sufficiently addressed. During the test, children usually seem insecure, nervous and stressed. In this condition, the child can not use all capabilities [3] [8]. Moreover, the examiner cannot make a proper examination without sufficient knowledge of the test item contents, test order, the time of each test, and test record. Furthermore, examination place, special equipment and tools are required. It is difficult to conduct an examination except at a specific place. Actually, according to investigation results for mentally retarded children and people in Japan in 2000 by the Japanese Ministry of Health and Welfare, the examination opportunity of mentally retarded children detection is 40.9% in "The Children Counseling Center" and 28% in "The hospital". This condition also indicates that mentally retarded children detection is quite difficult. It is also one cause of late detection of mental retardation in children.

In this study, we actualize a simple and quick child intelligence development test by applied Multimedia Education System Technology to eliminate various problems in conventional child intelligence development tests. The test is original. It is restrictive neither in terms of examiner, nor in terms of examination location, but it is capable of assessing early stages of retardation precisely. Below, from chapter 3 to chapter 6, we describe concretely the outline of the child intelligence development examination system of this research.

The last purpose is early automatic detection of mentally retarded children. As the first step, this study analyzes a child's reactions while its own feedback image is displayed for two minutes on a monitor; then we determine whether or not the child can be classified as mentally retarded [9] [10].

Assessing the recognition ability of mentally retarded children by this study will also serve as important data in understanding a facial recognition mechanism; therefore, it is possible to use it practically as new type of child's intelligence measures device [11] [12]. Moreover, not only applying for face recognition, but also it will

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be a useful study to elucidate the nature of the mentally retarded recognition function. Furthermore, this method could solve problematical points in the field of multimedia technology education system.

2. Mentally Retarded Children

A definition for mental retardation is found in Public Law 101-476, the Individuals with Disabilities Education Act (IDEA) of 1990: "Mental retardation means significantly subaverage general intellectual functioning existing concurrently with deficits in adaptive behavior and manifested during the developmental period that adversely affects a child's educational performance" [13].

In its 1992 manual on definition and classification, the American Association on Mental Retardation (AAMR) offers the following definition: "Mental retardation refers to substantial limitations in present functioning. It is characterized by significantly subaverage intellectual functioning, existing concurrently with related limitations in two or more of the following applicable adaptive skill areas: communication, self-care, home living, social skills, community use, self-direction, health and safety, functional academics, leisure and work. "Mental retardation manifests before age 18. Significantly subaverage intellectual functioning implies an IQ score of 70 to 75 or below on a standardized individual intelligence test. Related limitations refers to adaptive skill limitations that are related more to functional applications than other circumstances such as cultural diversity or sensory impairment" [14].

Mental retardation is classified to four categories: profound mental retardation, for which IQ is under 20 (in adults, mental age below three years); severe mental retardation, for which IQ ranges from 20-34 (in adults, mental age from 3 to under 6 years); moderate mental retardation, for which IQ ranges from 35 to 49 (in adults, mental age from 6 to under 9 years); severe mental retardation, for which IQ ranges from 49 to 70; and mild mental retardation, for which IQ ranges above 70 [15]. Intelligence development can not be measured by conventional child intelligence development tests; also, mental retardation is difficult to judge by only one test, observation of daily life scenarios are also necessary. Therefore, in our method, by analyzing child's reactions while a feedback image is being displayed for a short time, we could examine children with a single test and determine whether they should be classified as retarded or not.

Mental retardation is a common phenomenon. No country of the world, rich or poor, big or small, is free from this problem. In 1986, WHO reported that mentally retarded persons all over the world were about 90-130 million persons. Furthermore, the surveillance rate of severely mentally retarded persons under 18 years was 3-4:1000. The surveillance rate of mildly and moderately retarded persons was approximately 20-30:1000 [16]. According to UNICEF in 2000, there are 140 million disabled children in the world; during the 20-year period between 1980 and 2000, the total number of disabled children and adults of all ages likely rose from 400 to 600 million [17]. According to those results, mentally retarded children have become an international-scale problem. Therefore, until age 3, discovery of mentally retarded children at an early stage is really an important research theme.

