

Both individual and group-based neuropsychological interventions of
dyslexia improve processing speed in young adults - a randomized
controlled study

Authors:

Johanna Nukari^{1,2}, Erja Poutiainen^{1,2}, Eva Arkkila³, Marja-Leena Haapanen³, Jari Lipsanen², Marja Laasonen^{2,3,4}

¹ Rehabilitation Foundation, Helsinki, Finland,

² Department of Psychology and Logopedics, Faculty of Medicine, University of Helsinki, Finland,

³ Department of Otorhinolaryngology and Phoniatics, Head and Neck Surgery, Helsinki University Hospital and University of Helsinki, Finland

⁴ Department of Psychology and Speech-Language Pathology, Faculty of Social Sciences, University of Turku, Finland

Corresponding author:

Johanna Nukari, Rehabilitation Foundation, PL 39, 00411, Helsinki, Finland

phone: +358-445357279, email: Johanna.Nukari@kuntoutussaatio.fi

Abstract

Effectiveness of individual and group-based neuropsychological interventions on cognitive aspects of dyslexia in young adults was evaluated. Dyslexic adults were randomly assigned into individual intervention (n = 40), group intervention (n = 40) or wait-list control group (n = 40). The interventions focused on cognitive strategy learning, supporting self-esteem, and using psychoeducation. Cognitive performance and symptoms were assessed via psychometric testing and self-report questionnaires at baseline, after the intervention/wait-list control time at five months and at ten months. 15 months post intervention long-term status was checked via mailed inquiry. Wait-list control group also received an intervention after the five-month control period. No significant effects were found in primary self-report outcome measures. Both interventions had a positive effect on a measure of processing speed and attention and the effect remained after the five-month follow-up period. In self-reported cognitive symptoms, a positive trend was evident in self-reported reading habits. Further, minor self-evaluated benefits reaching up to 15 months post intervention were found. There were no significant differences between the results of individual and group intervention as both interventions improved cognitive performance. The results indicate that a structured neuropsychological intervention could be effective in ameliorating dyslexia related cognitive symptoms in young adults.

Keywords: reading disability, remediation, neuropsychology, effectiveness, RCT, follow-up

Introduction

Developmental dyslexia is a neurodevelopmental disorder characterized by a difficulty in acquiring reading skills in spite of normal intelligence and sufficient reading opportunities (Shaywitz, 1998). It affects about 5 to 10% of the population (Peterson & Pennington, 2012; Shaywitz, 1998) and

continues to affect cognitive performance and psychosocial wellbeing beyond childhood (Gerber, 2012; Raskind, Goldberg, Higgins, & Herman, 1999; Shaywitz et al., 1999).

Aside with problems in fluent reading and writing skills, dyslexic adults frequently have difficulties in phonological processing concerning areas of phonemic fluency, rapid naming, verbal short-term memory and working memory (Felton, Naylor, & Wood, 1990; Hatcher, Snowling, & Griffiths, 2002; Laasonen, Lehtinen, Leppämäki, Tani, & Hokkanen, 2010, Laasonen et al., 2012b, Leinonen et al., 2001; Smith-Spark, Fisk, Fawcett, & Nicolson, 2003). Difficulties in attention (Hari, Renvall, & Tanskanen, 2001; Laasonen et al., 2012a) and multimodal temporal processing (Ben-Artzi, Fostick, & Babkoff, 2005; Laasonen, Service, & Virsu, 2001; Laasonen, Service, & Virsu, 2002) have also been found as well as problems with processing speed (Catts et al., 2002; Moll et al., 2016; Peter, Matsushita, & Raskinda, 2011; Park & Lombardino, 2011). Especially deficits in verbal processing speed have been linked with reading disability in multiple orthographies (Moll et al., 2014) and regardless of whether or not simultaneous attention problems are also present (Moll et al., 2016). Processing speed problems are still evident in adulthood even in individuals whose dyslexia related reading deficits have resolved since childhood (Eloranta, Närhi, Eklund, Ahonen, & Aro, 2019).

In self-reports, adults with dyslexia describe having problems with reading speed, writing, memory and time organization (Hatcher et al., 2002). In self-report questionnaires dyslexic adults were found to be clinically impaired in attention and memory (Hatcher et al., 2002). University students with dyslexia report also slips of attention, absent-mindedness, problems with word-finding, planning, task monitoring, working memory and organization (Smith-Spark, Henry, Messer, Edvardsdottir, & Ziecik 2016; Smith-Spark, Fawcett, Nicolson, & Fisk, 2004) as well as difficulties in prospective and retrospective memory (Smith-Spark, Ziecik, & Sterling, 2016; Smith-Spark, Ziecik, & Sterling, 2017). The self-reported problems seem to reflect the same aspects as the observed cognitive difficulties, in general.

A special characteristic of adult dyslexia compared to that of children is the possible secondary consequences that arise due to the primary problem in reading (Rack, 1997). One of them is the lack of reading and writing experience. Dyslexic readers tend to read less than their non-dyslexic peers and that can affect the growth of vocabulary and general knowledge (Lyon, Shaywitz, & Shaywitz, 2003; Stanovich, 1986). Another often reported secondary consequence of dyslexia are the socio-emotional problems. Lack of confidence, low self-esteem and increased levels of frustration and anxiety can affect optimal functioning of dyslexic adults (Carroll & Iles, 2006; Davis, Nida, Zlomke, & Nebel-Schwalm, 2009; Riddick, Sterling, Farmer, & Morgan, 1999) and self-esteem issues can accentuate the problems in literacy skills (Riddick et al., 1999).

Neuropsychological rehabilitation aims to decrease the disadvantages caused by brain dysfunctions and increase everyday coping despite the possibly lingering deficits. Functioning is supported by training the impaired cognitive functions, by practicing new strategies to better cope with situations where the deficits pose problems, and by training the use of different aids and reshaping the environment to decrease the effects of the deficits. Also, an important part of neuropsychological rehabilitation is to help with psychological adaptation, which can be achieved by offering psychological support and enhancing self-understanding and acceptance (Sohlberg & Mateer, 2001; Wilson, Gracey, Evans, & Bateman, 2009).

Neuropsychological rehabilitation in the adult population is commonly used with patients with acquired brain injury. Its effectiveness has been shown in these patient groups in individual format, and there is a growing evidence of benefits in group-based format as well (Cicerone et al., 2005; Cicerone et al., 2011). Neuropsychological interventions are also used for example in neuropsychiatric conditions, like attention deficit/hyperactivity disorder (O'Connell, Belgrove, Dokree, & Robertson, 2006; Wasserstein & Lynn, 2001). Training compensatory strategies and giving support in recognizing one's strengths and weaknesses have been found to reinforce a positive rehabilitation outcome (Cicerone et al., 2011).

Previous research focusing on neuropsychological interventions in adult dyslexia is not known to the authors, and, in general, much more is known about the remediation of reading problems in younger than older children or adults (Petersen & Pennington, 2012). An example of reading focused intervention for adults is an intervention called Project Success Summer Program for Adult Dyslexics (Kitz & Nash, 1992). The 15-week long program included reading and spelling instruction using direct teaching of sound-symbol assignments with direct procedures for blending sounds together to form words. The intervention produced significant gains among subjects in reading real words in isolation, reading rate, passage comprehension, and spelling (Kitz & Nash, 1992). No control group was used, and the aim was specifically to improve reading and writing skills instead of improving the participants' wellbeing and adjustment in a wider context.

An intervention more closely resembling neuropsychological rehabilitation was a cognitive dyslexia intervention in which 60 unemployed adult participants were recruited to a 5-month full-time educational program aiming to improve reading, writing, verbal memory, self-esteem, and flexibility of perspectives (Jensen, Lindgren, Andersson, Ingvar, & Levander, 2000). The program included teacher guided reading, writing, mathematics and computer training along with an individual plan aiming to improve learning and memory. In addition, the teachers were focusing on improving motivation and enhancing the participants' self-confidence. Performance in the educational group improved significantly in tests assessing spelling, decoding of letters, self-confidence, and flexibility in comparison to the controls. Because of the full-time schedule for five months this kind of a program would be rather difficult to implement among people who are studying or working, thus a need for shorter interventions is obvious.

