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EFFECTIVENESS OF INDIVIDUAL AND GROUP-BASED NEUROPSYCHOLOGICAL INTERVENTIONS FOR YOUNG ADULTS WITH DYSLEXIA

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ACADEMIC DISSERTATION

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ABSTRACT

Dyslexia is a developmental learning disorder impacting cognitive performance and psychological well-being in multiple ways still in adulthood. Especially without adequate support, it may lead to lower-than-expected educational outcomes and increased unemployment and even psychiatric illness, increasing the risk for marginalization. Evidence-based means of support are needed, and particularly for adults, there are not enough such interventions.

In the present thesis, the effectiveness of individual and group-based neuropsychological interventions in supporting young adults with dyslexia was evaluated using a randomized, controlled study design. First, the possible effects of the interventions on the participants' subjective and objective cognitive performance were evaluated. Next, possible effects the interventions have on the participants' psychological well-being were assessed. Finally, the attainment of personally set intervention goals and factors related to goal attainment were evaluated, as well as concrete behavioral changes made in participants' study or working habits to ameliorate dyslexia-related challenges.

Participants were young adults with diagnosed dyslexia and aged between 18 to 35. They were randomly assigned into individual intervention (N = 40), group intervention (N = 40), or wait-list control group (N = 40). The interventions consisted of 12 sessions over a 5-month period and used methodology typical for neuropsychological rehabilitation focusing on cognitive strategy learning, supporting self-esteem, using psychoeducation, and in group format also peer support. The wait-list control group received an intervention after the 5-month control period. The assessments were performed at baseline and at 5 and 10 months. Long-term status was checked via a mailed inquiry 15 months post-intervention.

Cognitive performance and symptoms were assessed using psychometric testing, self-report questionnaires, and additional queries. Cognitive and behavioral strategies, mood states, quality of life, and self-esteem were assessed via self-report questionnaires. Attainment of personally set goals for the intervention was evaluated using Goal Attainment Scaling, and the participants were asked to report possible concrete changes they had made in their study or working habits, as well as the dyslexia-related aids they had in use.

Both interventions had a positive effect on processing speed compared to the control group, and the effect remained after the 5-month follow-up period. In self-reported cognitive symptoms, smaller improvement was evident in subjective reading-related performance and memory performance related to reading and writing. In addition, self-evaluated benefits in specific areas of cognitive functioning, as well as diminished disadvantage dyslexia causes in

studies and work, were found, and these benefits lasted up to 15 months post-intervention.

In psychological well-being, a positive effect on self-evaluated cognitive and behavioral strategies was evident in increasing success expectations compared to the control group and to a lesser degree, in diminishing task avoidance. The interventions also improved assessments of cognition-related quality of life compared to the control group, and to a lesser degree, self-esteem.

Personal intervention goals were, on average, met and more likely in individual than group intervention. Almost 50% of goal attainment was explained by intervention type, cognitive and behavioral strategies, concrete changes made in study or working habits, cognitive capacity, and time used for intervention matters between intervention sessions. New strategies and methods in study and working habits and dyslexia-related aids were picked up for use during the interventions significantly more than during the wait-list control period. 15 months post-intervention, over three-fourths of the participants reported still using the adopted strategies.

Some differences in the intervention effects were found between the two intervention types, which might suggest that combining the two intervention types could endorse the most positive changes. In the future, it would be beneficial to investigate this kind of combined intervention.

The studied neuropsychological interventions resulted in many positive and partly long-lasting changes in the intervention groups, potentially helping in ameliorating the cognitive and psychological challenges dyslexia brings to young adults. The impact of dyslexia is likely only to increase in our modern society, where so much is based on written information. Support for dyslexia should be offered also to young adults in secondary and post-secondary education and in working life, as well as in pursuing education or employment. Means of support for young adults with dyslexia are needed, and the investigated neuropsychological interventions could offer one suitable solution.

TIIVISTELMÄ

Dyslexia eli lukivaikeus on kehityksellinen neurobiologinen häiriö, joka koskettaa merkittävää osaa ihmisistä vielä aikuisenakin haitaten opinnoissa ja työssä suoriutumista sekä monen kohdalla myös psyykkistä hyvinvointia. Lukivaikeus voi etenkin ilman asianmukaista tukea johtaa alisuoriutumiseen opinnoissa ja työelämässä ja on riskitekijä syrjäytymiselle. Lukivaikeuden kuntoutukseen tarvitaan tutkimuksin toimiviksi osoitettuja tukimuotoja myös aikuisille.

Tässä väitöskirjassa tutkittiin yksilö- ja ryhmämuotoisen neuropsykologisen kuntoutuksen vaikuttavuutta nuorten aikuisten lukivaikeuden tukemisessa hyödyntäen satunnaistettua, kontrolloitua tutkimusasetelmaa. Ensimmäisessä osatutkimuksessa selvitettiin kuntoutuksen vaikutuksia subjektiivisesti ja objektiivisesti arvioitujen kognitiivisten oireiden lievittämisessä. Toisessa osatutkimuksessa arvioitiin kuntoutuksen vaikutuksia psyykkiseen hyvinvointiin. Viimeisenä tutkittiin yksilöllisten kuntoutustavoitteiden toteutumista ja tavoitteiden toteutumiseen vaikuttavia tekijöitä sekä konkreettisia muutoksia, joita osallistujat raportoivat tehneensä opiskelu- ja työskentelytapoihinsa helpottaakseen lukivaikeuden kanssa selviytymistä.

Osallistujat olivat iältään 18–35 -vuotiaita nuoria aikuisia, joilla oli diagnosoitu lukivaikeus. Heidät satunnaistettiin kolmeen ryhmään: yksilökuntoutus (N = 40), ryhmäkuntoutus (N = 40) ja kuntoutusta odottava kontrolliryhmä (N = 40). Kuntoutus sisälsi 12 tapaamista 5 kuukauden ajalla ja painottui tavanomaisestikin neuropsykologisessa kuntoutuksessa käytettyihin sisältöihin, kuten strategioiden harjoittamiseen, itsetunnon tukemiseen, itseymmärryksen lisäämiseen tähtäävään psykoedukaatioon ja ryhmämuotoisessa kuntoutuksessa myös vertaistukeen. Kuntoutusta odottava ryhmä sai kuntoutuksen 5 kuukauden odotusajan jälkeen. Vaikuttavuuteen liittyvät arvioinnit tehtiin ennen kuntoutuksen tai odotusajan alkua, 5 ja 10 kuukauden kuluttua alkumittauksesta sekä postikyselynä 15 kuukautta kuntoutuksen päättymisen jälkeen.

Kognitiivista suoriutumista arvioitiin objektiivisin psykometrisin testein, itsearviokyselyin sekä erillisten kysymysten avulla. Ajattelu- ja toimintastrategioita, mielialaa, elämänlaatua ja itsetuntoa tutkittiin itsearviokyselyin. Henkilökohtaisten kuntoutustavoitteiden toteutumista selvitettiin Goal Attainment Scaling -menetelmällä. Lisäksi osallistujia pyydettiin raportoimaan konkreettiset tekemänsä muutokset opiskelu- ja työskentelytavoissa, joita he mahdollisesti olivat tehneet helpottaakseen lukivaikeuden kanssa selviytymistä sekä mahdolliset käyttöönsä ottamat lukivaikeutta helpottavat apuvälineet.

Kuntoutukseen osallistuneilla havaittiin kontrolliryhmään verrattuna prosessointinopeuden kohenemista ja havaittu tulos säilyi 5 kuukauden

seurannan ajan. Pienempinä muutoksina itsearvioiduissa kognitiivisissa oireissa tapahtui lievittymistä koskien mm. lukemiseen liittyviä arvioita sekä lukemiseen ja kirjoittamiseen liittyviä muistitoimintoja. Lisäksi osallistujien itsearviointien perusteella kognitiivisissa oireissa sekä lukivaikeuden töissä ja opinnoissa aiheuttaman haitan suuruudessa ilmeni lievittymistä, joka oli havaittavissa vielä 15 kuukautta kuntoutuksen jälkeen.

Psyykkisen hyvinvoinnin alueella kuntoutukseen osallistuneilla havaittiin myönteistä muutosta kontrolliryhmään verrattuna itse arvioiduissa ajattelu- ja toimintastrategioissa, erityisesti suoritusoptimismin lisääntymisessä ja vähemmässä määrin tehtävien välttelyn vähenemisessä. Kuntoutus myös kohensi kontrolliryhmään verrattuna kognitiivisiin toimintoihin liittyvää elämänlaadun kokemusta ja vähemmässä määrin myös itsetuntoa.

Henkilökohtaiset kuntoutustavoitteet keskimäärin saavutettiin, ja todennäköisemmin ne saavutettiin yksilö- kuin ryhmäkuntoutuksessa. Kuntoutustavoitteiden saavuttamista selitti interventiotyypin lisäksi tietyt ajattelu- ja toimintastrategiat, konkreettiset opiskelu- tai työtapoihin tehdyt muutokset, kognitiivinen kyvykkyys sekä kuntoutusasioihin käytetty aika kuntoutustapaamisten välissä. Lukivaikeutta helpottavia apuvälineitä sekä uusia strategioita ja menetelmiä opiskelu- ja työskentelytapoihin lukivaikeuden tukemiseksi ilmoitettiin otetun käyttöön kuntoutusryhmissä kontrolliryhmää merkitsevästi enemmän. Vielä 15 kuukautta kuntoutuksen päättymisen jälkeen kolme neljäsosaa osallistujista raportoi edelleen käyttävänsä kuntoutuksessa omaksumiaan strategioita.

Yksilö- ja ryhmäkuntoutuksen tuloksellisuudessa havaittiin joitakin eroja, mikä voi viitata siihen, että parhaat kuntoutustulokset voitaisiin saavuttaa yhdistämällä yksilö- ja ryhmämuotoista kuntoutusta. Tätä olisi hyödyllistä tulevaisuudessa tutkia.

Tutkitut neuropsykologiset kuntoutusinterventiot johtivat moniin myönteisiin ja osin pitkäkestoisiin muutoksiin kuntoutusryhmissä kontrolliryhmään verrattuna, ja voivat osaltaan auttaa lievittämään sekä kognitiivisia että psyykkisiä lukivaikeuteen liittyviä haasteita nuorilla aikuisilla. Lukivaikeuden aiheuttaman haitan vaikutus yhteiskunnassamme todennäköisesti vain lisääntyy tulevaisuudessa, sillä hyvin suuri osa toiminnastamme nojaa tavalla tai toisella kirjalliseen tietoon. Tarvitsemme toimivia tukimuotoja lukivaikeuteen myös nuorille aikuisille niin peruskoulun jälkeisiin opintoihin ja työelämään kuin niihin pääsyn tukemiseenkin. Tämän tutkimuksen kohteena olleet neuropsykologiset kuntoutusinterventiot voivat olla yksi toimiva vaihtoehto.

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Johanna Nukari

CONTENTS

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications, referred to in the text by Roman numerals (Studies I-III)

I Nukari, J., Poutiainen, E., Arkkila, E., Haapanen, M.-L., Lipsanen, J., & Laasonen, M. (2020). Both individual and group-based neuropsychological interventions of dyslexia improve processing speed in young adults - a randomized controlled study. *Journal of Learning Disabilities, 53*(3), 213–227. https://doi.org/10.1177/0022219419895261

II Nukari, J., Laasonen, M., Arkkila, E., Haapanen, M.-L., Lipsanen, J., & Poutiainen, E. (2022). Neuropsychological intervention of dyslexia has a positive effect on aspects of psychological well-being in young adults - a randomized controlled study. *Dyslexia, 28*, 166–184. https://doi.org/10.1002/dys.1697

III Nukari, J., Laasonen, M., Arkkila, E., Haapanen, M.-L., & Poutiainen, E. (2022). Goal attainment in individual and group-based neuropsychological interventions for young adults with dyslexia in a randomized controlled trial. *Applied Neuropsychology - Adult*. https://doi.org/10.1080/23279095.2022.2137025

ABBREVIATIONS

ARHQ	Adult Reading History Questionnaire
EMQ	Everyday Memory Questionnaire
GAS	Goal Attainment Scaling
POMS	Profile of Mood States
SAQ	Strategy and Attribution Questionnaire
SDMT	Symbol Digit Modality Test
SPSS	Statistical Package for the Social Sciences
QOLIBRI-OS	Quality of Life after Brain Injury Overall Scale
WAIS-IV	Wechsler Adult Intelligence Scale, Fourth Edition

1 INTRODUCTION

Developmental dyslexia is one of the most common learning disorders, with an estimated prevalence of around 5 to 10% of the population (Peterson & Pennington, 2012; Shaywitz, 1998). Poor reading skills, including problems with accurate and/or fluent word recognition and decoding, are its core features (International Dyslexia Association, 2002). In related research, difficulties in various cognitive areas are associated with dyslexia, including problems in phonological processing (Laasonen et al., 2012b; Melby-Lervag et al., 2012), processing speed (Catts et al., 2002; Peter et al., 2011), multimodal temporal processing (Ben-Artzi et al., 2005; Laasonen et al., 2001; Laasonen et al., 2002), and attention (Hari et al., 2001; Laasonen et al., 2012a).

The various difficulties are manifested in functional neuroimaging research of dyslexia as underactivation of the ventral stream involving the occipitotemporal region, and of the dorsal stream involving temporoparietal areas, and as either underactivation or compensatory overactivation of the inferior frontal lobe (Fletcher & Grikorenko, 2017). Findings are less consistent from structural than functional imaging studies. Gray matter reductions in temporoparietal and occipitotemporal regions have been shown in children with a familial risk for dyslexia (Raschle et al., 2017). Around 50% of the variance of dyslexia is attributable to genetic influences (Peterson & Pennington, 2015).

Research on dyslexia has primarily focused on children and adolescents, despite being widely accepted that dyslexia often continues into adulthood (Maughan et al., 2009; Raskind et al., 1999; Shaywitz et al., 1999; Swanson, 2012). Living with the cognitive challenges that dyslexia brings, as well as the consequent failures in school, secondary psychological consequences are also likely to occur (Livingston et al., 2018). Problems with self-esteem and self-acceptance, and even anxiety and depression, have been associated with adults with learning disorders (Aro et al., 2019; Carroll & Iles, 2006; Carroll et al., 2005; Livingston et al., 2018; Riddick et al., 1999).

Effective methods of supporting dyslexia have been investigated. Interventions mainly focus on alleviating reading problems in younger children and less in older children or adults (Petersen & Pennington, 2012). Evidence-based interventions for dyslexia that go beyond the core problems in reading and writing are needed also for adults, but thus far, there are not enough evidence-based interventions available (Costantini et al., 2020; Doyle & McDowall, 2019; Gerber, 2012; Hock, 2012).

Neuropsychological interventions can be helpful in the rehabilitation of developmental learning disorders since these interventions cover many essential areas of support. Improving cognitive performance is naturally an important aim, but enhancing motivation and psychological adaptation by offering psychological support can be viewed as equally important for adults

with developmental difficulties (cf., Livingston et al., 2018). In neuropsychological intervention, one facet of support is helping to compensate for the challenges by reshaping the environment and taking advantage of assistive technology and accommodations (Sohlberg & Mateer, 2001; Wilson et al., 2009), which can be effective in compensating for dyslexia (de Beer et al., 2014).

By adulthood, comprehensive support spanning further than the literacy-related challenges is needed to alleviate the cognitive problems of dyslexia, as well as the secondary psychological consequences that can result from living with a developmental disorder. Without adequate support, dyslexia can lead to lower-than-expected educational outcomes and increased incidence of psychiatric disease and unemployment, thus augmenting the risk for marginalization (Aro et al., 2019; Eloranta, 2019; Livingston et al., 2018; Riddick et al., 1999). The aim of the present thesis was to investigate whether a neuropsychological intervention for young adults, either in individual or group format, might offer an effective way of support.

1.1 COGNITIVE PROFILE OF DYSLEXIA IN ADULTHOOD

Most of the findings concerning adults with dyslexia come from studies conducted in English (i.e., Swanson & Hsieh, 2009), which is assumed to have one of the most opaque orthographies. In a language with a transparent orthography with regular phoneme–grapheme correspondence, such as Finnish, almost all children learn to read accurately already in Grade 1, (Landerl & Wimmer, 2008). Instead of accuracy, in a transparent orthography, deficits in fluency are among the most common challenges in adolescents and adults with dyslexia (Eklund et al., 2015; Landerl & Wimmer, 2008). Reis et al. (2020), in their meta-analysis, reviewed 178 studies, including over 30% of the samples either from transparent or intermediate orthographies. The results indicate that adults with dyslexia perform more poorly than typical readers on all objective reading-related measures, even when context can assist in decoding as in text reading. Another finding was that adults with dyslexia perform more poorly on speed measures of word and pseudoword reading, phonological awareness, and orthographic knowledge than on corresponding accuracy measures. Struggling with accuracy issues in reading still in adulthood seems to be more of a problem in opaque orthographies, whereas reading speed problems seem to involve all adults with dyslexia, independent of the transparency of the orthography (Reis et al., 2020). In adulthood, training technical reading and reading speed per se need not to be the main focus of a dyslexia intervention. Instead, reading speed problems can be supported via strategic approaches, such as focusing on prioritizing which parts of texts to read, scheduling reading large amounts of

texts according to one's reading speed, as well as by guiding to use audiobooks when appropriate.

