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Dyslexia among Swedish prison inmates in relation to neuropsychology and personality

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Abstract

Several investigations have reported high frequencies of reading and writing disabilities in criminal populations. The aims of the present study were to assess the frequency of dyslexia among Swedish prison inmates and to relate dyslexia to other indices of neuropsychological functions. Sixty-three prison inmates with Swedish as their native language, age 19 to 57 years, were examined by interviews, tests of academic achievement, and neuropsychological assessment. Twenty-six (41%) were diagnosed as dyslexic. As expected, the dyslexic group performed more poorly on verbal tests as compared to the normal readers among the prison inmates, but they also performed more poorly on tests measuring nonverbal abilities. The dyslexic group had higher frequencies of paranoid and avoidant personality disorders compared to the nondyslexics. They also reported higher levels of anxiety and suspicion and a lower degree of socialization. Previous studies report low IQ to be associated with criminal propensity, supporting the interpretation that a double handicap (dyslexia and low IQ) increases the risk of entering a criminal career and remaining in it. (*JINS*, 1999, *5*, 452–461.)

Keywords: Dyslexia, Prison inmates, Neuropsychology, Personality

INTRODUCTION

There is a vast neuropsychological literature on reading disabilities among children, but only few studies on cognitive skills of adult poor readers (Felton et al., 1990). Similarly, there are many reports on the neuropsychology of juvenile delinquents in comparison to adult criminals. Studies of juvenile delinquency report significant correlations in the range −.20 to −.30 between intelligence and delinquent activity (Moffit et al., 1981; Stattin & Klackenberg-Larsson, 1993). Recidivists tend to have lower intelligence than one-time offenders (Ganzer & Sarason, 1973). Verbal IQ appears to be more strongly associated with delinquency than performance IQ. The data of Moffit et al. (1981) and Stattin and Klackenberg-Larsson (1993) support Schonfeld's (1990) hypothesis that young boys' poor verbal skills are predictive of later antisocial behaviors. Moffit and coworkers, as well as Stattin and coworkers suggest that poor language skills can actually be used for identification of boys at risk of an offender career.

Juvenile delinquents almost always fail at school. Part of this failure appears to be related to specific reading and writing difficulties (dyslexia). Many studies suggest a markedly higher frequency of dyslexia among juvenile delinquents (50–85%; Dalteg & Levander, 1998; Underwood, 1976). Also, the rate of dyslexia among prison inmates appears to be markedly higher as compared to the general population, with rates as high as 60% having been reported in North American studies (Underwood, 1976). A study of prisoners in one region of Sweden, using a limited set of pedagogical tools, concluded that 31% of the inmates had impairment in reading and spelling indicative of dyslexia (Alm & Andersson, 1995).

Bruck (1990) found that difficulty in reading nonwords, based on accuracy and latency, characterized adult dyslexics. Decker (1989) reported no significant differences on tests of mathematical or visuospatial ability between normal and reading-disabled readers and concluded that speed of letter naming and speed of recognition of pronounceable nonwords to be the best predictors of reading disabilities.

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In another study, Felton et al. (1990) found that people with reading disabilities performed consistently poorer on most neuropsychological tests when compared to normal readers. However, after covarying for intelligence and socioeconomic status, only tests of rapid naming, phonological awareness, and nonword reading were significantly discriminating between dyslexics and nondyslexics.

To distinguish dyslexia from other kinds of neuropsychological dysfunction, conventional measures of intelligence and higher cortical dysfunction have been used. However, conventional intelligence tests might penalize individuals with histories of school failure. From other studies with patients it appears that in such cases computerized tests that resemble computer games rather than school tasks are less anxiety-provoking and more culture-fair (see Levander, 1987a).

The main aim of the present study was to assess the frequency of dyslexia in a sample of Swedish-born prison inmates using an extensive diagnostic battery, including computerized tests. Additional aims were to relate dyslexia to other indices of neuropsychological functions and to personality characteristics. The main hypothesis was that the frequency of dyslexia would be much higher among prisoners than in the general population. Another hypothesis was that dyslexic and nondyslexic inmates would perform equally well on nonverbal neuropsychological tasks.

METHODS

Research Participants

Sixty-three prison inmates with Swedish as their native language (59 men, 4 women; age range 19–57 years; $M = 35.1$ $SD = 10.5$) in one regional locked unit ($N = 42$), and one local open unit ($N = 21$) participated, representing 75% of those invited to take part. Their crimes ranged from moderate (fraud, drunk driving) to severe (murder). A small sum ($40 U.S.) was paid to the participants, who signed an informed consent form in line with the recommendations for the study by the local ethics committee (Lund University).