From intervention research literature on children, it is known that better outcomes are associated with earlier intervention since they lead to greater automaticity in the targeted skills (Fletcher & Grigorenko, 2017). With later remedial efforts, automaticity is more difficult to achieve. It is also known that interventions training isolated skills, such as working memory or low level auditory and

visual processing, do not generalize to academic skills in general (Melby-Lervåg, Redick, & Hulme, 2016). Thus, the major focus in adult interventions need not to be the drilling of isolated reading related skills, but in improving efficient functioning in everyday life tasks where dyslexia might cause problems and in remediating the psychological consequences that living with dyslexia has caused.

In neuropsychological interventions, it is possible to ameliorate cognitive deficits as well as support self-esteem and enhance understanding of one's disability and its effects in different areas of life. Also, a person's strengths are reinforced to support the impaired cognitive areas. Because of these qualities and the positive effect that has been shown concerning other patient groups (Cicerone et al., 2005; Cicerone et al., 2011), we wanted to find out the possible effectiveness neuropsychological intervention has on cognitive functioning and psychosocial wellbeing among young adults with dyslexia.

Neuropsychological interventions can be delivered in either individual or group format, both having their own strengths. In individual intervention it is possible to focus more specifically on the particular difficulties the participant has. In group format, using peer support as a rehabilitative component can add value to psychological adjustment and wellbeing. We wanted to test both forms of neuropsychological intervention. The results are reported in two different sub-studies. The present sub-study aims to find out the effectiveness of neuropsychological interventions on objectively and subjectively measured cognitive aspects of dyslexia.

The main focus of the interventions regarding cognitive aspects was to train strategies to better cope with tasks where dyslexia causes problems (i.e., strategies for reading large amounts of texts efficiently and memorizing the essential of the text by using adequate and versatile note techniques, strategies for learning foreign languages etc.) and thus making processing more proficient. Memory functions were also targeted by teaching effective use of one's working memory capacity and practicing new strategies for memorizing different materials. The interventions also included

psychoeducation and offered psychological support to better cope with dyslexia and to support the participants' self-esteem. Changes in the ability to learn and use the kind of strategies trained in these interventions, or for example enhanced self-understanding, are not likely to show very strongly in laboratory-type cognitive tasks. Thus, the primary outcome measures were chosen to be self-report measures.

Psychometrically measured cognitive functions were also included in areas where the intervention was considered to possibly have an effect on, those being working memory and verbal learning, fluency, reading comprehension, processing speed, attention and executive control. A well-known practice effect due to repeated psychometric testing (Dikmen, Heaton, Grant, & Temkin, 1999) was expected to emerge in the results, thus having a control group was important in separating possible practice effects from actual intervention effects.

The pre-specified hypotheses were that both interventions show positive effects on perceived cognitive deficits. Additional research questions were whether the interventions have an effect on objective cognitive performance measures and whether either individual or group-based neuropsychological intervention is more effective than the other.

Methods

Participants

The recruitment process was continuous over a period of 23 months from November 2012 until August 2014. The participants were recruited by distributing information about the study via multiple different channels, including health care units, educational institutions, associations related to learning difficulties etc. The participants met the following inclusion criteria: 1) 18-35 years old during the year they were randomly assigned to the study. 2) Clinically confirmed developmental dyslexia based on a neuropsychological assessment and a medical examination by a physician specialized in phoniatrics. 3) Limited abilities in studies, work or employment related to dyslexia.

4) Subjective and objective need for an intervention because of dyslexia. Both the evaluation of limited abilities in studies, work or employment related to dyslexia and the subjective and objective need for an intervention were based on clinical evaluation utilizing the systematic interview and neuropsychological assessment. 5) Native language was Finnish.

Dyslexia was confirmed based on the participant's performance in five tests from two Finnish test batteries for dyslexia (Dyslexia Screening Test for Adolescents and Adults; Holopainen, Kairaluoma, Nevala, Ahonen, & Aro, 2004, and Reading and Writing Test for Adolescents and Adults; Nevala, Kairaluoma, Ahonen, Aro, & Holopainen, 2006). Oral reading measures involved reading aloud 30 Finnish words and 30 pseudowords. In silent reading measures, spelling errors were detected within single words during 3 min. 30 sec. and, in another task, word chains were separated during 1 min. 30 s. In dictation, 20 pseudowords were written. In order to qualify, the participant had to score A: at least 1 SD below average in at least three of the five subtests or B: at least 2 SD below average in at least two of the five subtests.

The exclusion criteria evaluated via an interview and questionnaires prior to assessments were: 1) Neurological illnesses. 2) Other learning disabilities than dyslexia. 3) Diagnosed or suspected ADHD (over 3 points in section A in the Adult ADHD Self-Report Scale, ASRS v1.1; Daigre et al., 2009, and over 45 points in Wender Utah Rating Scale, WURS; Ward, 1993). 4) Psychiatric diagnoses. 5) Severe depressive symptoms (over 28 points in Beck Depression Inventory-II; Beck, Steer, & Brown, 2004). A milder depression was accepted, but the condition had to be in a good treatment balance and there was no current need for participation in psychological treatment or therapy. 6) Alcohol or drug abuse controlled using a question concerning drug abuse and AUDIT-C (Babor, Higgins-Biddle, Saunders, & Monteir, 2001), with a cut-point of 9 for men and 8 for women. 7) Neuropsychological intervention received at the age of 16 or later.

Exclusion criterion in the neuropsychological assessment was general cognitive capacity being less than 80 points on the Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV; Wechsler,

2008, 2012) in either Verbal Comprehension Index or Perceptual Reasoning Index estimated by four subtests (Similarities, Vocabulary, Matrix Reasoning, Block Design).

All participants gave their written informed consent, and the study protocol was approved by the ethics committee of Helsinki Uusimaa Hospital district. Participants were randomly assigned into individual intervention, group intervention and wait-list control group using a stratified random number table. The randomization was stratified according to age (18–26 years vs. 27–35 years), gender (female vs. male), and education (basic and secondary education vs. higher education) and the randomization was performed by a blinded statistician. Of the 120 randomly assigned participants, 118 were assessed at baseline, 115 were assessed at five months, and 106 at ten months. The mailed battery of additional questions to check the long-term status was returned by 90 participants. The number and reasons for incomplete data are shown in Figure 1.

Assessment methods

The two primary outcome measures chosen were self-report questionnaires. Reading related behavior and attitudes were measured using a modified version of the Adult Reading History Questionnaire, ARHQ (Lefly & Pennington, 2000). The original ARHQ questionnaire includes questions concerning one's reading related childhood history and questions concerning current reading related behavior (i.e.: "What is your current attitude toward reading?"). The questions concerning current situations and attitudes and thus being replicable were used resulting in 13 questions measured on an a five-point-scale.

Subjective memory performance was measured using the Everyday Memory Questionnaire, EMQ (Sunderland, Harris, & Baddeley, 1983). A 36-item-version of the EMQ was used in this study. Answers for each question were given on a five-point-scale. The total scale and the five subscales (Speech, Reading and Writing, Faces and Places, Actions, Learning New Things) were analyzed.

In addition to the two primary outcome measures, secondary outcome measures concerning psychometrically measured cognitive performance often impaired in adult dyslexia, but not used in verifying dyslexia, are reported. The psychometric tests used were: 1) the Symbol Digit Modalities Test, SDMT (in a written format; Smith, 1968) assessing processing speed and attention. 2) Digit span sequencing (WAIS-IV, Wechsler, 2008, 2012) assessing working memory. 3) Word lists subtest (Wechsler Memory Test-III, WMS-III; Wechsler, 1997, 2008) assessing verbal learning. 4) Verbal Fluency with category switching (Delis-Kaplan Executive Function System, D-KEFS; Delis, Kaplan, & Kramer, 2001) assessing verbal fluency and executive control. 5) Design Fluency, (D-KEFS; Delis et al., 2001), assessing visual fluency and executive control. 6) Verbal Comprehension, V3 (a shortened version with 20 out of 40 items), a part of a Finnish Ability Test Battery, Kykytestistö AVO-9 (Pulliainen, 1995). V3 evaluates comprehension of complex written instructions, the ability to keep them in mind, process and execute them.