3. Displaying of Feedback Images

In recent years, research which applies information communication equipment to medical-examination support, continues to develop concomitant with the spread of information communication equipment. Therefore, the possibility of remote medical examination is also increasing. Actualization of remote medical care in every home may be a feasible result of this study. Considering annually increasing rates of personal computer use in homes, intelligence development tests for children using computers can be anticipated. Application of information communication equipment to medical-examination support has been advanced recently; the feasibility of remote medical examinations continues to increase [18].

Various merits are obtained through advancement of remote medical examination. For example, a patient does not need to attend a hospital; a patient could be diagnosed early, when the patient's condition is good. Also, remote medical treatment leads also to mitigating various burdens faced by patients.

If an automated child development test were conducted in a remote place, results would be independent of the child's intelligence development examiner or examination location. All mothers would freely have the opportunity to measure a child's development. This can enable early detection of mental retardation in children. As for the child's convenience, if intelligence development tests could be done in a familiar place, such as a residence, children's uneasy feelings, shyness, stress, etc. would be lower than with conventional evaluation in places such as hospitals or clinics. Therefore, a child can conduct intelligence development testing with a sense of security and comfort engendering accurate measurement.

Development of emotion recognition and cognitive ability in mentally retarded children is delayed compared to normal children. Furthermore, development of a newborn baby's social ability precedes development of motility and language. In many cases, delayed social development will hinder development of motility and language [19]. Since social capability is developed first, we infer that a social test is most suitable for early mental retardation detection.

Since all Child Counseling Centers in Japan use the Enjoji method (Child Development Test), in this study, we proposed social test items which can be realized using a monitor chosen from the Social Category of the Enjoji method. Actualization through a network is possible using a monitor because thinking about our study goal is actualization of a remote medical care system in every home for child intelligence development testing using a computer. The intelligence development test could be installed on a computer.

According to the Enjoji method: a two-month-old baby shows interest when viewing a human face; six-

month-old babies react; and eight-month-old babies begin to laugh or speak to their own images reflected in a mirror. Those reactions imply that we can measure a child's ability at less than one year using a mirror [20].

In our experiment, we do not ask children to perform a task, nor do we ask questions; even a very young baby can be examined. Merely by analyzing their reactions while a feedback image is displayed for two minutes, we can determine whether or not the child can be classified as mentally retarded. We also analyze whether results from use of a monitor and mirror are similar. Then, for analyzing practicality of using a monitor, we compare monitor test results to the Enjoji Checklist Scoring Test results. Furthermore, think about a judgment as mentally retarded children is considered as an essential problem, beside using Enjoji Checklist Scoring Test, the decision of retardation by another test method is desirable for certain evaluation. Since Child Counseling Centers in Japan also use Japanese Denver Developmental Screening Test, for children who judged as mentally retarded children by monitor test and Enjoji Checklist Scoring Test, would be tested again using Japanese Denver Developmental Screening Test.

Our proposed method is a simple method for examining a child's development, aside from examination, which requires only a short time compared to the conventional method. It sharply reduces the burden upon the child. Moreover, by this technique, equipment, tools and examination places, etc. other than a computer and a camera are not needed. Furthermore, automation of examinations is realizable because the examiner does not need to know examination contents or examination order; we anticipate that anyone can administer the test easily.

4. Social Test Experiment

In the Social Test Experiment, we performed two types of experiments: the Social Reaction Experiment and Social Learning Experiment. In each experiment, we examine three kinds of tests: the Monitor Test (our research method), Mirror Test (Enjoji method), and the Enjoji Checklist Scoring Test that is filled out by teacher in a nursery where children stay during the day. However, for subjects whose low scores or predicted as mentally retarded children, they will have another examination and analysis based on nursery teacher evaluation using Japanese Denver Developmental Screening Test for certain evaluation.

During Monitor and Mirror Tests, the subject's images were recorded by a digital video camera for two minutes simultaneously for later use in analysis by comparing the three test results. "Is it possible for a monitor to replace a mirror?", "Does the remote Monitor Test result provide the same evaluation as Enjoji Checklist Scoring results?" This study uses a statistical analytical method that addresses these two questions.