Questionnaires

Three self-report questionnaires were administered. Personality dimensions were assessed with the Karolinska Scales of Personality (KSP; Schalling, 1986), personality disorders with the SCID–II–Screen (American Psychiatric Association, 1987) using Swedish criteria that match the interview items (Ekselius, 1994). Data on social background and drug abuse were obtained by a custom designed form.

Interview

A semistructured interview was conducted concerning reading and writing abilities, hobbies, school and work history (Lindgren & Ingvar, 1998).

Tests of Academic Achievement

We expected a wide range of lexical ability among the participants and therefore chose a set of instruments designed and standardized for school Grades 4 to 6 (ages 10–12 years) by Madison (1985).

1. *Speed of reading*: The test consists of a text about a hedgehog (401 words). The text is interrupted 13 times by parenthesized sets of three words, of which only one is contextually appropriate. The participant is asked to read the text silently and to underline the salient word. Performance is assessed in words/min and in number of correctly underlined words.
2. *Spelling*: Twenty-five words are read one by one aloud to the participant. The task is to spell the words in writing. The number of wrongly spelled words is tallied.
3. *Reading words aloud*: Twenty-three words, selected to be hard to read for dyslexics, are written on a sheet. The task is to read the words aloud, consecutively. The number of wrongly read words are tallied, with commentaries on the type of errors.
4. *Decoding of words*: A word-chain test designed by Jacobson (1993), and standardized for children and adults was administered. The test consists of 120 word chains, each with three words (for example ithousebut). The task is to mark the borders between the words as fast as possible during 3 min. Performance is assessed as number of correctly marked word chains.

Neuropsychological Tests

1. *General and verbal knowledge* were assessed by the Information and Vocabulary subtests from the Swedish version of the WAIS–R (Bartfai et al., 1994).
2. *Verbal (auditory) learning and memory* was measured by a Swedish Verbal List Learning test (Claeson et al., 1971) where 10 unrelated two-syllable words are read aloud and may be repeated up to 10 times, with recall after each reading with a delay of 15 s. Free delayed recall was measured after 30 min.
3. *Nonverbal intelligence* was assessed by a Block Design Test corresponding to the one used in the WAIS (Wechsler, 1955), and Figure Classification (30 items of logical reasoning, in which one out of five figures does not belong to the set); both from a Swedish standard intelligence battery (SRB), developed by Dureman and Sälde (1959).
4. *Visual–perceptual speed* was measured by the Digit Symbol Substitution Test from the WAIS–R (Bartfai et al, 1994) and a Perceptual Speed Test (after Lezak, 1995, p. 355) comprising 10 rows of 40 random digits. The task is to cancel certain target digits on each row as fast as possible.

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5. *Visuoconstructive* as well as *executive functions* were assessed by the Rey–Osterrieth Complex Figure, which was administered with a copy session and free recall after 3 min (during which the perceptual speed test was given). Performance was scored according to the scoring system described by Taylor (1959) as shown in Lezak (1995, p. 572). The copy sheets were also rated for qualitative signs of organic brain dysfunction according to Hamby et al. (1991), as described by Lezak's (1995, p. 575), by a second neuropsychologist (M.L.) who was blind in relation to the participant's performance in other tests.

6. The Wisconsin Card Sorting Test (Heaton, 1981) was used to detect *frontal dysfunction*.

Computerized Tests

The Automated Psychological Test system (APT) comprises about 20 different neuropsychological tests suited and/or adapted for computerized administration and scoring (Levander, 1987b). The participant sits in front of a CRT screen and all responses are given on a custom-designed ergonomic keyboard. Instructions are given on the screen at a pace controlled by the participant, and can be read aloud by the examiner if the participant is a poor reader. Examples of test items are given in the beginning of all tests. Many of the tests are process controlled, to avoid floor and ceiling effects. The following tests were given in the present study:

1. *Reaction Time (RT)*: The test comprises four subtests with interstimulus intervals varying randomly between 1.5 and 6 s, and the following stimulus characteristics: *Simple Auditory RT*: nine tones, response with dominant hand; *Simple Visual RT*: nine light square stimuli (2.5 cm $\times$ 2.5 cm) in the center of the screen, response with dominant hand; *Two-Choice Visual RT*: 17 light stimuli (squares) appearing 8 cm to the right or left of the screen center, response with the corresponding hand; *Inhibition RT*: 25 light stimuli, identical to the Two-Choice Visual task, with two exceptions. There was a visual forewarning 1 s before stimulus onset. For 50% of the items a tone is presented together with the light stimulus. To these double modality stimuli responses should be withheld, otherwise the participant should press the appropriate (left or right key) as fast as possible. Median reaction time (in milliseconds) is calculated for each task, and the number of right/left errors and failed inhibitions is tallied.