The possible benefits of the interventions were also evaluated using questions outside established questionnaires concerning concentration, memory, processing speed and the ability to learn new information using a four-point-scale (i.e. “How well can you usually concentrate?” 0 = very well vs. 4 = very poorly). Participants were also asked to evaluate the disadvantage dyslexia causes in studies and at work using a numerical scale from 0 to 10. These two questions concerning perceived disadvantage were summed to form one variable. These questions were posed at the same time-points as the outcome measures, and additionally 15 months post intervention via a mailed inquiry.

Study Procedure

The assessments were performed at baseline, at five months (end of intervention or end of waiting period) and at ten months (after follow-up for the intervention groups and after intervention for the wait-list control group). The battery of additional questions was mailed 15 months post intervention. The assessments were timed identically in individual and group interventions so that the baseline assessment was 1 – 14 days before first intervention session and the follow-up

assessment 1-14 days after the last intervention session. The study protocol was published in advance (ClinicalTrials.gov identifier: NCT01930500). The allocation sequence was concealed from the assessing psychologist and the participants were advised not to mention which group they attended to. The questionnaires were filled separately from the cognitive assessments and an assistant was available throughout the process in case of questions.

Intervention

The therapists giving the interventions were registered as qualified neuropsychologists eligible to administer neuropsychological rehabilitation by the Social Insurance Institution of Finland. Fidelity of implementation was taken care by educating carefully the therapists on the administration of the intervention program. They were also given an intervention manual designed for this study.

Adherence to the intervention protocol was assured by having monitoring discussions with the therapists during the interventions. Two experienced therapists administered most of the individual interventions and all the group interventions (N = 90 participants).

The intervention model had 12 sessions and a fixed basic structure with each session having its own topic, see Table 1. The intervention model was developed at the Rehabilitation Foundation (Kuntoutussäätiö, <https://kuntoutussaatio.fi/en/home/>) based on earlier, somewhat similar interventions that had been developed at the Rehabilitation Foundation. The earlier models had not been scientifically tested for efficacy but had received encouraging feedback from the participants. The individual strategies and techniques used in these previous models were partly common methods used in clinical neuropsychological rehabilitation.

All sessions had specific materials and home assignments that were used by all therapists. The therapists also had some freedom to tailor the sessions and choose the strategies being taught according to the participants' needs and neuropsychological profile. For example, in individual sessions if more difficulties were evident in reading than writing, issues regarding writing could be

handled more lightly and part of that session could be used to further focus on reading. In group format, there were two therapists available on five sessions, and during those sessions they were able to divide the group on the basis of the participants' needs. In the revising sessions the themes to be revised were chosen based on the participants' needs and feedback.

Both interventions included same topics, but the content was delivered partly differently. For example, regarding stress management and relaxation methods, group intervention had their own session on this topic whereas in individual intervention this topic was dealt with within any session where it seemed appropriate by the therapist. Common principles and methods of neuropsychological rehabilitation were used (Sohlberg & Mateer, 2001; Wilson, Gracey, Evans, & Bateman, 2009). Cognitive tasks were utilized in both individual and group intervention to train new strategies and to improve metacognition. Other methods used in both interventions were psychoeducation, teaching compensatory strategies and offering psychological support to better cope with dyslexia.

Knowledge on the cognitive profiles of the participants was used when adequate in choosing suitable strategies for each, especially in supporting memory, concentration and executive functions. Psychological expertise was used in supporting aspects such as resolving emotional stress concerning previous negative learning situations and relieving anxiety in current learning situations. In supporting reading and writing, the methodology was partly similar as in pedagogic support.

A participant with good visual memory skills could for example benefit from a memory strategy where visual imagery is deliberately used to enforce memorizing literal material. Supporting executive functions and concentration included for example psychoeducation based on neuropsychological knowledge on what aspects these functions comprise of and how one can improve them by learning new ways of planning, initiating tasks and evaluating one's effort. Strategies to improve reading and reading comprehension could include for example training the participants to actively plan their reading, enhance understanding of the text by reactivating

previously memorized knowledge on the subject and learning effective note taking techniques. Learning new strategies was implemented preferably using tasks and materials from participants' real life, for example school or work assignments.

All participants received recommendations for accommodation in their work or studies and were introduced with aids designed to better cope with dyslexia (for example audio books and text-to-speech -software etc.). The group intervention session lasted for two hours thus being half an hour longer than the 1.5 hour long individual session. The slightly longer time was due to the fact, that in groups of ten people the 1.5 hours would not be enough to cover the topics. The group intervention also offered the possibility for peer support.

Compliance with intervention

In the individual intervention, everyone attending the five-month examination attended all the 12 sessions (if one session was cancelled a new appointment was set to get all the sessions completed), compliance rate being 100%. In the group intervention, 78% attended at least 75% of the sessions with attendance rates ranging from 50% (for three persons) to 100%.

Wait-list control group did not receive neuropsychological intervention or any other intervention during the first 5 months. After the control period, they were randomly assigned to receive either individual or group intervention. In the individual intervention, they attended all 12 sessions. In the group intervention 64% attended at least 75% of the sessions with attendance rates ranging from 58% (for two persons) to 100%. Missed group sessions were compensated by giving participants the materials of the missed session upon the next meeting.

Statistical Analyses

We included in the analyses all the participants who had an observation at the five-month endpoint thus using the observed cases (OC) protocol (Prakash, Risser, & Mallincrodt, 2008). Group differences in baseline characteristics were analyzed using Pearson chi-square test and one-way

analyses of variance (ANOVA). Intervention outcomes were analyzed using a linear mixed model (random intercept model; Singer & Willett, 2003, adjustment for multiple comparison: Bonferroni), assessing possible differences over time (baseline, five months and ten months), possible differences between groups (individual intervention, group intervention and wait-list control), and the interaction between time and group. For estimate of effect size, a formula suggested by Snijders and Bosker (1999, pp. 102-103) was used. A paired samples t-test was used to evaluate the stability of self-evaluations 15 months post interventions. The analyses were performed using IBM SPSS Statistics program version 22.0.

Results

Baseline comparisons

The level of education of the participants was divided as follows based on the highest completed or on-going studies: Basic education (7 %), Vocational education (11 %), High School (29 %), College (40 %) and University (13 %). Life-situations were divided as follows: student (61 %), employed (27 %), unemployed (8 %) and other (4 %). There were no differences between groups in the level of education ($F_{2,115} = 0.89, p = 0.413$) or life-situation ($F_{2,115} = 0.65, p = 0.524$). There were also no statistically significant differences between the intervention groups and the control group in any other background variables (Table 2). There were no statistically significant differences at baseline between the intervention groups and the control group in the self-report measures (ARHQ, EMQ, battery of additional questions, see Table 3 and Table 4) or the psychometric variables (see Table 5).

Change in self-reported cognitive symptoms

Using a linear mixed model analyses, the time x group interaction between individual intervention, group intervention and wait-list control group did not reach significance in the Adult Reading History Questionnaire, ARHQ ($F_{4,214} = 2.22, p = 0.068$) (Table 3). A smaller finding of significant

improvement was found in the intervention groups as they had a more positive estimation of their subjective reading related performance after the intervention compared to the control group. More specifically, the improvement from baseline to first follow-up at five months was statistically significant within individual intervention group ($p = 0.013$) and the improvement from baseline to second follow-up at ten months was statistically significant within those receiving group intervention ($p = 0.003$). Significant changes were not evident in the control group during the waiting-list period from 0 to 5 months ($p = 1.00$) or 0 to 10 months ($p = 1.00$).

Significant time x group interaction was not evident in the Everyday Memory Questionnaire (EMQ) total score between the intervention groups and the control group ($F_{4,213} = 0.85, p = 0.493$). In the EMQ subscale of Reading and Writing, there was a smaller finding of significant improvement within those who received group intervention from baseline to second follow-up at ten months ($p = 0.006$). Significant changes were not evident in the control group during the period from 0 to 5 ($p = 1.00$) or 0 to 10 months ($p = 1.00$). The same was true for the individual intervention during the period from 0 to 5 ($p = 0.068$) or 0 to 10 months ($p = 0.175$).