Among other measured abilities in the meta-analysis, young adults with dyslexia also performed poorer than typical readers on spelling, comprehension, phonological awareness (the awareness of and ability to manipulate sounds in spoken and written language), phonological memory, rapid automatized naming, tasks involving orthographic knowledge, vocabulary skills, and verbal working memory, with reading and writing problems being more pronounced than problems in the associated processes (Reis et al., 2020). Adults with dyslexia also had somewhat lower performance on full IQ and a lower verbal IQ than typical readers (Reis et al., 2020).

Deficits in both linguistic and non-linguistic processing speed have been connected to reading disability (Catts et al., 2002; Miller-Shaul, 2005; Pennington, 2006; Peter et al., 2011; Park & Lombardino, 2011) and even when simultaneous attention problems are not present (Shanahan et al., 2006). In 6–8-year-old children with a diagnosis of dyslexia, a non-linguistic visual matching measure was more powerful concurrent predictor of letter-word reading than phonological awareness measures (Park & Lombardino, 2011). Also, deficits in different types of processing speed tasks were more evident in older than in younger students with dyslexia (Park & Lombardino, 2011). In a follow-up study concerning Finnish population, cognitive challenges other than the core deficits in reading fluency were found to be even more persistent in adulthood than reading fluency problems, e.g., problems in processing speed, working memory, and verbal skills (Eloranta et al., 2019b). While childhood performance in rapid automized naming was connected to persisting reading problems in adulthood, processing speed problems measured by WAIS-IV processing speed index (Wechsler, 2008, 2012) were evident even among adults whose childhood reading disability had later been resolved (Eloranta et al., 2019b). However, some studies have found impairment only in linguistic processing speed (Moll et al., 2016) or have not found a significant difference compared to controls in non-linguistic processing speed when IQ has been controlled for (Bonifacci & Snowling, 2008).

Problems with executive functioning have also been demonstrated in adults with dyslexia, for example, in areas of set-shifting, inhibition of irrelevant stimuli, and updating information in working memory (Smith-Spark et al., 2016). Working memory problems can have a crucial influence on the study and work performance of adults with dyslexia (de Beer et al., 2014; Doyle & McDowall, 2015), and they have been evident also in university students with dyslexia (Bradshaw et al., 2021). A dyslexia intervention for adults should also acknowledge cognitive challenges outside literacy skills and aim to support, for example, executive functioning and working memory.

A notable factor concerning learning disorders is their relatively high comorbidity (i.e., Moll et al., 2020; Snowling et al., 2020). Estimates of the comorbidity of dyslexia and mathematical learning disability vary between

30% to even close to 70% (Koponen et al., 2018; Kovas et al., 2007; Landerl & Moll, 2010). Among children with dyslexia, around 50% have significant language impairments (McArthur et al., 2000), and the other way around, children who enter school with language impairments are at high risk of literacy difficulties, especially in reading comprehension (Psyridou et al., 2018). Comorbidity with other developmental difficulties, such as attention deficit/hyperactivity disorder, is also reasonably high, with estimates ranging from 15% to 40% (e.g., Hendren et al., 2018; Margari et al., 2013; Willcutt & Pennington, 2000; Willcutt et al., 2005). The comorbidities can complicate the response to intervention (Snowling et al., 2020), but excluding them can also include some challenges since comorbidities are estimated to be highly common, with about 40% of children with dyslexia having another learning disorder as well (Moll et al., 2020). Excluding comorbidities could make generalizing the results to the general population with dyslexia more unreliable.

The problems adults with dyslexia experience and report have also been investigated, and it is an important aspect to acknowledge in dyslexia interventions. The experienced problems are not limited to challenges in reading and writing and go well along with findings discovered using objective measures. When students with dyslexia were questioned about the subjective difficulties they face, they reported experiencing problems with the rate of reading, writing, time organization, and memory (Hatcher et al., 2002). In self-report questionnaires, they were found to be clinically impaired in attention and memory (Hatcher et al., 2002). Problems with executive functions, such as difficulties in planning, task monitoring, working memory and organization, as well as slips of attention and absent-mindedness, have been reported by university students with dyslexia (Smith-Spark et al., 2016; Smith-Spark et al., 2004). In neuropsychological dyslexia interventions, executive functions can be supported, for example, via endorsing planning, time management, and strategies to help with starting to do tasks and strategies for concluding them.

Cognitive challenges associated with dyslexia are not limited to problems solely in reading and writing but involve difficulties in multiple areas of cognitive functioning. Neuropsychological intervention can support not only literacy skills but also other dyslexia-related cognitive challenges. However, thus far there seems not to be evidence-based neuropsychological interventions for young adults with dyslexia which would include comprehensive support for cognitive functioning.

1.2 SECONDARY CONSEQUENCES OF DYSLEXIA

Dyslexia tends to have many far-reaching consequences by adulthood on psychological well-being, as well as in causing underachievement in studies and work (Aro et al., 2019; Eloranta, 2019; Livingston et al., 2018; Riddick et

al., 1999). Emotional adjustment to learning difficulties has been suggested as being a significant predictor of outcomes in individuals with developmental dyslexia (Livingston et al., 2018). Interventions supporting only literacy skills are not enough to endorse the well-being of these young adults. It is essential to also investigate how the secondary consequences of dyslexia can be alleviated in interventions, in addition to literacy and other cognitive difficulties.

1.2.1 CHALLENGES IN PSYCHOLOGICAL WELL-BEING

Supporting psychological well-being is an essential part of neuropsychological interventions (Sohlberg & Mateer, 2001; Wilson et al., 2009). The risk of developing secondary emotional and behavioral problems is elevated by experiences with educational challenges and failure associated with dyslexia throughout the school years. There may also be some shared genetic etiology between dyslexia and mental disorders (Gialluisi et al., 2021). An association has been pointed out in earlier literature between learning disorders and problems in adulthood in self-esteem and self-acceptance, as well as internalizing problems and mood disorders like anxiety and depression (Aro et al., 2019, Carroll & Iles, 2006; Carroll et al., 2005; Francis et al., 2019; Gerber, 2012; Klassen et al., 2011; Livingston et al., 2018; Riddick et al., 1999). Individuals with dyslexia have reported also experiencing stress, embarrassment, anger, aggression, guilt, isolation, and insecurity (Livingston et al., 2018).

Self-esteem has been found to be low among adults with dyslexia (Livingston et al., 2018; McNulty, 2003; Nalavany & Carawan, 2011; Riddick et al., 1999), yet self-esteem is essential to psychological functioning in adulthood. Especially, academic self-esteem has been found to be low in adults with dyslexia (Lithari, 2019; McArthur et al., 2020; Sumner et al., 2021). Poor academic self-esteem can lead to emotional insecurity and self-doubt, which will likely limit the confidence to succeed, further limiting the ability and motivation to learn (Livingston et al., 2018). Low academic self-esteem has been associated with internalizing difficulties, such as anxiety and depression (Terras et al., 2009). In adults with dyslexia diagnosed in childhood, reading fluency in adulthood was associated with self-esteem and psychological well-being: the more fluent the reading, the higher self-esteem and social functioning, and the less symptoms of depression they experienced (Eloranta et al., 2019b). Because of the associations low self-esteem has with difficulties in multiple domains (i.e., social, emotional, and behavioral), it makes a worthy target in dyslexia interventions in minimizing the negative consequences of dyslexia (see Livingston et al., 2018).

Poor readers (children, adolescents, and adults) are at moderate risk for experiencing internalizing problems (anxiety more than depression) compared to typical readers (Francis et al., 2019). Alongside lower self-esteem, university students with dyslexia have reported higher depression scores than

controls and higher levels of social and attentional problems and somatic complaints (Ghisi et al., 2016). In a Canadian study, some of the reported mental health problems (distress, depression, and suicidal thoughts) were more commonly reported among older (30–44 years) than younger (15–21 years) individuals with learning disabilities (Wilson et al., 2009). In a Finnish longitudinal study, the amount of sickness allowance and disability pensions granted based on psychiatric diagnoses, as well as reimbursements for anxiolytics and antidepressants, was greater among individuals with learning disabilities than among the control group (Aro et al., 2019). Population-based studies have found more psychiatric symptoms associated with dyslexia than other studies drawing samples from clinical populations where dyslexia was recognized already in childhood, suggesting that early identification can lead to better adult-age psychological outcomes (Undheim, 2003; Eloranta, 2019). In addition to supporting self-esteem, more profound psychological problems with mood should be acknowledged within neuropsychological dyslexia interventions.

Dyslexia was found to have an impact on the quality of life of students in higher education (Lambert & Dryer 2018). In an interview study, consequences on their quality of life were found concerning especially levels of stress or anxiety, self-esteem, time available for other activities, personal relationships, and financial pressures, but no control group was used. Lambert & Dryer (2018) point out that quality of life concerns were often associated with the extra time and effort students needed to invest in their studies as a way of compensating for the learning difficulties they faced. Another study did not find significant differences in general life satisfaction between young adults with dyslexia and a normative group. Nevertheless, differences emerged in isolated areas of quality of life concerning education, health, and friends, and these differences were found only in the group with dyslexia drawn initially from a psychiatric ward. The group with dyslexia drawn from a cohort study did not differ from the normative sample regarding life satisfaction in any area measured. (Undheim, 2003.) It is possible that adults with dyslexia might have a lowered level of quality of life in some areas of life and an intervention could possibly endorse these aspects of psychological well-being as well.

1.2.2 COMPENSATIONAL NEEDS IN EDUCATION

Earlier research has indicated that individuals with dyslexia are at risk for difficulties attaining high-level education (Hakkarainen et al., 2015; Hakkarainen et al., 2016; McLaughlin et al., 2014; Murray et al., 2000; Raskind et al., 1999). In a Finnish follow-up study, the educational level was lower in adults with dyslexia diagnosed in childhood than in the control group (Eloranta et al., 2019b). Achieving higher education (a university degree) was more common in the control group than in the dyslexia group, regardless of whether the reading fluency problems had been resolved since childhood

(Eloranta et al., 2019b). In another Finnish study, reading difficulties and behavioral problems predicted delayed graduation from upper secondary education (Hakkarainen et al., 2016).

These findings are understandable since dyslexia commonly continues to have an impact on studying skills and motivation still in adulthood, even in the case where some of the initial difficulties have been resolved. In a transparent orthography, such as Finnish, accuracy problems are not very common in adulthood; instead, problems with fluency do persist (e.g., Reis et al., 2020). A slow reading pace causes studying to take more time than expected. Fluency problems can also lessen the amount of text being read, thus influencing the growth of vocabulary and general knowledge (Lyon et al., 2003). When reading is fluent, more higher-level processes involved in text comprehension are available for understanding the content compared to the situation where reading itself takes up more effort and cognitive resources (Moojen et al., 2020). This leads to a situation where slow reading can also affect reading comprehension (Kuhn & Stahl, 2003; Shaywitz et al., 2008), and even university students with dyslexia demonstrate impairments that are likely to affect success in higher education (Bradshaw et al., 2021). In dyslexia interventions, it is possible to endorse study skills and train strategies to alleviate the disadvantage dyslexia poses. Also, advising and encouraging students to apply for proper accommodations for dyslexia in educational institutions is essential since, for example, giving more time for accomplishing written tasks or exams or having the possibility to use compensatory assistive technologies can be crucial for students with dyslexia (see, e.g., Afeli, 2019; Shaywitz et al., 2008).

1.2.3 COMPENSATIONAL NEEDS IN WORKING LIFE

Support in working life for dyslexia and other learning disorders is usually even more sparse than for students (cf. de Beer et al., 2014). Previous research has raised evidence of an elevated risk for individuals with dyslexia having a lower income (McLaughlin et al., 2014) and more challenges in work participation (Aro et al., 2019; de Beer et al., 2014; Maughan et al., 2020; Undheim, 2003; Virtanen et al., 2020) than the general population, emphasizing the need to support individuals with dyslexia also in working life. When reading disability diagnosed as a child was still evident in adulthood, unemployment was almost four times more common among Finnish adults with dyslexia than that of controls (Eloranta et al., 2019b), and especially slow adult-age reading was associated with long-term unemployment (Kortteinen et al., 2021). More favorable outcomes have been reported with employment rates comparable to the general population when a higher education degree has been accomplished (Madaus, 2006).

In a review analyzing ICF-classified (International Classification of Functioning, World Health Organization [WHO], 2001) domains of functioning in dyslexia in the context of work, it was shown that all domains

of functioning could be influenced by dyslexia, and the influence was mainly negative (de Beer et al., 2014). Different ways for seeking support or adaptation were also identified: the employees with dyslexia embraced several learning or coping strategies or chose self-disclosure, and asked for support, accommodations, or assistive technology (de Beer et al., 2014). One reason for not getting adequate support for learning difficulties at the workplace has to do with disclosure of dyslexia. Adults with dyslexia are somewhat reluctant to disclose their disability at the workplace, making it thus harder to ask for accommodations (Gerber & Price, 2012). In a study of university graduates with learning disorders, only 55% reported telling about their disability to their employer, and only 12% requested accommodations (Madaus, 2008). Increasing self-knowledge and supporting self-esteem as a part of neuropsychological dyslexia intervention could enhance possibilities for disclosure of dyslexia, thus increasing the chances for receiving appropriate support. Getting the needed accommodations and taking advantage of assistive technology can positively influence work participation (de Beer et al., 2014).

1.3 SUPPORTIVE FACTORS IN THE CONTEXT OF LEARNING DISORDERS

Many factors have been identified to contribute to success in life in people with dyslexia. It is essential to investigate whether some of these aspects could also be endorsed in dyslexia interventions. Some of the identified supportive factors include personal attributes, such as perseverance, proactivity, adaptability, self-awareness, learned creativity, and the use of effective social support systems (Gerber, 2012; Goldberg et al., 2003). Adequate use of learning and study strategies has proven essential, especially for academic success (Zeng et al., 2018), as well as adaptable cognitive and social strategies for coping with challenges more generally (Eronen, 2000).

Among personal attributes, persistence and determination have been found to be important in academic success in young adults with dyslexia (Zeng et al., 2018; Field et al., 2003). In their review, Zeng et al. (2018) concluded, that self-determination (e.g., self-efficacy, self-advocacy, self-awareness) could be improved through training, and it also impacted academic success. However, there seems to be a lack of studies focusing on self-determination instruction for students (Zeng et al., 2018). Endorsing self-efficacy and self-awareness within neuropsychological interventions might have a positive impact on academic success.

Creating and using social support systems effectively can enhance the handling of study or work-related tasks in individuals with dyslexia (Goldberg et al., 2003; Nalavany et al., 2011). Taking advantage of support systems requires one to communicate the disability to others. Accepting one's difficulties and choosing not to conceal the learning disorder can relieve a

person from emotional stress and make accepting support easier (Nalavany et al., 2015; Pachankis, 2007). Through increasing self-knowledge regarding the challenges, as well as the strengths one has, neuropsychological interventions can aim to support acceptance of one's difficulties. Sharing experiences and receiving support from people with similar challenges in a group-based intervention might support the use of social support systems in the broader context as well.

Eronen (2000) defines achievement strategies as cognitive, motivational, and attributional processes through which people aim to achieve their goals, regulate their anxiety, control events and outcomes, and maintain their self-esteem in study-related situations, and social strategies as the intricate organization of feelings, thoughts, effort-arousal, and actions by which people accomplish their personally meaningful goals (see also Cantor, 1990). A high degree of task involvement and persistence in the face of obstacles have been identified as adaptive cognitive achievement strategies in study-related situations (Onatsu-Arvilommi et al., 2002; Aunola et al., 2000). The cognitive and social strategies of young adults contributed to their success in dealing with the academic and interpersonal challenges they faced in a new study environment (Eronen, 2000). Cognitive and social strategies have high stability, but they are nevertheless susceptible to change due to environmental feedback (Eronen, 2000). People with dyslexia with more advanced planning and metacognition report higher job satisfaction and self-efficacy (Leather et al., 2011). On the other hand, poor self-efficacy and maladaptive attributions are associated with negative affect and even depression (Berkeley et al., 2011). Since cognitive and social strategies are susceptible to change, endorsing the use of adaptive strategies could be one supportive aspect of dyslexia interventions for adults.