2. *Finger Tapping*: Motor speed and coordination are measured both with index finger tapping (analogous to the Finger Tapping Test in the Halstead-Reitan battery), and with index–middle finger alternation; first with the right hand, then with the left. Cross-lateral coordination is measured with alternation between right and left index fingers. Each task lasts 12 s. Mean number and standard deviation of key presses/s are calculated for the last 8 s in each task.

3. *Associative Learning Test and Long-Term Memory Test*: As in the WAIS Digit Symbol substitution, digits are to be matched with symbols; in this case letters. A translation table of 10 digits with corresponding letters is shown on the top of the screen throughout the learning phase. The participant is to respond with the corresponding digit key each time a single letter is presented below the table. This test runs for 5 min. In the recall phase, 20 min later, the same 5-min task is presented again, this time with no digit–letter translation table available. Responses (right–wrong) and response times are recorded.

4. *Digit Span*: Digits (3.8 cm high) are presented consecutively on the screen, with an interval of 1 s. The participant has to enter the digit series in the same order on the keyboard, and then press a "finished" key. The number of digits in each item is process-controlled, starting with three digits. After 13 forward items, 11 items follow, where the order of digits is to be reversed in the response, starting with two digits. The median of the number of recalled digits of the three last items in each task (forward and backward) is recorded.

5. *Selective Attention (the k-test)*: This continuous performance test is given in two versions (Dalteg et al., 1997; Levander et al., 1995). In the first one, a series of items comprising 10 letter-sized filled squares (5 $\times$ 12 mm) are presented on the screen in random positions. For 50% of the items one square is replaced by the letter 'k.' The task is to press a *Yes* key if 'k' is present, and the *No* key if it is absent. The test runs for 5 min. In the second version, other letters are used as distracters instead of squares, making the task more difficult and forcing the strategy to shift from global to sequential. Mean response times and the signal detection parameters d' and beta are calculated for each version separately.

6. *The Perceptual Maze Test (Elithorn, 1955; Elithorn et al., 1976)*: The task is to select the optimal pathway through a triangular maze pattern, which passes the maximal number of target nodes. Back-tracking and redirection of the route is possible. The solution is acknowledged by a separate *Finish* key. Two versions were given. In the first (5 min) a number presented to the right of the maze shows the maximal number of targets that can be obtained. In the second version this information is withheld until the feedback after each item. Whereas the first version invites a point-counting, serial strategy, the second demands a more spatial, holistic approach. In both versions, the level of difficulty (maze size) is process controlled. The results are presented as size-independent indices of response speed, accuracy (percent correctly solved items), and strategy (inspection time and number of backtracks).

7. *Simultaneous Capacity Test*: Background task: Random digits appear consecutively in the center of the screen at a pace of 1/s. The task is to scan for three consecutive odd digits, responding within 2 s with the nondominant

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hand. d' and beta are calculated on these responses. Foreground task: Short messages appear at random frequent intervals in the upper part of the screen. Many of these can be ignored, since they require no response, like "Onward, Christian soldiers!" and the different feedback messages; for example, "Response OK" or "Incorrect Response." Other messages, for instance "Press 5," and "Press 4 + 3" (i.e., press Key 7), require a response with the dominant hand within 2 s. Percent correct responses, and three types of errors (omission errors, commission errors, and wrong responses) are tallied. The test continues for 10 min with increasing difficulty as long as the participant manages the two tasks well enough (process control).

8. *Word Recognition Test*: This is a classic lexical decision task, in which the participant has to decide whether a combination of letters is a word or not (*Yes–No* keys). In the present study we used one version with Swedish four-letter combinations and one with English three-letter combinations. The 80 items of each test comprise four categories: high-frequency words (e.g., "cat," "eat"), low-frequency words (e.g., "fur," "ode"), pronounceable nonwords (e.g., "sor," "hix"), and nonpronounceable nonwords (e.g., "sro," "xhi"). Percent correct responses and mean response time in milliseconds for each category are calculated.

Procedure

The participants received the self-report questionnaires about 1 week before the interview and test session, and were supposed to complete them before meeting in the session. All test data were collected in one session with a total time of approximately 4 hr, 30 min. In order to make the test sessions more endurable, the tests were mixed so that difficult tests were followed by easy tests, and verbal and practical tasks were intermingled. The data collection procedure is presented in Table 1.