In addition to the questionnaires above, targeted questions were used to gather information on the participants' subjective experiences on their cognitive functioning and the estimated disadvantage dyslexia is causing in their everyday life. This information was collected also at the 15 months post intervention follow-up. There were no significant interactions between the intervention groups and the control group in self-evaluations concerning concentration ability ($F_{4,217} = 2.24, p = 0.066$), memory ($F_{4,216} = 0.99, p = 0.414$), speed of handling things in mind ($F_{4,215} = 0.43, p = 0.785$) or the ability to learn new information ($F_{4,215} = 1.34, p = 0.256$) (Table 4). Yet, smaller positive findings were evident in three of these areas.

In self-evaluated ability to concentrate there was a significant improvement within those who received group intervention from baseline to second follow-up at ten months ($p = 0.012$). There were no significant changes in self-evaluated concentration ability within individual intervention or the control group.

In self-evaluated memory performance, there was a significant improvement within individual intervention from baseline to first follow-up at five months ($p = 0.011$), and the evaluation did not change significantly during follow-up from five months to ten months ($p = 1.00$). In self-evaluated processing speed, there was a significant improvement within individual intervention from baseline to second follow-up at ten months ($p = 0.026$). There were no significant changes within group intervention or the control group in self-evaluations of memory or processing speed.

Using a paired samples t-test within each group separately, the self-evaluations did not change significantly during follow-up from the end of intervention to 15 months post intervention concerning concentration ($t(28) = -1.29, p = 0.206$), memory ($t(28) = 1.28, p = 0.212$) or processing speed ($t(28) = 0.83, p = 0.415$).

Using a linear mixed model analyses, there was no significant interaction between the intervention groups and the control group in the self-evaluated disadvantage dyslexia causes in studies and work ($F_{4,214} = 0.94, p = 0.439$) (Table 4). A smaller positive finding was evident concerning the evaluated

disadvantage. The perceived disadvantage diminished significantly within individual and group intervention from baseline to first follow-up at five months (individual: $p = 0.002$, group: $p = 0.009$) and these evaluations did not change significantly during follow-up from five months to ten months (individual $p = 1.00$, group $p = 1.00$). There was no significant change in the control group from baseline to first follow-up at five months ($p = 0.326$). In the control group, there was a significant change from baseline to second follow-up at ten months, the time-point in which they also had had the intervention ($p = 0.005$).

Using a paired samples t-test within each group separately, the perceived disadvantage remained at the same level 15 months post intervention as it was at the end of the intervention at five months for individual ($t(33) = 0.28$, $p = 0.784$) and group interventions ($t(27) = -0.52$, $p = 0.606$). For the wait-list control group, the perceived disadvantage diminished from follow-up at ten months to the time-point 15 months post intervention ($t(26) = 2.42$, $p = 0.023$).

Change in psychometric cognitive functions

Using a linear mixed model analyses, there was a significant time x group interaction between the intervention groups and the control group in the Symbol Digit Modalities test (SDMT) score ($F_{4,213} = 2.86$, $p = 0.024$). Effect size for the whole model was $R_1^2 = 0.093$. Both intervention groups performed significantly better after the intervention (from baseline to first follow-up, individual $p < 0.001$, group $p = 0.003$). The improvement in the intervention groups remained stable also during follow-up after intervention from five to ten months. Performance in the control group did not improve during the control period from baseline to first follow-up at five months ($p = 1.00$). Performance in the control group improved significantly during the intervention after control period from first follow-up at five months to second follow-up at 10 months, ($p = 0.013$) (Figure 2).

There were no other significant time x group interactions between the intervention groups and the control group in the other psychometric measures. Instead significant differences in time ($p <$

0.001) were evident in all three groups and all psychometric variables over the three time-points (baseline, first follow-up and second follow-up), reflecting the practice effect due to repeated testing (Table 5).

Discussion

This study shows that neuropsychological interventions for adult dyslexia can have a positive effect on the cognitive performance of young adults when compared to non-intervention. The results demonstrate that both individual and group-based neuropsychological interventions improve processing speed and attention and the gains from the intervention remain even after the five-month follow-up.

Additionally, there was a positive trend in improvement of subjective reading related performance and reading and writing related memory performance in the intervention groups, although we failed to show significant interaction effects in these measures. Also, a trend for improvement was evident in self-evaluated concentration, memory and speed of handling things in mind as well as a diminishing of the perceived disadvantage dyslexia causes in studies and at work. The gains concerning areas that were self-evaluated 15 months post intervention showed that the effects remained even this long.

In processing speed and attention, the intervention resulted in better performance while the wait-list control group showed no improvement. The significance of the finding was accentuated by the wait-list control group that also showed a significant change in performance, after they received the intervention. The improvement in wait-list groups' performance was a bit smaller than in the intervention groups despite being statistically significant.

Processing speed difficulties have been linked with reading disability (Catts et al., 2002; Moll et al., 2016; Peter et al., 2011; Park & Lombardino, 2011). Slow processing speed has even been argued to be a core deficit in identifying students with dyslexia, processing deficits being more evident in

older than younger children (Park & Lombardino, 2011). General processing speed is also critical for utilizing many other cognitive skills effectively, and as such improvement in this area is important (Dang, Braeken, Colom, Ferrer, & Chang, 2015; Poll et al., 2013; Salthouse, 1996). For example, better processing speed can enable faster rehearsal in short term memory, which, in turn, allows the maintenance of larger amounts of information in the short-term storage where information is available only for a limited amount of time (Schweizer, 2005). Also, performing complex mental operations can be limited if slower processing speed makes the simpler operations too slow, which are needed to be executed before the more complex operations can be performed (Salthouse, 1996). Thus, improvement in processing speed could potentially generalize also to other cognitive skills.

The test (SDMT) used for evaluating processing speed and attention is widely used for testing these skills for example in patients with multiple sclerosis (MS). It has also been shown to be sensitive to impairments of information processing speed following mild to severe traumatic brain injury (Ponsford & Kinsella, 1992). In previous research, it has demonstrated sensitivity as well as reliability and validity, in addition to good reproducibility and minimal practice effects in cognitive assessment of MS (Benedict et al., 2008; Drake et al., 2010). Good reliability and minimal practice effects have also been shown within healthy students (Register-Mihalik et al., 2012). Thus, the SDMT can be considered an appropriate test for measuring processing speed. In the other cognitive measures, significant differences in time between the three time-points were found in all groups including the control group, which can in part be attributed to the practice effect due to repeated testing (Dikmen et al., 1999). Increased familiarity with the test material resulting from repeated assessments as well as reduced test-related anxiety could improve performance. Concerning SDMT this seems not to be the case – repeating the test does not seem to improve performance as the control group's performance did not improve in this task during the waiting period.

In the self-report measures, a positive trend toward a difference favoring the intervention groups in reading related performance was found when measured by the ARHQ, which was in line with our hypotheses. In the individual intervention, there was a significant positive change immediately after the intervention reflecting a positive change in reading habits, attitudes and estimates of one's own reading skills. These are areas that the intervention aimed to support. Interestingly, a similar positive change in group intervention reached significance at the later 10-month follow-up. The found delayed effect in group intervention compared to individual intervention needs further studies.

Despite their average level of general cognitive capacity, the participants' objectively measured memory performance in the beginning of the interventions was slightly below average, as can be seen from the standard scores (Table 5), leaving room for possible improvement also for memory. Yet, self-reported everyday memory performance did not improve during the interventions as measured with the EMQ total score. A positive change was found in the memory performance related to reading and writing measured with a subscale of the EMQ. There was significant improvement within group intervention between baseline and the ten-month follow-up and a non-significant positive trend in individual intervention for improvement during the intervention. Yet, more changes in subjective memory performance were expected. Perhaps the interventions did not offer enough support for memory performance in general and the smaller positive findings were thus focused on memory performance directly linked to reading and writing.

