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A Study of Executive Functions in Delinquents with Developmental Disabilities within a Japanese Reformatory

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Many attempts have been made to address the relation between antisocial behavior and executive function deficits. The purpose of this paper is to evaluate executive functions in juvenile delinquents with developmental disabilities by using the Behavioral Assessment of the Dysexecutive Syndrome (BADS), and then cross referencing this to their performance on Wechsler IQ Test, Das Naglieri Cognitive Assessment System (DN-CAS), and Rey's Auditory Verbal Learning Test (AVLT). The data was collected from 164 participants with Mental Retardation (MR), Pervasive Developmental Disorder (PDD), and Attention Deficit-Hyperactivity Disorder (ADHD), and a factor analysis was applied to results of the BADS. Two factors were extracted from the results; one factor was interpreted as low-degree of freedom executive ability (LDF-EA) and the other factor as high-degree of freedom executive ability (HDF-EA). There was no difference in IQ-matched groups with MR, ADHD and PDD, or in either factor in age- and IQ-matched groups with ADHD and PDD. While both factors had correlations with IQ and AVLT, where subjects were confined to MR, the HDF-EA had no correlation. Neither factor showed correlation with the DN-CAS performance. Moreover, scores of the LDF-EA increased associated with increases in IQ levels, however, scores of the HDF-EA appeared broadly unrelated to IQ points. The results suggested that the HDF-EA could be interpreted as a different level of executive functions compared to the LDF-EA. It is difficult to evaluate executive abilities by using only IQ testing, and the BADS would be useful to assess the level of high-degree of freedom executive functions.

INTRODUCTION

Executive functions, which involve sustaining attention and concentration, planning, reasoning and working memory, have been suggested to play an important role in human activities. Executive control is essential for success in goal-directed behavior, and is related to planning activities and social problem solving in everyday life. One might therefore infer that in everyday life, executive function impairments would interfere with social functioning and quality of life. Various neuropsychological tests to assess aspects of executive function have recently been developed. The Wisconsin Card Sorting Test, Modified Stroop test, and Tower of Hanoi are commonly used tests, but are not sufficiently sensitive to adaptive life skills in real-world settings. The Behavioural Assessment of the Dysexecutive Syndrome (BADS), which is a neuropsychological battery of cognitive flexibility tests, developed by Wilson, Alderman, Burgess, Emslie, and Evans (1996) was adapted into a Japanese BADS in 2003. The BADS presents the subject with a series of unstructured tasks that are designed to simulate real life situations.

In Japanese juvenile reformatories, treatment corresponding to individual needs has just begun to be conducted (individualization of treatment), paying full consideration to each person's personality, good points, future plans, physical and mental conditions, and delinquent tendencies. The juvenile reformatory in this study is categorized as a facility providing special education programs for delinquents with developmental disabilities such as Mental Retardation (MR), Learning Disorders (LD), Pervasive Developmental Disorder (PDD), and Attention Deficit-Hyperactivity Disorder (ADHD).

A number of studies over the years have been conducted on executive function deficits in MR, PDD and ADHD. Zelazo, Carter, Reznick, and Frye (1997) stated that the executive function is a basis with which we can solve the problems. Many delinquents with developmental disabilities commit crimes or misdemeanors due to inappropriate problem solving skills in various problem situations. Moffitt (1993) says that the results of

neuropsychological tests in relation to executive functions are obviously related to seriousness of delinquency.

While enhancement of guidance and support for employment is indispensable in order to prevent repeating delinquency/offenses and to promote rehabilitation, problem solving skills could positively affect opportunities for future employment, employee retention rate and levels of recidivism. It is necessary for inmates to improve problem solving abilities, but before this can take place, appropriate reliable assessment of their problem solving skills (that is executive functions) are essential towards educating inmates not to repeat delinquency. Intelligent functions of delinquents incarcerated in Japanese reformatories are mainly assessed with Wechsler IQ Test in the juvenile classification home. However it might be difficult or even impossible to assess their abilities solely by their IQ; in cases where subjects with the same IQ levels have different levels of problem solving skills.

The purpose of the present study is to investigate features of executive functions in juvenile delinquents incarcerated with developmental disabilities, to investigate the relationships of the BADS to age, diagnosis, and IQ, to investigate the relationship between the BADS and other tests, to investigate the applicability of the BADS using factor analysis of the BADS.