Table 1. The data collection procedure

Test
Speed of reading
Spelling
Wordchains
Reading words aloud
APT Associative Learning
APT Reaction Time
APT Finger Tapping
APT Long-Term Memory
APT Word-Recognition Test (English three-letter version)
WAIS Information
C-D Verbal List Learning (learning)
WAIS Digit Symbol substitution test
Figure Classification
Wisconsin Card Sorting Test
C-D Verbal List Learning (recall)
Block Design Test
Rey–Osterrieth Complex Figure (copy)
Perceptual speed
Rey–Osterrieth Complex Figure (recall)
WAIS Vocabulary
APT Perceptual Maze (with target information)
APT Perceptual Maze (without target information)
APT Selective Attention (square version)
APT Selective Attention (letter version)
APT Digit Span
APT Simultaneous Capacity Test
APT Word Recognition Test (Swedish four-letter version)

Treatment of Data and Diagnostic Criteria

The results from the semistructured interviews concerning reading and writing abilities and the results from the academic achievement and neuropsychological tests were analyzed by a neuropsychologist (M.L.), according to clinical criteria for a dyslexia diagnosis (Lindgren & Ingvar, 1998). When assessing the occurrence of reading and writing disability the diagnostic criteria in DSM–III–R (American Psychiatric Association, 1987; 315.00 and 315.80) were used. The participant's reading achievement and writing skills were tested with four different tests, individually administered. Intellectual capacity was tested with tests of visuospatial capacity (block design test) and nonverbal reasoning ability (figure classification), also individually administered. In order to be assessed as having reading and writing disabilities–dyslexia performance on the academic achievement tests had to be markedly below the expected level (greater than 2 stanine units) given the participant's intellectual capacity and considering age and education. Typical errors for dyslexics in spelling and reading aloud were also considered.

Statistics

The results of the psychometric tests were mainly expressed in raw scores and the statistical analyses were based on these scores. The WAIS–R data were transformed to scaled scores to get data comparable to the normal population. In the statistical analyses, Student's t tests or one-way ANOVAs were used for comparing dyslexics and nondyslexics, without correction for multiple comparisons (since the study is exploratory). For some data, nonparametric tests were used.

RESULTS

Diagnosis of Dyslexia

Twenty-six (41%) of the 63 participants were diagnosed as dyslexic and an additional 6 (10%) as borderline cases who needed further investigation to obtain a definitive diagnosis. The borderline cases did not fulfill the criteria to be diagnosed as dyslexics but performed markedly below the

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expected level in some of the tests of academic achievement. The quantitative results of the dyslexia screening for the three groups (nondyslexics, $N = 31$; borderlines, $N = 6$; and dyslexics, $N = 26$), are reported in Table 2. The borderline group was small and displayed a large variance in the tests, and was therefore excluded from most of the remaining analyses. There were no differences in age between the two remaining groups (dyslexics $M = 34.7$ and nondyslexics $M = 34.2$ years; $t(55) = 0.21$, n.s), but the dyslexics had on average less education (9.1 ± 1.5 *vs*. 10.4 ± 2.1 years; $t(55) = 2.51$, $p < .05$). Onset of criminality was earlier for dyslexics. According to self-reports, 65% were registered for an offense already during elementary school compared to 39% for the nondyslexics ($\chi^2(1, N = 57) = 4.03$, $p < .05$).

Noncomputerized Tests

The Wisconsin Card Sorting Test yielded no differences between the two groups. The other results from the conventional tests for dyslexics and nondyslexics are shown in Table 3.

APT Data

Dyslexics were slower and performed more poorly as compared to the nondyslexics on most tests, with the exception of tests of basal functions such as Reaction Time and Finger Tapping. An outline of the most important APT test results is presented in Table 4 and Table 5. In Table 6, more detailed data from the most salient test in this context are presented, that is, the APT lexical decision tasks.

Multivariate Analysis

In order to estimate the power and usefulness of the APT battery to assess dyslexia, a stepwise discriminant analysis was conducted, entering 11 compound APT indices as predictors. These compound indices were selected on the basis of a series of factor analyses of various materials, including the present one, which was conducted in order to reduce the extensive information provided with each APT subtest evaluation. Typically, the number of orthogonal factors were one-third of the number of parameters entered, explaining 70% of the variance, and with good agreement in various materials (total N approximately 400). Results in these 11 compound parameters are now presented as the standard overview of the results of an APT test session.