Positive trends reaching up to 15 months post intervention were found concerning answers to single questions about concentration, memory and processing speed. Also, the perceived disadvantage caused by dyslexia was diminished after the interventions with these effects being evident still over a year after the interventions. Unfortunately, due to logistic reasons the other measures were not repeated at this late follow-up via mailed inquiry, but the hints on possible long-term effects gained from these simpler measures were promising.

This study aimed to meet the essential criteria for a high-quality study (van Tulder et al., 2003) and the drop-out rate was acceptable. Yet, there are some limitations that must be considered when making conclusions based on the current study. The blinding of participants and therapists administering the intervention was understandably not possible as the interventions were based on continuous interaction between the participant and the therapist. Also, as a wait-list control group was used, they did not receive any placebo intervention, which means that the non-specific effects of interventions cannot totally be controlled for. The young adults participating in this study were relatively highly educated and comorbid, yet common conditions were ruled out by the exclusion criteria, such as, other developmental learning disabilities than dyslexia, ADHD symptomology or severe depressive symptoms. Thus, the results might not generalize to all young adults with dyslexia. Also, there were considerably more women than men participating in the interventions, which could make generalizing the results to male population less adequate.

The reason for excluding those with overall poor cognitive capacity was due to the nature and length of the intervention. It was strategy-based and relatively short, which allows us to speculate that, to be able to benefit from this kind of intervention, the difficulties cannot be too complex or widespread. In such a short time and a limited amount of intervention sessions it is not likely for a person with very complicated symptomatology to be able to pick up the strategies taught and implement them in daily life. On the other hand, it is very important to acknowledge that when a milder/more narrow dyslexic symptomatology is in question, even a 12-session intervention does improve both objectively assessed and to a lesser amount, self-reported cognitive functioning.

The differences in the effects between individual intervention and group intervention were not prominent in the cognitive aspects investigated in this study. The intervention contents were essentially the same in both formats, but naturally handling of the topics in groups as large as ten participants means that it is less individualized. Having two therapists present in five of the group sessions may have helped to tailor the content slightly more, since during these sessions the group

was often divided in two based on the participants' difficulties and needs. Attendance rates differed somewhat between individual and group interventions, because in individual intervention it was possible to set a new appointment if one was cancelled thus making an attendance rate of 100 % possible. In group sessions this was not possible. A lower attendance rate did not seem to markedly affect the results for the group intervention.

The results demonstrate that both individual and group-based neuropsychological interventions improve processing speed and, to a lesser extent, subjective reading-related performance, reading-related and writing-related memory performance as well as self-evaluated concentration, memory and speed of handling things in mind. It is possible that we have not found all the best measures to bring out all the effects of our strategy-based neuropsychological intervention with has multifaceted aims. More research using comprehensive methodologies will be needed in the future to evaluate the effectiveness of neuropsychological interventions aimed at improving coping with dyslexia among young adults.

Group-based interventions could be considered as an alternative to individual interventions in adult dyslexia rehabilitation. Since the control group did not receive any placebo intervention, more research is still needed to confirm the advantages of this type of neuropsychological intervention. In the future, investigating also a combination of individual and group interventions should be considered. This could create an optimal combination of individualized help and peer support.

Young adults suffering from dyslexia need to be supported to successfully manage studies and working life in our modern society where almost all functions rely on written information in one way or another. Neuropsychological interventions can be administered also outside school and study environments, as part of the healthcare system, thus reaching also adults who are working or outside employment. One eligible way of support for young adults with dyslexia could be neuropsychological intervention, either in individual or group format.

Funding

This study has been supported by the Social Insurance Institution of Finland (Dnro 36/26/2012).

Declaration of Conflicting Interests

The authors declare no conflicts of interest.

REFERENCES

- Babor, T., Higgins-Biddle, J., Saunders, J., & Monteiro, M. (2001). *The Alcohol Use Disorders Identification Test. Guidelines for Use in Primary Care*. Second Edition. World Health Organization.
- Beck, A., Steer, R., & Brown, G. (2004). *BDI-II Käsikirja*. [BDI-II Manual in Finnish]. Helsinki, Finland: Psykologien Kustannus oy.
- Ben-Artzi, E., Fostick, L., & Babkoff, H. (2005). Deficits in temporal-order judgments in dyslexia: Evidence from dichotic stimuli differing spectrally and from dichotic stimuli differing only by perceived location. *Neuropsychologia*, *43*, 714–723.
- Benedict, R.H., Duquin, J.A., Jurgensen S, Rudick, R. A., Feitcher, J., Munschauer, F. E. ... Weinstock-Guttman, B. (2008). Repeated assessment of neuropsychological deficits in multiple sclerosis using the Symbol Digit Modalities Test and the MS Neuropsychological Screening Questionnaire. *Multiple Sclerosis*, *14*, 940–946.
- Carroll, J., & Iles, J. (2006). An assessment of anxiety levels in dyslexic students in higher education. *British Journal of Educational Psychology*, *76*(3), 651–662.
- Catts, H., Gillispie, M., Leonard, L., Kail, R., & Miller, C. (2002). The role of speed of processing, rapid naming, and phonological awareness in reading achievement. *Journal of Learning Disabilities*, *35*, 509–524.
- Cicerone, K., Dahlberg, C., Malec J., Langenbahn, D., Felicetti, T., Kneipp, S., ... Catanese, J. (2005). Evidence-based cognitive rehabilitation: updated review of the literature from 1998 through 2002. *Archives of Physical Medicine and Rehabilitation*, *86*, 1681–92.

- Cicerone, K., Langenbahn, D., Braden, C., Malec, J., Kalmar, K., Fraas, ... Cantor, J. (2011). Evidence-based cognitive rehabilitation: updated review of the literature from 2003 through 2008. *Archives of Physical Medicine and Rehabilitation*, 92, 519–30.
- Daigre, C., Ramos-Quiroga, J. A., Valero, S., Bosch, R., Roncero, C., Gonzalvo, B., Norgueira, M., & Casas M. (2009). Adult ADHD Self-Report Scale (ASRS-v1. 1) symptom checklist in patients with substance use disorders. *Actas Espanolas De Psiquiatria*, 37, 299–305.
- Dang, C.-P., Braeken, J., Colom, R., Ferrer, E., & Chang, L. (2015). Do processing speed and short-term storage exhaust the relation between working memory capacity and intelligence? *Personality and Individual Differences*, 74, 241–247.
- Davis, T., Nida, R., Zlomke, K., & Nebel-Schwalm, M. (2009). Health-related quality of life in college undergraduates with learning disabilities: The mediational roles of anxiety and sadness. *Journal of Psychopathology and Behavioral Assessment*, 31, 228 - 234.
- Delis, D., Kaplan, E., & Kramer, J. (2001). *Delis-Kaplan Executive Function System (D-KEFS): Technical Manual*. San Antonio TX: The Psychological Corporation.
- Dikmen, S., Heaton, R., Grant, I., & Temkin, N. (1999). Test-retest reliability and practice effects of expanded Halstead-Reitan Neuropsychological Test Battery. *Journal of International Neuropsychological Society*, 5, 346–356.
- Drake, A., Weinstock-Guttman, B., Morrow, S., Hojnacki, D., Munschauer, F., & Benedict, R. H. (2010). Psychometrics and normative data for the Multiple Sclerosis Functional Composite: Replacing the PASAT with the Symbol Digit Modalities Test. *Multiple Sclerosis*, 16, 228–237.
- Eloranta, K., Närhi, K., Eklund, K., Ahonen, T., & Aro, T. (2019). Resolving reading disability – Childhood predictors and adult-age outcomes. *Dyslexia*, 25, 20–37.
- Felton, R., Naylor, C., & Wood, F. (1990). Neuropsychological profile of adult dyslexics. *Brain and Language*, 39, 485–497.