Getting dyslexia diagnosed earlier rather than later in life might contribute to better outcomes (e.g., Eloranta et al., 2019a; Ghisi et al., 2016). The diagnosis can bring awareness of one's condition and explain the literacy difficulties, thus allowing improving one's learning, and even increase motivation (Pino & Mortari, 2014). While previous school experiences may have produced a feeling of being 'stupid', the diagnosis provides another, more adequate, and acceptable explanation. With improved self-knowledge, students can acquire a more balanced view of their strengths and weaknesses and develop cognitive and affective strategies that positively affect their learning experience (Pino & Mortari, 2014). Sometimes dyslexia is diagnosed later in adulthood, for example, when seeking support for the experienced difficulties in learning. When this is the case, room for dealing with newly acquired diagnosis can be needed in the intervention.

1.4 INTERVENTIONS FOR DYSLEXIA

Scientifically verified ways of dyslexia support are needed, but especially for adults, there are not enough evidence-based interventions available (Costantini et al., 2020; Doyle & McDowall, 2019; Gerber, 2012; Hock, 2012). Interventions for dyslexia typically focus on children and different aspects of reading skills. Snowling et al. 2020 point out that to date, the evidence suggests that the most effective interventions for children with dyslexia are phonologically based, involving training in phoneme awareness and letter knowledge combined with structured reading practice. The effectiveness of interventions has to do with age since phonics interventions have shown to be more effective until grade one, after which comprehension and mixed interventions tend to be associated with more significant effect sizes (Galuschka et al., 2020). Nevertheless, a phonologically based training program has also shown improvement in adults (Eden et al., 2004). Various types of comprehension-focused intervention studies have shown to be effective in children and adults with dyslexia, especially when using explicit, strategy-focused approaches, however, the effect sizes have been variable (0.20–0.70), and the ability of students to apply the learned strategies in new text context and comprehension situations is less consistent (Shaywitz et al., 2008). Snowling et al., 2020 express that there is also a need for treatment plans to consider the comorbidities associated with dyslexia since they can influence the response to intervention.

In a review of academic interventions for postsecondary students with learning disorders, 75% of the interventions included primarily assistive technology, direct assistance, or strategy instruction, and only 25% described comprehensive support programs to promote students' academic skills and self-determination via interventions based on their needs (Zeng et al., 2018). One of the two comprehensive programs found in the review included two or four hours of individual and small-group work each week with an assigned learning specialist and writing specialist or student-initiated appointments with a staff member on an 'as needed' basis (Troiano et al., 2010). The learning and writing specialists focused on textbook reading, note-taking, test preparation, test-taking, writing strategies, research skills, time management, and self-advocacy. Based on the results, students who attended these supportive appointments consistently tended to have higher grade point averages and persisted to graduation (Troiano et al., 2010). In the other comprehensive program found in the review, students were provided with an updated psychoeducational assessment identifying their learning strengths and weaknesses, self-advocacy training, individualized coaching to improve their self-awareness of their disability, specialized study and learning strategies support, and instruction and support in the proper use of assistive technology where appropriate (Harrison et al., 2012). The dropout rate of students in these support programs was substantially lower than the rate reported for college and university students in general. Comparison of pre and

post-participation data demonstrated an improved understanding of their learning disability, ability to explain their disability to others, and ability to self-advocate following participation in the programs, but no control group was used (Harrison et al., 2012). Especially the latter comprehensive support program seems to have common elements with the current neuropsychological intervention being examined, particularly in training the use of different strategies and assistive technology and in aiming to increase self-awareness and identifying the strengths and weaknesses of the participants.

Another non-academic intervention somewhat resembling the neuropsychological interventions in the current study was a cognitive dyslexia intervention for unemployed adult participants. Sixty 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 et al., 2000). The program included teacher-guided reading, writing, mathematics, and computer training along with an individual plan aiming to improve learning and memory. The teachers also focused on improving motivation and enhancing the participants' self-confidence. Performance in the educational group improved significantly in spelling, decoding of letters, self-confidence, and flexibility compared to controls. Because of the full-time schedule for five months, this kind of program would not be easy to implement among people who are studying or working; thus, a need for shorter interventions is obvious.

Practices that have yielded promising results for dyslexia interventions for students have included interventions with the number of sessions up to 70 and/or lasting for a minimum of 23 hours in total (de Lima et al., 2018). Also, individual interventions or interventions in pairs have been more efficient than group interventions, as well as interventions conducted by a researcher with a defined script and interventions based on multiple strategies (de Lima et al., 2018).

Research on psychosocial interventions for adults with dyslexia is sparse (Costantini et al., 2020). In a review of psychosocial interventions for adults with dyslexia, initial evidence was found that supporting specific personal resources, such as self-confidence, organization, time management, and stress management, can be effective in these adults' positive adjustment in the workplace (Costantini et al., 2020).

1.5 NEUROPSYCHOLOGICAL INTERVENTIONS

Neuropsychological rehabilitation aims to decrease the disadvantages caused by brain dysfunctions and to support everyday coping with lingering deficits (Sohlberg & Mateer, 2001; Wilson et al., 2009). Impaired cognitive functions can be trained and new strategies to cope with the deficits learned. Learning to use different aids and reshaping the environment to support coping are also part of the rehabilitation methodology. Better functioning can be supported by enhancing psychological adaptation by increasing self-understanding and acceptance and by offering psychological support (Sohlberg & Mateer, 2001; Wilson et al., 2009).

Neuropsychological interventions in the adult population are typically used among acquired brain injury patients. Its effectiveness has been shown in these patient groups in individual format, and evidence of benefits in group-based format is getting stronger (Cicerone et al., 2005; Cicerone et al., 2011; Cicerone et al., 2019). Most evidence on the effectiveness of neuropsychological rehabilitation is found in treatments focusing on compensation or adjustment to cognitive impairments rather than restoring cognitive functions (Cicerone et al., 2011). Training compensatory strategies and supporting recognizing one's strengths and weaknesses have been found to reinforce a positive rehabilitation outcome (Cicerone et al., 2011).

1.5.1 NEUROPSYCHOLOGICAL INTERVENTION IN DYSLEXIA

Using neuropsychological intervention in supporting dyslexia has many advantages. In addition to improving cognitive performance, enhancing psychological adaptation by offering psychological support is essential since a developmental disorder has often, by adulthood, brought along secondary consequences to well-being (cf. Livingston et al., 2018). Psychoeducation for increasing knowledge related to the learning disorder can make communicating the disability easier. Reshaping the environment via arrangements at school or work, and for example, taking advantage of assistive technology and accommodations can be of use in coping with dyslexia (de Beer et al., 2014). Neuropsychological interventions aim to reduce the impact of cognitive deficits in individuals' daily life and to help manage or come to terms with the cognitive deficits and their secondary consequences (see, e.g., Loschiavo-Alvares et al., 2011; Wilson, 2013).

Neuropsychological interventions can be delivered in either individual or group format, both having their strengths. In individual intervention, it is possible to focus more specifically on the particular difficulties the participant has. In a group format, using peer support can add value to psychological adjustment and well-being (see, e.g., Cicerone et al., 2019). Practices in administering neuropsychological interventions vary between countries. In Finland, neuropsychological rehabilitation is part of the healthcare system, meaning it can be offered regardless of an individual's life situation. For

students with learning disabilities, it is usually offered if special education as a means of support is not enough, or the problems are affecting areas beyond academic skills.

Studies on neuropsychological interventions of dyslexia often focus on children (e.g., Goldstein & Obrzut, 2001; Joly-Pottuz et al., 2008; Lorusso et al., 2022; Zygouris et al., 2018), or on computerized training of cognitive domains such as phonological processing, visual processing, or attention (e.g., Cancer, 2017; Lorusso et al., 2011; Lorusso et al., 2006). Interventions training isolated skills, such as working memory or low-level auditory and visual processing, do not seem to generalize to academic skills in general (Fletcher & Grigorenko, 2017; Melby-Lervåg et al., 2016).

Among the sparse neuropsychological rehabilitation interventions in the literature for older people with dyslexia is a program that aims to stimulate executive functioning and to promote self-regulated learning, especially for study competencies (use of time, organization of the study environment and materials, homework, note-taking, and preparing for exams) and reading comprehension. The initial evaluation of the program by expert judges was satisfactory, but the model needs to be studied further to evaluate its efficacy. (de Lima et al., 2017.)

The primary focus in adult interventions need not be in the drilling of isolated reading-related skills, but in improving efficient functioning in everyday life tasks including functioning in education and work where dyslexia might cause problems. Also, remediating the psychological consequences that living with dyslexia has caused is important. One benefit of neuropsychological interventions is that they can be offered irrespective of the participant's life situation, as this form of support is available also to young adults outside educational institutions, which is where almost all the scarce support is currently being offered.

1.5.1.1 Accommodations and assistive technology

An essential aspect of neuropsychological interventions is helping to compensate for the challenges by taking advantage of assistive technology and accommodations (Sohlberg & Mateer, 2001; Wilson et al., 2009). Accommodations to help compensate for dyslexia can be classified typically into three general types: by-passing the reading difficulty by providing information through an auditory mode, providing compensatory assistive technologies, and providing additional time so that persons with dyslexia will be able to demonstrate their knowledge (Shaywitz et al., 2008). Assistive technology, by definition, includes devices and software whose "primary purpose is to maintain or improve an individual's functioning and independence and thereby promote their wellbeing" (Khasnabis et al., 2015).

All the above can be taken advantage of in supporting adults with dyslexia, and accommodations and assistive technology can positively influence study and work participation (Dawson et al., 2019; de Beer et al., 2014). Audiobooks

have been shown to induce significant improvement in reading accuracy, as well as an improvement in school performance and greater motivation and involvement in school activities (Milani et al., 2010). In a review of academic interventions for postsecondary students with learning disabilities, speech synthesis systems (i.e., text-to-speech) which can be used in listening to also other digital texts than books, and voice recognition software (i.e., speech-to-text) were two types of assistive technology found to be frequently utilized (Zeng et al., 2018).

1.5.1.2 Setting personal goals for an intervention

Setting individually meaningful goals for intervention and supporting the participant in attaining them is regarded as an essential aspect of client-centered interventions (Playford et al., 2009; Stevens et al., 2013). Setting concrete personal goals for intervention may support motivation, and achieving the goals reflects the practical benefits of the intervention (Wilson et al., 2017). Using a measurement instrument in goal-setting, can further promote the desired behavioral change (Stevens et al., 2013).

One of the commonly used goal attainment measures is the Goal Attainment Scaling (GAS; Kiresuk et al., 1994). It is recommended to be used in measuring neuropsychological rehabilitation outcomes, having benefits such as sensitivity to the clients' values, the ability to measure progress responsively, and encouraging more accurate self-awareness (Malec, 1999). GAS can help prioritize problems needing support or change and detect also more negligible progress in an objective way by having concrete endpoints and steps to aim toward (Malec, 1999; Stevens et al., 2013). GAS can also be used as an outcome measure both in clinical work and research to assess the effectiveness of an intervention based on personally relevant goals (Krasny-Pacini et al., 2016). Limitations regarding the use of GAS include the demands of building a 5-level scale for the identified individual goals and evaluating the outcome of each goal which can be time-consuming and demands professional's competency to guide the participant through the process (Grant & Ponsford, 2014; Stevens et al., 2013).

Despite the recognized importance of goal setting and measurement in interventions in many fields (Krasny-Pacini et al., 2013; Playford et al., 2009), factors associated with successful goal attainment are not often evaluated in the related research. In dyslexia interventions, even the information on setting and attaining personal goals is often lacking (e.g., Zeng et al., 2018). However, it would be essential to find out how personal goals are attained in dyslexia interventions and how goal attainment might be supported.

1.6 AIMS OF THE STUDY

The present thesis aimed to examine the effectiveness of individual and group-based neuropsychological interventions for young adults with dyslexia using a randomized controlled study design. Another aim was to compare whether individual or group-based intervention has different effects.

In Study I, the aim was to assess the possible effects the interventions have on the participants' subjective and objective cognitive performance.

In Study II, the aim was to examine the possible effects the interventions have on the participants' psychological well-being, including self-reported cognitive and behavioral strategies, quality of life, mood, and self-esteem.

In Study III, the aim was to examine the attainment of personally set intervention goals and factors related to goal attainment, as well as concrete behavioral changes made in participants' studying or working habits to ameliorate dyslexia-related challenges.

2 METHODS

2.1 PARTICIPANTS

The recruitment process, which continued alongside the already started interventions, lasted for 23 months, from November 2012 until August 2014, see Figure 1. Data collection ended in September 2016. The participants were recruited by distributing information about the study via multiple channels, including health care units, educational institutions, associations related to learning difficulties, related internet pages, and mailing lists, etc.

The following inclusion criteria were met by the participants: 1) age 18–35 years during the year they were randomized to the study. 2) Developmental dyslexia clinically confirmed on the bases of a clinical neuropsychological assessment and a medical examination by a physician specialized in phoniatrics. 3) Limited abilities in studies, work, or employment related to dyslexia evaluated based on a systematic interview and the neuropsychological examination. 4) Subjective and objective need for intervention for alleviating dyslexia symptoms assessed by clinical evaluation utilizing the systematic interview and neuropsychological assessment. 5) Native language was Finnish.

Dyslexia was confirmed in the neuropsychological examination based on the participant's performance in five tests from two Finnish test batteries for dyslexia (Dyslexia Screening Test for Adolescents and Adults; Holopainen et al., 2004, and Reading and Writing Test for Adolescents and Adults; Nevala et al., 2006). Oral reading was tested by reading aloud 30 Finnish words and 30 pseudowords. Other reading measures included detecting spelling errors within single words for 3 min 30 s. and separating word chains for 1 min 30 s. Writing was tested using dictation with 20 pseudowords to be written. To qualify for the study, the participant had to score either at least 1 *SD* below average in at least three of the five subtests or at least 2 *SD* below average in at least two of them.

The exclusion criteria were evaluated at first via an interview and questionnaires prior to assessments. The exclusion criteria included the following: 1) Neurological illnesses. 2) Other prominent learning disorders than dyslexia. 3) Diagnosed or suspected ADHD. Suspected ADHD was controlled by the Adult ADHD Self-Report Scale (ASRS v1.1; Daigre et al., 2009) with a cut-point of over 3 points in section A and by the Wender Utah Rating Scale (WURS; Ward, 1993) with a cut-point of over 45 points. 4) Psychiatric diagnoses. 5) Severe depressive symptoms controlled using a cut-point of over 28 points in the Beck Depression Inventory-II (Beck et al., 2004). A milder depression was not an exclusion criterion, 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) Excessive alcohol use

controlled by the AUDIT-C (Babor et al., 2001), with a cut-point of 9 for men and 8 for women, and drug abuse controlled using one question concerning drug abuse. 7) Previous neuropsychological intervention received at the age of 16 or later.

In the neuropsychological examination, an exclusion criterion was set for verbal comprehension and perceptual reasoning to exclude possible developmental or other problems in language or non-verbal performance. The exclusion criterion for general cognitive capacity was set for less than 80 points on the Wechsler Adult Intelligence Scale – Fourth Edition (WAIS-IV; Wechsler, 2008, 2012) in either Perceptual Reasoning Index or Verbal Comprehension Index estimated by four subtests (Similarities, Vocabulary, Matrix Reasoning, Block Design).

At the time of entering the study, the mean age of the participants was 25 years, and 80% were women (see Table 3). The highest ongoing or highest completed education at the time of enrollment to the study was at least high school level for 82% of the participants, and 53% studied or had completed a degree in college or university. Regarding their life situation, 61% of the participants were studying, 27% were employed (of which 3% part-time), and for 12%, their life situation was classified as other (e.g., unemployment, sick leave, at home with a child).

Regarding the identification of dyslexia, 26% reported that their dyslexia was not identified before entering the current intervention. For those whose dyslexia was recognized prior to the intervention by a professional (e.g., teacher, special education teacher, psychologist, speech therapist, neuropsychologist, physician), the mean age for recognition was 15 years (*SD* = 5.7, range 6–34 years, mode 18 years).

Information on previous support received for dyslexia was also gathered. The most common form of support was remedial instruction at school, which was reported by 52% in primary and lower secondary education and by 10% after lower secondary education. Special education was received by 14% in primary and lower secondary education and by three participants (3%) after that. Speech therapy was received by 7 participants (6%), and one participant reported having received neuropsychological rehabilitation before. Other forms of support included a course related to learning disabilities (9%) and a peer group related to learning disabilities (3%).

The study protocol was approved by the ethics committee of the Helsinki Uusimaa Hospital District (§ 60, 14.3.2012, 93/13/03/01/2012). Written informed consent to participate in the study was received from all the participants. After the inclusion criteria were fulfilled, the participant information was given to a blinded statistician who was not otherwise involved in the study. A stratified random number table was used by the statistician, and the randomization was stratified according to age (18–26 years vs. 27–35 years), gender (female vs. male), and education (primary and secondary education vs. higher education). After randomization, the researcher was informed of which group the participant was allocated to. Altogether 120

participants were randomized to the study (40 in individual intervention, 40 in group intervention, and 40 in the wait-list control group). Of these, 118 were assessed at baseline, 115 at five months, and 106 at ten months. The long-term follow-up by mail was completed by 90 participants. Reasons for dropping out of the research project included, e.g., physical illness, logistical reasons, or loss of interest.

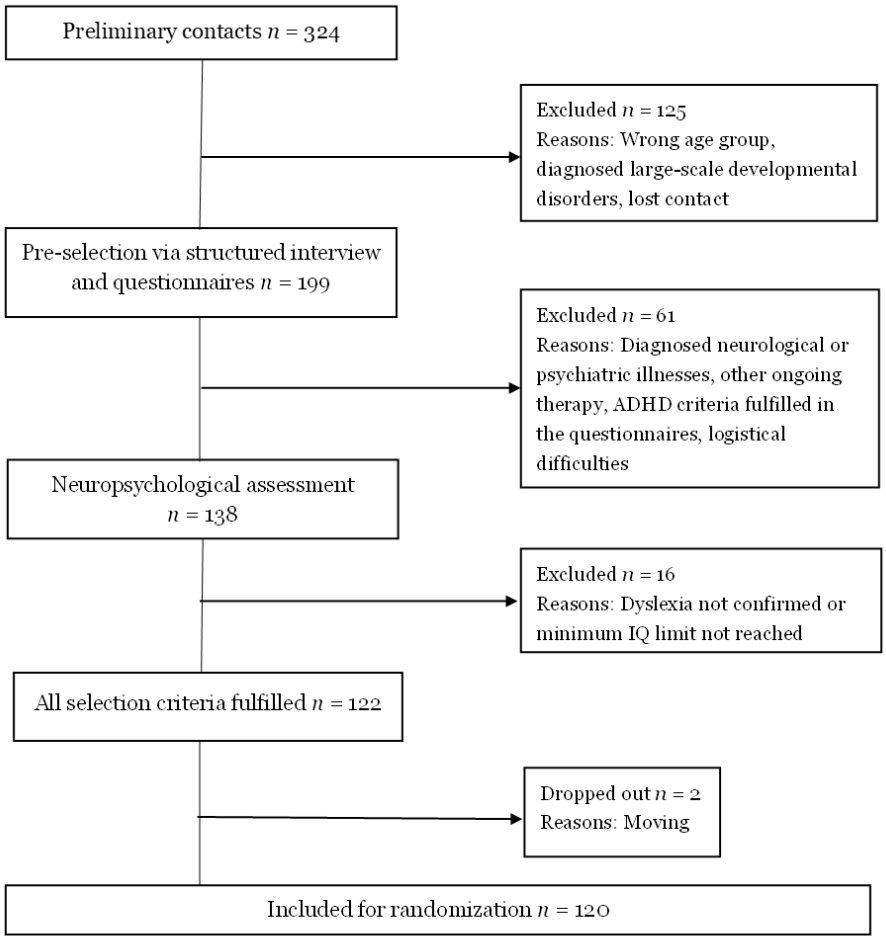


Figure 1 Flowchart of the recruitment process of participants for the study of neuropsychological intervention for dyslexia in young adults.

2.2 STUDY PROCEDURE

The study protocol was published in advance (ClinicalTrials.gov identifier: NCT01930500). A parallel assignment was used as the intervention model. The assessments using objective cognitive measures and self-report questionnaires were performed at baseline, at five months (at the end of intervention or end of the waiting period), and at ten months (after follow-up for the intervention groups and after intervention for the wait-list control group). Long-term status was assessed using a mailed inquiry 15 months post-intervention for all groups. The assessments were timed identically in both interventions having the baseline assessment 1–14 days before the first intervention session and the follow-up assessment 1–14 days after the last intervention session.

Assessing the self-reported concrete changes made by the participants during the past five months was done at the five-month and ten-month follow-ups. Assessing the self-reported time used for intervention matters was done immediately after the intervention for all groups. Personal goals were set before the intervention in all groups, meaning that the wait-list control group set their goals at the beginning of their intervention (at five months), not at the beginning of the waiting period (at baseline). Goals were set individually with a professional in both intervention types; in the individual intervention, they were set together with the neuropsychologist administering the intervention and in the group intervention, they were set with a psychologist/neuropsychologist individually at a separate meeting. See the timing of the different assessment methods and the number of participants in each group at different time points in Table 1.

The allocation sequence was concealed from the assessing psychologist. The participants were advised not to mention which group they attended to when conducting the cognitive assessments with the psychologist. This request was well accepted and complied with. The questionnaires were filled separately from the cognitive assessments, and an assistant was available throughout the process in case of questions.

Table 1 *The methods used, and the number of participants present at each time-point of the intervention study for young adults with dyslexia. In parentheses is the number of the study related to the methods in question.*

	Baseline at 0 months	**1. Follow-up at 5 months**	**2. Follow-up at 10 months**	**Follow-Up 15 months post int**
Individual intervention	*n* = 40, *Cognitive* test battery (I) *Questionnaires* of cognitive and psychological well-being (I,II) *Questions* of self-perceived cognition, disadvantage (I), aids *Goal* setting (III)	*n* = 39, *Cognitive* test battery (I) *Questionnaires* of cognitive and psychological well-being (I,II) *Questions* of self-perceived cognition, disadvantage, made changes, used time (I,III), aids *Goal* attainment (III)	*n* = 38, *Cognitive* test battery (I) *Questionnaires* of cognitive and psychological well-being (I,II) *Questions* of self-perceived cognition, disadvantage, made changes (I,III), aids	*n* = 34 *Questions* of self-perceived cognition, disadvantage, made changes (I,III), aids
Group intervention	*n* = 39, *Cognitive* test battery (I) *Questionnaires* of cognitive and psychological well-being (I,II) *Questions* of self-perceived cognition, disadvantage (I), aids *Goal* setting (III)	*n* = 37, *Cognitive* test battery (I) *Questionnaires* of cognitive and psychological well-being (I,II) *Questions* of self-perceived cognition, disadvantage, made changes, used time (I,III), aids *Goal* attainment (III)	*n* = 35, *Cognitive* test battery (I) *Questionnaires* of cognitive and psychological well-being (I,II) *Questions* of self-perceived cognition, disadvantage, made changes (I,III), aids	*n* = 29 *Questions* of self-perceived cognition, disadvantage, made changes (I,III), aids
Wait-list control group	*n* = 39, *Cognitive* test battery (I) *Questionnaires* of cognitive and psychological well-being (I,II) *Questions* of self-perceived cognition, disadvantage (I), aids	*n* = 39, *Cognitive* test battery (I) *Questionnaires* of cognitive and psychological well-being (I,II) *Questions* of self-perceived cognition, disadvantage, made changes (I, III), aids *Goal* setting (III)	*n* = 33, *Cognitive* test battery (I) *Questionnaires* of cognitive and psychological well-being (I,II) *Questions* of self-perceived cognition, disadvantage, made changes, used time (I,III), aids *Goal* attainment (III)	*n* = 27 *Questions* of self-perceived cognition, disadvantage, made changes (I,III), aids

2.3 ASSESSMENT MEASURES

The assessment measures were chosen to cover the functions the intervention aimed to support. For example, increasing mechanical reading speed was not a target of this intervention; hence, mechanical reading speed was not measured as an outcome variable. Subjective and objective assessment measures were both included to help build a multifaceted view of the possible benefits.

2.3.1 OBJECTIVE AND SUBJECTIVE COGNITIVE MEASURES (STUDY I)

The two primary outcome measures for the study were a modified version of the Adult Reading History Questionnaire, ARHQ (Lefly & Pennington, 2000), and the Everyday Memory Questionnaire, EMQ (Sunderland et al., 1983).

The ARHQ assesses reading-related behavior and attitudes. The 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?", and "How much do you read in your free time?). Only questions concerning current situations and attitudes were included since they were replicable. This resulted in 13 questions measured on a 5-point scale (included questions were: 9–12, 14, 16–23). The total score for the questions was analyzed.

The EMQ measures subjective memory performance. A 36-item version of the EMQ was chosen for this study. Answers for each question were given on a 5-point scale. The questions were i.e., "How often do you forget a friend's or relative's name or call them by a wrong name?" or "In the middle of doing something, how often do you forget what you were doing?". The full scale and the five subscales of Speech, Reading and Writing, Faces and Places, Actions, and Learning New Things, were analyzed.

Secondary outcome measures concerning psychometrically measured cognitive performance often impaired in adult dyslexia, but not used in verifying dyslexia were also included in the study. The psychometric tests were: 1) the Symbol Digit Modalities Test (SDMT) in a written format (Smith, 1968) for evaluating processing speed and attention. The test is similar to the WAIS-IV Coding (Wechsler, 2008, 2012), but instead of drawing symbols under matching numbers an examinee is asked to write numbers under matching symbols for 90 seconds. 2) Digit span sequencing from WAIS-IV (Wechsler, 2008, 2012) for evaluating working memory. 3) Word lists subtest from Wechsler Memory Test-III (WMS-III; Wechsler, 1997, 2008) for assessing verbal learning. 4) Verbal Fluency with category switching from Delis-Kaplan Executive Function System (D-KEFS; Delis et al., 2001) for evaluating verbal fluency and executive control. 5) Design Fluency from D-KEFS (Delis et al., 2001), for assessing visual fluency and executive control. 6)

Verbal Comprehension (V3) from a Finnish Ability Test Battery, Kykytestistö AVO-9 (Pulliainen, 1995) for evaluating comprehension of complex written instructions, the ability to keep them in mind, process, and execute them. It is a paper-and-pencil -test where an examinee is asked to solve tasks presented by short instructions. A shortened version with 20 out of 40 items was used.

In addition, questions outside established questionnaires were utilized to evaluate the possible benefits of the interventions. The questions covered subjective cognitive aspects such as concentration, memory, processing speed, and the ability to learn new information. They were evaluated using a 4-point scale (i.e., "How well can you usually concentrate?" 0 = *Very well* vs. 4 = *Very poorly*). Using a numerical scale from 0 to 10, the participants were also asked to evaluate the disadvantage dyslexia causes in studies and the disadvantage dyslexia causes at work. These two questions concerning perceived disadvantage were summed to form one variable. All the questions were timed identically with the other outcome measures and were repeated additionally 15 months post-intervention via a mailed inquiry.

2.3.2 MEASURES OF PSYCHOLOGICAL WELL-BEING AND COGNITIVE AND BEHAVIORAL STRATEGIES (STUDY II)

Four different questionnaires were utilized to measure psychological well-being and the use of cognitive and behavioral strategies. For measuring self-perceived cognitive and behavioral strategies, the Strategy and Attribution Questionnaire (SAQ; Nurmi et al., 1995) was administered. A shortened version of 20 questions and four subscales using a 7-point scale (from 1 = *Strongly disagree* to 7 = *Strongly agree*) was chosen for this study. The Success expectation subscale measures the extent to which people expect success and are not anxious about the possibility of failure (e.g., "When I go into new situations, I usually expect I will manage"). The Social pessimism subscale measures the extent of anxious feelings towards social situations and concerns over other people's feelings towards oneself (e.g., "No matter what I do, people have a negative opinion of me"). The Social optimism subscale measures the extent of positive expectations towards social situations (e.g., "When things do not go smoothly, it is best to talk it over with friends"). The Task avoidance subscale measures the extent to which people tend to behave in a way that prevents them from, rather than helps them in carrying out a task (e.g., "If I have a difficult task before me, I notice that often I do not really try"). In the SAQ, individual subscales were analyzed. The scale does not have a total score.

For the evaluation of the quality of life, the Quality of Life after Brain Injury Overall Scale (QOLIBRI-OS; von Steinbuechel et al., 2012) was used. The questionnaire includes six questions on a 5-point scale (from 0 = *Not at all* to 4 = *Very*). The instruction for answering is, "These questions are about how you feel overall now (including the past week)." Areas covered by the questionnaire include physical condition, cognition, emotions, function in

daily life, personal and social life, and current situation and future prospects. The full scale was analyzed, as well as each individual question separately since all the individual questions measure a unique area of life quality.

For assessing the mood of the participants, the Profile of Mood States (POMS; McNair & Lorr, 1964; McNair et al., 1992) was used. The Finnish version contains 38 adjectives (e.g., "active", "unhappy", "annoyed"), that were rated on a 5-point-scale (from 0 = *Not at all* to 4 = *Extremely*) (Hänninen, 1989; for a 37-item English version, see Shacham, 1983). The question formulation concerning each adjective is "Choose the option that best describes your feelings over the past week." The total score was analyzed.

Self-esteem was assessed using the Rosenberg's Self-Esteem Scale (Rosenberg, 1965), which includes ten questions on a 4-point scale (from 1 = *Strongly agree* to 4 = *Strongly disagree*). The scale includes five positive and five negative statements concerning the self (e.g., "On the whole, I am satisfied with myself" or "I feel I do not have much to be proud of"). The total score was analyzed.

2.3.3 MEASURES OF GOAL ATTAINMENT, CONCRETE CHANGES, AND TIME USED FOR INTERVENTION (STUDY III)

Attainment of personal goals set for the intervention was evaluated using the GAS (Kiresuk et al., 1994). Intervention goals were set individually by the participant together with a professional, using a 5-point scale to describe the concrete steps showing progress in attaining the goal. The scaling for the attainment of each goal is rated as follows: for achieving the expected level, the score is 0. For achieving a better-than-expected outcome, the score is + 1 or + 2, and for achieving less progress than expected, the score is –1. If nothing has changed regarding achieving the goal, the score is –2. The level of meeting the set goals is converted into a standardized t-score (mean 50 ± 10).

A self-assessment questionnaire was used to evaluate possible concrete changes made by the participants in their study or working habits. The question at five and ten months was formulated as follows: "Have you made some changes in your study or working habits during the past five months to help get by with dyslexia?". The answer was given by choosing the number of changes made (options: 0, 1, 2, 3, or 4 or more) and by describing each change. If the participant marked four or more changes, the described changes were calculated to get the exact amount of changes made. The number of changes was analyzed. At long-term follow-up 15 months post-interventions via a mailed inquiry, the question was formulated as follows: "Have you still been using the different strategies and means of support you possibly started using during the intervention to help get by with dyslexia?" Answers were given by marking one of the three options: "Yes, I am still using them", "I no longer use the strategies I used after the intervention", "I never picked up any strategies for use".

For evaluating the used time for intervention, the participants were asked to report the time they used between intervention sessions on the matters they had dealt with during the sessions. The used time was evaluated by the participants at the end of the intervention for all groups by marking one of the offered options: not at all / approximately: 15 minutes / 30 minutes / 45 minutes / 1 hour / 1 hour 30 minutes / over 1 hour 30 minutes. The answers were scaled from 0 (not at all) to 6 (over 1 hour 30 minutes).

The psychological variables evaluated for possible connection with goal attainment were the following self-report questionnaires: The SAQ, QOLIBRI-OS, Rosenberg's Self-Esteem Scale, and the POMS.

Possible connection with goal attainment and cognitive variables was also evaluated using a measure of the severity of dyslexia calculated as the number of dyslexia test scores that were either 1 *SD* or 2 *SD* below the mean of the control group, and the WAIS-IV index estimated by four subtests (Similarities, Vocabulary, Matrix Reasoning, Block Design).

The background variables evaluated for possible connection with goal attainment were age, sex, and education classified as Basic education (In Finland: Primary and lower secondary education), Vocational education, High School (In Finland: General upper secondary school), College / University of Applied sciences, and University).

2.3.4 MEASURE FOR DYSLEXIA-RELATED AIDS IN USE (NUKARI ET AL., UNPUBLISHED RESULTS)

To measure the use of dyslexia-related aids, the participants were asked about them in the assessment battery with the following question: "Which aids do you use at the moment to compensate for dyslexia?" A list of 11 common aids was given and space to report any other aids not mentioned in the list. The participants were asked to mark all aids they were using. The number of aids used was calculated.

2.4 INTERVENTION

The intervention model was developed at the Rehabilitation Foundation (Kuntoutussäätiö, https://kuntoutussaatio.fi/en/home/) based on earlier interventions that had been developed at the Rehabilitation Foundation for individual and group-based support for adults with developmental learning disorders. The earlier models also focused on other specific learning disorders than dyslexia and had not been scientifically tested for efficacy. However, these models had received encouraging feedback from the participants on the potential usefulness of both individual and group-based support.

The interventions were administered by therapists registered as qualified neuropsychologists eligible to administer neuropsychological rehabilitation by the Social Insurance Institution of Finland. Most of the individual

interventions and all the group interventions were administered by two experienced therapists (N = 90 participants). Four other neuropsychologists administered the rest of the individual interventions.

The intervention had a fixed basic structure, with each session having its topic. An intervention manual was prepared for the therapists that included the essential elements of each individual or group session. Adherence to the intervention protocol was monitored by having discussions with the therapists during the interventions. Nevertheless, this was not a strictly manualized intervention, and the goal was to handle topics relevant to the participant's current life situation (problems in studying, at work, or attaining them). The therapists could decide which exercises would suit which participants best, as well as make up content related to the participants' life situations using materials, for example, from their school or work assignments.

The holistically oriented intervention aimed at improving performance in cognitive tasks, as well as enhancing psychological well-being. The first two of the 12 intervention sessions were held one week apart, and after that, the sessions took place once in two weeks resulting in a five-month intervention period. One session lasted 1.5 hours for the individual intervention and 2 hours plus a break for the group intervention. The slightly more extended time in group intervention was due to the fact that in groups of ten people, the 1.5 hours would not be enough to cover the topics.

The topics that were covered with all the participants included the following: Setting goals, psychoeducation on dyslexia and learning disorders, reading and writing strategies and aids, foreign language learning strategies, memory strategies, strategies for supporting attention and concentration, supporting self-esteem and promoting self-knowledge, relaxation methods and stress management, plans for future and evaluating the attainment of goals. There was also optional content, for example, mathematics could be chosen as a theme in one session, if needed, in either intervention format. In individual intervention, it was possible to have a family member present in one session if giving insight to a family member about dyslexia and the problems related to it was felt useful. Examples of intervention content are presented in Table 2.

Based on systematically collected anonymous feedback, the content covered with all the participants was considered quite/very necessary by 82–97% of the participants, depending on the topic in question. All sessions had specific materials that could be used in the sessions. After each session, the participants received materials that included a summary of the handled topic and home assignments related to the topic. The home assignments included tasks like trying out the learned new strategies in one's study or work context and reporting experiences concerning them. Based on systematically collected feedback, 73% considered the home assignments quite/very necessary. In individual sessions, it was possible to focus intervention content according to the participant's needs and neuropsychological profile, as long as the focused topic was among the regular content (i.e., more focus on problems in reading

than writing). All the mentioned topics were meant to be at least briefly covered. In a group format, along with the neuropsychologist in charge of the intervention, there was an additional therapist available in five sessions. During those sessions, it was possible to divide the group based on the participants' needs. In the revising sessions the themes to be handled were chosen together with the participant/participants based on their needs and feedback.

The interventions used typical principles and methods of neuropsychological rehabilitation (Sohlberg & Mateer, 2001; Wilson et al., 2009). Cognitive tasks were included in both individual and group interventions to train new strategies and to improve metacognition. Other methods included in both intervention types were psychoeducation, teaching compensatory strategies, and offering psychological support to better cope with dyslexia. Self-knowledge was also supported by going through the results from the neuropsychological examination done at the entrance to all the participants. In group format, it was done in a more general way, in individual intervention in more personal detail. All participants were also given recommendations for accommodations in their work or studies if needed and were introduced to dyslexia-related aids to help them cope with dyslexia (for example, audiobooks, text-to-speech -software, etc.). The group intervention also offered the possibility for peer support as time was taken in each group session for sharing the experiences of the participants. Small-group work was also utilized.

Compliance with the intervention was 100% in the individual intervention, where a new appointment could be given in case of missing a session. In group intervention, 78% attended at least 75% of the sessions. The attendance rates ranged from 50% (for three persons) to 100%.

The wait-list control group did not receive neuropsychological intervention during the first five months. Also, not receiving any other intervention during that period was controlled for. After the wait-list period, the control group was randomly assigned to receive either individual or group intervention. In the individual intervention of the control group, compliance with the intervention was 100%. In the group intervention after the control period, 64% attended at least 75% of the sessions, with attendance rates ranging from 58% (for two persons) to 100%. Missed group sessions could not be compensated by a new session. They were compensated by giving the participants the materials of the missed session upon the next meeting.

Table 2 *Examples of intervention content from the neuropsychological intervention of dyslexia for young adults, following the schedule of the individual intervention. Similar themes were covered in the group intervention. Stress management did not have its own session in the individual intervention, but was covered among the other sessions.*

Session	Session topic, individual intervention	Examples of content
1	Feedback from the assessment, setting goals	Understanding one´s cognitive profile including challenges and strengths, goal setting using the GAS
2	Reading strategies and aids	Strategies to support reading large amounts of text and understanding what is essential in the text, supporting effective note taking, getting to know audiobooks
3	Writing strategies and aids	Strategies to support planning and executing writing tasks, for increasing the amount of text produced, and detecting writing errors, getting to know speech to text -aids
4	Memory strategies and aids	Understanding memory functions, memory strategies based on one´s cognitive strengths, aids supporting memory
5	Foreign language learning strategies	Strategies to support memorizing foreign words and improving writing/speaking/understanding the language
6	Revising a needed previous theme/themes	Choosing one of the previous themes which the participant considers most important for more profound handling
7	Attention and concentration	Psychoeducation on attention and strategies to support focusing and sustaining concentration on the needed tasks acknowledging the participant's attention span
8	Executive functions and time management	Strategies to support planning, beginning, and executing needed tasks, strategies to support scheduling and keeping up with plans
9	A family member present or revising	A family member present for psychoeducation on dyslexia and its impact on the participant's life, or if considered more essential, revising a previous theme
10	Mathematics or revising	Strategies for supporting the basics in arithmetic, e.g., decimal system, sequencing, bonds of ten, or if considered more essential, revising a previous theme
11	Self-knowledge and self-esteem	Increasing self-knowledge via psychoeducation and supporting self-esteem by focusing on successfully achieved tasks and enhancing acceptance
12	Conclusion, evaluating goals, plans for future	Concluding the intervention, evaluating achieved goals, making plans for future, and discussing future places for support

2.5 STATISTICAL ANALYSES

All the participants who had an observation at the five-month endpoint were included in the analyses, thus using the observed cases (OC) protocol (Prakash et al., 2008). Group differences in baseline characteristics were analyzed using the Pearson chi-square test, the Kruskall-Wallis Test, and one-way analyses of variance (ANOVA). Intervention outcomes in studies I and II and in dyslexia-related aids (unpublished results) were analyzed using linear mixed model analyses (random intercept model; Singer & Willett, 2003), 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. In all the post-hoc pairwise comparisons, Bonferroni correction was used. The effect size was estimated using a formula suggested by Snijders and Bosker (1999, pp. 102-103). A paired samples t-test was used to evaluate the stability of self-evaluations 15 months post-interventions (Study I, Study III for the number of concrete changes made to working habits and in unpublished results for the use of dyslexia-related aids).

In questionnaires concerning psychological well-being and behavioral and cognitive strategies (Study II), the significance of the changes at the individual level was assessed by calculating reliable change (RC) for those variables where a significant change at the group-level was found using the linear mixed model analyses. A formula suggested by Jacobson & Truax (1991), [RC = (measurement 2 – measurement 1)/Sdiff where Sdiff(=√(2∗[SEM12])], was used for calculating reliable change. A confidence level of 95%, indicating a significant change in one-sided testing, was used (Duff, 2012).

In Study III, differences between individual and group interventions concerning goal attainment were evaluated using multivariate analysis of variance. Correlations between goal attainment and age, education, concrete changes made during the intervention, and time used for intervention matters were evaluated using Spearman's ρ. Correlations between goal attainment and cognitive variables, psychological variables, and gender were evaluated using Pearson's r. To assess, which of the variables together would best predict goal attainment, the variables were selected by a linear regression analysis using the backward method. Semi-partial correlations for the predictors were retrieved and squared to observe the variance in the outcome associated with each variable. Assumptions of linearity and homoscedasticity were met when inspecting the residuals graphically and using normality tests. Multicollinearity was checked by having no substantial correlation between the variables ($r < .6$) and by having the variance inflation factor (VIF) for each predictor < 2 and the tolerance > .6.

The analyses were performed using the IBM SPSS Statistics program versions 22.0, 25.0 and 27.0

3 RESULTS

3.1 CHARACTERISTICS OF THE PARTICIPANTS

Characteristics of the participants regarding sociodemographic and cognitive factors at inclusion are presented in Table 3. There were no statistically significant differences between the intervention groups and the control group in any of the background variables (age, gender, educational level), cognitive performance as measured by the WAIS-IV index, or the severity of dyslexia calculated as the number of dyslexia test scores measured at inclusion that were either 1 *SD* or 2 *SD* below the mean of the control group.

Table 3 *Characteristics of the participants regarding sociodemographic and cognitive factors in individual and group-based neuropsychological intervention for dyslexia and wait-list control group at inclusion to the study.*

	Individual intervention	Group intervention	Wait-list control	P value	All participants
	n = 40	*n* = 39	*n* = 39		*n* = 118
Age in years, M (SD)	25.0 (5.6)	25.7 (5.7)	24.6 (6.1)	.69 [a]	25.1 (5.8)
Female/male freq.	32 / 8	30 / 9	32 / 7	.85 [b]	94 / 24
Educational level M (SD)	3.4 (1.2)	3.5 (1.1)	3.5 (1.0)	.96 [c]	3.4 (1.1)
WAIS-IV M (SD)	101.0 (11.7)	100.3 (13.0)	99.7 (12.7)	.99 [a]	100.3 (12.4)
Severity of dyslexia M (SD)	4.3 (0.9)	4.2 (0.8)	4.4 (0.8)	.55 [a]	4.3 (0.8)

Note. Educational level: Lower secondary education = 1, Vocational education = 2, High school = 3, University of Applied sciences = 4, University = 5. WAIS-IV: Wechsler Adult Intelligence Scale – Fourth edition (Wechsler, 2008, 2012). [a] ANOVA, [b] Pearson Chi-Square, [c] Kruskall-Wallis Test

3.2 CHANGES IN COGNITIVE PERFORMANCE (STUDY I)

3.2.1 CHANGES IN SELF-EVALUATED COGNITIVE PERFORMANCE

In examining subjective cognitive performance, no time x group interactions between individual intervention, group intervention, and wait-list control group were found using linear mixed model analyses, see Table 4 and Table 5. However, smaller positive findings concerning improvements within the intervention groups were found, and these are described below.

In the estimation of subjective reading-related performance using the ARHQ, a significant improvement was found in both intervention groups after

the intervention. The improvement in the individual intervention was statistically significant from baseline to first follow-up at five months (p = .013) and in group intervention from baseline to second follow-up at ten months (p = .003). Significant changes were not evident in the control group, see Table 4.

In the subjective evaluation of memory performance using the EMQ, within-group findings were evident only in one of the subscales, the subscale of Reading and Writing. Significant improvement in group intervention was found in this subscale from baseline to second follow-up at ten months (p = .006). Significant changes were not evident in other groups.

The participants' subjective experiences of their cognitive functioning were also evaluated through four targeted questions outside established questionnaires. This information was collected additionally at the long-term follow-up 15 months post-intervention. A significant improvement ($p < .05$) was found in the self-evaluated ability to concentrate in group intervention from baseline to second follow-up at ten months, in self-evaluated memory performance in individual intervention from baseline to first follow-up at five months, and in self-evaluated processing speed in individual intervention from baseline to second follow-up at ten months, see Table 5. The question regarding learning new information and new things did not produce significant results in any of the groups. The positive self-evaluations did not change significantly during follow-up from the end of intervention until 15 months post-intervention (concentration [$t(28) = -1.29$, $p = .206$], memory [$t(28) = 1.28$, p = .212] or processing speed [$t(28) = .83$, $p = .415$]).

The self-evaluated disadvantage dyslexia causes in studies and work diminished significantly in individual and group intervention from baseline to first follow-up at five months (individual: $p = .002$, group: $p = .009$). These evaluations did not change significantly during follow-up from five months to ten months. In the control group, no significant change was evident during the wait-list period from baseline to first follow-up at five months, but a significant change was evident from baseline to second follow-up at ten months, the time-point in which they also had had their intervention ($p = .005$). 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 ($t(33) = .28$, p = .784) and group interventions ($t(27) = -.52$, $p = .606$). For the wait-list control group, the perceived disadvantage diminished from follow-up at ten months to the time-point 15 months post-intervention ($t(26) = 2.42$, $p = .023$).

Table 4 *Comparisons between individual and group-based neuropsychological intervention for young adults with dyslexia and wait-list controls in self-reported and objectively measured cognitive performance 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 int.ac.[a]**
	0mos. *n* = 39	5mos. *n* = 38	10mos. *n* = 38	0mos. *n* = 37	5mos. *n* = 37	10mos. *n* = 34	0mos. *n* =39	5mos. *n*=39	10mos. *n* = 32			
ARHQ	30.6 (6.3)	**28.4[b]** (5.7)	29.2 (6.5)	31.5 (5.7)	30.6 (5.6)	**29.0[c]** (6.0)	30.9 (6.4)	31.1 (7.4)	30.3 (7.5)	**.002**	.577	.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)	.198	.146	.493
SDMT	48.2 (8.4)	**52.5[d]** (9.2)	54.7 (9.0)	51.4 (8.3)	**54.5[e]** (7.9)	55.6 (7.5)	47.2 (9.7)	47.6 (9.9)	**49.5[f]** (7.1)	**<.001**	**.012**	**.024**
V3 Verbal comp.	9.1 (3.6)	10.9 (3.7)	11.4 (3.6)	9.0 (2.5)	10.8 (2.9)	11.4 (3.1)	9.6 (3.4)	10.4 (3.1)	10.4 (3.9)	**<.001**	.977	.346
WAIS-IV Digit span seq.	8.1 (1.9)	8.4 (1.8)	8.9 (2.1)	7.9 (1.7)	8.5 (2.0)	8.5 (1.4)	7.6 (2.0)	8.2 (2.0)	8.3 (1.7)	**<.001**	.444	.926
WMS-III Word List	32.7 (4.7)	38.2 (5.0)	38.7 (4.4)	33.1 (5.2)	37.9 (4.4)	38.2 (5.3)	31.9 (5.5)	36.3 (4.6)	37.6 (4.5)	**<.001**	.294	.756
Verbal Fluency Switching	13.2 (2.2)	13.7 (2.8)	14.1 (2.6)	13.8 (2.6)	13.5 (3.7)	14.2 (2.3)	12.5 (3.5)	13.4 (2.5)	14.1 (2.4)	**.001**	.564	.343
Design Fluency Switching	23.5 (5.8)	29.0 (6.4)	31.0 (6.3)	25.7 (6.5)	29.5 (6.7)	32.3 (6.5)	24.0 (6.6)	28.0 (7.2)	28.8 (6.9)	**<.001**	.307	.285

Note. Figures are mean raw scores (SD). Statistically significant figures for linear mixed model and within-group change in ARHQ and SDMT are bolded. Less points equals better result in ARHQ and EMQ. [a]Linear mixed model analyses. [b]0mos. vs 5mos. p=0.013, [c]0mos. vs 10mos. p=0.003, [d]0mos. vs 5mos. p<0.001, [e]0mos. vs 5mos. p=0.003, [f]5mos. vs 10mos. p=0.13, ARHQ: Adult Reading History Questionnaire, EMQ: Everyday Memory Questionnaire. SDMT: Symbol Digit Modalities Test; V3 Verbal Comp: V3 Verbal Comprehension; WAIS-IV Digit Span seq: WAIS-IV Digit Span Sequencing; Verbal Fluency and Designs Fluency Switching: D-KEFS

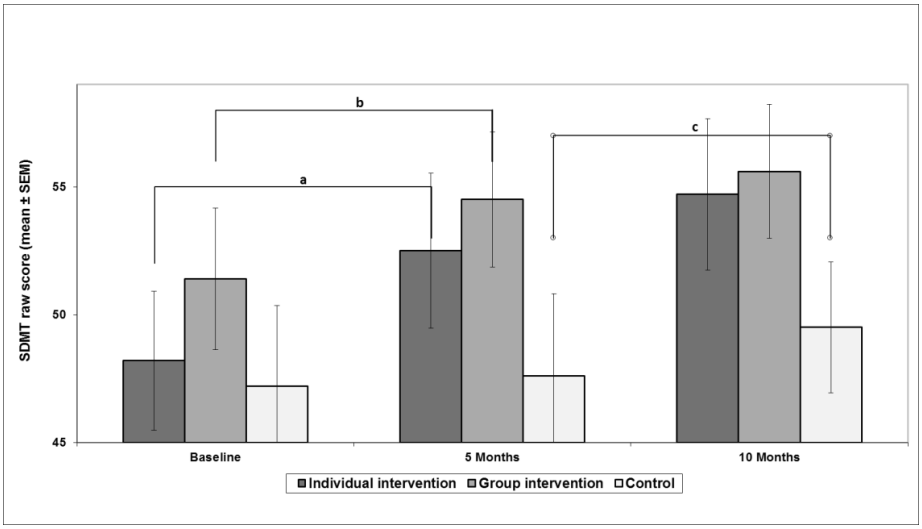
Table 5 *Comparisons between individual intervention, group intervention and wait-list controls in single-question based self-evaluations at baseline, at 5 months and at 10 months and descriptive values for the scores at 15 months after the interventions.*

Self-evaluation	Individual intervention				Group intervention				Wait-list control group				Linear mixed model for timeframe 0, 5 and 10 m.[a]		
	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 (0.7)	1.37 (0.5)	1.42 (0.6)	1.44 (0.9)	1.75 (0.8)	1.47 (0.7)	**1.37**[b] (0.7)	1.69 (0.7)	1.59 (0.7)	1.72 (0.8)	1.62 (0.6)	1.44 (0.6)	0.390	0.112	0.066
Memory	1.72 (0.8)	**1.39**[c] (0.6)	1.50 (0.7)	1.53 (0.8)	1.75 (0.8)	1.67 (0.8)	1.63 (0.8)	1.59 (0.9)	1.74 (0.8)	1.69 (0.8)	1.56 (0.7)	1.70 (0.6)	**0.020**	0.543	0.414
Speed	1.79 (0.8)	1.66 (0.8)	**1.47**[d] (0.8)	1.50 (0.9)	1.78 (0.8)	1.69 (0.7)	1.66 (0.8)	1.69 (0.9)	1.97 (0.8)	1.87 (0.7)	1.74 (0.8)	1.78 (0.8)	**0.010**	0.303	0.785
Learning	1.49 (0.8)	1.29 (0.7)	1.26 (0.6)	1.38 (0.7)	1.69 (0.7)	1.42 (0.7)	1.43 (0.7)	1.45 (0.8)	1.56 (0.8)	1.64 (0.8)	1.38 (0.7)	1.52 (0.8)	**0.009**	0.334	0.256

Note. Figures are mean raw scores (SD). Less points equals a better result in all. [a] m. = Month. [b] 0mos. vs 10mos. p = 0.012, [c] 0mos. vs 5mos. p = 0.011, [d] 0mos. vs 10mos. p = 0.026. 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.

3.2.2 CHANGES IN OBJECTIVELY MEASURED COGNITIVE FUNCTIONS

Concerning the objective cognitive measures, a significant time x group interaction between the intervention groups and the control group was found in the Symbol Digit Modalities test (SDMT) score, using a linear mixed model analysis ($F_{4,213}$ = 2.86, p = .024). The effect size for the whole model was R_1^2= .093. The interaction resulted from both intervention groups performing significantly better after the intervention (from baseline to first follow-up, individual p < .001, group p = .003). In contrast, performance in the control group did not improve during the control period from baseline to first follow-up at five months (p = 1.00). The improvement in the intervention groups remained stable also during follow-up after intervention from five to ten months. Performance in the control group improved significantly during their intervention after the control period from first the follow-up at five months to the second follow-up at ten months (p = .013), see Figure 2.



Note. [a] p < .001, [b] p = .003, [c] p = .013. The changes from baseline to 10 months were significant in all three groups. For the intervention groups, this change was significant at the p < .001 level and in the control group at the p < .01 level.

Figure 2 The changes in Symbol Digit Modalities Test (SDMT) scores in the individual and group-based neuropsychological interventions for dyslexia in young adults and the control group measured at baseline, at five months and at ten months. Reproduced with permission from Sage Publishing (Nukari et al., 2020).

There were no other significant time x group interactions between the intervention groups and the control group in the other psychometric measures. However, significant differences in time ($p < .001$) were found in all three groups in all the psychometric variables over the three time points (baseline, first follow-up, and second follow-up), reflecting the practice effect due to repeated testing.

Taken together, improvement regarding cognitive functioning was evident as an interaction in processing speed and in significant within-group changes without an interaction in subjective reading-related performance and reading- and writing-related memory performance, self-evaluated concentration, memory, speed of handling things in mind, and in diminishing the perceived disadvantage dyslexia causes in studies and at work.

3.3 CHANGES IN COGNITIVE AND BEHAVIORAL STRATEGIES AND PSYCHOLOGICAL WELL-BEING (STUDY II)

3.3.1 CHANGES IN COGNITIVE AND BEHAVIORAL STRATEGIES

Behavioral and cognitive strategies were evaluated using subscales of the SAQ. A significant time x group interaction between the intervention groups and the control group was evident in the subscale of Success expectation (linear mixed model analyses: $F_{4.214} = 3.82$, $p = .005$). The effect size for the fixed effects of the whole model was $R_1^2 = .029$. Success expectations increased in group intervention significantly during the intervention from baseline to first follow-up at five months ($p = .012$), and the result remained stable also during the follow-up period after intervention from five months to ten months. The changes in the individual intervention or the control group were not significant, see Table 6. To evaluate the possible statistical and clinical significance of the observed changes at the individual level, reliable change was calculated. Reliable change was evident in 19.4% of participants in group intervention. For results on all groups, see Table 7.

No other significant time x group interactions were found between the intervention groups and the control group in the other SAQ subscales. However, in the SAQ subscale of Social pessimism, the interaction between the intervention groups and the control group came extremely close to significance ($F_{4.214} = 2.39$, $p = .052$). This was due to the ratings remaining stable over time in individual intervention and control group and the ratings of the amount of experienced social pessimism decreasing in group intervention from baseline to first follow-up at five months. However, this change within group intervention was not statistically significant ($p = .16$).

A smaller finding of significant change within the intervention groups was evident in task avoidance as there was a significant decrease in the SAQ subscale of Task avoidance in individual and group interventions from

baseline to second follow-up at ten months (individual p = .048, group p = .003). In the control group, there were no significant changes. In the subscale of Task avoidance, reliable change was evident in 20.0 % of participants in group intervention and 10.5% of participants in the individual intervention, see Table 7.

Table 6 *Comparisons between individual and group-based neuropsychological intervention for young adults with dyslexia and wait-list controls in self-report measures of psychological well-being, measured at baseline, at 5 months and at 10 months.*

	Individual intervention			Group intervention			Wait-list control			p time	p group	p time x group int.ac.[a]
Measures	0mos. *n* = 39	5mos. *n* = 38	10mos. *n* = 38	0mos. *n* = 36	5mos. *n* = 36	10mos. *n* = 35	0mos. *n* = 39	5mos. *n* = 39	10mos. *n* = 33			
SAQ Success expectation	25.7 (4.2)	26.5 (4.1)	25.5 (4.3)	23.3 (5.5)	**25.2**[c] (4.6)	**25.2**[d] (5.0)	24.1 (4.7)	23.1 (5.4)	24.6 (5.5)	.187	.124	**.005**
SAQ Social optimism	26.6 (4.1)	27.5 (3.8)	27.1 (4.2)	25.9 (4.8)	26.4 (5.2)	26.7 (5.4)	25.7 (4.9)	25.9 (5.0)	25.9 (5.6)	.222	.486	.962
SAQ Social pessimism[b]	12.4 (4.5)	12.2 (5.2)	13.8 (5.3)	14.1 (5.7)	12.8 (5.4)	12.7 (5.3)	14.5 (4.5)	14.3 (5.2)	14.2 (5.4)	.355	.377	.052
SAQ Task-avoidance[b]	17.2 (5.7)	15.7 (6.3)	**15.5**[d] (6.8)	17.4 (6.5)	16.3 (6.5)	**14.7**[d] (5.7)	16.5 (5.2)	17.4 (6.1)	16.7 (5.6)	**.005**	.855	.076
POMS total score[b]	38.6 (16.7)	35.9 (17.0)	36.9 (19.1)	41.2 (16.8)	46.9 (22.5)	38.3 (19.6)	39.6 (19.3)	47.4 (21.8)	46.8 (25.3)	.138	.141	.081
Rosenberg self-esteem	30.7 (4.6)	**32.8**[c] (4.7)	31.7 (4.9)	29.4 (5.4)	30.8 (5.4)	**32.1**[d] (5.0)	29.2 (7.0)	29.6 (6.1)	29.2 (6.6)	**.009**	.114	.183
QOLIBRI-OS Question 2	2.1 (0.9)	**2.6**[c] (0.9)	2.3 (1.0)	1.8 (1.1)	2.1 (1.0)	**2.3**[d] (0.9)	2.0 (1.3)	1.7 (1.0)	2.1 (1.2)	**.025**	.084	**.026**

Note. Figures are mean raw scores (*SD*). Statistically significant figures are bolded. [a] Linear mixed model analyses [b] Less points equals a better result [c]Statistically significant within-group change from 0 to 5 mos. and [d] from 0 to 10 mos. SAQ: Strategy Attribution Questionnaire; POMS: Profile of Mood States, Finnish version of the POMS includes 38 questions; Rosenberg: Rosenberg self-esteem scale. QOLIBRI-OS Question 2: The Quality of Life after Brain Injury Overall Scale, Question for Concentration & memory. The rest of the five questions in QOLIBRI-OS did not include significant changes.

3.3.2 CHANGES IN PSYCHOLOGICAL WELL-BEING

Psychological well-being was assessed by evaluating the quality of life, self-esteem, and mood states. For evaluations on the quality of life, the time x group interaction between the intervention groups and the control group was not significant in the total QOLIBRI-OS score. Of the six questions measuring different components of quality of life, the time x group interaction on the question concerning cognition ("Overall, how satisfied are you with how your brain is working, in terms of your concentration, memory, thinking?") was statistically significant (linear mixed model analyses: $F_{4,216} = 2.82$, $p = .026$). The effect size for the fixed effects of the whole model was $R_1^2 = .040$. Perceived satisfaction with cognitive functioning increased in individual intervention significantly during the intervention from baseline to first follow-up at five months ($p = .017$) and in group intervention from baseline to second follow-up at ten months ($p = .030$). In the control group, there were no significant changes, see Table 6.

In subjective evaluations of self-esteem using the Rosenberg Self-Esteem Scale, no significant time x group interaction between the intervention groups and the control group was found. A smaller finding of significant change within the intervention groups was evident as there was a significant increase in self-esteem in individual intervention from baseline to first follow-up at five months ($p = .027$) and in group intervention from baseline to second follow-up at ten months ($p = .012$). Self-esteem did not change significantly in the control group over time, see Table 6. In self-esteem, reliable change was evident in 31.4% of participants in the group intervention and 21.6% of participants in the individual intervention. For results on all groups, see Table 7.

For mood symptoms evaluated using the POMS questionnaire's total score, no significant time x group interaction between the intervention groups and the control group was found, see Table 6. The mean baseline score for the participants in the POMS total score was 39.8 points ($SD = 17.5$), which is 26.2% of the maximum score (152 points).

Table 7 *The number of participants demonstrating reliable change reported at the 95% confidence level in the individual and group-based neuropsychological intervention of dyslexia and wait-list control group in subjectively evaluated psychological variables at the timepoint where statistically significant change was found within at least one of the groups using linear mixed model analyses.*

	Reliable change	
	n	%
SAQ Success expectation		
Individual intervention at 5 months	1	2.6
Group intervention at 5 months*	7	19.4
Wait-list control group at 5 months	1	2.6
SAQ Task avoidance		
Individual intervention at 10 months*	4	10.5
Group intervention at 10 months**	7	20.0
Wait-list control group at 10 months	1	3.0
Rosenberg self-esteem		
Individual intervention at 5 months*	8	21.6
Group intervention at 10 months*	11	31.4
Wait-list control group at 5 months	5	12.8
Wait-list control group at 10 months	6	18.2

* Significant change within-group at $p < .05$ level using linear mixed model

** Significant change within-group at $p < .01$ level using linear mixed model

Taken together, improvement regarding psychological well-being was evident as an interaction in increased self-evaluated success expectations and in improved self-evaluated quality of life related to cognitive functioning. Smaller findings as significant within-group changes were evident in diminished self-evaluated task avoidance and in increased self-esteem.

3.4 ATTAINMENT OF PERSONAL INTERVENTION GOALS AND CONCRETE BEHAVIORAL CHANGES MADE BY THE PARTICIPANTS (STUDY III)

3.4.1 GOAL ATTAINMENT

Goal attainment was evaluated only during the interventions, not during the wait-list period. The wait-list control group is included in the GAS data on the bases of whether they were in individual or group intervention after the waiting period.

The participants could freely choose to set between one to three goals. Only one goal was set by 23.9% (out of $N = 109$) of the participants. Two goals were set by 57.8%, and 18.3% set three goals. In individual intervention, the participants set on average of 2.2 goals ($SD = 0.7$, $N = 55$) and in group intervention, on average of 1.7 goals ($SD = 0.5$, $N = 54$). The personally set goals dealt mainly with improving areas of cognitive functioning ($N = 194$), such as improving reading, writing, learning foreign languages, or memory,

and to a lesser degree with aspects regarding improving psychological well-being and knowledge (N = 12), such as relaxation and stress management or increasing self-knowledge.

Goals were, on average, met (GAS t score; M = 50.6, SD = 10.4, range 25.0–70.0). In individual intervention, the average GAS t score was 53.3 (SD = 9.7, N = 55), and in group intervention, 47.8 (SD = 10.5, N = 51). Since a different number of goals were set in individual and group interventions, also attaining only the first set goal was evaluated. In individual intervention, the first goal was attained at an average level of 0.3 (SD = 1.0) and in group intervention at an average level of –0.2 (SD = 1.0).

Possible differences between individual and group intervention in goal attainment were compared using multivariate analysis of variance, including the number of set goals, achieving the first set goal, and achieving all the set goals. A significant effect of the intervention format on setting and achieving GAS goals was observed, $F(3, 101) = 11.47$, $p < .001$, Wilk's $\Lambda = .746$. Separate univariate tests for the outcome variables pointed to significant group effects in all three variables (the number of set goals, $p < .001$; achieving the first goal, $p = .011$; achieving all the goals, $p = .005$).

3.4.2 CONCRETE CHANGES IN STUDY AND WORKING HABITS AND TIME USED FOR INTERVENTION CONTENTS BETWEEN INTERVENTION SESSIONS

Concrete changes made in the participants' study and working habits were evaluated for all three groups (individual intervention, group intervention, wait-list control group) separately. The participants were asked at five months and ten months to report possible concrete changes they had made in their study or working habits to help cope with dyslexia. The number of changes made at five months differed significantly between the groups ($F_{2,110} = 18.58$, $p < .001$), and more precisely, the wait-list control group differed significantly from both intervention groups ($p < .001$). The difference between individual and group intervention was non-significant. The difference in the number of changes made between five months and ten months did not differ significantly between the groups ($F_{2,102} = 2.54$, $p = .084$), as adapting new strategies in use seemed to continue for the intervention groups even after the interventions, see Table 8.

Table 8 *The number of concrete changes reported having been made in the individual and group-based neuropsychological intervention of dyslexia for young adults and wait-list control group between zero to five months (evaluated at five months) and between five to ten months (evaluated at ten months).*

	5 months[a]			10 months		
	n	*M*	*SD*	*n*	*M*	*SD*
Individual intervention	38	2.4	1.6	38	1.4	1.5
Group intervention	36	1.9	2.0	34	1.6	1.5
Wait-list control group	39	0.3	0.7	33	2.2	1.7

Note. [a] Difference between intervention groups and wait-list control group significant at the $p < .001$ level.

The participants were asked via a mailed self-assessment questionnaire 15 months post-interventions whether they were still using the strategies and methods of support they had picked up for use during the interventions. Most of the participants, 76.4% (out of $N = 102$), reported still using the strategies and methods they had picked up during their intervention. Five participants (5.6%) reported never having picked up any strategies or methods for use, and 18.0% reported having stopped using the strategies they had used when they finished with their intervention.

The time used for intervention contents between intervention sessions was evaluated only after the interventions. The wait-list control group is included in the data for used time on the bases of whether they were in individual or group intervention after the waiting period. Most participants (57.3%, $N = 96$) reported using 15 - 30 minutes between intervention sessions for matters dealt with during the intervention session. Having used no time for intervention contents between the sessions was reported only by 2.1%, and on the other end, 31.2% of the participants reported having used an hour or more. See for more specific results in Table 9. When comparing individual and group intervention on the used time, more time was used in the individual intervention (time scaled 0–6; $M = 3.07$, $SD = 1.61$, $N = 54$) compared to group intervention ($M = 2.17$, $SD = 1.48$, $N = 42$), $t(94) = 2.835$, $p = .006$.

Table 9 *Time used for intervention content between the intervention sessions for participants in individual and group-based neuropsychological dyslexia interventions for young adults.*

How much time have you used between the intervention sessions in matters dealt with in the intervention? *n* = 96	Both groups together	Individual intervention	Group intervention
	%	%	%
Not at all	2.1	0.0	4.8
Approximately 15 minutes	24.0	16.7	33.3
Approximately 30 minutes	33.3	31.5	35.7
Approximately 45 minutes	9.4	11.1	7.1
Approximately 1 hour	15.6	20.4	9.5
Approximately 1.5 hours	7.3	9.3	4.8
Over 1.5 hours	8.3	11.1	4.8
Total	100	100	100

3.4.3 FACTORS ASSOCIATED WITH GOAL ATTAINMENT

The background variables (age, gender, education) or the cognitive variables evaluated at inclusion (WAIS-IV index, severity of dyslexia) did not correlate with goal attainment. For the psychological variables evaluated at baseline, self-esteem (r = .218, p = .026) and three of the cognitive and behavioral strategies; SAQ Success expectation (r = .285, p = .003), SAQ Social optimism (r = .229, p = .019), SAQ Social pessimism (r = –.313, p = .001) correlated with goal attainment. Also, the reported time used between the intervention sessions (Used time, r = .421, p < .001) and the concrete changes reported having been made during the interventions (Made changes, r = .490, p < .001) correlated with goal attainment.

The background-, cognitive- and psychological variables, as well as used time and made changes, were included in a backward linear regression analysis to evaluate which of the variables together would best predict goal attainment. Since goals were attained differently in the two intervention formats, also the intervention type (individual/group) was entered into the model. The regression analysis produced nine models, all of which fit the data well (p < .001). The last model with the least number of variables was chosen since excluding variables did not significantly lessen the model fit. Also, the variables left in the last model were all statistically significant except for one (Used time). This model *($F_{7.81}$* = 11.49, p < .001, N = 89*)* explained 49.8% (R^2 = .498) of the variation in goal attainment, see Table 10.

Table 10 *Linear regression model of predictors of Goal Attainment Scaling (Kiresuk et al., 1994) using the backward method for participants in the individual and group-based neuropsychological intervention of dyslexia for young adults. Confidence intervals for B are reported in parentheses, N = 89. Reproduced with permission from Taylor & Francis (Nukari et al., 2022).*

	B	*SE B*	β	*t*	*p*	sr^2
Constant	57.86 (38.34, 77.38)	9.81		5.90	< .001**	
WAIS-IV index	–.15 (–.29, –-02)	.07	–.19	–2.26	.026*	.032
SAQ Success expectation	.46 (.05, .86)	.20	.22	2.25	.027*	.031
SAQ Task avoidance	.40 (.09, .72)	.16	.22	2.56	.012*	.041
SAQ Social pessimism	–.64 (–1.02, –.26)	.19	–.31	–3.34	.001**	.069
Made changes	1.29 (.29, 2.28)	.50	.24	2.57	.012*	.041
Used time	1.07 (–.06, 2.21)	.57	.18	1.88	.063	.022
Intervention type	-5.05 (–8.43, –1.68)	1.70	–.25	12.98	.004*	.055

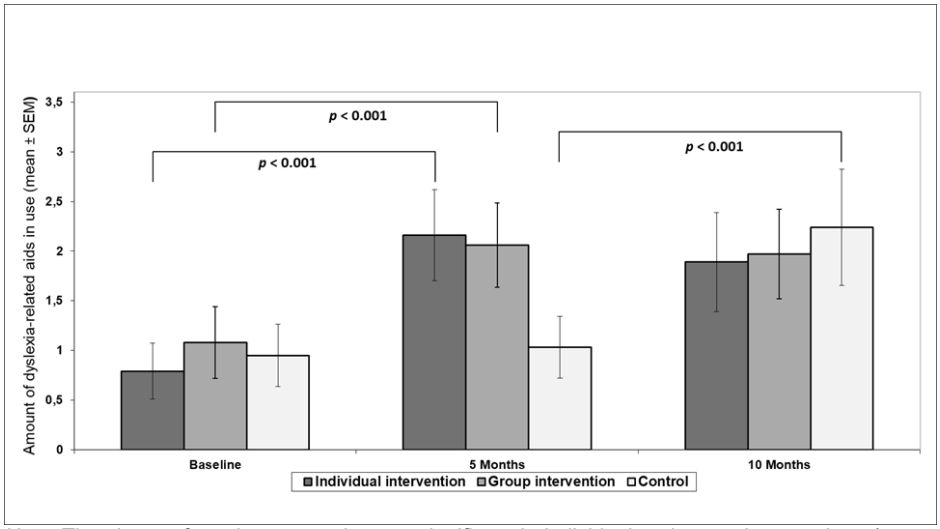
Note. R^2 = .498; *B* = unstandardized regression coefficient; *SE B* = standard error of the unstandardized regression coefficient; β = standardized coefficients Beta; sr^2 = squared semi-partial correlation; WAIS-IV: Wechsler Adult Intelligence Scale – Fourth edition; SAQ: Strategy Attribution Questionnaire; Made changes: Self-reported number of changes the participants have made in their study of working habits to help get by with dyslexia; Used time: Self-reported time used between interventions for intervention content; * $p < .05$; ** $p < .001$

Taken together, goals were, on average, met but better in individual than group intervention, even when only the first goal was evaluated. More concrete changes were reported to have been made in the intervention groups compared to the wait-list control group. Goal attainment was mostly explained by social pessimism and intervention type followed by changes made in one's study and working habits, task avoidance, cognitive capacity measured by the WAIS-IV index, success expectations, and time used for intervention matters in between intervention sessions.

3.4.4 USE OF DYSLEXIA-RELATED AIDS (NUKARI ET AL., UNPUBLISHED RESULTS)

There was a significant time x group interaction between the intervention groups and the control group in the number of aids used by the participants to compensate for dyslexia-related difficulties ($F_{4.212} = 8.311, p < .001$). There was also a significant difference in time ($p < .001$). The effect size for the fixed effects of the whole model was $R_1^2 = .154$. The use of aids increased significantly in both intervention groups from baseline to first follow-up at five months ($p < .001$) and remained stable during the follow-up period from five months to ten months. The use of aids did not increase in the control group during the control period from zero to five months, but it increased significantly as the

control group received the intervention between five months and ten months ($p < .001$), see Figure 3. Using a paired samples t-test, the amount of aids in use decreased during long-term follow-up until 15 months after the interventions ($M = 1.8$, $SD = 1.5$, $N = 90$) compared to the level it had reached by the 10-month assessment ($M = 2.1$, $SD = 1.5$, $N = 90$), the point at which all the three groups had received their intervention, $t(89) = 2.66$, $p = .009$, mean difference 0.34, 95% CI [0.09, 0.60]. However, the amount of aids in use 15 months post-interventions was still significantly higher than the amount of aids in use at baseline before the interventions ($M = 0.9$, $SD = 1.0$, $N = 90$), $t(89) = -5.37$, $p < .001$, mean difference −0.84, 95% CI [−1.16, −0.53].



Note. The change from 0 to 5 months was significant in individual and group interventions (post hoc analyses: $p < .001$). In the control group, the change from 5 to 10 months was significant (post hoc analyses: $p < .001$).

Figure 3 *The changes in the number of aids in use to compensate for dyslexia-related challenges in individual and group-based neuropsychological interventions for dyslexia in young adults and the control group, measured at baseline, at five months, and ten months.*

The dyslexia-related aid that was most often picked up for use during the interventions was audiobooks. Audiobooks were used by 13.2% of the participants ($N = 114$) before the intervention. After individual and group intervention, 55.6% of participants in these groups ($N = 72$) used audiobooks, while in the control group ($N = 39$), only 17.9% used audiobooks after the wait-list period. After the control group had their intervention, 54.5% of this group ($N = 33$) also used audiobooks.

4 DISCUSSION

In these presented studies, the effectiveness of individual and group-based neuropsychological interventions for young adults with dyslexia was evaluated. The interventions resulted in positive changes in both intervention types compared to the wait-list control group. Most significant changes evident as an interaction, were found in processing speed, subjectively evaluated success expectations, quality of life related to cognition, and dyslexia-related aids in use. In addition, more concrete changes were reported to have been made in study or working habits to help get by with dyslexia in the intervention groups compared to the wait-list control group. The personal goals set for the interventions were, on average, met.

More minor changes demonstrated as significant within-group changes without an interaction, were evident in subjectively evaluated cognitive and behavioral strategies regarding task avoidance and subjective evaluations of self-esteem and various aspects of cognition, as well as evaluated disadvantage dyslexia causes in studies and work. Some differences between individual and group interventions emerged. In part, they had to do with the timeframe within which the changes became visible and partly with the content of the changes. Some of these differences were quite easily interpreted, and some need further investigation. The gains from the interventions mainly lasted until the end of follow-up which was, depending on the measure, either five months or 15 months after the intervention.

4.1 POSITIVE FINDINGS IN SELF-REPORTED COGNITIVE PERFORMANCE AND INCREASED PROCESSING SPEED (STUDY I)

For the primary outcome measures concerning self-reported cognitive performance, significant interaction effects were not found. As a more minor finding, positive changes within the intervention groups in subjective reading-related performance and reading- and writing-related memory performance were evident.

A significant positive within-group change in subjective reading-related performance as measured by the abbreviated ARHQ was evident in individual intervention immediately after the intervention and in group intervention at the later 10-month follow-up, even though an interaction between the intervention groups and the control group was not evident. These results can reflect a positive change in reading habits, attitudes, and estimates of one's reading skills, which are areas the intervention aimed to support. In an ARHQ study, questions concerning current reading attitude, which were also included in our 13-question version of the ARHQ, were associated with three

objective measures of reading or reading comprehension (Welcome & Meza, 2018). In a Finnish study, the ARHQ questions (eight out of 12 of the same questions as in our version), correlated, depending on the sample, moderately to strongly with objective reading accuracy and fluency measures (Khanolainen et al., 2022). It could be speculated that changes in the ARHQ self-report scores might, in some cases, reflect changes in the participants' actual reading ability as well.

Self-evaluated everyday memory performance in total did not improve during the interventions, and there were no interactions in the sub-scales either. However, a smaller result of significant positive within-group change was found in the memory performance related to reading and writing. A significant improvement within group intervention was evident between baseline and the ten-month follow-up. Memory problems are known to be even more persistent among adults with dyslexia than reading fluency problems (Eloranta et al., 2019b) and the objectively evaluated memory performance of the participants was below average at baseline (see Study I, Nukari et al., 2020), so there could have been room for improvement. Supporting memory was only one part of the intervention, which had many other topics to cover. Depending on the participant's needs, it could have also been handled in sessions for revising chosen themes. Perhaps the interventions did not offer enough support for memory performance in general, and the minor positive changes found were, thus focused on memory performance directly linked to reading and writing.

In self-evaluations by single questions concerning different domains of cognitive functioning, an interaction effect between the groups was not detected. As a more minor finding, significant improvement within the intervention groups was found in concentration, memory, and speed of handling things in mind. These subjective improvements concerned areas related to the intervention content and, as such, were expected. Even though not reaching an interaction, positive changes within intervention groups were also evident in diminishing the perceived disadvantage dyslexia causes in studies and at work. All these self-evaluated benefits lasted until 15 months post-interventions reflecting long-lasting results in self-reported cognitive performance.

Self-evaluations of cognitive performance were set as the primary outcome measures, and objectively measured cognitive functions were set as secondary outcome measures before the start of the interventions. However, the most substantial result regarding cognition was found among measures assessing objective cognitive performance. The interventions resulted in improved performance in processing speed and attention, while the wait-list control group showed no improvement. The gains from the intervention remained even after the five-month follow-up. The significance of the finding was accentuated by the wait-list control group, which also showed a significant change in performance after they received the intervention. Unlike other cognitive measures used in the study, the measure for processing speed

(SDMT) did not have a strong practice effect due to repeated testing (see Dikmen et al., 1999). This feature of the SDMT has been demonstrated previously in healthy subjects (Register-Mihalik et al., 2012).

Difficulties in both linguistic and non-linguistic processing speed have been linked with reading disability (Catts et al., 2002; Eloranta et al., 2019b; Miller-Shaul, 2005; Pennington, 2006; Park & Lombardino, 2011; Peter et al., 2011; Shanahan et al., 2006), and slow processing speed has even been argued to be a core deficit in identifying students with dyslexia. In previous research, processing deficits have been more evident in older than younger children (Park & Lombardino, 2011). Improvement in processing speed could potentially alleviate some difficulties associated with dyslexia. General processing speed has been argued to be critical for utilizing many other cognitive skills effectively (Dang et al., 2015; Poll et al., 2013; Salthouse, 1996). For example, larger amounts of information can be held in short-term storage if better processing speed enables faster rehearsal in short term memory (Schweizer, 2005). Slower processing speed can limit performing complex mental operations by making the simpler operations needed to be executed before the more complex operations too slow (Salthouse, 1996). Acknowledging the above, improvement in processing speed could potentially generalize also to other cognitive skills.

When considering the result of improved processing speed after the interventions, a closer inspection of the measure used to achieve this result is due. Although commonly called a measure of processing speed (e.g., Benedict et al., 2017; Strober et al., 2019), the SDMT has been found to measure multiple cognitive processes, like attention, visual scanning, and motor speed (Sheridan et al., 2006). In a study with healthy subjects, educational level, along with a measure of reading level and measures of motor response, was a significant contributor to performance in the SDMT (Crowe et al., 1999). The authors speculated that the association between education and the SDMT might be explained by familiarity to test-taking skills, such as paper-and-pencil tests, in subjects with higher education (Crowe et al., 1999). Using the oral version of the SDMT in a clinical population of MS patients, memory performance also emerged as an important component contributing to the performance, along with lexical access and information processing speed (Sandry et al., 2021). In a non-clinical sample using a computerized version of the SDMT, memory performance did not play a significant role (Denney et al., 2015). The role of memory has also shown to be rather small, explaining only 4 to 5% of the variance in the WAIS Digit Symbol subtest (Joy et al., 2003), which closely resembles and highly correlates with the SDMT (Lezak, 2004).

Considering the findings in the literature, the improved result in the SDMT among the participants in the current interventions could be related to improvements also in other underlying cognitive factors than processing speed and attention. The ability to concentrate did improve in subjective evaluations in the group intervention and self-evaluated speed of handling things in mind in the individual intervention, which does go together with the

improved result in the SDMT. It could also be speculated that one part of the improved performance might come from enhanced ability in paper-and pencil work, if the interventions have increased the amount of time spent with this kind of tasks. Improved memory performance, which was evident only partly in the subjective evaluations of the participants, does not come out as a strong candidate for explaining the improved performance in the paper-and pencil version of the SDMT used in this study.

4.2 POSITIVE CHANGES IN COGNITIVE AND BEHAVIORAL STRATEGIES AND PSYCHOLOGICAL WELL-BEING (STUDY II)

Regarding the secondary outcome measures for self-evaluated psychological well-being, the strongest results demonstrated as an interaction, were evident in expectations of succeeding in future tasks and in the quality of life concerning cognitive functioning. As a more minor finding of significant within-groups change without an interaction, avoidance of tasks diminished, and self-esteem increased significantly in both interventions.

Success expectations increased most prominently in group intervention. Improving success expectations was a positive finding since expectations for succeeding even in a difficult task can increase motivation and predict success (e.g., Bandura, 1997). When expecting to do well, people tend to set task-related goals, and put effort into planning their realization and carrying them through (Eronen, 2000; Nurmi et al., 1995; Mischel & Shoda, 1995). This can create a positive cycle that increases the probability of success in the task at hand and enhances further deployment of functional strategies (Eronen, 2000). On the other hand, if a person anticipates failure, he might try to avoid the situation or behave in ways that will provide excuses for possible failure (Berzonsky et al., 1999; Eronen, 2000; Peterson & Seligman, 1984). This kind of behavior is likely to decrease the chances of success (Berzonsky et al., 1999; Cantor, 1990; Eronen, 2000).

Both interventions seemed to help also in diminishing avoidance of tasks expected to be difficult, even though an interaction effect was not evident. Supporting the participants in getting started with the tasks at hand (i.e., homework or work assignments) was among the intervention targets. Not postponing working on the tasks one has is likely to increase the possibility of succeeding, which, in turn, could enhance feelings of self-efficacy, a high level of which has been linked to improving future performance (Elliot & Dweck, 2005; Liem et al., 2008).

In group intervention, there was a non-significant trend for diminishing social pessimism. Negative feelings associated with social situations might have grown smaller when interacting with a group of people sharing the same difficulties and establishing a trusting atmosphere in the group. The individual

intervention included interaction only with a professional, which might not have induced the same effect on participants' social attitudes.

Significant improvement was evident for both intervention types in the quality of life concerning cognition, which fits the content of the interventions, where supporting cognitive functions was a part of the interventions. Changes were not evident in other components of life satisfaction. One reason might be that in these areas, satisfaction with one's functioning was already at a higher level at the beginning of the interventions leaving less room for improvement. These findings somewhat fit the results from previous research where evidence for diminished quality of life in certain areas among students with dyslexia was found (Lambert & Dryer, 2018) and no differences in general life satisfaction between young adults with dyslexia and a normative group was evident (Undheim, 2003).

Regarding self-esteem, a more minor finding of a significant increase in self-esteem was evident in both intervention groups, even though an interaction effect was not evident. Low self-esteem has been regarded as the most common psychological problem for individuals with developmental dyslexia (McNulty, 2003). Failing to reach expected academic goals can be damaging to self-esteem, especially in Western societies, where academic attainment is emphasized (Lithari, 2019; Sumner et el., 2021). The therapists aimed to support the self-esteem of the participants by helping them to see dyslexia as only one feature they have and deliberately focusing also on the strengths and talents of each participant.

Despite the known connection between dyslexia and problems in psychological well-being (e.g., Aro et al., 2019; Livingston et al., 2018), changes in mood were not evident at the group-level among the participants. The most obvious explanation could be that the participants had quite a low level of mood symptoms, to begin with, leaving little room for improvement. The level of self-reported mood symptoms was reasonably close to a non-clinical normative sample of American young adults (Yeun & Shin-Park, 2006). Severe depression and psychiatric diagnoses were an exclusion criterion, but milder mood symptoms were not a reason for exclusion. However, the participants enrolled ended up being at a fairly high level concerning their mood.

In addition to group-level results, clinically meaningful change for psychological variables was evaluated at an individual level using reliable change analyses. This completed the group-level results by demonstrating that there are also significant individual-level changes behind the significant group-level results and the results are not made up of only minor and as such perhaps clinically less significant changes in the individuals. Using a strict significance level (95%) for reliable change, around 10 to 30% of the participants reached it, depending on the variable. In the future, it would be beneficial to try to find out what characterizes those participants who benefit from an intervention like this the most.

4.3 ATTAINING PERSONAL INTERVENTION GOALS AND MAKING CONCRETE CHANGES (STUDY III)

In addition to cognition and psychological well-being, which in ICF terms are classified as body functions (WHO, 2001), one aim of this study was to evaluate possible intervention-related changes in the level of activities and participation. This level of functioning has even been viewed as the level where the outcome of neuropsychological interventions actually should be measured (van Heugten et al., 2020; see also Cicerone et al., 2019). To evaluate this level of functioning, the attainment of personal intervention goals, self-reported concrete changes made in one's study or working habits to help get by with dyslexia, and the use of dyslexia-related aids were examined. The intervention goals were, on average, met, and various factors predicting goal attainment were identified. Self-reported concrete changes made in one's study and working habits and the use of dyslexia-related aids both increased more in the intervention groups compared to the control group.

The set personal goals were mainly related to improving different aspects of reading, writing, learning foreign languages, or memory. Goals concerned with cognitive functioning were clearly more common than goals related to psychological well-being (i.e., self-knowledge and acceptance). In addition to cognition-related goals likely being the most important ones to the participants, they were also perhaps more easily operationalized as concrete goals with observable steps than goals dealing with the emotional domain (see, e.g., Stevens et al., 2013). The goals were, on average, attained, as was hypothesized, but better in individual than group intervention. In the individual intervention, the sessions could be tailored more according to the participants' personal needs, which might have encouraged them to set more goals and reach them better. Goal attainment correlated with the self-reported time spent between sessions on the matters dealt with during the intervention sessions. This might offer one explanation for the differences in goal attainment since more time was reported to have been spent in individual than group intervention. The connection between used time and goal attainment also highlights the importance of participants' active involvement in the intervention in making the desired changes happen (see, e.g., Wilson et al., 2017).

Several concrete changes in study or working habits were reported to have been made in both intervention groups, while hardly any changes were reported in the control group during the wait-list period. The participants in the group intervention might have learned effective strategies also from each other since sharing the experiences of living and coping with dyslexia was an essential part of the group intervention. In brain injury rehabilitation, feedback from other participants in an intervention group has had an even more significant impact on participants' behavior than the feedback they had received from intervention staff or parents (Malec, 1999). A correlation was

found between the number of reported concrete changes made during the intervention and attaining personal goals, underlining again the importance of the participant's active role in making the desired changes happen (Wilson et al., 2017). During the follow-up period after the interventions, the participants even continued to implement new study and working strategies independently, and over three-fourths of the participants reported still using the adopted strategies 15 months post-intervention. Materials used in the interventions were relevant to the everyday life of the participants, e.g., related to their study or work assignments, which might have supported adopting the strategies for long-time use. In rehabilitation for attention after brain injury, the outcome of interventions was improved when using methods relevant to everyday life (Cicerone et al., 2000).

To find out how goal attainment might be supported during this kind of intervention, different factors that could potentially predict goal attainment were evaluated. These included psychological variables (mood, cognitive and behavioral strategies, self-esteem, quality of life), cognitive variables (cognitive capacity, severity of dyslexia), and background variables (age, gender, level of education), as well as previously discussed used time, reported behavioral changes and intervention type. Based on the results, almost 50% of goal attainment was explained by three behavioral and cognitive strategies (Social pessimism, Success expectation, Task avoidance), intervention type (individual or group), cognitive capacity estimated by the WAIS-IV index, reported changes made in study or working habits and reported time used for intervention matters outside the intervention sessions. After assessing each variable individually, it was discovered that social pessimism and intervention type explained most of the variance in goal attainment, followed by task avoidance and reported changes made during the intervention. Also, cognitive capacity, success expectations, and time used for matters dealt with within the intervention session explained part of the variance in goal attainment.

Effective use of social support systems to better handle the problems caused by dyslexia has, in previous research, been shown to enhance successful functioning in adulthood (Gerber, 2012; Goldberg et al., 2003). A relatively strong connection between social pessimism and goal achievement could reflect this. Having a connection between task avoidance and goal attainment is quite understandable since not postponing and avoiding the tasks at hand increases the potential to succeed in them. This may create a positive cycle by enhancing feelings of self-efficacy, a high level of which has been linked to improving future performance (Liem, Lau, & Nie, 2008). The concrete changes reported in study or working habits to help get by with dyslexia being a factor in explaining goal attainment emphasizes the importance of implementing intervention content in actual real-life settings.

Regarding the significance of cognitive capacity in explaining goal attainment, the GAS includes individually set goals that can be adjusted to one's capability with the help of a professional, which might explain the more minor significance of cognitive capacity on goal attainment. The role of success

expectations might be understood in the light of previous research showing that expecting to succeed even in a difficult task can increase motivation and predict success (e.g., Bandura, 1997; Eronen, 2000; Mischel & Shoda, 1995). The time used for intervention content between the intervention sessions correlated independently with goal attainment but became less significant in the model where the effects of other variables were included.

Considering the above, it might be possible to support goal attainment by fostering positive attitudes towards being together in group intervention and by supporting engaging in tasks and having positive expectations towards succeeding in them. Also, encouraging spending time and effort in making concrete behavioral changes based on the intervention content could potentially endorse the attainment of personal intervention goals.

4.3.1 INCREASED USE OF DYSLEXIA-RELATED AIDS (NUKARI ET AL., UNPUBLISHED RESULTS)

Dyslexia-related aids were picked up during the interventions as expected, while during the wait-list period, the use of dyslexia-related aids did not increase. Learning to use dyslexia-related aids and assistive technology can positively influence study and work participation (Dawson et al., 2019; de Beer et al., 2014), and thus, this was considered an important finding. The most common aid picked up for use were audiobooks. Audiobooks have, in previous research, induced significant improvement in reading accuracy, as well as an improvement in school performance and greater motivation and involvement in school activities (Milani, Lorusso, & Molteni, 2010).

During the past few years, the number of applications for mobile devices to help compensate for difficulties related to dyslexia has significantly increased, and they are also increasingly being offered free of charge. Because of the easier access and minimal costs, it is likely that the use of dyslexia-related assistive technology will be growing and has already changed since the time the presently examined interventions took place. At its best, assistive technology use can enable academic engagement and social participation, and especially acknowledging the potential of mainstream devices as assistive technology for all students will facilitate inclusion and reduce stigma (McNicholl et al., 2019).

4.4 DIFFERENCES BETWEEN INDIVIDUAL AND GROUP INTERVENTIONS

One of the aims of this study was to find out whether individual and group intervention have different effects. Indeed, some differences in the intervention effects were found. For some variables measured, the found significant change was evident with a slight delay in group intervention compared to individual intervention. This was the case for subjective reading-related performance, self-esteem, and quality of life concerning cognition, where significant positive change was evident at the five-month evaluation for the individual intervention and the 10-month evaluation for the group intervention. Based on this study, no clear explanation for this delayed effect was found. Participants in group intervention used less time on intervention matters during the intervention than participants in the individual intervention. It could be speculated that this might have slowed down the occurrence of the positive intervention-related changes. Making concrete changes in study and working habits continued for both groups after the interventions, signaling that implementing intervention content even after the active intervention period seems to have continued.

For some results, the positive change was evident only in one of the intervention formats at any point in time. This was the case for the reading and writing subscale of everyday memory performance, success expectations, the non-significant trend in social pessimism, and self-evaluated ability to concentrate which displayed positive changes only in group intervention. Personal intervention goals were better attained in individual intervention and positive changes in self-evaluated memory performance and processing speed were evident only in individual intervention.

Having an increase in success expectations only in group intervention might have something to do with seeing other people with similar difficulties in the group manage with their challenges. This might increase the optimistic expectations for one's own performance as well. The diminishing trend in social pessimism in group intervention was quite understandable, as interacting with a group of people sharing the same difficulties and establishing a trusting and open atmosphere in the group might have helped diminish negative feelings associated with social situations. The difference between groups in self-evaluated memory performance concerning reading and writing does not seem to have a simple explanation as to why this evaluation improved more in group than individual intervention.

In one-question-based self-evaluations of different domains of cognitive functioning, the group intervention enhanced positive evaluations of concentration, and the individual intervention enhanced positive evaluations of memory and processing speed. Perhaps being in a group was more demanding on concentration than individual intervention, which was held between only two people in a quiet setting and managing the group sessions might have led to an improved evaluation of the ability to concentrate. In

individual intervention, it was possible to target strategies and methods for improving cognitive functions more precisely according to the needs of the individual participants, which might have led to evaluations of improved memory and processing speed.

Participants in both intervention formats improved equally in processing speed, task avoidance, made concrete changes in study and working habits, use of dyslexia-related aids, and in self-evaluations regarding the disadvantage dyslexia causes in studies and work.

4.5 STRENGTHS AND LIMITATIONS OF THE STUDY

Among the biggest strengths of this study was the randomized, controlled study design and entering the planned number of participants to the study despite having strict inclusion and exclusion criteria. Also, the dropout rate was very acceptable, and more participants were included than in most dyslexia treatment studies (see for a review Toffalini et al., 2021). Contributing to the low dropout rate might have been the fact that the intervention content was well received by the participants, based on the systematically collected, anonymous feedback from the participants.

The methodology used in assessing the effectiveness of the interventions was versatile, including subjective and objective assessment measures tapping both cognitive performance and psychological well-being, as well as concrete changes reported to have been made in the participants' lives. This gives a multifaceted view of the possible benefits. Also, the statistical methods used in this thesis were diverse in utilizing measures for both individual-level and group-level changes. Linear mixed model type of analyses has been regarded as appropriate for dyslexia treatment studies, even though they may have slightly less power than another type of analyses (Toffalini et al., 2021).

Regarding limitations of this study, one is having a wait-list control group without a placebo intervention, meaning that the non-specific effects of the interventions cannot totally be controlled for. Also, the blinding of participants and therapists administering the intervention was understandably impossible since the interventions are based on continuous interaction between the participant and the therapist. In addition, a comparison between intervention groups and wait-list control group was not possible for all the measures (e.g., goal attainment).

Despite the known reasonably high comorbidity among learning disorders (i.e., Snowling et al., 2020), other major learning disorders than dyslexia were excluded from this study to find out the influence of the intervention on dyslexia, specifically. It was also speculated that, for example, wider ranging problems in language or non-verbal performance or ADHD symptomology might have made benefitting from this relatively short intervention more difficult. Dyscalculia was not an exclusion criterion in the neuropsychological

examination, as long as it was not accompanied by major problems in the visual reasoning domain, where an exclusion criterion was set. However, research among children on interventions targeting both ADHD and dyslexia, has shown that rehabilitating either problem alone was successful even in the case of having both conditions comorbidly (Tamm et al., 2018). Based on these results, it could be speculated that perhaps this intervention might have been successful, even if the participants had had comorbid ADHD.

It should also be considered that the participants were relatively highly educated, as 53% studied or had completed a degree in college or university. Having a relatively high education level might have helped the participants to adopt the new strategies in use. The participants also had a relatively low level of mood symptoms, despite the known comorbidity between dyslexia and challenges in psychological well-being (e.g., Livingston et al., 2018). Generalizing the results to the male population can be somewhat challenging since there were considerably more women than men participating in the interventions. Women are known to be more aware of sources of health-related information and to be more active in searching for this kind of information (Ek, 2013), so they might have become acquainted with this intervention more likely than men.

Even though we used multiple methods for gathering information on the possible effects of the intervention, including structured subjective and objective evaluations, it can be speculated that perhaps interesting additional information could have been obtained by interviewing the participants on their experiences of the interventions. In a Norwegian follow-up study of adults with dyslexia, it was concluded that the information obtained by an interview revealed more information than the questionnaire data concerning current life situations, school experiences, self-concept, and emotional problems experienced during school (Undheim, 2003).

4.6 CONCLUSIONS AND FUTURE DIRECTIONS

In this thesis, the effects of individual and group-based neuropsychological interventions for dyslexia for young adults were examined using versatile methodology and a randomized controlled study design. The investigated neuropsychological interventions resulted in positive changes in processing speed, subjectively evaluated success expectations, and quality of life related to cognition, as well as an increase in the use of dyslexia-related aids. Also, more self-reported behavioral changes were reported as having been made in study or working habits to help get by with dyslexia in the intervention groups compared to the wait-list control group. The personal intervention goals were, on average, met. More minor significant within-group changes, although without an interaction, were evident in other subjectively evaluated cognitive and behavioral strategies and in subjective evaluations of self-esteem and various aspects of cognition and reading-related behavior. The perceived

disadvantage dyslexia causes in studies and at work diminished. The found changes that were re-evaluated five or 15 months post-intervention were still evident after this follow-up period. Some differences between individual and group intervention emerged, including delayed changes in some variables in the group intervention and some differential benefits in either format.

It seems that the support previously received by the young adults with dyslexia participating in the present study was relatively minute, especially since the time they completed primary and lower secondary education. The most common form of support was remedial instruction, but in secondary and post-secondary education, it was received by only 10% of the participants. Special education was almost non-existent after primary and lower secondary education, and the same goes for other forms of support, such as neuropsychological rehabilitation. Around one fourth of the participants had their dyslexia recognized only when entering the intervention, and even among those whose dyslexia was recognized prior to the intervention, the mean age of recognition was 15 years. Because of relatively late diagnoses, the participants might have faced additional hardships, as a postponed recognition or diagnosis can have a negative impact on the understanding, adjustment, and self-perception of individuals with dyslexia (Gibson & Kendall, 2010; see also McNulty, 2003).

As for future studies, it would be beneficial to investigate whether entering participants with more problems in psychological well-being in the interventions could still lead to positive results in the intervention aims (see also Cicerone et al., 2019). Allowing also comorbid learning disorders for participants in the intervention would be a beneficial target for future investigation (cf. Tamm et al., 2018). The partly different effects of individual and group intervention also raise the question of whether combining the two intervention types could enhance the most positive changes and, in the future, it would be beneficial to investigate this kind of intervention. Evidence of the benefits of combining the two intervention types has emerged in neuropsychological rehabilitation studies concerning traumatic brain injury and stroke (Cicerone et al., 2019). Since the primary and secondary consequences of developmental dyslexia are highly integrated, multiple avenues of support are needed (e.g., Livingston et al., 2018), and more research is warranted on different kinds of dyslexia interventions for adults (Costantini et al., 2020; Zeng et al., 2018).

The impact of dyslexia is likely to increase in the future in our modern society, where written information is emphasized and finding and keeping a job is almost impossible without at least secondary education. Offering support should continue for those in need in secondary and post-secondary education and for endorsing successful entry and performance in working life. Means of support for young adults with dyslexia are needed, and the investigated neuropsychological interventions could offer one suitable solution.

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