For the Monitor Test, we examined subject's reaction while a feedback image was displayed on a monitor (Fig. 1). In this case, if we displayed the feedback image on the monitor, right and left side images would be re-
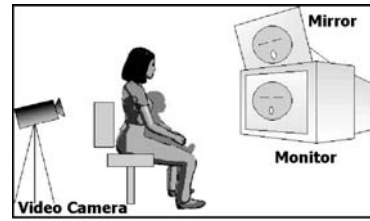

Fig. 1.   Scene of monitor test.

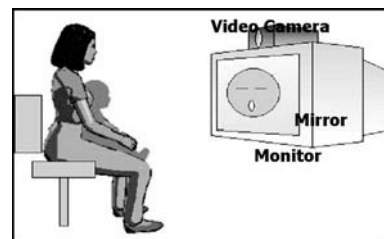

Fig. 2.   Image of monitor test.

Fig. 3.   Scene of mirror test.

Fig. 4.   Image of mirror test.

versed. Therefore, we put a mirror on the top of monitor and controlled the mirror's direction so that the examinee's image reflected in the mirror. Next, we merely recorded the image reflected by the mirror using a video camera and displayed it on the monitor (Fig. 2).

For the Mirror Test, we examined a subject's reaction while viewing his or her own image reflected on the mirror (Fig. 3). We placed a mirror with the same size as the monitor on the monitor screen. Then, we put a video camera on top of the monitor for recording a subject's image during the experiment (Fig. 4).

We did experimental tests in a nursery. In these experiments, we asked the subject's caregiver in the nursery to hold the subject and take a seat in front of the computer. While a feedback image was displayed, teachers were advised to remain expressionless and to not say anything to the subject, because teacher's expressions and conversations could affect the subject's expression.

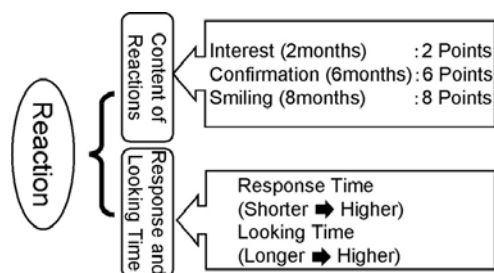Contents of Social Reaction Experiment and Social

Fig. 5.   Evaluation of social test experiment.

Table 1.   Response time evaluation.

Response Time	Score
0 10 sec	7 Points
11 20 sec	5 Points
21 30 sec	3 Points
31 40 sec	1 Point
above 40 sec	0 Point

Table 2.   Looking time evaluation.

Looking Time	Score
0 20 sec	3 Points
21 40 sec	4 Points
41 60 sec	5 Points
61 80 sec	6 Points
above 80 sec	7 Points

Learning Experiment are explained below.

4.1 Social Reaction Experiment   For the Social Reaction Experiment, three kinds of tests, the Monitor Test, Mirror Test, and Enjoji Checklist Scoring Test were performed once each. We conducted tests for two days: on the first day, we used monitor (Monitor Test); a mirror is used on the last day (Mirror Test); and Enjoji Checklist Scoring Test filled by teacher in nursery house. Subject's ages varied from 6 to 36 months.

4.2 Social Learning Experiment   For the Social Learning Experiment, we examined reproducible results and familiarized influence of Social Reaction Experiment. In the Social Learning Experiment, a Monitor Test and a Mirror Test were performed five times each. The Monitor Test and Mirror Test were performed once each on the same day at one-week intervals for five weeks (five times total). Subject's s ages varied from 13 to 39 months. Subjects of the Social Reaction Experiment and Social Learning Experiment were not the same.

5.   Analysis of Social Test Experiment Results

In a Social Test Experiment, two evaluations are used for measuring children's intelligence development, which are contents of a 'Reaction Evaluation' and 'Response Time and Looking Time Evaluation' (Fig. 5). Moreover, evaluation of the same grade as the Social Category of Enjoji Checklist is considered. Furthermore, Japanese Denver Developmental Screening Test is used for confirming the decision of mental retardation in children.

5.1 Reaction Evaluation   On Reaction Evaluation, we performed systematic evaluation of children's reactions to evaluate their reactions as shown in Fig. 5 on the basis of the Enjoji Child Development Test. Since reactions of 'Interest', 'Confirmation', and 'Smiling' are included in the social category of the Enjoji Child Development Test, we classified those reactions as social reactions. For example, according to the Enjoji method, a two-month-old baby begins to express an interest while viewing human faces; therefore, 2 points are set for this kind of reaction. Similarly, six-month-old babies react, while eight-month-old babies begin to laugh to their own images that appear in a mirror. Therefore, subjects receive 6 points and 8 points, respectively.

During the experiment, subjects expressed various reactions while feedback images were displayed. For subjects who begin to express an 'Interest' while viewing their own displayed image, 2 points are set. 'Confirmation' (6 points) is reaction of subject who is looking back immediately or waving hand or shaking head, etc. while feedback images were displayed because the subject wanted to confirm whether the images that have been seen were exist or not. Furthermore, 8 points are set for subject who is 'Smiling' or 'Laughing' while viewing their own image that appear in the monitor or mirror. A confirmation score was not given to subjects who smiled or laughed because the reaction of confirmation is also included in the smiling or laughing reaction.

5.2 Response Time and Looking Time Evaluation   For Reaction Evaluation, we classified a child's reaction as 'Interest', 'Confirmation', and 'Smiling'. For Time Evaluation, we performed 'Response Time Evaluation' to measure time during which a confirmation or smiling reaction is shown. By evaluating response time of 'Confirmation' and 'Smiling' reactions, we were able to evaluate brain efficiency such that the shorter the response time, the faster the brain comprehends information; therefore, a higher score is awarded (Table 1). In addition to 'Response Time Evaluation', we also performed 'Looking Time Evaluation' to measure how long a subject looks at feedback images according to their 'Interest' reaction evaluation. The longer a subject looks at the feedback image, the greater the interest in looking at the feedback image; therefore, the score is higher (Table 2).

5.3 Enjoji Checklist Scoring Test Evaluation   At the Enjoji Checklist Scoring Test (Enjoji Checklist), each category of social, motility, and language of child's development items are shown: " " and "×" designate whether those items are attained. A Social Test experiment examines whether evaluation with a monitor test has the same grade as Enjoji Checklist is possible. A nursery caregiver attaches " " to social development items which the subject has attained using Enjoji Checklist. The number of these " "s is added and considered as an Enjoji Checklist evaluating point. In this report, we compare this Enjoji Checklist evaluating point and evaluation of the Monitor Test. Evaluation for 'Looking Time' and 'Response Time' mentioned above is calculated to revise evaluation with this system because this system cannot provide evaluation of various development items like Enjoji Checklist method. Identical

evaluation to that of the Enjoji Checklist is performed by adding the Social Test Evaluation Score of a development items.

In this system, we pursued that the evaluation of a Subject's Social Test Score is total of calculation of: [Interest Score] + [Looking Time Score] + [Confirmation/Smiling Score] + [Response Time Score] as shown in formula 1.

$$\text{Score} = (I + LT_I) + (C_{or}Sm + RT_{C_{or}Sm}) \cdots (1)$$

Score	Social Test Score
I	Interest Score
LT_I	Looking Time Score
$C_{or}Sm$	Confirmation/Smiling Score
$RT_{C_{or}Sm}$	Response Time Score

5.4 Japanese Denver Developmental Screening Test Evaluation Japanese Denver Developmental Screening Test is a widely used assessment for examining children 0-6 years of age as to their developmental progress. Japanese Denver Developmental Screening Test will assess a child's development in four areas: personal/social, fine motor/adaptive, language and gross motor [8].

In this report, for confirming the decision of retardation, a nursery caregiver appraises a child's performance on various age-appropriate tasks and overall behavior, then identify score of child's personal/social test item as advanced, normal, caution or delayed using Japanese Denver Developmental Screening Test. And we evaluate whether the retardation judgment with a monitor test and Enjoji Checklist Scoring Test has the same grade as Japanese Denver Developmental Screening Test is possible.

6. Experimental Result

In this study, comparison of Monitor Test result, Mirror Test result and Enjoji Checklist Scoring Test results in two experiments, i.e. Social Reaction Experiment and a Social Learning Experiment has analyzed using statistical method and graphically comparison.

6.1 Result of Social Reaction Experiment
6.1.1 Statistical Analysis of Social Reaction Experiment This study uses the F test and T test for analyzing the difference between monitor and mirror test results. Through comparison of three test results, we can answer the following two questions: "Is it possible for monitor to replace the mirror?" and "Is the Monitor Test result distantly have the same evaluation as Enjoji Checklist Scoring result?". Two-tailed F test and T test with a 5% significance level did not indicate significant differences; distributions of results were the identical (Table 3). There is no difference between Monitor Test and Mirror Test results.

Table 3. Statistical test of social reaction exp.

Test	Monitor-Mirror	Monitor-Checklist
F Test	1.40	1.54
T Test	1.77	-

F Test:2.07 T Test:2.04(5% Significant Level)

Next, we are using F test for analyzing the result distribution on 5% significance level to compare result of monitor test and Enjoji Checklist and to provide usefulness of monitor test. F test results show that data distribution of Monitor Test and Enjoji Checklist Scoring result are the same. Therefore, usefulness of this system (monitor test) in Social Reaction Experiment is proved.

6.1.2 Graphic Analysis of Social Reaction Experiment We evaluate three items of "Correlation between Monitor Test and Mirror Test", "Correlation between subject's age and Social Reaction Test Score" and "Detection of mentally retarded children" using the graph shown in Fig. 6. The abscissa is the score, and the ordinate shows the subject's age. Subject's age increase from left to right. The Social Reaction Score of Monitor Test and Mirror Test in each subject yield almost identical results. Moreover, we understood that the Social Reaction Score is increasing as age rises. From the graph in Fig. 6, because low results were obtained for three subjects, they are inferred to be retarded. By comparing their ages, their Social Reaction Scores of Monitor Test and Mirror Test are equal to 7-month-old subjects. Therefore, the possibility of having serious developmental handicapped can be considered.

Next, Fig. 7 shows results of the Enjoji Checklist Scoring Test and Monitor Test. The abscissa is the score, and the ordinate shows the subject's age. Graph shows that Social Reaction Score of Enjoji Checklist Scoring Test is also increasing as the age rises. If Social Reaction Scores of 33 to 36-month-old subjects are equal to a 27-month-old subject, ability of those three subjects is judged as an individual difference not as retarded children. According to the Enjoji method, considering children's personalities, there are three subjects (12 to 15 months old) whose Monitor Test results are the same as 7-month-old subjects, but they are not categorized as mentally retarded children, because the gap between the ages are considered to children's personality. Moreover, a 36-month-old child showing similar development to the 27-month-old child is still categorized as a normal child. However, because the Social Reaction Score of three subjects whose age 33 to 36-month-old on both monitor test result and Enjoji Checklist Scoring Test result has the same grade with the 7-month-old subject, the Development Quotient score is judged about 19 to 21 (Development Quotient DQ = Developmental Age / Chronological Age × 100) therefore, they are judged as mentally retarded children.