- Fletcher, J., & Grigorenko, E. (2017). Neuropsychology of Learning Disabilities: The Past and the Future. *Journal of the International Neuropsychological Society*, 23, 930–940.
- Gerber, P. (2012). The Impact of learning disabilities on adulthood: A review of the evidence-based literature for research and practice in adult education. *Journal of Learning Disabilities*, 45, 31–46.
- Hari, R., Renvall, H., & Tanskanen, T. (2001). Left minineglect in dyslexic adults. *Brain*, 124, 1373–1380.
- Hatcher, J., Snowling, M. J., & Griffiths, Y. (2002). Cognitive assessment of dyslexic students in higher education. *British Journal of Educational Psychology*, 72, 119–133.
- Holopainen, L., Kairaluoma, L., Nevala, J., Ahonen, T., & Aro, M. (2004). *Lukivaikeuksien seulontamenetelmä nuorille ja aikuisille*. (Dyslexia Screening Test for Adolescents and Adults.) Jyväskylä: Niilo Mäki Instituutti.
- Jensen, J., Lindgren, M., Andersson, K., Ingvar, D., & Levander, S. (2000). Cognitive intervention in unemployed individuals with reading and writing disabilities. *Applied Neuropsychology*, 7(4), 223–236.
- Kibby, M., Marks, W., Morgan, S., & Long, C. (2004). Specific Impairment in Developmental Reading Disabilities: A Working Memory Approach. *Journal of Learning Disabilities*, 37(4), 349–363.
- Kitz, W., & Nash, R. (1992). Testing the Effectiveness of the Project Success Summer Program for Adult Dyslexics. *Annals of Dyslexia*, 42, 3–24.
- Laasonen, M., Lehtinen, M., Leppämäki, S., Tani, P., & Hokkanen, L. (2010). Project DyAdd: Phonological processing, reading, spelling, and arithmetic in adults with dyslexia or ADHD. *Journal of Learning Disabilities*, 43(1) 3–14.
- Laasonen, M., Salomaa, J., Cousineau, D., Leppämäki, S., Tani, P., Hokkanen, L., & Dye, M. (2012a). Project DyAdd: Visual attention in adult dyslexia and ADHD. *Brain and Cognition*, 80, 311–327.
- Laasonen, M., Service, E., & Virsu, V. (2001). Temporal order and processing acuity of visual, auditory, and tactile perception in developmentally dyslexic young adults. *Cognitive, Affective, & Behavioral Neuroscience*, 1(4), 394–410.

- Laasonen, M., Service, E., & Virsu, V. (2002). Crossmodal temporal order and processing acuity in developmentally dyslexic young adults. *Brain and Language*, 80(3), 340–354.
- Laasonen, M., Virsu V., Oinonen S., Sandbacka M., Salakari A., & Service E. (2012b). Phonological and sensory short-term memory are correlates and both affected in developmental dyslexia. *Reading and Writing*, 25, 2247–2273.
- Lefly, D. L., & Pennington, B. F. (2000). Reliability and validity of the adult reading history questionnaire. *Journal of Learning Disabilities*, 33, 286–296.
- Leinonen, S., Müller, K., Leppänen, P., Aro, M., Ahonen, T., & Lyytinen, H. (2001). Heterogeneity in adult dyslexic readers: Relating processing skills to the speed and accuracy of oral text reading. *Reading and Writing: An Interdisciplinary Journal*, 14, 265–296.
- Lyon, G., Shaywitz, S., & Shaywitz, B. (2003). Defining dyslexia, comorbidity, teachers' knowledge of language and reading. A definition of dyslexia. *Annals of Dyslexia*, 53, 1–14.
- Melby-Lervåg, M., Redick, T., & Hulme, C. (2016). Working memory training does not improve performance on measures of intelligence or other measures of “far transfer” evidence from a meta-analytic review. *Perspectives on Psychological Science*, 11, 512–534.
- Moll, K., Göbel, S., Gooch, D., Landerl, K., & Snowling, M. (2016). Cognitive Risk Factors for Specific Learning Disorder: Processing Speed, Temporal Processing, and Working Memory. *Journal of Learning Disabilities*, 49(3) 272–281.
- Moll, K., Ramus, F., Bartling, J., Bruder, J., Kunze, S., Neuhoff, N., ... & Tóth, D. (2014). Cognitive mechanisms underlying reading and spelling development in five European orthographies. *Learning and Instruction*, 29, 65–77.
- Nevala, J., Kairaluoma, L., Ahonen, T., Aro M., & Holopainen, L. (2006). *Lukemis- ja kirjoittamistaitojen yksilötestistöä nuorille ja aikuisille*. (Reading and Writing Test for Adolescents and Adults.) Jyväskylä: Niilo Mäki Instituutti.

- O'Connell, R., Belgrove, M., Dokree, P., & Robertson, I. (2006). Cognitive remediation in ADHD: effects of periodic non-contingent alerts on sustained attention to response. *Neuropsychological rehabilitation, 16*(6), 653–665.
- Park, H., & Lombardino, L. (2011). Relationships among cognitive deficits and component skills of reading in younger and older students with developmental dyslexia. *Research in Developmental Disabilities, 34*, 2946–2958.
- Peter, B., Matsushita, M., & Raskinda, W. (2011). Global Processing Speed in Children with Low Reading Ability and in Children and Adults with Typical Reading Ability: Exploratory Factor Analytic Models. *Journal of Speech, Language, and Hearing Research, 54*, 885–899.
- Peterson, R., & Pennington, B. (2012). Developmental dyslexia. *Lancet, 379*, 1997–2007.
- Poll, G., Miller, C., Mainela-Arnold, E., Adams, K., Misra, M., & Park, J. (2013). Effects of children's working memory capacity and processing speed on their sentence imitation performance. *International Journal of Language & Communication Disorders, 48*(3), 329–342.
- Ponsford, J. L., & Kinsella, G. (1992). Attentional deficits following closed-head injury. *Journal of Clinical and Experimental Neuropsychology, 14*, 822–838.
- Prakash, A., Risser, R., & Mallincrodt, C. (2008). The impact of analytic method on interpretation of outcomes in longitudinal clinical trials. *International Journal of Clinical Practice, 62*(8), 1147–1158.
- Pulliainen, H. (1995). *Kykkytestistö AVO-9*. [Finnish Ability Test Battery]. Helsinki, Finland: Työministeriö and Psykologien kustannus oy.
- Rack, J. (1997). Issues in the assessment of developmental dyslexia in adults: theoretical and applied perspectives. *Journal of Research in Reading, 20*(1), 66–76.
- Raskind, M. H., Goldberg, R. J., Higgins, E. L., & Herman, K. L. (1999). Patterns of change and predictors of success in individuals with learning disabilities: results from a twenty-year longitudinal study. *Learning Disabilities, Research & Practice, 14*, 35–50.

- Register-Mihalik, J., Kontos, D., Guskiewicz, K., Mihalik, J., Conder, R., & Shields, E. (2012). Age-related differences and reliability on computerized and paper-and-pencil neurocognitive assessment batteries. *Journal of Athletic Training, 47*(3), 297–305.
- Riddick, B., Sterling, C., Farmer, M., & Morgan, S. (1999). Self-esteem and anxiety in the educational histories of adult dyslexic students. *Dyslexia, 5*, 227–48.
- Rosenberg, M. (1965). *Society and the adolescent self-image*. Princeton, NJ: Princeton University Press.
- Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review, 103*, 403–428.
- Schweizer, K. (2005). An overview of research into the cognitive basis of intelligence. *Journal of Individual Differences, 26*(1), 43–51.
- Shaywitz, S. (1998). Current concepts in dyslexia. *The New England Journal of Medicine, 338*(5), 307–312.
- Shaywitz, S. E., Fletcher, J. M., Holahan, H. M., Schneider, A. E., Marchione, K. E., Stuebing, K. ...
 Shaywitz, B. A. (1999). Persistence of dyslexia: The Connecticut Longitudinal Study at Adolescence. *Pediatrics, 104*(6), 1351–1359.
- Singer, J. D., & Willett, J. B. (2003). *Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence*. Oxford: Oxford University Press.
- Smith, A. (1968). *The symbol-digit modalities test: A neuropsychologic test of learning and other cerebral disorders*. In: Helmuth, J. (ed.) Learning disorders. Seattle: Special Child Publications, 83–91.
- Smith-Spark, J. H., Fawcett, A. J., Nicolson, R. I., & Fisk, J. E. (2004). Dyslexic students have more everyday cognitive lapses. *Memory, 12*(1), 174–182.
- Smith-Spark, J. H., Fisk, J., Fawcett, A. J., & Nicolson R. I. (2003). Investigating the central executive in adult dyslexics: Evidence from phonological and visuospatial working memory performance. *European Journal of Cognitive Psychology, 15*(4), 567–587.

