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Mastermind Despite Specific Learning Disabilities?

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1. Introduction

Efforts towards defining, conceptually and diagnostically, specific performance disturbances that are present despite at least average intelligence, have found their expression in a wealth of varying definitions and explanation concepts (cf. Johnson & Myklebust 1971, Berger 1977). In more recent literature, a suitable description is seen in the concept of the *specific learning disability* (SLD, plural SLDs) that has reference to the localization of the discrepancy between the general performance prerequisites and performance disturbances in the single areas. General specific performance deficits with a presence of general efficiency at the same time are understood here as specific learning disabilities (SLDs). With this concept, the close localization of specific functional disturbances with a presence of an efficiency of other psychic functions is emphasized. Disturbances are analysed symptom-orientatedly within this framework, the description of the disturbance suffices without the implication of the requirement of an explanation. A prerequisite for the diagnosis is that the development of the respective - disturbed - skill and/or function is affected from the early stages of development onwards vithout an absence of opportunities to learn having played a role, without reduced intelligence being in existence and without there having been a cause through brain damage in early childhood or massive outer factors present (cf. DSM III-R; American Psychiatric Association 1987).

No references to content and extent of SLD and its diagnostics are given with this unspecific definition. The possibility of diagnosing each form of learning disability and efficiency decrease as a SLD remains where the above mentioned conditions are present. Subsequently, there also came into being various approaches to the classification of SLD.

In the *psychiatric classification schemata* part performance disturbances are extensively defined as localized development lags that come into view, above all, in the insufficient mastering of school demands. In particular, for example, the following disturbances from the DSM III-R (Axis 2) are named:

- specific developmental disturbances of speech and language
- specific developmental disturbances in school accomplishments
- specific developmental disturbances of motor functions.

According to Schmidt (1988), the disadvantage of such a general classification, in which merely complex efficiency disturbances are taken into consideration, lies in the fact that the main categories are not completely independent of one another as, for example, pathogenetic connections are not taken into consideration in the course of development. Related to school achievement, merely the result of the disturbance is named in this classification so that the manifold and varying SLDs that have contributed towards the disturbance do not count. Thus the analysis of the coming into being of the disturbance is made difficult; this presents an essential prerequisite for suitable interventions.

A further *classification approach* of SLD based on cognitive psychology results lies in the enlisting of orderliness aspects of the information processing procedure. Bush and Waugh (1971) listed 40 identified SLD and allocated them to five levels of information processing:

- Process of sensorial orientation (e.g. SLD in auditive discrimination)
- Process of retention (e.g. SLD in auditive short-term memory)
- Process of absorbing information (e.g. SLD in visual figure ground differentiation)
- Process of integration (e.g. SLD in sound synthesis)
- Process of expression (e.g. SLD in writing)

These "behavior-near" classification attempts are opposed to *neuro-psychologically orientated, brain-near classification approaches* (cf. Dietl 1985). Graichen (1981) attempts, to some extent, to draw upon the functional brain units according to Luria (1971) as a classification criterion and apart from these structural integration disturbances also to define functional integration disturbances. The structural integration disturbances are subdivided analogous to processes of information processing into (a) disturbances in the intake, analysis and accumulation (=first functional brain unit of information and (b) disturbances in the programming, regulation and execution (=second functional brain unit) of actions. Alongside these structural integration disturbances Graichen sees functional integration disturbances i.e. disturbances in the regulation of tonus, activation and consciousness (=third functional brain unit) as SLDs. To the functional integration disturbances he counts e.g. displacement of the activation level (=over and/or under activation), a stimulus filter weakness, the restriction of the selective attention to exceptional stimulation configurations, an insufficient habituation of the orienting reaction as well as the restricted ability of undertaking comparison processes between assimilated information and the experience repertoire.

The widespread classification approaches make it clear that the general definition of SLD, that is to say, the specific performance deficit with a presence of general performance ability is, according to the theoretical concept that is referred to, interpreted differently. Complex abilities, specific cognitive efficiencies as well as regulation procedures within information processing are equally termed as SLDs.

Corresponding to this difference over contents and extent of SLDs there also exist no homogeneous diagnostics for the recording of them. Esser and Schmidt (1987) suggest pragmatic, empirically applicable diagnostics. They diagnose a SLD when, in a specific performance test, a performance deficit occurs that deviates two sigmas (=two standard deviation units) from the individual thought efficiency (measured with intelligence tests highly-loading on the g-factor). In an epidemiological field study they examined SLDs with techniques for cognitive impulsiveness, auditory seriation, spelling, the immediate retention, concentration and visuomotor "gestalt" comprehension. Although the IQ of the children with SLDs was higher (IQ=109.9) than those in the total random sample, significantly more frequent school difficulties (in particular in the subject reading and spelling), behavior problems at school (recorded by the mark for "conduct" in the school report) as well as psychiatric conspicuousnesses were observed. Amongst the SLDs, a high prevalence of school and behavior problems is attributed particularly to the auditory seriation. Thus the SLD defined in this way proved to be relevant risk factors for the occurrence of psychiatric conspicuousnesses.

These findings, that were obtained in an examination of 8 year-old children, were able to be confirmed in a follow-up examination five

years later. In longitudinal development, the SLDs prove to be good predictors for psychiatric conspicuousnesses. With these findings, the psychiatric relevance of SLD is pointed out and the connection between specific performance deficits and the failure in complex school skills is substantiated.

To one's surprise, the thus defined SLDs are seen as being independent from the development of the abstract ability to think. This assumption is in contradiction to current developmental psychological concepts, according to which the abstract ability to think develops from the gradual development of the sensumotoric action to the "thought" action. As far as we know, however, there exist to date no systematic, longitudinal developmentally planned examinations in which the development of the abstract ability to think in children with varying SLDs is analysed.

Against the background of these problems an empirical investigation was planned; this should serve to answer the following questions:

(1) Do specific SLDs, defined according to Esser and Schmidt, lead to specific school achievement problems?

(2) Do the SLDs, defined according to Esser and Schmidt have effects on the abstract ability to think?

(3) Do SLDs lead to a changed development in the composition of the abstract ability to think?

In the following section methodical aspects are demonstrated, that were taken into consideration in the planning and execution of the investigation.

2. Methods

In the first place, the diagnostics of specific SLDs are dealt with. Then random sample and examination instruments are introduced. Finally it is a question of the hypotheses that include our result expectations.

2.1 Reasons for the choice of specific SLDs

According to Esser and Schmidt, a SLD is diagnosed then when the performance measure deviate in a specific performance test by two sigmas from the individual thought efficiency as measured by the general IQ. This definition allows the methodically-exact determination of SLD, but, however, leaves the complexity of the performance, that is uncovered by the respective performance test, open: Is the specific performance equated with a specific skill or is it "only" a question of the partial ability of a complex performance that is recorded by the subtest of a procedure? Esser and Schmidt give no clear definition, they have measured SLD with tests for auditory seriation, spelling, visuomotoricity, concentration and impulsiveness, i.e. they have used subtests of techniques in the same way as techniques for recording more complex skills and for regulating performance behavior. Should the concept of SLD, however, be clearly defined and diagnosed then the performance deficits must be measured on the same level and correlations between the techniques (e.g. between auditory seriation and spelling) must be taken into consideration.

Following these reflections, we have carried out the diagnosis of SLD in different psychic function areas. The areas chosen were speech, memory and motoricity. Within these areas, a more complex part-performance should be affected respectively.

For the area of *speech* the PET (Angermaier's 1974 Psycho-linguistic Development Test) was carried out and a two-sigma-deviation in the subtest "sound connecting" (auditory seriation) was determined as a definition criterion. This criterion was determined according to Esser and Schmidt's findings (1987), as a result of which a high prevalence for school and behavior problems can be attributed to performance deviations in this subtest. Restrictively, to the choice of this subtest is to comment that the PET subtests are not independent of one another and children who have a two-sigma-deviation in the subtest "sound connecting" also produce below average achievements in other PET subtests. In relation to the individual thinking (measured with an intelligence test free of speech), however, speech and intellectual performance differed widely.

For the area of *memory*, the aspect of short-time ability to remember, measured by the subtest "memory for figures" of HAWIK (Hardesty & Priester 1956) was chosen.

A two-sigma deviation in the subtests 1 and 2 of the KTK (Schilling's 1974 body cooperation test for children) was rated as *motor* SLD. These subtests were employed as a diagnostic criterion as they have, on the one hand, the highest load on the factor "body coordination" and, on the other hand, have also proved to be selective criteria in Esser and Schmidt's (1987) factor analysis for case-based definition on several levels

2.2 Random sample

At the start the random sample included a total of 43 children born in 1970/71 with varying SLDs and 19 children parallelized according to IQ, age and sex with no cognitive and motor impairments. All of the children were on average 10.0 years old (age span 9.3 - 10.5) at the time of the first investigation and were tested in 1980, 1982 and 1986 with various techniques on complex problem-solving abilities (cf. Fritz 1984, Fritz & Funke 1988).

The children were chosen from examination groups of two research projects from the research society "The physically handicapped child"; in these children a "MCD" (minimal cerebral disease) had been diagnosed within the limits of previous research projects (cf. Fritz & Gürster 1983, von Müller & Nitsche 1987). Criterion for the establishment of the diagnosis was, in both research projects, a summation diagnosis, i.e. a diagnosis in which the varying performance weaknesses and behavior conspicuousnesses were added together to form a total value. Much criticism of this form of diagnosis has been made; for its accomplishment any amount of single characteristics with varying distinction is sufficient. Esser and Schmidt (1987) recommend the procurement of a greater diagnostic clarity by orientating the diagnosis to the clearly discrepant performance weaknesses (cf. definition SLD). Backed-up by the definition of SLD given by Esser and Schmidt, we chose those children from the "MCD" random sample who showed a two-sigma-deviation on individual ability to think in the performance tests "sound connecting", "ability to remember" and/or "body cooperation". Some of the children (n=5) had worked on the HSET (Heidelberg Speech Development Test, Grimm & Schöler 1978) within the limits of the "MCD" diagnosis for recording speech abilities and not on the PET; the HSET contains no analogous subtest for "sound connecting". For these children, the diagnosis "SLD in the area of speech" was then made when, in addition to the diagnosed conspicuousnesses in the HSET, also in 1980 a two-sigma-difference in the subtest "sound connecting" was measured.

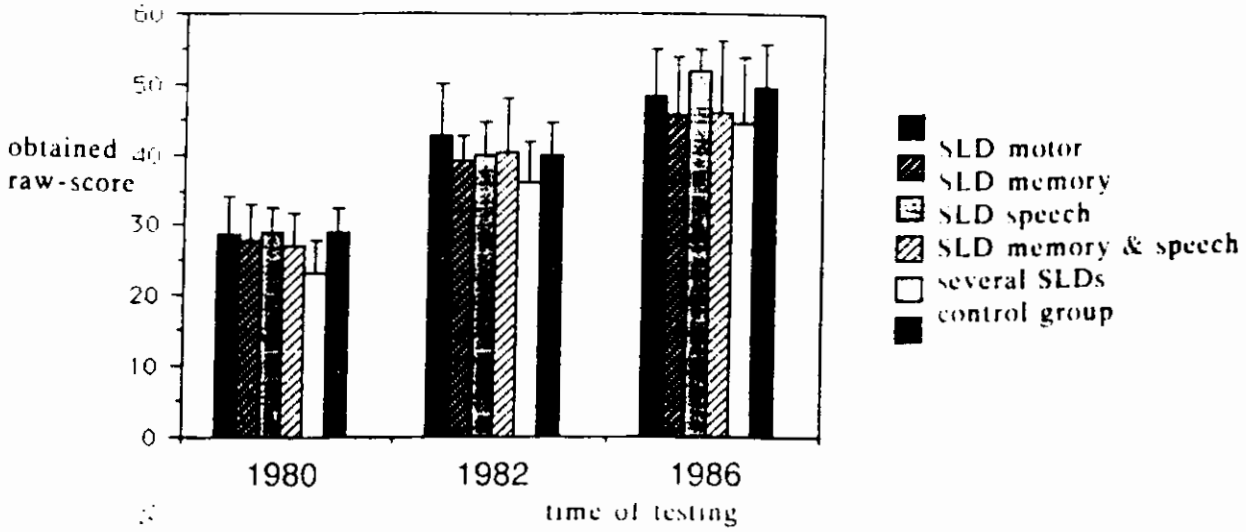
At that time in 1980, 43 of the "MCD" children could be allocated to different SLD groups. In 5 children, the earlier diagnosed conspicuousnesses had turned out to be transitory development delays that had already been made good by the time of testing in 1980. Two children, who had had several SLDs at an earlier time of measuring but, however, still achieved average intelligence test results, proved to be of below average intelligence when tested in 1980 and so the diagnosis SLD no longer applied to these children.

The remaining 36 children were allocated to SLD groups corresponding with their conspicuousnesses. It was shown that not only single SLDs occurred in these children, but some had two or three SLDs. The following distribution resulted for the 36 children: SLD memory: 13; SLD speech: 6; SLD motor: 7; SLDs memory and speech: 4; all three SLDs: 6.

A comparison of the IQ levels between the single SLD groups and the control group parallelized according to age and sex shows that also the single SLD groups do not vary from one another as far as their IQ levels are concerned (cf. Figure 1, p., 150).

There were also no significant group differences in the course of development (time of testing 1982 and 1986). For measuring intelligence Raven's (1938,1958) progressive matrices were chosen because of their high load on the g-factor (cf. e.g. Spearman 1946; Vernon 1961, 1963; Putz-Osterloh 1981). Despite the much-confirmed high validity of Raven's test, no binding norms were present so that the comparison of the

Figure 1: Comparison of the obtained IQ raw-scores for the six different groups and the three times of testing



IQ levels was carried out on the basis of the obtained raw-scores. The conversion of the obtained raw-scores according to the norms present today (cf. Schmidtke, Schaller & Becker 1980; Kratzmeier & Horn 1987) resulted in average IQ levels.

For a longitudinal developmental evaluation of the data for complex problem solution we put the following examination units together. Of the total of 19 children in the *control group* (KG), 10 were chosen for whom data was available from all three measuring times (1980, 1982 and 1986). In the same way, of the total of 36 children in the *"MCD" group* (EG), those 22 children were chosen for whom complete data were available from the three measuring times. Following the concept of SLD described in 2.1, of the 22 EG children, 7 were classified with SLD "memory", 3 with SLD "speech", 4 with SLD "motor", 5 with SLD "memory" *and* SLD "speech", as well as 3 with multiple SLD. The choice of those subjects who had supplied data at each measuring time followed the reflection that for longitudinal developmental analyses otherwise non-controlled (learn) effects of the measuring repetition could endanger the interpretation of the results.

For the cross-sectional analyses that were also carried out, all subjects from one measuring time were defined as an analysis unit, independent of their other participation in the total project. These analyses are thus based upon increased case figures.

2.3 Specific learning disabilities and school achievements

Before the results of the SLD groups in the complex problem solution task are listed in detail, an overall view of the children's school achievements should be given.

Within the scope of the total investigation, at each test appointment, alongside the problem solution tasks also school-related performance tests were carried out and current school-related problems and questions were discussed. At the end of the 1986 examination, in addition an interview was made separately with the parents and adolescents with the retrospective reflection upon the child's "school career". Corresponding to the question as to whether SLDs are predicative for school performance disturbances, the center of the interview was questions about the "school career" in the sense of the occurrence of specific and general school performance disturbances and the dealings with and mastering of

the specific learning disabilities. Regarded as specific school performance disturbances are: a diagnosed dyslexia, serious developmental delays in the process of learning to read and write, a distinct arithmetic weakness, problems in learning a foreign language (was not recorded separately when it occurred in children with a reading and writing weakness). Furthermore, general performance problems, that were reflected for many years in bad marks and repeating a school year without, however, specifically affecting any one subject, were listed. If school difficulties only occurred temporarily and the achievements became stable again then these facts were not taken into consideration in the listing. Over the total group of the SLD children the following distribution occurred (cf. Table 1).

Table 1

Overall view of school career and school performance problems for the various groups

SLD	N	SS	HS	RS	GY	sE	Wd	LD	LM	LS	wL	Rü
speech	6	0	1	3	2	2	4	3	0	2	1	0
memory	13	1	3	6	3	2	3	5	1	2	4	4
motor	7	0	3	3	1	0	1	1	0	0	2	2
speech and memory	4	0	3	1	0	1	3	4	0	0	0	1
multiple	6	0	4	2	0	2	5	2	1	0	3	2

Key - SS=special school, HS=secondary school, RS=(better form of) secondary school, GY=grammar school, sE=started school later, Wd=number of school years repeated (voluntarily) within the examination period, LD=performance disturbance in German, LM=performance disturbance in mathematics, LS=performance disturbance in languages, wL=changing performance problems, Rü=the number of times the child has had to go down one school year within the examination period

Table 2

Overall view of the existence of school performance problems at the three test times

SLD	n	1980	1982	1986
speech	6	3 (50%)	6 (100%)	4 (66%)
memory	13	8 (62%)	11 (85%)	4 (31%)
motor	7	4 (68%)	1 (17%)	1 (17%)
speech and memory	4	4 (100%)	4 (100%)	2 (50%)
multiple	6	6 (100%)	5 (83%)	5 (83%)
total	36	25	27	16

It can be seen in the overall view that the number of SLDs independent of the IQ has an influence upon the amount of school success: Only 23% and/or 33% of the children with two and three SLDs attended a "higher" school, whereas this is the case in 57%-88% of the children with one defined SLD. The overall view explains further that SLDs lead increasingly to school performance disturbances. A confrontation: school performance disturbances yes-no shows that with the exception of the children with a SLD in the "motor" area (43%), school performance disturbances occurred in all the other children with SLD (exception in the SLD "memory": 92%). Consequently, SLD in the motor area, if it occurs without further SLDs, has the best school-related prognosis. In contrast to this, in connection with the other SLD, school difficulties occurred and continued for a long time. A specific pairing between single SLDs and specific school problems could, however, not be made. Only for the concurrence of SLD in the area of memory and speech can a delay in the acquisition of writing and speaking skills be predicted. A SLD in the area of auditory seriationen, in contrast to this, does not necessarily lead to problems in the acquisition of writing and speaking skills. School difficulties came into being here too if a foreign language had to be learned. Table 2 illustrates evidences on the seriousness and persistence of school difficulties as a consequence of SLD because of the existence of school performance disturbances at the three test times in 1980, 1982 and 1986.

From the overall view, it can be seen that SLDs influenced the children's learning process and school success for a long time. School difficulties began frequently in primary school and still continued after primary school time. In a number of SLD children school difficulties did not begin until the change to secondary education. The group of children with a SLD in the motor area was again an exception, here the difficulties appeared to become stable in the course of primary school education.

2.4 Mastermind problem

The task planned for the recording of the information processing process was the tackling of the game "Mastermind". Here, in as few steps as possible, the player has to find out the combination of coloured pegs (symbols) hidden by the experimenter. Step by step the player leaves hypotheses in the form of symbol combination that are feed backed by the experimenter concerning the amount of correct symbols as well as correct positions.

As far as we know, the use of this game as a data-collecting paradigm for cognitive psychology was first suggested by Funke and Hussy (1979) as it has various desirable characteristics (e.g. simple manipulation of the problem area, compulsion of step by step handling). Empirical studies of this paradigm were presented by different authors (Hussy 1989; Laughlin et al. 1982; von Eye & Hussy 1981; Wickboldt 1980). Irving (1978) and Knuth's (1976) works on the optimal strategy in a "four out of six" problem are available.

Execution of the task.
Similar criteria were applied for the execution of this part of the task as in Funke and Hussy (1979, p.53ff). The hidden combination is only laid down *after* the first move in order to maintain standardized starting conditions for each subject. The reply given for each solution proposal assesses position successes (the right symbol at the right place) and symbol successes (the right symbol at the wrong place) independent of one another. No symbol may be used repeatedly in a solution proposal.

From the basic amount of the different-coloured counters and of the selected amount from which the play combination is formed, two stages of difficulty were defined: "3 out of 5" and "4 out of 6". The task was presented as a game with different-coloured wooden blocks; the presentation and run of the game do not differ otherwise from the traditional game, which is available on the market. The run of the game had no time limit, in the difficulty stage "3 out of 5" after 12 moves and in the difficulty stage "4 out of 6" after 18 moves, however, a success report was given, regardless of the score, in order not to abandon the game with a failure and/or not to demotivate the subject with a long-lasting problem process.

Derivation of dependent variables.
The characteristic values for the performance in the Mastermind Game are (1) the number of moves needed up to the solution, (2) the inconsistency of an actual combination with preceding replies as far as the symbols are concerned,

Table 3

Computation of the inconsistency index by one example

move	combination			reply		inconsistency	
				S	P	S	P
1	2	4	1	2	1	-	-
2	1	2	4	2	1	1.00	1.00
3	4	2	1	2	0	1.00	0.00
4	1	3	4	3	1	0.00	0.67
5	1	4	3	3	3	0.00	0.00

Table 4

Results of the two factor ANOVAs (uni- resp. multivariate F-values)

source	Dependent Variables df	moves	miSy	suSy	miPo	suPo
between subjects						
Group (GR)	1	0.42	2.07	0.64	0.52	0.98
within subjects						
time (ZP)	2.29	4.18*	5.70*	3.92*	9.23*	10.72*
GR*ZP	2.29	2.64*	1.53	3.31*	0.52	2.46

n.b. - the abbreviations of the Dependent Variables indicate with "mi" resp. "su" the average resp. added-up values, "Sy" and "Po" mean symbol resp. position inconsistency. - *:$p \leq 0.10$.

(3) the inconsistency as far as the positions are concerned as well as (4) the amount of repeated moves (redundancies).

The inconsistency index represents a variant of the "backwards analysis", described by Hussy et al. (1981) as well as Hussy (1989): Separately for symbol and position level, it is counted out with how much percent of the previous reply a move in hand is inconsistent. In the most unfavourable case this index is 100%, i.e. it is inconsistent with each reply given until them, in the most favourable case, on the other hand, 0% (for the correct solution this *must* be inevitably so). One example (cf. Hussy 1989, p.29) should illustrate this kind of index definition (cf. Table 3); this was chosen as opposed to the way of action described by Hussy (1989) in order to bring the greatly varying "depth" of the backwards analysis in an unlimited amount of moves to comparable levels.

Move 2 is inconsistent with the one and only preceding move 1 as far as the symbol amount and the positions are concerned: the first reply makes the exchange of one of the three symbols with a symbol that has not been used until now necessary, at the same time the position of the two retained symbols be changed. Move 4 is, in fact, consistent with move 3 as far as the positions are concerned, but not with moves 1 and 2; the position-inconsistency for this move is thus 2 out of 3 possible inconsistencies or 67%. For each task, the average and the added-up symbol and/or position inconsistencies were determined following this procedure, whereby, in each case, the first and last moves were left out. In the example the average inconsistency is 0.56 for positions and 0.67 for symbols, added-up the values are 1.66 resp. 2.00.

2.5 Hypotheses

Our expectations concerning the mastermind performances can be grouped into three areas: (1) Differences concerning EG and KG, (2) test time effects and (3) difficulty effects.

Group differences. Concerning the problem treatment we expect clear differences between EG and KG. The presence of a SLD ought to slow down the solution process and thus lead to an increased amount of moves until a solution can be achieved. We also expect performance differences between the single SLD groups, whereby the group with several SLDs ought to demonstrate the most distinct performance deviations. The slightest effects of SLD on the more complex problem solution ability is expected in the group with motor SLD.

Testing times. Concerning the three testing times of 1980, 1982 and 1986, we expect improvements that are attributed to exercises and/or cognitive development processes. In accordance with Douglas and Peters (1979) findings, according to which IQ differences between cognitively conspicuous and cognitively non-conspicuous children occur with increasing age, we expect a slighter performance increase with time in the group with several SLDs.

Problem difficulties. For both groups and the testing times 1982 and/or 1986 it should count that the problem type "3 out of 5" is easier than "4 out of 6".

Potential *interactions* cannot be excluded but are not expected by us. At the outside, it could be that the developmental processes of the KG are more abrupt than those of the EG.

3. Results

First of all, results of longitudinal analyses are reported, followed by additional cross-sectional data analyses that are based on more subjects each time.

3.1 Hypotheses-orientated data analysis: longitudinal

Because of the incomplete split-plot design (at the testing time of 1980, only the problem "3 out of 5" was employed, whereas in 1982 and 1986 respectively the stage of difficulty "4 out of 6" was also presented) evaluations based on analyses of variance were carried out with above-named dependent variables in two variants for the data analysis:
(1) with the inclusion of all three testing times, a two factor analysis of variance (ANOVA) with the factors "group affiliation" (KG v. EG; because of the low amount of cases in the groups with specific SLDs these subjects were combined for the time being) and "age/testing time" (1980, 1982, 1986; repeated measurement);

(2) doing without the first testing time, a three-factor ANOVA with the factors "group affiliation" (KG v. EG), "problem difficulty" ("3 out of 5" v. "4 out of 6") and "age/testing time" (1982 v. 1986) with repeated measurement in the two factors mentioned last. Because of the low number of cases, an error probability of alpha ≤ 0.10 is allowed for all analyses. Table 4 shows an overall view of the results of the analyses following the first model.

There was no significant main effect of the group affiliation for any of the five DEPENDENT VARIABLEs. Instead of that there is a significant age and/or testing time effect (average values for each of the three measuring times, order of the DEPENDENT VARIABLEs as in table 4: 6.72, 6.94, 5.22; 0.31, 0.19, 0.20; 1.74, 1.70, 0.90; 0.57, 0.36, 0.34; 2.70, 2.41, 1.24) in the sense that all subjects achieve better values. For the DEPENDENT VARIABLEs "moves" as well as "added-up symbol inconsistency" there is, in addition, an interaction between group affiliation and age and/or testing time. These last-mentioned effects should be illustrated by an inspection of the corresponding means (cf. Figures 2a and 2b).

Figure 2a: Problem type "3 out of 5"

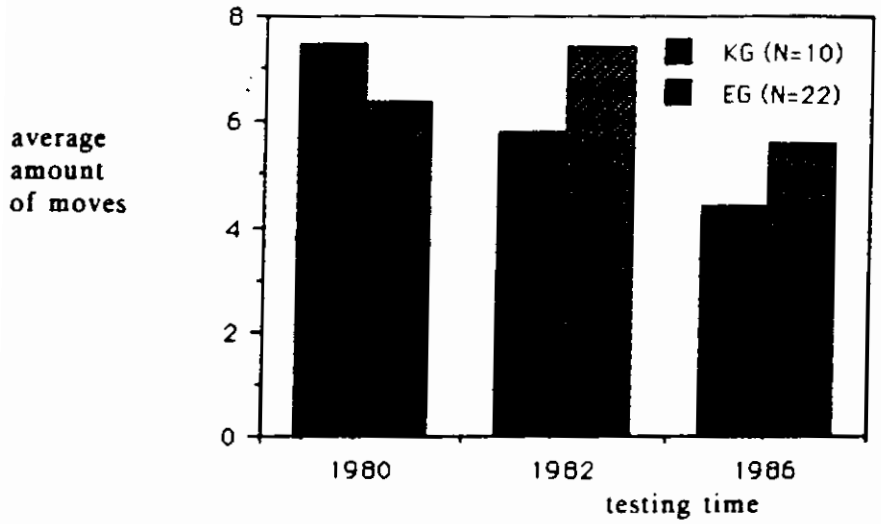


Figure 2b: Problem type "3 out of 5"

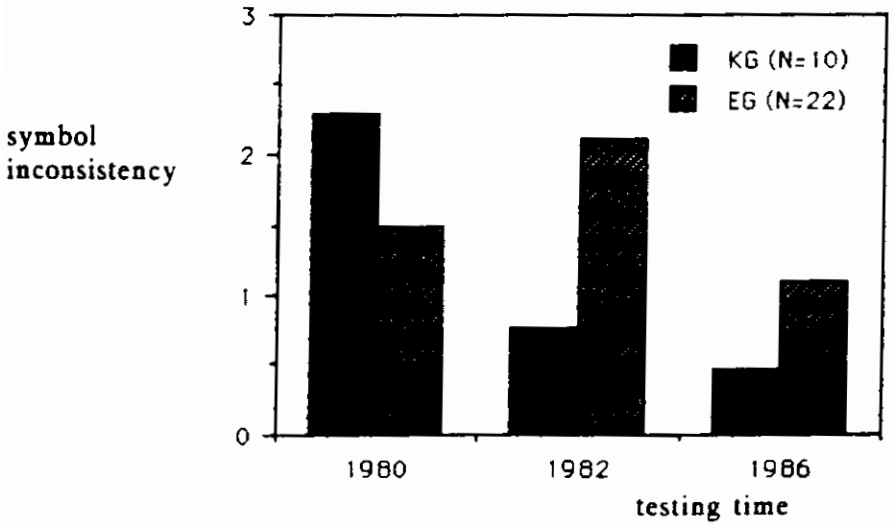


Fig. 2: Figure of the interaction of testing time effects and group affiliation: a) for average amount of moves, b) for average symbol inconsistency

As this shows, the average number of moves to the solution as well as the added-up symbol inconsistency decreases for the KG from one testing time to another, whereas, in the EG, less distinct and, above all, non-continuous improvements occur.
Table 5 shows the results obtained following the second analysis model, in a summary form.

Table 5

Results of the three factor ANOVAs (univariate F-values)

source	df	Dependent Variables moves	miSy	suSy	miPo	suPo
Between subjects						
group (GR)	1	2.19	4.15*	3.07*	0.65	3.63*
within subjects						
time (ZP)	1	5.59*	0.06	4.43*	0.10	4.09*
GR * ZP	1	0.30	0.90	0.01	0.76	0.01
problem (PR)	1	17.77*	31.50*	16.03*	7.43*	14.88*
GR * PR	1	0.20	0.36	0.22	0.00	0.65
ZP * PR	1	0.41	0.04	0.67	0.00	0.19
GR * ZP * PR	1	1.08	0.07	0.48	0.89	1.40

n.b. - the abbreviations of the Dependent Variables denote with the addition of "mi" and/or "su" the average and/or added-up values, "Sy" and "Po" stand for symbol and/or position inconsistency - *:$p<0.10$

Here significant group differences now become apparent: In the sense of a main effect "group affiliation" in both symbol-related DEPENDENT VARIABLEs as well as the added-up position inconsistencies the cell averages of the EG groups are increased (average symbol inconsistency: 0.21 vs. 0.31; added-up symbol inconsistency: 1.46 vs. 2.66; added-up position inconsistency: 1.92 vs. 3.41).

Age and/or testing time effects are present in the DEPENDENT VARIABLEs "number of moves" (1982: 8.61, 1986: 6.54), "added-up symbol inconsistency" (2.59 vs. 1.54) as well as "added-up position inconsistency" (3.24 vs. 2.10).

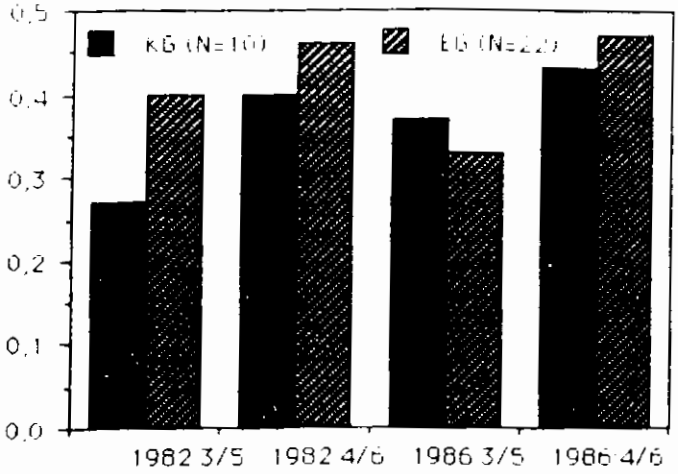
A main effect "problem type" is found in all DEPENDENT VARIABLEs, in the sense that - as not to be expected otherwise - the problem "3 out of 5" proves to be easier than "4 out of 6" (the respective average values for the easy and/or difficult version, the sequence of the DEPENDENT VARIABLEs follows that of table 5: 5.81 vs. 9.34; 0.17 vs. 0.35; 1.11 vs. 3.01; 0.34 vs. 0.44; 1.63 vs. 3.71). As the F-values suggest, it is a question here, as a rule, of a strong effect.

Figure 3 shows the fundamental effects according to the second analysis model once again for the five different DEPENDENT VARIABLEs.

It is interesting to see that interactions between the group affiliation and either the age/testing time or the problem type or both together are absent, just as the interaction of time and problem type (cf. Table 5). This is surprising in as much as here too (analogous to the results following the first analysis model) we could have expected a "scissor effect" between EG and KG with increasing age.

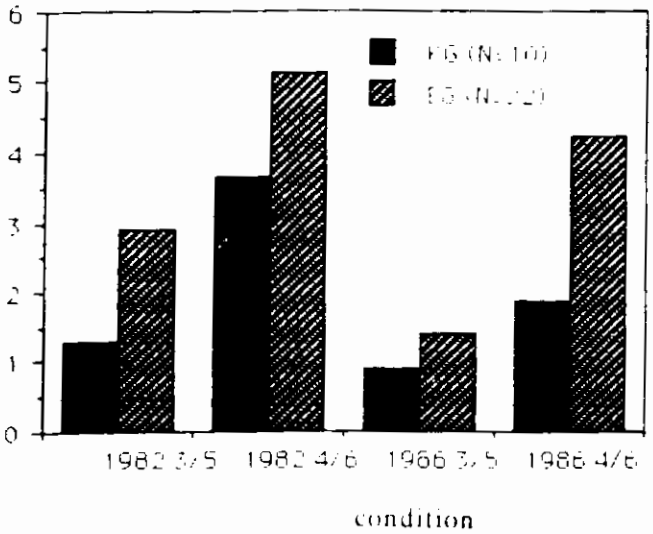
Summary: If we only look at the data of the easy level of difficulty, but do this over all three

Figure 3d



average position inconsistency

Figure 3e



added-up position inconsistency

Fig. 3: **Average values of the different trial conditions for the DEPENDENT VARIABLEs**
(a) number of moves,
(b) average symbol inconsistency,
(c) added-up symbol inconsistency,
(d) average position inconsistency and
(e) added-up position-inconsistency

measuring times, then there are no striking group differences, instead common improvements with time and - in two cases - an interaction between group affiliation and testing time to such a degree that the KG, in comparison to the EG, achieves stronger improvements (cf. Fig. 2). If we look at the data from the perspective of the second analysis model then significant and expectation-confirming group differences are found in three of the five DEPENDENT VARIABLEs.

Age and/or testing time effects in the sense of an overall improvement from 1982 to 1986 also in three of the five DEPENDENT VARIABLEs as well as difficulty effects amongst all DEPENDENT VARIABLEs. The possible interactions remain insignificant in this model throughout.

3.2 Cross-sectional data analysis

The cross-sectional analyses of the complete data of one examination time should help, above all, in making differentiated statements about inter-group differences in the EG, that is to help in answering the question about the differential effects of the various SLDs. For this, analyses of variance were carried out on the named dependent variables, whereby this time not the rough dichotomy of KG and EG was used as independent variable but, alongside the KG, the five afore-mentioned groups with specific SLD were differentiated.

The results of these analyses are summarized in a few sentences: (1) In 1980 there were no

Figure 4

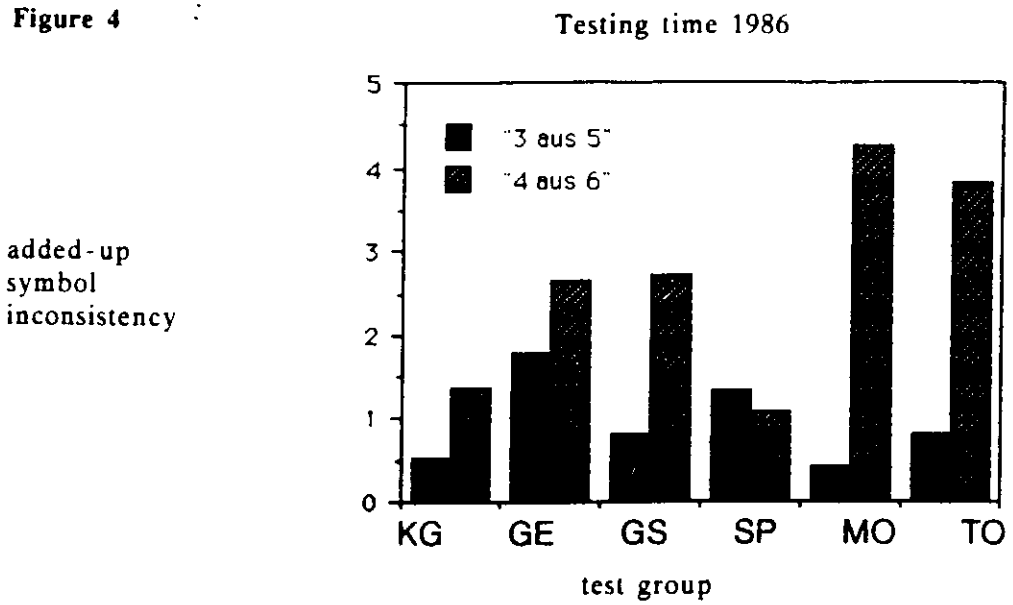


Fig. 4: Average values of the added-up symbol inconsistency for the six groups (KG=control group, GE=memory-SLD, GS=memory *and* speech SLD, SP=speech-SLD, MO=motor SLD, TO=multiple SLD) from the cross-sectional analysis of 1986

statistically significant effects. (2) In 1982 and 1986 significant difficulty effects are established in all but one of the variables. (3) In 1982 group differences occur in the average amount of position mistakes, in 1986 in the added-up symbol mistakes; here, in addition, an interaction effect "group x difficult" occurred, which is illustrated in Fig. 4.

As we can see from this, problems arise in the digestion of symbol information when there is a change from easy to more difficult problem types, this, above all, in the MO and TO groups. Subjects of the GE and SP groups were already above the KG standard with the easy task.

The predominant nonappearance of significant group differences must be evaluated carefully as the specific disability-groups are equipped partially with a low number of cases and the strength of the statistical test suffers because of this.

Discussion

In specialized literature, the diagnosis cognitive disturbances just as specific learning disability, attention disturbances, the "syndrome MCD" was unanimously connected with an at least average intelligence and/or "adequate intelligence capacity" (Johnson & Myklebust 1971). Thus Clements (1966) already describes those children with cerebral dysfunction as being "children with just about average and above average general intelligence with certain learning or behavior disturbances of a light to more serious kind that are connected with function deviations of the central nervous system" (p.9f). Also the definition of SLD refers to the discrepancy between the general intellectual abilities (individual standard of thought) and the performance impairment in the learning of specific skills.

The phenomenon of complex performance ability despite basal and cognitive function disturbances has been attempted to be explained in that possibly higher mental processes are compensatingly involved in the coming into being of "lower" mental operations. This means that basal disturbances can be counter-balanced by complex problem solution abilities (cf. Remschmidt 1977).

The assumption that abstract thought abilities can develop despite the presence of specific cognitive disturbances is based on the concept of the independent development of the functional brain organs. Neurophysiologically, in accordance with these concepts, the development of abstract thought abilities is based in other functional brain organs so that their development can occur unaffectedly.

These assumptions are confronted with development psychological theories and findings of the successive development stages and the development of abstract thought from the sensomotorical action. Based upon development psychological findings, the occurrence of basal and cognitive function disturbances was seen in a spiral development that, proceeding from basic disturbances, has effects upon the development of the abstract thought ability.

Douglas and Peters (1979), who found a scissor effect in the intelligence development of attention-disturbed children, also announce their doubt of an unimpaired intelligence development in children with cognitive disturbances. If younger attention-disturbed children still achieved unimpaired intelligence performances then during the development a relative deterioration of intelligence occurred when the test demands became more complex.

An explanation of the question as to whether the occurrence of specific SLDs remains without effects on the development of the abstract thought ability and/or in what respect the presence of certain cognitive disturbances appears unfavourable for the development of more complex problem solution abilities has been investigated in the examination on hand.

To the investigation on hand should be said restrictively that it was not planned as a longitudinal examination but that three examintion times with the same population, at which the mastermind task was given, underwent a comparative analysis. In the respective cross-sectional investigations there were loss of subjects which, unfortunately, limited the number of cases for a longitudinal observation divided into SLD groups. The weak effects in the data are possibly a consequence of these low case numbers; with larger populations stronger effects could be proved.

In general, it can be said for the connection between SLDs and school performance that SLDs have a high prevalence for school difficulties which, with the exception of the group of children with motor SLD, also continue for a long time. The school difficulties are mainly consequences of impaired performances in specific subjects. For the SLD children's school success, it also applies that grammar school attendance of 17% SLD children lies well below the population average.

In what respect the school problems of the children go along with impairments in their intelligence development and/or in the development of complex problem solution abilities cannot be clearly deduced from our longitudinal analyses. A comparison of the IQ-values with Raven's (CPM and SPM) speech-free intelligence test with a heavy emphasis upon the factor "reasoning" brought no significant differences between the single SLD groups and the KG. Also in the course of development there was no

difference between the achievements of the KG and those of the SLD groups. A scissor-effect, just as Douglas and Peters (1979) found, could not be confirmed with the IQ data. The simple examination of the average values indicates slighter performance goods of the multiple SLD group each time, but also this non-significant difference remains stable throughout the testing times.

The following findings resulted for the problem "mastermind" in the two-factor analysis of variance with the factors group and testing time: whereas in the KG, over the years (1980-1986) a steady performance improvement (=reduction in the average number of moves) was to be observed because of a more effective strategic mastering of the task (reduction in the symbol inconsistency), in the entire group of all SLD children, there was also an increase in performance at the third test examination, the increased performance and the effectivity of the problem tackling were, however, much less continuous.

The statement of the discontinuous course of development found no additional confirmation in the further assessments (three factor analysis of variance with the factors group/problem difficulty/testing time). The total group of all SLD children achieved indeed slighter performances than the KG in both task difficulties and the increased performance over the testing times was less high, but as the tendency in the KG and EG is parallel, no significant interaction effect occurred.

The cross-sectional analyses determined for the third testing time, separated according to the respective SLDs resulted in no statistically significant group differences for the testing time of 1980. From 1982 onwards difficulty effects could be detected in the direction that all SLD groups found the second stage of difficulty much more difficult than the KG.

Alongside this main effect, in the test examination of 1986, a differentiated influence of certain groups of subjects was detected. For the groups with multiple SLDs and motor SLD there is a massive difficulty effect. In comparison with the performance goods of all other groups these two groups have considerably greater difficulties in solving the task "4 out of 6". Here development delays or performance limits in the development of the abstract thought ability seem to suggest themselves. These findings are not expected for the children with multiple SLDs (cf. average values of the IQ tests), are surprising, however, for the children with a SLD in the motor area. If we relate this result to the children's school performance ability, then, on the contrary to other SLD children, these children show no specific school difficulties but had more general problems effecting various subjects in view of the small size of the groups. It should not be further speculated here as to in what respect the school problems of children with delayed development in abstract thought ability are connected.

In summarizing it can be said that no clear statements can be made on the question of the development of abstract thought abilities of children with learning disabilities on the basis of the findings on hand. The results that take into consideration the coming into being of more complex problem solution performances point out problems in the SLD groups when tasks make higher cognitive demands. A statement, that the development of the abstract thought ability occurrs completely unaffected from SLDs on hand, can thus not be clearly formulated. By the same token, the presence of SLDs in the areas motor, memory, speech as well as memory and speech seems, however, to have no serious influence upon the development of the abstract thought ability as it has been described in the literature on the cognitive development of children with different development disturbances (cf. e.g. Esser & Schlack 1984).

Further long-term-set research in this area is, however, still necessary in order to be able to meet with reliable statements on the connection between SLD and abstract thought ability.

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