METHODS

Participants

One hundred sixty four juvenile delinquents (age range = 13–19 years, mean age = 16.6, SD = 1.8; 100% boys) incarcerated in Reformatory 'M' with developmental disabilities were selected in all inmates admitted during the past two years. Participants were diagnosed by qualified psychiatrists in the juvenile classification home. Ninety four subjects met DSM-IV-TR (American Psychiatric Association, 2000) criteria for MR (mean age = 16.8, SD = 1.7; mean IQ = 61.5, SD = 6.3; IQ range = 42-69), forty participants met the DSM-IV-TR criteria for PDD (mean age = 16.7, SD = 1.8; mean IQ = 85.1, SD = 16.2; IQ range = 71-114), and thirty participants met the DSM-IV-TR criteria for ADHD (mean age = 15.9, SD = 1.7; mean IQ = 85.7, SD = 12.0; IQ range = 69-114). The present study was approved by the ethical committee of Reformatory 'M'. All participants' names were coded through data collection and analysis so that individuals could not be identified. All participants were informed that they could discontinue testing at any time and that under no circumstances would disadvantages occur, whatever the test results indicated.

Measures

All participants were assessed with WAIS-III (Wechsler, 1997) or WISC-III (Wechsler, 1991) test (mean IQ = 71.8, SD = 15.9; IQ range = 42–114) in the juvenile classification home and tested with the BADS and Rey's auditory verbal learning test (AVLT) in the facility. Additionally, 50 participants who were selected randomly among MR group from 13 to 17 year-old were tested with the Das Naglieri Cognitive Assessment System (DN-CAS). Participants were given verbal assurances that under no circumstances would disadvantages occur, whatever the test results indicated.

Behavioural Assessment of the Dysexecutive Syndrome (BADS)

The BADS was designed to assess executive deficits in a way that reflects the difficulties such patients have in daily life (Wilson et al., 1996). The BADS consists of six tests. The Rule Shift Cards Test, the Action Program Test, the Key Search Test, the Temporal Judgement Test, Zoo Map Test, and the Modified Six elements Test. For each of the tasks, a summary profile score is obtained (range 0-4) and these are summed up to obtain a total

profile score (maximum 24). The English version was adapted into a Japanese BADS in 2003.

Das Naglieri Cognitive Assessment System (DN-CAS)

The DN-CAS is organized into four Scales representing the PASS (Planning, Attention, Simultaneous and Successive) theory of cognitive function (Das, Naglieri, & Kirby, 1994). The PASS theory is based on the views of Luria, whose insights linking brain anatomy and function are fundamental to neuropsychology (Luria, 1976). The DN-CAS evaluates Planning, Attention, Simultaneous, and Successive cognitive processes of individuals. Each of the four PASS scales is comprised of three subtests. These composite scales and the Full Scale score are reported as standard scores with a mean of 100 and SD of 15. The English version was adapted into a Japanese CAS in 2007.

Rey's Auditory Verbal Learning Test (AVLT)

The AVLT requires the free recall of the same list of 15 unrelated words (Rey, 1964). Participants are given a list of 15 unrelated words repeated over five different trials and are asked to repeat. In the present study, the total number of words recalled from the acquisition phase (trial I-V) was used as AVLT score. Scores vary from 0 to 75.

RESULTS

Table I presents mean scores and standard deviations of three groups (MR, PDD and ADHD) on all tests. A principal factors analysis using promax rotation was carried out with the scores from six tests of the BADS (Table II). Two factors emerged with factor loadings in excess of .35, eigenvalues in excess of 1.00, accounting for 50.76% of the total variance.

Table I. Mean scores and standard deviations of the BADS, AVLT, the DN-CAS for MR, PDD and ADHD group

	MR			PDD			ADHD		
	n	Mean	SD	n	Mean	SD	n	Mean	SD
BADS									
Rule shift cards	94	2.5	1.2	40	3.2	0.9	30	3.1	0.9
Action program	94	2.2	1.2	40	3.2	0.9	30	2.7	1.0
Key search	94	1.7	1.3	40	2.6	1.2	30	2.5	1.3
Temporal judgement	94	2.1	1.1	40	2.8	0.8	30	2.5	0.9
Zoo map	94	2.1	0.9	40	2.6	1.1	30	2.7	1.0
Modified six elements	94	2.5	1.4	40	3.1	1.3	30	2.9	1.3
BADS profie score	94	13.1	3.7	40	17.5	3.4	30	16.3	3.6
AVLT	94	38.0	9.8	40	45.9	10.8	30	45.8	9.5
DN-CAS									
Total score	50	55.0	11.7						
Planning	50	65.6	14.3						
Simultaneous	50	60.7	9.5						
Attention	50	71.4	14.3						
Successive	50	65.9	13.8						

Table II. Rotated factor matrix (Promax rotation) from principal factors analysis of tests of the BADS

Scale	**Factor 1**	**Factor 2**
Rule shift cards	**.55**	- .06
Temporal judgement	**.53**	- .11
Zoo map	**.42**	.02
Action program	**.42**	.19
Modified six elements	- .15	**.60**
Key search	.23	**.40**

Note. Factor loadings > .35 are in boldface.

Scores from The Rule Shift Cards Test, the Action Program Test, the Temporal Judgement Test and Zoo Map Test loaded highly on the Factor 1. Scores from the Modified Six elements Test and the Key Search Test loaded highly on the Factor 2. Spearman correlations between two factors' total scores and performance on the IQ, AVLT and the DN-CAS are presented in Table III. The score for factor 1 moderately correlated with IQ and AVLT, but the score for factor 2 only weakly or moderately correlated. Although principal factor analysis was carried out in each group with MR, PDD and ADHD, the same two factors did not emerge. Therefore we examined correlations within the limits of the MR group using two factors derived from all participants. The score for factor 1 moderately correlated with IQ and AVLT, but the score for factor 2 did not correlate. Similarly, neither factor significantly correlated with the DN-CAS. Meanwhile there were mild to moderate correlations between IQ and both factors among the PDD and ADHD groups (PDD; factor 1: r = .65**, factor 2: r = .37*, ADHD; factor 1: r = .422*, factor 2: r = .32*, **: P < .01, *: P < .05).

Table III. Bivariate Correlations between two factors and IQ, AVLT and the DN-CAS

	All (n=164)		MR (n=94)	
	F1	F2	F1	F2
F1	-	.34**	-	.15
F2	.34**	-	.15	-
IQ	.63**	.40**	.64**	.20
AVLT	.47**	.24**	.42**	.17
DN-CAS			MR (n=50)	
Total score			.30	.21
Planning			.29	.09
Simultaneous			.31	.19
Attention			.25	.23
Successive			.30	.28

F1: Factor 1, F2: Factor 2 **: p <.01

Effect of Age

To examine the effect of age on the MR group, the PDD group and the ADHD group in both factors, three diagnosis groups were split into three age subgroups (13-15 years, 16-18 years, over 19 years; Table IV). There were no age-group differences on IQ in the MR group. An analyses of variance (ANOVA) with age group (three levels) as between-subject factor were conducted, but none of the group effects were significant in either factor (Factor 1: F(2, 91) = .208, p = .813, Factor 2: F(2, 91) = .017, p = .983).

There were no age-group differences on IQ in the PDD group. An ANOVA with age group as between-subject factors were conducted, but none of the group effects were significant in either factor (Factor 1: F(2, 37) = .674, p = .516, Factor 2: F(2, 37) = 1.262, p = .295). Since the sample of over-19 years is very small (n = 4) in the ADHD group, we examined only two age groups (13-15 years and 16-18 years). There were no age-group differences on IQ in the ADHD group. Therefore t-test was carried out for the two groups, but neither groups differed significantly from each other (Factor 1: t(24) = .043, p = .966, Factor 2: t(24) = .1.539, p = .137).

Table IV. Mean scores and standard deviations of IQ, F1, F2 factor for MR, PDD and ADHD group in each age-range

	age range	n	IQ (SD)	F1 (SD)	F2 (SD)
MR	age 13-15	20	62.2 (7.7)	8.6 (2.7)	4.2 (2.3)
	age 16-18	52	61.2 (5.9)	8.8 (2.8)	4.2 (2.0)
	age 19	22	62.2 (6.1)	9.2 (2.9)	4.1 (1.9)
PDD	age 13-15	12	83.2 (16.8)	10.9 (2.2)	4.6 (2.3)
	age 16-18	18	86.0 (15.3)	11.3 (2.0)	5.8 (1.7)
	age 19	10	85.8 (18.6)	10.3 (2.4)	5.6 (2.4)
ADHD	age 13-15	14	86.3 (15.4)	11.7 (2.6)	5.0 (2.1)
	age 16-18	12	84.3 (8.2)	11.8 (1.3)	6.3 (2.0)
	age 19	4	78.3 (8.5)	11.8 (2.5)	6.8 (1.5)

Note. There were no significant differences in IQ-matched groups with MR, ADHD and PDD

Effect of IQ

To examine the effect of IQ in both factors, all participants were split into four IQ groups ([1 : -59], [2 : 60-69], [3 : 70-84], [4 : 85-]) and presents in Table V. An ANOVA with IQ group as between-subject factors were conducted. The ANOVA scores resulted in a main effect significantly in both factors (Factor 1: $F(3,160) = 33.20$, $p < .01$, Factor 2: $F(3,160) = 8.79$, $p < .01$; Table V). Post hoc comparisons using Scheffe tests showed that the mean score of Factor 1 was larger in [4 : 85-] than in [2 : 60-69], [3 : 70-84], and larger in [2 : 60-69], [3 : 70-84] than in [1 : -59], the mean score of Factor 2 was larger in [4 : 85-] than in [1 : -59], [2 : 60-69].

Table V. Mean scores and standard deviations of F1, F2 factor in each IQ-range

IQ range	n	F1 (SD)		F2 (SD)	
1 : -59	33	7.1 (2.6)	**	4.0 (2.4)	++
2 : 60-69	62	9.7 (2.4)		4.2 (1.9)	
3 : 70-84	40	10.6 (1.7)	**	5.2 (1.8)	++
4 : 85-	29	12.5 (1.9)		6.2 (2.1)	

** : Significantly different from [2: 60-69], [3: 70-84] ($p < .01$)
++ : Significantly different from [4: 85-] ($p < .01$)

The difference between the PDD group and the ADHD group

We examined the difference between the PDD group and the ADHD group within the age range of 13–15 and 16-18 in both factors. There was no difference in IQ between the two groups. Therefore t-test was carried out with age group as between-subject factors, but neither group differed significantly from each other (Factor 1: $t(54) = 1.093$, $p = .279$, Factor 2: $t(54) = .500$, $p = .619$).

DISCUSSION

The Rule Shift Cards Test, the Action Program Test, the Temporal Judgement Test and Zoo Map Test, which were loaded highly on Factor 1, are tasks of executive function where

a clear goal and the solving process are constructed under the rules with a comparatively low degree of freedom. While the Modified Six elements Test and the Key Search Test, which were loaded highly on Factor 2, are tasks of executive function where the goal and rules are presented, but there are many means to the same end. The degree of freedom in Factor 2 is relatively higher than in Factor 1, furthermore, participants are specifically required to have the ability to monitor and evaluate their own performance. There are two types of tasks in evaluating executive functions. One type are low degree of freedom tasks which are well-defined problems with a clearly defined problem area, and the other type are high degree of freedom tasks which required unstructured planning, initiation, or organizational skills in a real daily life situation. Factor 1, which is considered to be similar in function to the former, was interpreted as low-degree of freedom executive ability (LDF-EA), Factor 2 similar to the latter as high-degree of freedom executive ability (HDF-EA).

There were no significant differences in age-group matched for diagnosis and IQ in either factor. Concerning age-related changes in executive function among teenagers, there was a study of 208 children, aged 8-15 years, using the BADS-C (Behavioural Assessment of the Dysexecutive Syndrome for Children), which is an adaptation of the BADS designed for adults (Yegera, Josmana, and Rosenbluma, 2009). According to this study, while the 10-11 years and 11 months age group achieved significantly higher scores than 8-9 years and 11 months age group, no significant differences were found between the 10-11 years and 11 months and 12-15 age groups. Ozonoff et al. (2004) showed no significant differences between age groups (under 12 years, 12-19 years, and 20 years and over) on the Stocking of Cambridge from CANTAB (Cambridge Neuropsychological Test Automated Battery) in the ASD (Autism Spectrum Disorders) group, included 79 participants with a wide age range (6-47 years) and IQ range (71-142 points).

Besides changes in cognitive functions of participants without developmental disorders in four age groups (7-, 11-, 15-, and 21-years olds) were examined in Working Memory, Shifting, and Inhibition of responses, the Wisconsin Card Sorting Test (WCST), and the Tower of London (ToL) (Huizinga, Dolan & Van der Molen, 2006). The study showed that Working Memory, Shifting and Inhibition (with the exception of one sub-test) reached adult levels between 11 and 15 years, and while the performance on the WCST and the ToL reached adult levels between 11 and 21 years, on some sub-tests adult levels were attained by 15 years. Kobayashi and Kobayashi (2007) also presented that no significant differences in six sub-tests of the BADS Japanese version between 14 years (n=18) and 20-22 years (n=10). The result of the present study that age-related changes in executive function could not be found in juvenile matched on IQ is consistent with these previous studies. Problem-solving training is conducted for inmates in the facility, it has actually been observed in the training that older participants' problem-solving skills are similar to younger ones.

There have been various and consistent reports of relation between IQ scores and executive functions. Wood and Liossi (2007) explored the relationship between general intelligence (measured by WAIS-III) and Zoo Map and Key Search sub-tests from the BADS battery in a sample of 118 severely brain injured individuals, and reported that modest correlations (0.31–0.41) were found. Meanwhile, another study with 40 people with intellectual disability carried out using the BADS-C and the Cambridge Executive Functioning Assessment (CEFA) found no relation between WASI (Wechsler Abbreviated Scale of Intelligence) and the BADS-C (Willner, Bailey, Parry, and Dymond, 2010).

In the present study there was a significant difference between IQ and two factors, while the correlation between IQ and the LDF-EA was .63, the one between IQ and the HDF-EA was .40. The LDF-EA can be interpreted as more elementary cognitive functions on the

grounds that scores of the LDF-EA increased associated with increases in IQ levels (see Figure 1). On the other hand, scores of the HDF-EA were broadly unrelated to IQ points, although IQ-group: [4 : 85-] indicated scores higher than other two IQ-groups ([1 : -59] and [2 : 60-69]) (Table V). Therefore, the HDF-EA and the LDF-EA can be interpreted as different level of executive functions.

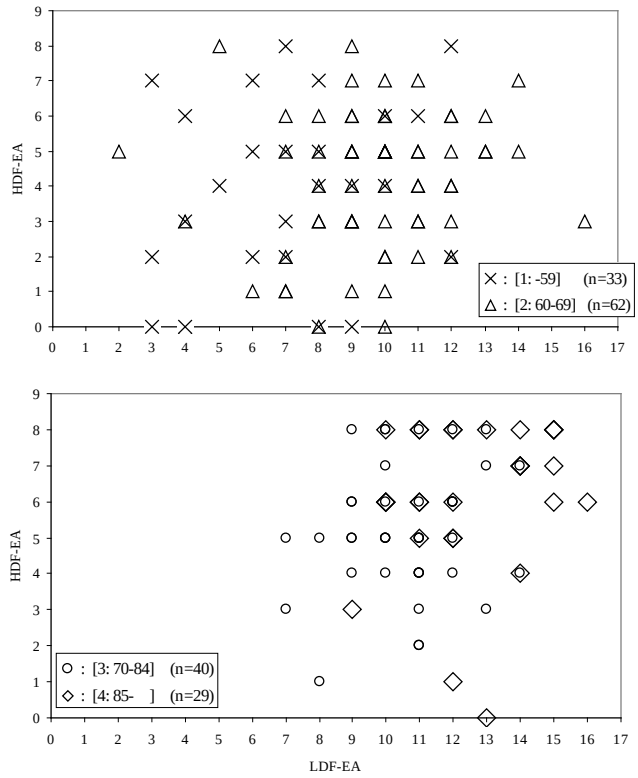

Figure 1. Plot of both scores (the LDF-EA and the HDF-EA) by each IQ-range. Above figure shows IQ-group: [1 : -59] and [2 : 60-69], below figure shows IQ-group: [3 : 70-84] and [4 : 85-]. Scores of the LDF-EA increased associated with increases in IQ-ranges. On the other hand, scores of the HDF-EA indicated variously unrelated to IQ-ranges.

Several studies have proposed a multiple dimensional theoretical model for executive function. Sohlberg and Mateer (2001) described a clinically useful framework of frontal lobe functions, based on the premise that there is a hierarchy of interrelated independent functions. They described sensation and basic knowledge as the lowest part of the hierarchy, executive functions as the middle component, and self-reflectiveness as the highest component. When contrasting our findings with the model by Sohlberg and Mateer, it is likely that the LDF-EA corresponds to the concept of the middle component, and the HDF-EA corresponds to the concept of the highest component. That is, the HDF-EA is a set of abilities which can execute and correct a plan at any time while evaluating the result, and it is thought that the HDF-EA includes not only abilities to execute what was ordered, but to also act “voluntarily and creatively” involving self-monitoring. It is in these terms of “voluntarily and creatively” that the HDF-EA is supposed to be more highly functioning than the LDF-EA. Amongst tests

examining executive function, the 'Tinker toy test', which Lezak (1995) devised, involves high degree of freedom tasks, therefore it is expected that there is a strong correlation with the HDF-EA (Harada et al, 2008). In a previous research paper on hierarchy of executive functions, factor analysis of the BADS in 65 brain-injured patients produced two factors (action planning ability and estimating ability) and authors suggested a possible hierarchy of both factors in which the estimating ability is higher cognitive function than action planning ability (Youine, Karinaga, Yamamoto, Yagi, and Tanemura, 2009). Different factors were extracted, but from this study it is thought that the estimating ability to execute tasks having a higher degree of freedom is a higher set of cognitive functions.

This study showed correlations between the LDF-EA and IQ scores among adolescents with MR, hence, the Wechsler Intelligence Scale seemed to be a valid measure of low-degree of freedom problem-solving abilities among them, but showed no correlation between HDF-EA and IQ scores, it was found to be a difficult to assess high-degree of freedom problem-solving abilities by using Wechsler Intelligence Scale. There are quite a few good problem solvers who have low IQ scores within the facility. These cases highlight the difficulty in assessing high-degree of freedom executive abilities by using only IQ testing.

The current study did not demonstrate significant correlations between the DN-CAS performance or either factor among MR group. Notably, the Planning subtests of the Basic Battery of the DN-CAS showed no correlation with either factor. Although the Planning process is closely related to executive functions and involves control of Attention, Simultaneous, and Successive processes, the Planning of the DN-CAS may be different from executive functions assessed by the BADS designed to be sensitive to "everyday" skills in people with a diagnosis of MR.

It follows from this study that it is difficult to predict high-degree of freedom executive abilities in people with MR using various IQ tests including the Wechsler Intelligence Scale and the DN-CAS. It is also suggested that people with MR who have higher executive abilities than their IQ level exist. Juvenile delinquents such as our inmates may have been diagnosed as having mental retardation due to external factors such as negative environments with stimulus deprivation and/or failure to obtain adequate special educational services. In such cases it is thought that higher executive abilities have a low relation to negative environmental causes. On the other hand, the correlation between IQ and both factors were significant in the PDD and ADHD groups. When IQ is more than a constant value like the participants in the PDD and ADHD groups, it is thought that the influence of negative environmental causes on intelligence is low. Therefore the Wechsler Intelligence Scale could predict degrees of freedom of executive abilities of in these groups.

In the current study no difference between the PDD group and the ADHD group of either factor was found. Another study (Happe, Booth, Charlton, and Hughes, 2006) compared age- and IQ-matched groups (aged 8 to 18) with ASD and ADHD on a battery of executive function tasks. In the study the ADHD group showed greater inhibitory problems on a Go-no-Go task than the ASD group. Meanwhile, this study showed the PDD group and the ADHD group did not differ in either factor in six subtests of the BADS, and there was a difficulty in making distinctions between both groups using the BADS. The reason why the same two factors did not emerge, even though additional principal factor analysis was carried out in each groups with MR, PDD and ADHD, may be that the sample number was too low.

Numerous attempts have been made to show the relation between antisocial behavior and executive functioning deficits. Understanding executive functions is indispensable in order to prevent repeating delinquency/offenses and to promote rehabilitation. We would be able to render assessments for juvenile delinquents more objective by adding executive function

tasks like the BADS to IQ testing; knowing which level of problem solving they have felt difficulty in school, daily life or on the job. Taking these results into consideration; further appropriate support for juvenile delinquents will obviously be necessary in the future.

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