- Smith-Spark, J. H., Henry, L. A., Messer, D. J., Edvardsson, E., & Ziecik, A. P. (2016). Executive functions in adults with developmental dyslexia. *Research in Developmental Disabilities, 53-54*, 323–341.
- Smith-Spark, J. H., Ziecik, A. P., & Sterling, C. (2016). Self-Reports of increased prospective and retrospective memory problems in adults with developmental dyslexia. *Dyslexia, 22*, 245–262.
- Smith-Spark, J. H., Ziecik, A. P., & Sterling, C. (2017). Adults with developmental dyslexia show selective impairments in time-based and self-initiated prospective memory: Self-report and clinical evidence. *Research in Developmental Disabilities, 62*, 247–258.
- Snijders, T. A. P., & Bosker, R. J. (1999). *Multilevel analysis: an introduction to basic and advanced multilevel modeling*. London: Sage.
- Sohlberg, M. M., & Mateer, C. A. (2001). *Cognitive Rehabilitation: An Integrative Neuropsychological Approach*. New York: The Guilford Press.
- Stanovich, K. (1986). Matthew effect in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly, 16*, 32–71.
- Sunderland, A., Harris, J. E., & Baddeley, A. D. (1983). Do laboratory tests predict everyday memory? A neuropsychological study. *Journal of Verbal Learning and Verbal Behavior, 22*, 341–357.
- van Tulder, M., Furlan, A., Bombardier, C., Bouter, L., & the Editorial Board of the Cochrane Collaboration Back Review Group (2003). Updated method guidelines for systematic reviews in the Cochrane collaboration back review group. *Spine, 28*, 1290–1299.
- Ward, M. F. (1993). The Wender Utah Rating Scale: An aid in the retrospective diagnosis of childhood attention deficit hyperactivity disorder. *American Journal of Psychiatry, 1*, 885.
- Wasserstein, J., & Lynn, A. (2001). Metacognitive Remediation in Adult ADHD. *Annals of the New York Academy of Sciences, 931*, 376–384.
- Wechsler, D. (1997). *WMS-III - Wechsler Memory Scale - 3rd ed.* San Antonio: The Psychological Corporation.

Wechsler, D. (2008). *WMS-III käsikirja*. [The WMS-III. A Finnish manual]. Helsinki: Psykologien Kustannus Oy.

Wechsler, D. (2008). *Wechsler adult intelligence scale – Fourth Edition (WAIS-IV)*. London: The Psychological Corporation.

Wechsler, D. (2012). *WAIS-IV käsikirja*. [The WAIS-IV. A Finnish manual]. Helsinki: Psykologien Kustannus Oy.

Wilson, B., Gracey, F., Evans, J., & Bateman, A. (2009). *Neuropsychological Rehabilitation: Theory, Models, Therapy and Outcome*. Cambridge: Cambridge University Press.

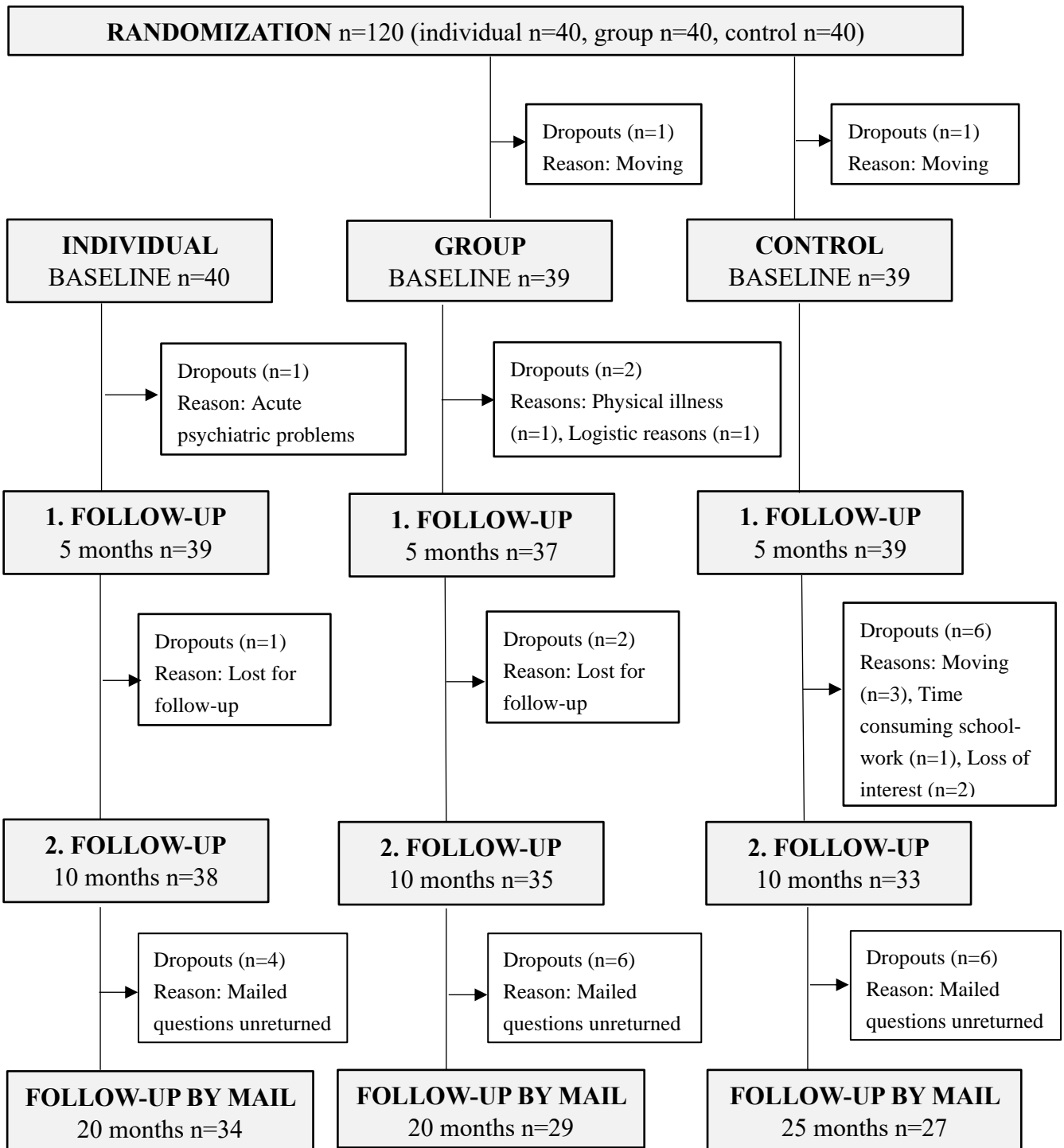


Figure 1. Flowchart of the study procedure and number and reasons for incomplete data.

Table 1. The topics of the intervention sessions.