A linear combination of three of these 11 parameters, Digit Span (number of remembered digits), Word Recognition (speed) and Long-Term Memory (number of remembered combinations) correctly classified 86% of the participants as dyslexics or not (Table 7).

Brain Dysfunction Index

Indication of suspected brain dysfunction was based on results in the Rey–Osterrieth Complex Figure. Performance was scored according to the scoring system described by Taylor (1995), as shown in Lezak (1995, p. 572) and the copy sheets were also assessed regarding qualitative signs of organic brain dysfunction according to Hamby et al. (1991), described in Lezak (1995, p. 575). The percentile accuracy scores according to Osterrieth (1944), as described in Lezak (1995, p. 475) were considered as well as the results from a Swedish unpublished study (Gunilla Hellberg-Edström, personal communication). In the latter, participants with accuracy scores below 20 and/or 14 or more score differences between copy and recall were found to have brain dysfunctions. An experienced clinical neuropsychologist (M.L.), who was blind in relation to the participant's performance in other tests, assessed the inmates results in the Rey–Osterrieth Complex Figure Test and found that 65% of the prison inmates were suspected to have organic brain dysfunction. There were no differences between dyslexics (62%) and nondyslexics (68%). Those with indication of organic brain dysfunction performed more poorly on the Block Design test (25.8 ± 6.9 *vs*. 30.2 ± 6.2;

Table 2. Reading–writing ability and intellectual capacity among criminal dyslexics, borderline readers, and nondyslexics

Task	Dyslexics ($N = 26$) $M \pm SD$	Borderline ($N = 6$) $M \pm SD$	Nondyslexics ($N = 31$) $M \pm SD$	F*	p*
Speed of reading (words/min)	154 ± 44	179 ± 36	216 ± 48	13.0	<.001
Spelling (misspelled words)	11.9 ± 5.0	7.8 ± 2.5	3.4 ± 2.5	36.5	<.001
Reading aloud (errors)	7.0 ± 5.4	4.0 ± 2.5	1.7 ± 2.5	12.5	<.001
Decoding (word chains/3 min)	49 ± 15	64 ± 5	74 ± 14	23.3	<.001
Stanine value	2.8 ± 2.0	5.2 ± 0.8	6.6 ± 2.1	25.8	<.001
Figure Classification					
Stanine value	5.8 ± 2.0	5.7 ± 1.0	7.0 ± 1.8	3.4	<.05
Block Design					
Stanine value	5.3 ± 2.1	5.8 ± 0.8	6.7 ± 1.9	3.9	<.05

*Refers to one-way ANOVAs.

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Table 3. Results on the noncomputerized neuropsychological tests for dyslexics and nondyslexics

Factor	Dyslexics ($N = 26$) $M \pm SD$	Nondyslexics ($N = 31$) $M \pm SD$	t*	p*
Claeson-Dahl (T-scores)				
Learning Ability	43.8 ± 15.6	53.9 ± 8.4	3.12	<.01
Retention (30 min)	66.0 ± 22.8	72.8 ± 15.8	1.34	n.s
WAIS–R subtests (scaled score)				
Information	6.5 ± 3.7	10.2 ± 3.4	3.92	<.001
Vocabulary	5.5 ± 3.0	9.1 ± 3.5	4.18	<.001
Digit symbol	6.5 ± 2.8	9.7 ± 2.7	4.46	<.001
Kohs blocks	24.8 ± 7.5	29.5 ± 5.7	2.66	<.05
Rey–Osterrieth				
Copy	33.3 ± 2.9	34.8 ± 2.7	2.02	<.05
Retention (3 min)	20.4 ± 7.4	19.9 ± 7.9	0.24	n.s
Figure	19.6 ± 5.6	22.6 ± 4.2	2.32	<.05
Perceptual Speed (#/s)	4.2 ± 1.0	5.2 ± 1.2	3.33	<.01

*Refers to Student's *t* test.

$t(55) = 2.41$, $p < .05$) but displayed no significant difference on APT reaction time variables, although both tests are sensitive to brain damage. Thirty-six percent of the inmates were reported to have seen a physician because of some kind of head trauma at least once. These inmates were equally distributed in the two groups (indication of brain dysfunction and no such indication).

Personality

The dyslexics had a higher frequency of two specific personality disorders: Paranoid Personality Disorder (58% of the dyslexics *vs.* 19% of the nondyslexics, $\chi^2(1, N = 57) = 8.93$, $p < .01$); and Avoidant Personality Disorder (35% *vs.* 11%, $\chi^2(1, N = 57) = 5.29$, $p < .05$). The frequencies of

Table 4. APT results for dyslexics and nondyslexics on basal neuropsychological functions

Parameter	Dyslexics ($N = 26$) $M \pm SD$	Nondyslexics ($N = 31$) $M \pm SD$	t*	p*
Finger tapping (#/s)				
Tapping right	6.53 ± 0.86	6.39 ± 0.87	0.60	n.s
Tapping left	5.51 ± 0.66	5.82 ± 0.87	1.50	n.s
Alternation right	3.47 ± 1.00	3.54 ± 1.06	0.28	n.s
Alternation left	3.38 ± 0.76	3.54 ± 0.91	0.69	n.s
Alternation left–right	3.81 ± 0.66	3.84 ± 0.90	0.13	n.s
Reaction time (ms)				
Audio	217 ± 59	200 ± 37	1.31	n.s
Visual	218 ± 40	211 ± 30	0.76	n.s
Two-choice right	299 ± 52	283 ± 48	1.21	n.s
Two-choice left	297 ± 59	277 ± 41	1.48	n.s
Left/right error	0.18 ± 0.15	0.17 ± 0.14	0.27	n.s
Inhibition right	504 ± 125	460 ± 125	1.32	n.s
Inhibition left	466 ± 117	419 ± 106	1.60	n.s
Failed inhibition	0.13 ± 0	0.09 ± 0.09	1.77	n.s
Simultaneous capacity				
d' (background)	1.59 ± 1.03	2.41 ± 0.92	3.08	<.01
Percent correct (foreground)	68 ± 27	73 ± 31	0.62	n.s
Spurious (foreground)	2.17 ± 3.99	5.12 ± 11.2	1.28	n.s

*Refers to Student's *t* test.

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Table 5. APT data for dyslexics and nondyslexics

Parameter	Dyslexics ($N = 26$) $M \pm SD$	Nondyslexics ($N = 31$) $M \pm SD$	t*	p*
Associative Learning				
Correct responses (#)	44.1 ± 8.4	54.0 ± 8.3	4.09	<.001
Response time (msec)	2632 ± 575	2230 ± 551	2.69	<.01
Long-Term Memory				
Remembered combinations	2.6 ± 2.1	4.8 ± 3.2	2.99	<.01
Retention response time	2113 ± 678	1641 ± 405	3.25	<.01
Digit Span				
Max. correct forward	6.0 ± 1.2	7.2 ± 0.8	4.34	<.001
Max. correct backward	5.0 ± 1.2	6.2 ± 1.1	3.91	<.001
Selective Attention (square distracters)				
d'	3.54 ± 0.80	3.55 ± 1.02	0.04	n.s
Response time	1005 ± 264	804 ± 190	3.33	<.01
Yes–no time ratio	0.77 ± 0.11	0.76 ± 0.09	0.41	n.s
Selective Attention (letter distracters)				
d'	3.45 ± 1.09	3.69 ± 0.60	1.05	n.s
Response time	1807 ± 365	1596 ± 275	2.49	<.05
Yes–no time ratio	0.65 ± 0.08	0.65 ± 0.07	0.14	n.s
Maze (with target information)				
Max. rows	11.9 ± 2.2	13.5 ± 2.9	2.25	<.05
Percent correct	82 ± 15	84 ± 18	0.58	n.s
Processing speed	3.00 ± 1.20	4.13 ± 2.32	2.24	<.05
Inspection speed	8.9 ± 7.1	13.4 ± 18.1	1.20	n.s
Check time	0.99 ± 0.49	0.75 ± 0.28	2.32	<.05
Maze (no target information)				
Max. rows	12.4 ± 2.7	13.1 ± 3.0	0.93	n.s
Percent correct	73 ± 16	73 ± 17	0.02	n.s
Processing speed	3.88 ± 1.98	4.99 ± 3.99	1.30	n.s
Inspection speed	12.3 ± 12.1	19.1 ± 33.6	0.97	n.s
Check time	0.86 ± 0.32	0.65 ± 0.25	2.79	<.01

*Refers to Student's *t* test.

personality disorder are showed in Table 8. Data from the self-report KSP questionnaire suggested that dyslexics scored higher on the anxiety-related scales, were more suspicious and were lower in socialization compared to the nondyslexics (see Table 9).

DISCUSSION

Dyslexia was found to be common among prison inmates. The frequency obtained in the present study is comparable with North American data (Underwood, 1976). To obtain a reliable frequency of dyslexia in the normal population is not an easy task. Lundberg (1985), using other criteria than in the present study, found in a study of children that 5 to 8% suffered from dyslexia. The frequency of dyslexia in the present study is also higher than among unemployed people, of whom 17% were dyslexic according to the same diagnostic criteria (Lindgren & Ingvar, 1998). A recent international study (Organization for Economic Co-operation and Development, 1995) reported that about 27% of the adult population in Sweden have functional reading and writing disabilities to some extent, although most of them were not considered dyslexic by diagnosis. In conclusion, the frequency of dyslexia among the criminals appears to be much higher than in the normal population.

Verbal skills were generally on a lower level for dyslexics as compared to normal readers among the prison inmates. Highly significant differences were obtained for the two WAIS–R subtests (Information and Vocabulary) as well as for the APT Word Recognition task. According to Lezak (1983), vocabulary is the single best measure of verbal skill in the WAIS–R battery. Bruck (1990) suggests that a measure that reflects difficulties in decoding nonwords (based on accuracy as well as response speed indices) appear to be most strongly correlated with dyslexia. In this study, the response speed to the four kinds of the APT word stimuli were all strongly associated with dyslexia. Even the three-letter word version in English shows the same pattern as the four-letter combinations. Since high-frequency three-letter words can be perceived more easily as a gestalt, it suggests that the prison dyslexics might have problems already at this level. Thus, within the present group, dyslexia appears to

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Table 6. Results on the APT lexicon decision task for dyslexics and nondyslexics

Parameter	Dyslexics ($N = 26$) $M \pm SD$	Nondyslexics ($N = 31$) $M \pm SD$	t*	p*
Swedish four-letter stimuli				
High-frequency words				
Ratio	0.97 ± 0.03	0.97 ± 0.03	0.87	n.s
Response time (ms)	721 ± 138	587 ± 72	4.69	<.001
Low-frequency words				
Ratio	0.88 ± 0.08	0.85 ± 0.11	1.38	n.s
Response time (ms)	981 ± 342	725 ± 149	3.76	<.001
Pronounceable nonwords				
Ratio	0.81 ± 0.17	0.92 ± 0.11	3.04	<.01
Response time (ms)	1158 ± 383	828 ± 266	3.82	<.001
Nonpronounceable nonwords				
Ratio	0.93 ± 0.11	0.97 ± 0.03	1.69	n.s
Response time (ms)	834 ± 184	684 ± 166	3.24	<.01
English three-letter stimuli				
High-frequency words				
Ratio	0.91 ± 0.06	0.93 ± 0.06	1.50	n.s
Response time (ms)	861 ± 226	669 ± 119	4.10	<.001
Low-frequency words				
Ratio	0.47 ± 0.20	0.29 ± 0.26	1.14	n.s
Response time (ms)	1233 ± 496	987 ± 313	2.26	<.05
Pronounceable nonwords				
Ratio	0.50 ± 0.22	0.66 ± 0.19	2.90	<.01
Response time (ms)	1232 ± 475	1004 ± 330	2.12	<.05
Nonpronounceable nonwords				
Ratio	0.94 ± 0.07	0.96 ± 0.07	1.09	n.s
Response time (ms)	839 ± 245	640 ± 118	4.00	<.001

*Refers to student's *t*-test

be associated with a general verbal impairment rather than with separate dimensions of verbal skills.

The three tests discriminating for dyslexia were somewhat expected since slow speed of decoding of words and impairment in short term memory have been reported previously (Lindgren & Ingvar, 1998). The precision of the classification, based on tests that can be administered in less than 20 min, appears promising (86% correct), but has to be cross-validated before any firm conclusions can be drawn (i.e., if the tests can be used diagnostically or only for screening). One should expect less predictive power in a new sample, particularly if the frequency deviates much from the ideal prediction situation of 50% dyslexics among the participants (41% in our group).

Table 7. Dyslexia classification by psychologist *versus* discriminant analysis

Discriminant analysis	Psychologist classification: Dyslexic	Psychologist classification: Nondyslexic
Dyslexic	21	3
Nondyslexic	5	28

Previous studies on noncriminals strongly suggest that dyslexics and nondyslexics perform at the same level in nonverbal neuropsychological tests. This was not the case in the present study. Dyslexics were characterized by inferior performance and by longer response times on all but the least complex tests (i.e., there were no differences in the APT Reaction Time and Finger Tapping tests). Correlating average IQ-factor-sensitive APT Perceptual Maze (max. rows) with WAIS Information ($r = .38$, $N = 57$, $p < .01$), WAIS Vocabulary ($r = .22$, n.s), WAIS Digit Symbols ($r = .54$, $N = 57$, $p < .001$) and Figure Classification ($r = .53$, $N = 57$, $p < .001$) indicates that the dyslexics' inferior performances on verbal tests mainly depend on less overlearning and education, but cannot explain the inferior performance on nonverbal tests. This suggests that the dyslexics among the prisoners actually had a lower average IQ, in addition to their specific verbal impairment. It should be noted that the dyslexia diagnosis is based on expected reading–writing ability when compared to nonverbal test performance. This means that the nondyslexics have a reading ability at the same level as their intellectual capacity, whereas the dyslexics' reading ability is markedly be-

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Table 8. Personality disorders among prison inmates in relation to dyslexia (frequencies; percentage)

Personality disorder	Dyslexics ($N = 26$)	Nondyslexics ($N = 31$)	χ^2	p
Avoidant	34.6	9.7	5.29	<.05
Dependent	3.8	9.7	0.73	n.s
Obsessive	19.2	19.4	0.00	n.s
Passive-Aggressive	15.4	16.1	0.01	n.s
Masochistic	26.9	22.6	0.14	n.s
Paranoid	57.6	19.4	8.93	<.01
Schizotype	34.6	12.9	3.79	n.s
Schizoid	3.8	3.2	0.02	n.s
Histrionic	3.8	19.4	3.16	n.s
Narcissistic	23.1	29.0	0.26	n.s
Borderline	50.0	32.2	1.85	n.s
Antisocial	50.0	25.8	3.77	n.s

low their intellectual capacity even when corrected for their somewhat lower IQ level. Since there were no differences between the groups in terms of the index of suspected brain dysfunction there is little reason to believe that the difference in IQ reflects cognitive decline caused by brain damage, such as that induced by drug abuse or by head trauma, which are both common in the prison population.

The differences in personality characteristics between the criminal dyslexics and nondyslexics make some sense. The dyslexics had a higher level of anxiety and difficulty in social interactions and role-taking, and the extent of these problems reached a pathological level in many cases. Furthermore, there was a trend that the dyslexics had a higher frequency of Antisocial Personality Disorder (50%) compared to the nondyslexics (26%, $\chi^2(1, N = 57) = 3.56$, $p <$ .06). It is possible that a child at risk, who has an additional handicap of dyslexia, more easily crosses the border into a persistent antisocial lifestyle (see Dalteg & Levander, 1998).

The dyslexics not only had dyslexia but were also impaired on a range of other neuropsychological tasks. One possible interpretation might be that dyslexics with low IQ run a higher risk of entering a criminal career. Most studies on dyslexia are carried out on samples that exclude low-IQ participants, which restricts the range of this parameter, and makes it more difficult to establish correlations with external criteria. A low IQ appears to be at least weakly associated with criminal propensity in studies not specifically focusing on dyslexia, supporting the interpretation that a double handicap (dyslexia and low IQ) increases the risk of entering a criminal career and remaining in it.

Table 9. Personality differences between dyslexics and nondyslexics in a criminal population

Personality factor	Dyslexics ($N = 26$) $M \pm SD$	Nondyslexics ($N = 31$) $M \pm SD$	t	p
Detachment	22.3 ± 4.9	19.9 ± 5.1	1.81	n.s
Guilt	12.6 ± 2.2	12.0 ± 2.0	1.12	n.s
Impulsiveness	26.0 ± 5.0	26.1 ± 6.2	0.02	n.s
Indirect aggression	12.2 ± 3.3	11.1 ± 2.8	1.35	n.s
Inhibition of aggression	22.3 ± 5.0	20.7 ± 5.3	1.21	n.s
Irritability	11.9 ± 2.8	12.0 ± 2.8	0.10	n.s
Monotony avoidance	26.2 ± 5.0	26.4 ± 5.9	0.11	n.s
Muscular tension	21.0 ± 5.7	16.6 ± 6.1	2.78	<.01
Psychic anxiety	22.2 ± 6.1	18.9 ± 6.0	2.02	<.05
Psychasthenia	23.8 ± 3.9	23.8 ± 5.0	0.03	n.s
Somatic anxiety	21.9 ± 6.3	17.1 ± 6.0	2.95	<.01
Social desirability	27.7 ± 4.3	25.6 ± 4.8	1.70	n.s
Socialization	50.3 ± 12.1	58.3 ± 16.0	2.08	<.05
Suspicion	12.0 ± 2.2	10.4 ± 2.2	2.74	<.01
Verbal aggression	13.2 ± 2.6	13.1 ± 3.7	0.12	n.s

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