In this study, for confirming their retardations, we had another child development test analysis based on nursery teacher examination using Japanese Denver Developmental Screening Test for certain evaluation (Fig. 8). The abscissa is the Developmental Age, and the ordinate shows the Chronological Age. Subject's age increase from left to right and from bottom to up. Graph shows that subject's score is also increasing as the age rises. The results of Japanese Denver Developmental Screening Test shows that except for the three subjects whose age 33 to 36-month-old, all of subjects are clas-
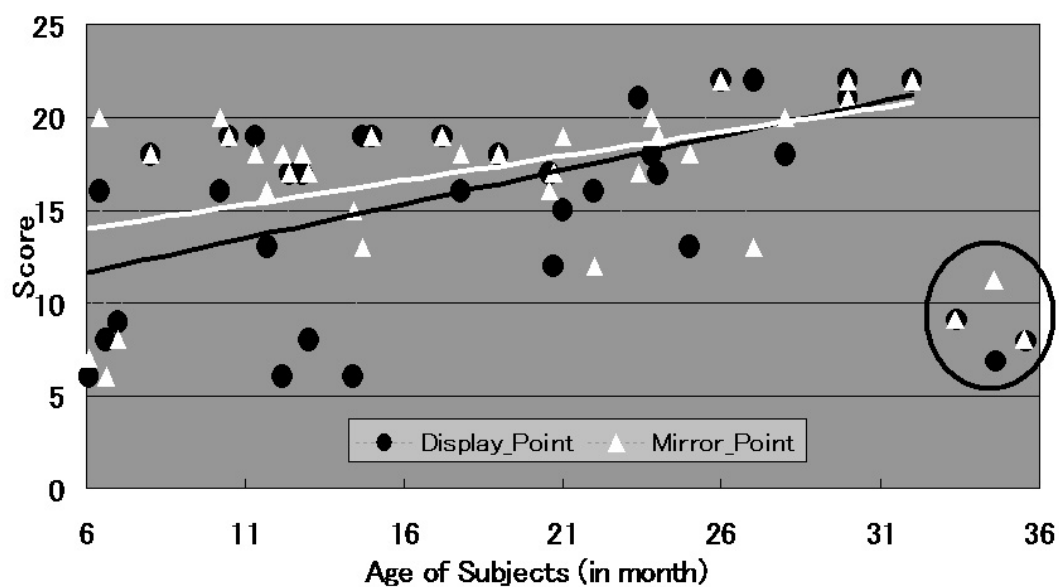
Fig. 6.   Monitor Test and Mirror Test of Social Reaction Exp.
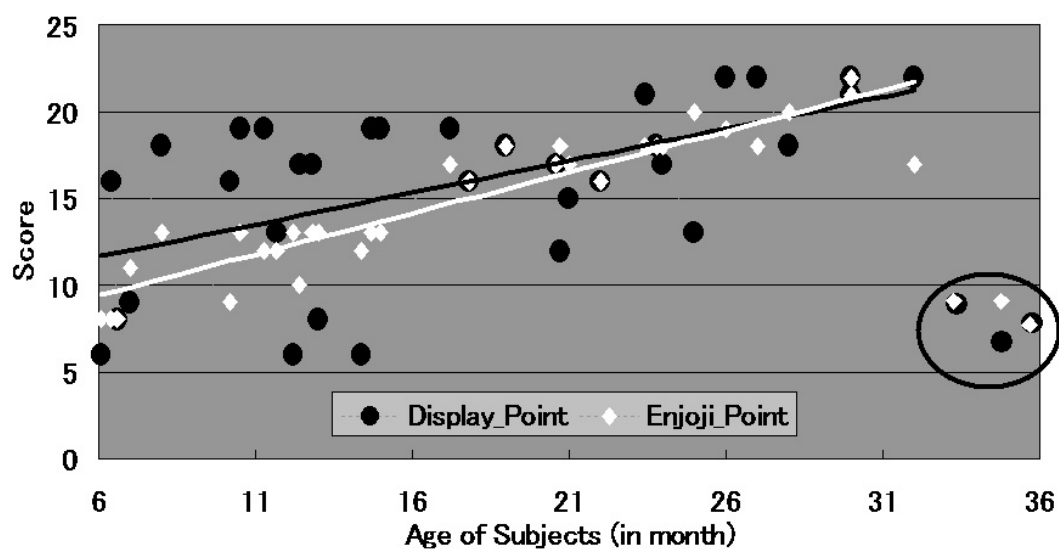

Fig. 7.   Monitor Test and Enjoji Checklist Scoring Test of Social Reaction Exp.
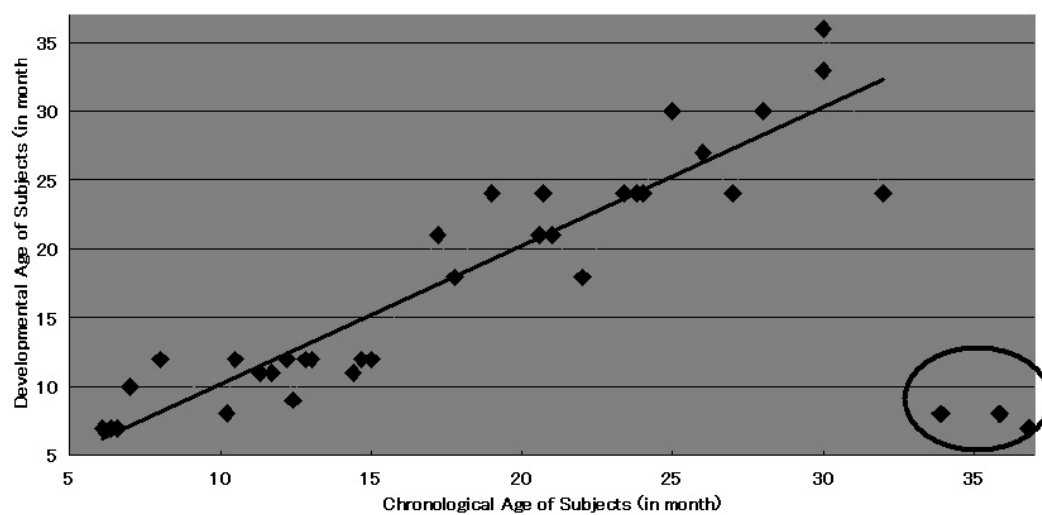

Fig. 8.   Japanese Denver Developmental Screening Test.

sified to normal children. Even there are some subjects whose developmental ages lower than the chronological ages, ability of those subjects is judged as an individual difference. But results of three subjects whose ages 33 to 36-month-old using Japanese Denver Developmental Screening Test show that since their scores have the same grade with the 6 to 7-month-old subject, the Development Quotient score is about 17 to 21. Therefore by this analysis method they are also judged as mentally retarded children.

This result implies that detection results by Monitor Tests are useful. Also, these results indicate that children's intelligence development measured by Monitor Test also have similar evaluation degrees with both of Enjoji and Japanese Denver method's result. Moreover, by this measuring method, we can separate children whose brains react normally from those that have

Table 4.　Statistical test of Social Learning Exp.

F Test : 2.07 (5% Significant Level)

	1	2	3	4	5
Monitor-Mirror	1.14	1.24	1.75	1.71	2.02
Monitor-Checklist	1.60	1.21	1.25	2.04	1.80

T Test:2.04 (5% Significant Level)

	1	2	3	4	5
Monitor-Mirror	1.63	1.76	1.97	1.88	2.04

Table 5.　Statistical test of each Monitor Test.

F Test : 2.07 (5% Significant Level)

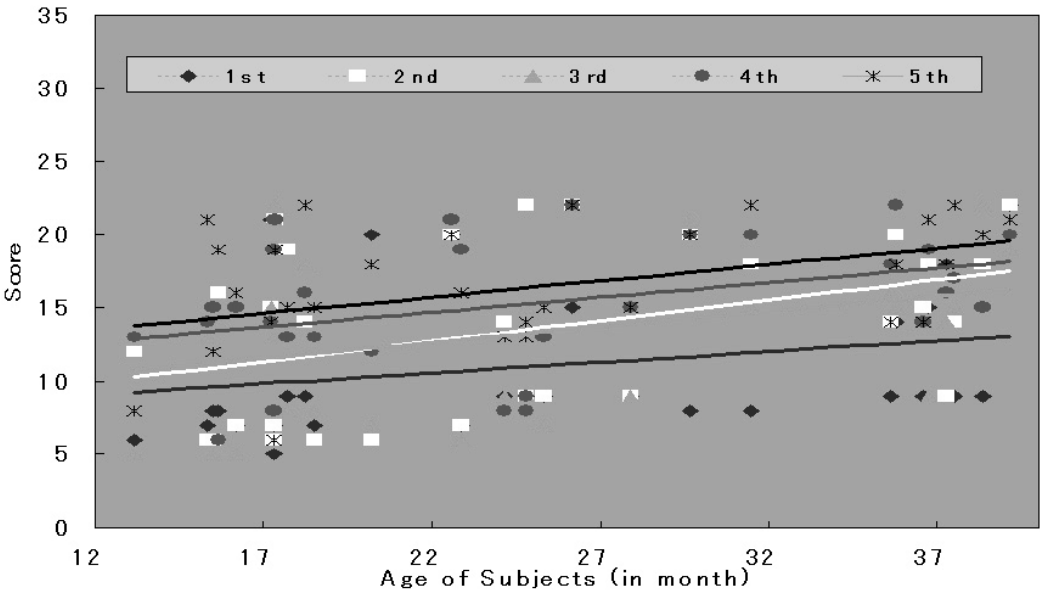|	1	2	3	4	5
1		1.31	1.25	1.27	1.24
2			1.04	1.66	1.63
3				1.59	1.56
4					1.02
5					

Fig. 9.　Monitor Test of Social Learning Exp.

Fig. 10.　Enjoji Checklist Scoring Test of Social Learning Exp.

difficulty recognizing and understanding information.

6.2 Social Learning Experiment

6.2.1 Stastical Analysis of Social Learning Experiment

On the Social Learning Experiment, we examined reproducible results and familiarized influence of Social Reaction Experiment of five times experiments on monitor and mirror tests using F test and T testof statistical method (Table 4). Considering two-tailed F test and T test results with a 5% significant level, significant difference of five times experiments were not recognized too, and also the distribution of results were equal. Those results mean that on Social Learning Experiment there are no difference between Monitor Tests and Mirror Tests either. Next, a two-tailed F test was performed to each result of five monitor tests in Table 5. Considering two-tailed F test result on 5% significant level, significant difference on each of five Monitor Tests is not recognized either.

Next, in order to compare each result of Monitor Tests and Enjoji Checklist Scoring Test and to provide the usefulness of monitor test, we are using F test for analyzing the result distribution on 5% significant level. Comparisons by statistical method show that distribution of monitor tests and Enjoji Checklist Scoring Test results are equal. Therefore, just as in the Social Reaction Experiment, the utility of this system (monitor test) in Social Learning Experiment has provided too.

6.2.2 Graphic Analysis of Social Learning Experiment

As for the Social Reaction Experiment, we also evaluate three items of "Correlation between Monitor Test and Mirror Test", "Correlation between subject's age and "Social Test Score" and "Detection of mentally retarded children" using graph as shown in Figs. 9 and 10 for each experiment. The abscissa is the score, and the ordinate is the subject's age. Subject's age increase from left to right. All Monitor Test results show that Social Reaction Score increases with age (Fig. 9). Also, whenever the test is repeated, the social reaction score rises. In addition, familiarity influence was verified, but precise evaluation was possible even where familiarity occurred. These results indicate no mentally retarded children.

Next, Fig. 10 shows the Social Reaction Score result from evaluation by a nursery teacher using the Enjoji Checklist Scoring Test. This evaluation also found no retardation in subjects. This study indicated reproducibility of these results.

7. Conclusion

Detection of mentally retarded children at an early age is necessary because the population of mentally retarded children (persons) is increasing every year. This study has realized mentally retarded children detection within 2 minutes using the Social Test Score method by displaying a feedback image on the computer. Moreover, 3-year-old or younger children, who until now were unable to have a development test, were able have their intelligence development measured easily by this method at an early stage.

Comparison of Monitor Test (our method) to Mirror Test (Enjoji method), shows no difference between Monitor Test and Mirror Test results; it proves the possibility of a monitor to replace a mirror for remote medical treatment application. And by comparing monitor test result to Enjoji Checklist Scoring Test result that is used in Child Counseling Center all over Japan, usefulness of this system is proved.

Furthermore, because result of Social Reaction Experiment (once) and Social Learning Experiment conducted 5 times obtained the same result, mentally retarded children detection on this system was possible only by a single test.

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