Session	Individual intervention	Group intervention
1	Feedback from the assessment*, setting goals	Feedback from the assessment*, setting goals
2	Reading strategies and aids	Dyslexia information, getting to know the group
3	Writing strategies and aids	Reading strategies and aids
4	Memory strategies and aids	Writing strategies and aids**
5	Foreign language learning strategies	Memory strategies and aids
6	Revising a needed previous theme/themes	Stress management and relaxation methods**
7	Attention and concentration	Revising a needed previous theme/themes**
8	Executive functions and time management	Foreign language learning strategies**
9	A family member present or revising	Executive functions, attention, time management
10	Mathematics or revising a previous theme	Mathematics or revising a previous theme**
11	Self-knowledge and self-esteem	Self-knowledge and self-esteem
12	Conclusion, evaluating goals, plans for future	Conclusion, evaluating goals, plans for future

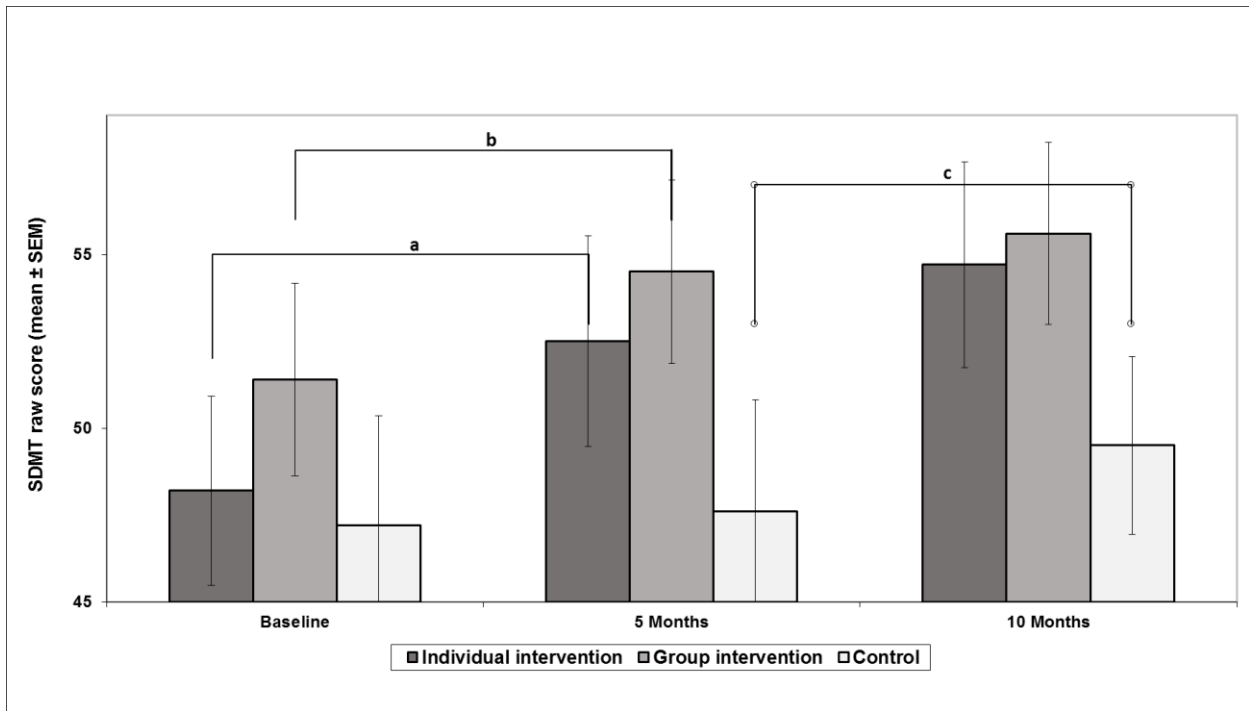
* the neuropsychological assessment performed for all participants when recruiting

** two therapists present (additional neuropsychologist / physiotherapist /special education teacher)

Table 2. Background characteristics of the participants.

	Individual intervention (n=40)	Group intervention (n=39)	Wait-list control (n=39)	P value	All participants (n=118)
<i>Age, years, M (SD)</i>	25.0 (5.6)	25.7 (5.7)	24.6 (6.1)	0.69 ^a	25.1 (5.8)
<i>Female/male, freq.</i>	32 / 8	30 / 9	32 / 7	0.85 ^b	94 / 24
<i>WAIS-IV, M (SD)</i>	101.0 (11.7)	100.3 (13.0)	99.7 (12.7)	0.99 ^a	100.3 (12.4)

^a) ANOVA, ^b) Pearson Chi-Square χ^2 . WAIS-IV: Wechsler Adult Intelligence Scale – Fourth edition (Wechsler, 2008, 2012)



^a $p < 0.001$, ^b $p = 0.003$, ^c $p = 0.013$

Figure 2. The changes in Symbol Digit Modalities Test (SDMT) in the intervention groups and control group at baseline, at 5 months and at 10 months. The changes from baseline to 10 months were significant in all three groups. For the intervention groups this change was significant at the $p < 0.001$ level and in the control group at the $p < 0.01$ level.

Table 3. Comparisons between individual intervention, group intervention and wait-list controls in self-report measures at baseline, at 5 months and at 10 months.

	Individual intervention			Group intervention			Wait-list control group			p time	p group	p time x group
	0 months	5 months	10 months	0 months	5 months	10 months	0 months	5 months	10 months			
Self-reported cognitive performance	n = 39	n = 38	n = 38	n = 36	n = 36	n = 35	n = 39	n = 39	n = 33			int.ac.^a
ARHQ	30.6 (6.3)	28.4 (5.7)	29.2 (6.5)	31.5 (5.7)	30.6 (5.6)	29.0 (6.0)	30.9 (6.4)	31.1 (7.4)	30.3 (7.5)	0.002	0.577	0.068
EMQ	40.6 (17.5)	38.4 (18.6)	38.0 (17.8)	48.3 (18.1)	47.1 (17.3)	44.0 (19.4)	44.2 (19.7)	45.0 (17.9)	44.5 (16.3)	0.198	0.146	0.493

Note. Figures are mean raw scores (SD). Less points equals a better result in all. ^a Linear mixed model analyses. ARHQ: Adult Reading History Questionnaire, EMQ: Everyday Memory Questionnaire.

Table 4. Comparisons between individual intervention, group intervention and wait-list controls in single-question based self-evaluations at baseline, at 5 months and at 10 months and descriptive values for the scores at 15 months after the interventions.

	Individual intervention				Group intervention				Wait-list control group				Linear mixed model for timeframe 0, 5 and 10 m. ^a		
Self-evaluation	0m. n = 39	5m. n = 38	10m. n = 38	15m. n = 34	0m. n = 36	5m. n = 36	10m. n = 35	15m. n = 29	0m. n = 39	5m. n = 39	10m. n = 34	15m. n = 27	p time	p group	p time x group
Concentration	1.38 (0.71)	1.37 (0.49)	1.42 (0.64)	1.44 (0.89)	1.75 (0.81)	1.47 (0.74)	1.37^b (0.65)	1.69 (0.66)	1.59 (0.72)	1.72 (0.76)	1.62 (0.60)	1.44 (0.64)	0.390	0.112	0.066
Memory	1.72 (0.83)	1.39^c (0.64)	1.50 (0.73)	1.53 (0.79)	1.75 (0.77)	1.67 (0.76)	1.63 (0.77)	1.59 (0.87)	1.74 (0.82)	1.69 (0.83)	1.56 (0.71)	1.70 (0.61)	0.020	0.543	0.414
Speed	1.79 (0.81)	1.66 (0.75)	1.47^d (0.76)	1.50 (0.93)	1.78 (0.80)	1.69 (0.71)	1.66 (0.82)	1.69 (0.93)	1.97 (0.84)	1.87 (0.70)	1.74 (0.75)	1.78 (0.75)	0.010	0.303	0.785
Learning	1.49 (0.82)	1.29 (0.69)	1.26 (0.60)	1.38 (0.74)	1.69 (0.71)	1.42 (0.69)	1.43 (0.74)	1.45 (0.78)	1.56 (0.82)	1.64 (0.84)	1.38 (0.70)	1.52 (0.80)	0.009	0.334	0.256
Disadvantage	12.1 (3.25)	10.4^e (3.40)	10.0 (3.49)	10.4 (3.50)	13.5 (3.26)	11.9^f (2.98)	12.2 (3.96)	12.1 (3.37)	13.6 (3.30)	12.9 (3.74)	11.9^g (3.63)	10.8 (3.01)	<0.001	0.009	0.439

Note. Figures are mean raw scores (SD). Less points equals a better result in all. ^am. = Month. ^bBaseline vs 10 months, $p = 0.012$. ^cBaseline vs 5 months, $p = 0.011$. ^dBaseline vs 10 months, $p = 0.026$. ^eBaseline vs 5 months, $p = 0.002$, ^fBaseline vs 5 months, $p = 0.009$, ^gBaseline vs 10 months, $p = 0.005$. Concentration: “How well can you usually concentrate?”, Memory: “How would you evaluate your memory at the moment?”, Speed: “How fast can you process things in your mind?”, Learning: “How would you evaluate your capacity to learn new information and new things?”, Perceived disadvantage: