Study on the Standardization of DE-Visual Sequential Memory Test (VSM)

—Part II. Validity and Reliability of the DE-VSM in Primary School Children—

Osamu SHOJI*, Akiko KAWAKAMI**, Mika SAKUMA**, Eri MURATA**
Ikuko SATO**, Keiko MARUYAMA**, Tadao MUKAI***, Yukio MUKAI**

Synopsis: The purpose of this study is to elucidate the validity and reliability of the DE-VSM in primary school children. This test was developed by the authors' research group as one of the screening tests for neurological disorders such as mental retardation, epilepsy and minimal brain dysfunction syndrome in school children.

The authors have already reported the standard value of DE-VSM by age and sex for the primary school children in part 1 of this study.

In this paper (part 2), we studied the validity and reliability of DE-VSM.

Subjects were 116 neuro-developmentally disordered school children (mental retardation 14, epilepsy 90, borderline 12), ranging from six to twelve years of age in M. Clinic.

The following methods were employed

1. To examine the validity of this test.
   Correlations between the DE-VSM and the Intelligence test, DE-Bender Gestalt Test, DE-Motor Function Test (DEMT), and the subtest of visual sequential memory in ITPA were determined.
2. To examine the reliability of this test.
   Correlations between the score of the initial test and the re-test was determined.
3. Effectiveness of this test was examined by comparing with other CNS developmental indices using the Ibaraki Index.

As a result of this study, we found that the DE-VSM has adequate validity and reliability.

Introduction

The authors' research group has been developing a new field of pediatrics and advocating "Developmental Neuro-epidemiology" (Mass Neuro-pediatrics). The group is concerned with various fields involving neuro-pediatric disorders including their prevention.

Developmental neuro-epidemiology is a new subspeciality in pediatrics and it applies Yamamoto's definition of epidemiology. He defined epidemiology as the science of determining

* Ryutsu Keizai University
** Institute of Developmental Epidemiology
*** Mito Clinic

the law governing the frequency and distribution of health phenomena in a population. The purpose of developmental neuro-epidemiology is not only to promote diagnosis and treatment of neuro-developmentally disordered children but also to maintain and promote neuro -developmental health in all children.

The authors have already published many papers concerning the simplified developmental tests which are the core of their research into developmental neuro-epidemiology.

Through detailed study, the authors conclude that the simple health indices have various functions. They function, not only as screening tests, but also as health indices of the child population.

The purpose of this study is to develop a new simplified visual sequential memory test (VSM) for school children. The visual sequential memory (the ability to reproduce sequences of non -meaningful figures from memory) is represented at the intersection of the organizing process, the visual-motor channel, and the automatic level. It is well-known that children who are diagnosed as having psycholinguistic learning disabilities often have visual sequential memory.

The authors reported the standard value of the DE-VSM in the population of primary school children in part 1 of this study.

In this paper the authors examine the validity and reliability of the DE-VSM for the same cross -section of school children.

Subjects and Method

The subjects in this study are neuro-developmentally disordered children aged 6-12 as shown in table 1. The total number of children is 116 (mental retardation 14, epilepsy 100 and borderline 12). Among 14 mentally retarded children 6 (42.1%) had an IQ of 55 or more, and 8 (57.1%) had an IQ of less than 55.

The Intelligence test used in this study was the New K-Intelligence test (KIT). Mentally

Table 1 **Subjects: Neuro-developmentally disordered children by age and sex**

Age / Sex	6		7		8		9		10		11		12		Total	
	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy	Girl
Mental retardation	0	0	2	0	0	2	3	1	0	2	2	1	0	1	7	7
Epilepsy IQ 85 or more	6	7	7	5	8	4	7	6	11	12	4	5	6	2	49	41
Borderline IQ 70−84	0	0	0	0	1	1	0	2	0	2	2	0	2	2	5	7
Total	6	7	9	5	9	7	10	9	11	16	8	6	8	5	61	55
	13		14		16		19		27		14		13		116	

1) Mental retardation with epilepsy are classified in Mental retardation
2) Borderline children with epilepsy are classified in Borderline

retarded children with epilepsy are classified as mental retardation in Table 1.

The term validity refers to whether or not the test is actually measuring what it purports to, and the term reliability refers to whether or not the test gives the same result when retested as that of the initial test (whether or not a different examiner can obtain the same result using the test).

In order to evaluate the validity and reliability of the test, following methods were employed.

1. The validity.

1) The correlation coefficient relating the DE-VSM score and the mental age (MA) of the KIT was determined.
2) The correlation coefficient relating DE-VSM score and the DE-Bender Gestalt Test score was determined.
3) The correlation coefficient relating DE-VSM score and the DEMT score was determined.
4) The correlation coefficient relating the DE-VSM score and the score of the subtests of visual sequential memory in ITPA was determined.
5) The false negative rate and validity score when using DE-VSM as the screening test for developmental disorders were examined.

2. The reliability.

The correlation between the score of the initial test and the re-test was determined.

3. Effectiveness was examined by comparing with other CNS developmental indices using the Ibaraki index.

Results and Discussion

1. The validity of DE-VSM

1) To evaluate the validity of this test, the authors initially determined the correlation coefficient relating the score of the DE-VSM and the mental age (MA) given by the New K-Intlligence test (KIT). (This is often used as a clinical individual test in the neuro-psychological field).

The authors considered that if there was good correlation between the results of the above two tests, it represented evidence for the validity of the DE-VSM.

The correlation coefficient relating the DE-VSM score and the MA of cognitive adjustment area of the new KIT was 0.78. The correlation coefficient relating the DE-VSM score and the MA of language and social area was 0.71 and that relating MA of the total area of the KIT and the score of this test was 0.77. There was good correlation between these two tests ($p<0.01$) as shown in table 2.

The authors administered the DE-VSM twice and the correlation coefficient relating the average score and the MA of the KIT were determined. The validity coefficient for the subjects (boy and girl) calculated using the above method was higher (boys were 0.81, girls were 0.80, Total was 0.81).

2) The Correlation coefficient relating the DE-VSM score and the DE-Bender Gestalt Test (BGT) score.

Table 2 Correlation coefficient relating the DE-VSM score and the mental age of the New K-Intelligence Test (KIT)

Sex	Boy			Girl			Total		
Area of KIT	Cog & Adap	L & S	A	Cog & Adap	L & S	A	Cog & Adap	L & S	A
Number of cases	111	111	111	102	102	102	213	213	213
correlation coefficient	** 0.75	** 0.70	** 0.75	** 0.82	** 0.72	** 0.79	** 0.78	** 0.71	** 0.77

** P<0.01
Cog.: Cognition Adap.: Adaptability
L.: Language S.: Sociability A.: All area

The original BGT consists of nine simple designs, each of which is presented to the subject for him to copy on a sheet of paper. Considerable literature exists documenting the use of this technique as visuo-motor test and it has been used as a clinical diagnostic tool. The test is evaluated by studying how the subject's reproductions deviate from the original designs.

It has been reported by many researchers that the test is effective to screen brain damaged children from normal children because the reproduction by brain damaged children shows greater deviation. Therefore the BGT is known as one of the individual clinical visuo-motor tests to aid diagnosis and it is useful for the prognosis management in the case of psycho-neurological patients.

The authors simplified the original BGT in order to apply it to a group of children. In our simplified test, which was named the DE-BGT, one examiner gave the test to 45 (or less) children simultaneously.

The authors have already reported the standard value, validity, and reliability for the DE-BGT for the children.

The correlation between the DE-VSM score and DE-BGT score was shown in table 3. The correlation coefficients relating these two tests were 0.61 for boys, 0.75 for girls, 0.68 was the total.

3) The correlation coefficient relating the DE-VSM score and the DEMT score.

The authors developed a simplified motor function test for children. This test consists of 9 test items and is one of the simplified developmental indices for central nervous system (CNS) function. We named this the "DE-Simplified Motor Function Test" (DEMT) for school children. Only 5-6 minutes are required to administer this test to each child.

The authors have reported the standard value, validity and reliability of the DEMT before.

Table 4 shows the correlation coefficients relating the DE-VSM score and the DEMT score. The correlation coefficients relating these two tests were 0.60 for boys, 0.72 for girls, 0.65 was the total.

Table 3 Correlation coefficient relating the DE-VSM score and DE-Bender Gestalt Test score

Sex	Boy	Girl	Total
Number of cases	124	102	226
Correlation coefficient	** −0.61	** −0.75	** −0.68

** P<0.01

Table 4 Correlation coefficient relating the DE-VSM score and the DEMT score

Sex	Boy	Girl	Total
Number of cases	124	102	226
Correlation coefficient	** 0.60	** 0.72	** 0.65

**P<0.01
DEMT: DE-Motor Function Test

4) The correlation coefficient relating the DE-VSM score and one of the subtests (visual sequential memory)of the ITPA.

The authors determined the correlation coefficient relating the DE-VSM score and the psycholinguistic age of visual sequential memory of the ITPA.

Table 5 shows that the correlation coefficients relating above these two tests were as follows: 0.64 for boys and 0.57 for girls.

The authors consider that a validity coefficient of around 0.6 is not so low considering that both of these tests are highly simplified.

In order to increase of the validity of the DE-VSM, the authors gave the test to the subjects twice and the average of the two test scores was made the final score for each child. Table 6 shows the correlation coefficients relating the mean score of the DE-VSM and the psycholinguistic age of ITPA. The correlation coefficients relating the two tests was 0.81 for the total.(table 6.)

The visual sequential memory test of ITPA is a simplified test and takes only five minutes to administer to each subject.

From the result of the four methods, the authors deduce that the DE-VSM is a valid test and

Table 5 Correlation coefficient relating the DE-VSM score and the psycholinguistic age by ITPA

Sex	Boy	Girl
Number of Cases	51	49
Correlation Coefficient	** 0.64	** 0.57

**P<0.01
ITPA: Illinois Test of Psycholinguistic Abilities

Table 6 Correlation coefficient relating mean score (two times)of the DE-VSM and psycholinguistic age by the ITPA

Sex	Boy	Girl	Total
Number of Cases	54	47	101
Correlation Coefficient	** 0.81	** 0.82	** 0.81

**P<0.01

that the DE-VSM is suitable for use as a simplified CNS function test to screen neuro-developmentally disordered children.

5) The false negative rate and validity score when using the DE-VSM as a screening test for developmental disorders.

Table 7 shows the changing percentile of false negative rate and validity score when the screening level is shifted to various levels in case of using DE-VSM as a screening test for neuro-developmentally disordered children.

When the screening level is placed at the level of 97.7%ile (M-2.0 S. D.) the validity score of mental retardation was 83.4. In order to screen the neuro-developmentally disordered from general population using a simplified test, the false negative (FN) and false positive (FP) should be carefully monitored because these two indices exhibit a seasaw-like relationship. (see Fig.1) The lower the false negative rate is, the higher the false positive is, and vice versa. On the other hand, validity score is determined using the following formula.

Validity score (%)=100 − (FN+FP)

This evaluation method showed a high validity score for mentally retarded children and thus the DE-VSM is effective to screen the neuro-developmentally disorders.

2. The reliability of the DE-VSM

To evaluate the reliability of the DE-VSM, the authors determined the correlation coefficient relating the scores of the initial test and the retest (the period of time between the initial test and the retest was less than one month).

This evaluation showed a high reliability coefficient both for the same examiner 0.9 and when retested by the different examiner 0.84 (see table 8).

Table 9 shows the reliability coefficients by age and sex of the DE-VSM. The older age group showed higher coefficients than the younger ones, but there were no significant differences.

In comparison between boys and girls, the girls showed a higher coefficient than boys, but there were no significant differences between them either. The total reliability coefficient of 0.82 however suggests that the DE-VSM has reliable reproducibility for use as a screening test for neuro-developmentally disordered children.

The simplified group test is considerably inferior to the individual clinical test as far as validity is concerned, but the reliability coefficient should be higher than the individual test or at least the same level as a clinical test, because the lower reliability coefficient of the simplified test means that it can not be used as an index for the school health diagnosis and community child health diagnosis.

Table 7 Changing percentile of false negative rate and validity score when the screening level is shifted to various levels

——In case of using DE-VSM as a screening test for the developmental disorders——

screening level	Mental retardation (N=14)				Borderline Children (N=13)			
	Number of "Pass"	FN (%)	S (%)	VS (%)	Number of "Pass"	FN (%)	S (%)	VS (%)
M−0S. D. 50%ile	0	0	100	50.0	0	0	100	50.0
M−0.5S. D. 69.1%ile	0	0	100	69.1	1	7.7	92.3	61.4
M−1.0S. D. 84.1%ile	0	0	100	84.1	5	38.5	61.5	45.9
M−1.5S. D. 93.3%ile	2	14.3	85.7	79.0	9	69.2	30.8	24.1
M−2.0S. D. 97.7%ile	2	14.3	85.7	83.4	9	69.2	30.8	28.5

FN: False negative
S: Sensitivity
VS: Validity score

3. The evaluation of effectiveness of the DE-VSM as a neuro-developmental index by means of the Ibaraki Index value.

The authors research group has been advocating the Ibaraki Index for many years. It is easy to see that developmental indices with small dispersions are likely to be effective indices of development, but it is not always a simple matter to compare directly the dispersions in the measured values of two or more analogous indices, because of different units which are used to express them. The authors considered it necessary to stipulate that the Ibaraki Index should be an abstract number. This is essential for an index which is to show relative evaluations of the effectiveness of two or more analogous developmental indices which are expressed in different units.

The Ibaraki Index is applicable not only to developmental indices, which are ratio scales, but

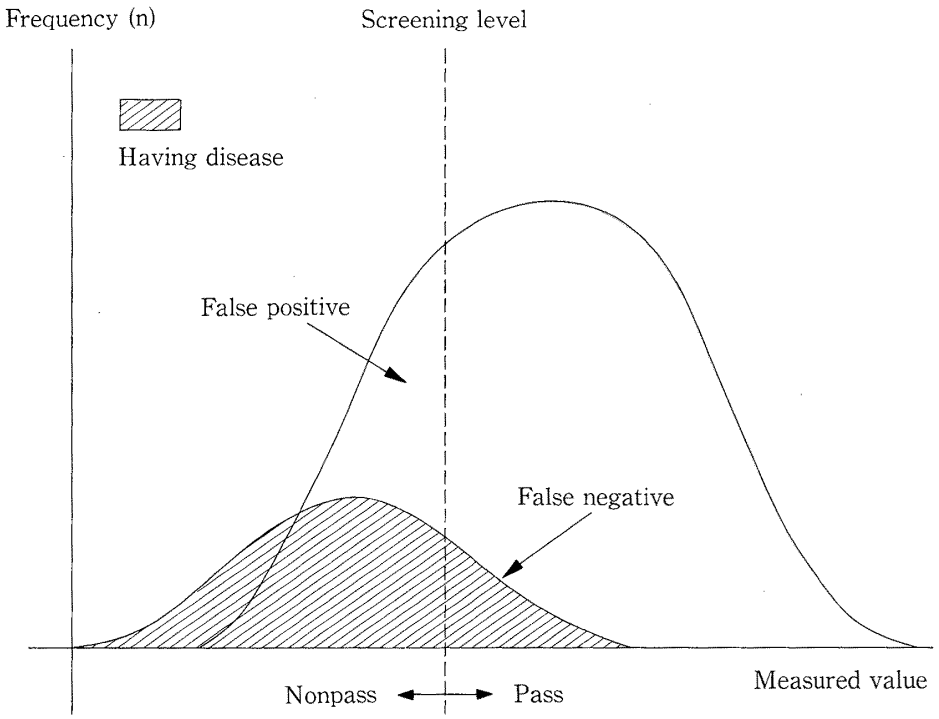

Fig. 1 The relationship between screening level and false negative rate or false positive rate

Table 8 Reliability coefficient of the DE-VSM for primary school children when retested by the same examiner or different examiners

Examiner	Same examiner	Different examiners	Total Cases
Number of Cases	39	53	92
Correlation Coefficient	** 0.79	** 0.84	** 0.82

**P<0.01

Table 9 Reliability coefficient by age and sex of the DE-VSM for primary school children

	Age and sex				Sex		Total
Subjects	6~8		9~12		Boy	Girl	
	Boy	Girl	Boy	Girl			
Number of Cases	14	16	32	30	46	46	92
Reliability Coefficient	** 0.63	** 0.70	** 0.81	** 0.83	** 0.79	** 0.84	** 0.82

**P<0.01

also to those which are interval scales. It is expressed by the following formula:

$$\text{Ibaraki Index} = \frac{\text{V (mean developmental velocity by age)}}{\text{SD (standard deviation of the measured value by age)}}$$

The higher the Ibaraki Index of the developmental index is, the more effective the developmental index is.

Table 10-1 and table 10-2 show that the Ibaraki index value of the DE-VSM is at the same level as those of other neuro-developmental indices for primary school children. The Ibaraki Index value for the DE-VSM therefore indicated that it had the same level of effectiveness as the DE-BGT, DEMT, and the frequency analysis value of occipital basic rhythm in EEG.

In conclusion, this study proved that the DE-VSM was a valid and reliable simplified test for screening neuro-developmentally disordered children.

Table 10－1 Ibaraki Index Value of neuro-developmental indices for primary school children

Tests (Developmental Indices) \ Age	sex	6	7	8	9	10	11
DE－Visual Sequential Memory Test (DE－VSM)	Boy		0.45	0.49	0.61	0.46	0.48
	Girl		0.84	0.82	0.74	0.70	0.15
Frequency analysis value of Occipital basic rhythm (α rhythm)		0.36	0.33	0.31	0.17	0.20	0.23
TB－Intelligence Test		0.88	0.88	0.65	0.78	0.85	0.75
ITPA		1.59	1.77				
Head Circumference	Boy	0.27	0.03	0.15	0.24	0.19	0.30
	Girl	0.23	0.29	0.17	0.18	0.25	0.39

Table 10－2 Ibaraki Index Value of neuro-developmental indices for primary school children

Tests (Developmental Indices) \ Age	sex	7	8	9	10	11
DE－Visual Sequential Momory Test (DE－VSM)	Boy	0.45	0.49	0.61	0.46	0.48
	Girl	0.84	0.82	0.74	0.70	0.15
DE－Bender Gestalt Test (DE－BGT)	Boy	0.88	0.64	0.39	0.29	0.33
	Girl	0.73	0.56	0.31	0.32	0.39
DE－Motor Function Test (DEMT)	Boy	0.82	0.50	0.67	0.44	0.14
	Girl	0.73	0.63	0.57	0.20	0.27

References

1. Mukai Y. : Proposal of Developmental Epidemiology, Jap. J. of School Health, Vol. 25 No.5 pp165-168, 1983.
2. Mukai Y. : Development of School Health for Minimal Symptoms, J. of School Health, Vol.30,4, pp162-168, 1988.
3. Ono E., Mukai Y. et al: Study on a Simplified Motor Function Test for High School Students, The Standard Value of DEMT for High School Students Jap. J. of School Health, Vol.23,6, pp286-294,1981.
4. Hashimoto Y., Mukai Y. et al: Study on a Simplified Motor Function Test, The Validity and Reliability of DEMT for High School Students, Jap. J. of School Health, Vol.23,6, pp444-450m, 1981.
5. Mukai Y. : Manual of MN-Developmental Screening Test, with Special Reference to Developmental Neuro-epidemiology, New Medical Sha, Mito, pp8-118,1982.
6. Kawakita E., Mukai Y, et al :DE-Bender Gestalt Test (BGT) for High School Students, Standard Value of DE-BGT, J. of Ibaraki Univ. Education Faculty, Vol. 28, 3, pp97-110, 1979.
7. Hashimoto Y., Mukai Y. et al : DE-BGT for High School Students, Validity and Reliability of DE-BGT, J. of Ibaraki Univ. Education Faculty, Vol. 28, pp111-122, 1979.
8. Shoji O., Onuma J., Mukai Y. et al : Study of the Simplified Motor Function Test for Children, Standard Value of DEMT for Children Aged 3-6, J. of Ryutsu Keizai Univ., Vol.25,2, pp27-39, 1990.
9. Shoji O., Kitami R., Mukai Y. et al : Study of the Simplified Motor Function Test for Children, Validity and Reliability of DE-BGT for Children Aged 3-6, J. of Ryutsu Keizai Univ., Vol.25,3, pp39-50, 1990.
10. Shoji O., Sumita C., Mukai Y. : Study of the Cause of Insufficient Predictive Validity of Developmental Tests, J. of Ryutsu Keizai Univ., Vol.25,3, pp39-50, 1990.
11. Shoji O., Suzuki N., Mukai Y. : Proposal of a New Method in the Prognostic Study of Neuro-pediatric Disorders, J. of Ryutsu Keizai Univ., Vol.26,1, pp11-18, 1991.
12. Shoji O., Kikuchi E., Mukai Y. : Developmental Neuro-Epidemiologic Study on Criteria of Normal High School Students, J. of Ryutsu Keizai Univ., Vol.26,2, pp30-40, 1991.
13. Shoji O., Ando C., Mukai Y., Standard Value of the DE-Bender Gestalt Test in Primary School Children, J. of Ryutsu Keizai Univ., Vol.27,1, pp17-29, 1992.
14. Ikuzawa M., Manual of New K-Developmental Test, Nakanishiya Shuppan,1985
15. Kirk S. A., McCarthy J. J., Kirk W. D., Examiner's Manual Illinois Test of Psycholinguistic Abilities Revised Edition (translated in Japanese) Nihon Bunka Kagakusha, Tokyo Japan 1968.
16. Kirk S. A., Kirk W. D., Psycholinguistic Learning Disabilities: Diagnosis and remediation. University of Illinois Press Chicago,1971.
17. Shoji O., Mukai Y., et al: Study on the Standardization of De-Visual Sequential Memory Test (VSM), Standard Value of the DE-VSM in the Primary school children, J. of Ryutsu Keizai Univ., Vol.28,2, pp73-84, 1993.