Time to Plan

How to support everyday planning in
adolescents with intellectual disability

Lisa Palmqvist

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Abstract

Children and adolescents with intellectual disability (ID) have difficulties in executive functioning and when coping with everyday planning tasks. However, the literature cannot explain whether individuals with ID perform according to their developmental level or not. The studies in this thesis investigated if life experience could be a contributing factor to the diversity seen in the literature. Planning performance can be improved by either using external or internal support. Assistive technology for cognition (ATC) is an example of external support. This thesis investigated how the ATC is being used in an everyday planning situation which has not been investigated before. Furthermore, this thesis explored whether the internal supports of cognitive abilities and life experience correlate with planning ability in adolescents with ID, and if planning ability can be trained using a cognitive training program for everyday planning. Results showed that ATC supported cognitive functions, but that the children did not formulate the plans themselves. Furthermore, the results support the difference model of ID since planning correlated with different cognitive measures and life experience in adolescents with ID compared to children with a typical development. Adolescents with ID got better at the planning tasks in the training program, however, no transfer effects to untrained planning tasks were found. To conclude, the planning was supported by external and internal support. However, ATC needs to be designed and prescribed in a way that increases independence. Practitioners should actively support in training planning and should be cautious when introducing cognitive interventions if the transfer gap is too large.

Sammanfattning

Barn och ungdomar med intellektuell funktionsnedsättning (IF) har svårt med sina exekutiva funktioner och dagliga planeringsuppgifter. Litteraturen kan dock inte förklara om individer med IF presterar enligt deras utvecklingsnivå eller inte. Studierna i denna avhandling undersökte om livserfarenhet kan vara en bidragande faktor till varför denna skillnad ses i litteraturen. Planeringsförmågan kan förbättras genom att använda externt eller internt stöd. Hjälpteknik för kognition (HM-K) är ett exempel på externt stöd. Denna avhandling undersökte hur HM-K används i en vardaglig planeringssituation vilket inte har undersökts tidigare. Vidare undersökte denna avhandling om de interna stöden för kognitiva förmågor och livserfarenhet korrelerar med planeringsförmåga hos ungdomar med IF, och om planeringsförmåga kan förbättras med hjälp av ett kognitivt träningsprogram för vardagsplanering. Resultaten visade att HM-K stödde kognitiva funktioner, men att barnen inte formulerade planerna själva. Vidare stöder resultaten skillnadsmodellen för IF eftersom planering korrelerade med olika kognitiva mått och livserfarenhet hos ungdomar med IF jämfört med barn med en typisk utveckling. Ungdomar med IF blev bättre på planeringsuppgifterna i träningsprogrammet, men inga överföringseffekter till otränade planeringsuppgifter hittades. Avslutningsvis så stöds planeringen av externa och interna stöd. HM-K måste dock utformas och förskrivas på ett sätt som ökar självständighet. Praktiker bör aktivt stödja träning av planering och bör vara försiktiga när de inför kognitiva insatser om överföringsgapet är för stort.

How to support everyday planning in adolescents with intellectual disability

List of papers

This thesis is based on the following papers, referred to in the text by their Roman numerals:

- I. Palmqvist, L., & Danielsson, H. (2019). Parents act as intermediary users for their children when using assistive technology for cognition in everyday planning – Results from a parental survey. *Assistive Technology*, 1-9.
<https://doi.org/10.1080/10400435.2018.1522523>
- II. Palmqvist, L., Danielsson, H., Jönsson, A., & Rönnerberg, J. (2020). Cognitive abilities and life experience in everyday planning in adolescents with intellectual disabilities – Support for the difference model. *Journal of Intellectual Disability Research*. 64(3), 209–220.
<https://doi.org/10.1111/jir.12710>
- III. Palmqvist, L., Danielsson, H., Jönsson, A., & Rönnerberg, J., Feasibility of a computer-based program for training everyday planning in adolescents with intellectual disability.
- IV. Palmqvist, L., Danielsson, H., Jönsson, A., & Rönnerberg, J., Training effects on a computer-based training program for improving everyday planning in adolescents with intellectual disability.

Contents

Abbreviations.....	1
Introduction	2
Intellectual Disability	2
The Developmental Delay and Difference Models	3
Planning	4
Summary	18
General Aims and Study Rational	19
General Method	20
Disability Research	20
Ethics.....	21
Participants	22
Procedure for Paper II-IV	22
Materials.....	22
Behavioural Tests	26
Summary of the Papers	32
Paper I	32
Paper II	32
Paper III	33
Paper IV	33
General Discussion	34
Parents are Intermediary Users	34
Life Experience and Cognitive Functions in Planning	36
The Difference Model and Planning	38
Planning and Executive Functioning Assessment	39
Training Everyday Planning.....	40
Strategy Competencies in Individuals with ID	41
External and Internal Support.....	42

Clinical Implications	42
Future Directions.....	42
Concluding Remarks	43
Acknowledgements.....	44
References	46
Papers I-IV	60

Abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
ASD	Autism Spectrum Disorder
ATC	Assistive Technology for Cognition
CA	Chronological Age
DS	Down Syndrome
EF	Executive Functions
ICF	The International Classification of Functioning, Disability and Health
ID	Intellectual Disability
MA	Mental Age
RCPM	Raven's Coloured Progressive Matrices
TD	Typical Development
WM	Working Memory
WS	Williams Syndrome

Introduction

Children and adolescents with intellectual disability (ID) have difficulties in everyday planning. Two ways to compensate are either to use external support in the form of assistive technology for cognition (ATC), or to have internal support such as using one's executive functions or life experience. The internal supports might also be trainable. The overall aim of this thesis was to investigate external and internal planning supports in adolescents with ID, and to compare the results to individuals with a typical development (TD) matched on mental age (MA). The thesis also evaluated an intervention to improve everyday planning using a tablet-based training program.

Intellectual Disability

ID is defined according to the diagnostic and statistical manual of mental disorders 5 (American Psychiatric Association, 2013). The criteria for ID are three-fold: 1. The individual must present deficits in intellectual functioning, 2. They must have deficits in adaptive functioning, and 3. The deficits must occur during the developmental period. Deficits in intellectual functioning include difficulties in various cognitive abilities such as reasoning, problem-solving, abstract thinking, and academic or experiential learning. The level of intellectual functioning is measured by IQ-tests, with a score approximately two standard deviations below average (i.e. $IQ < 70$) representing a significant intellectual deficit. Adaptive functioning includes skills needed to live an independent life such as communication skills, social skills, taking care of one's hygiene, eating, cleaning, or using public facilities such as libraries and public transport. Adaptive functioning is commonly assessed using standardized measures with informants (e.g., a parent or other family member; teacher; care provider) and the individual to the extent possible. If the patient acquired the symptoms after the developmental period, another diagnosis should be considered (e.g. traumatic brain injury or dementia). In Sweden, a diagnosis of ID is assessed by a licensed psychologist after a thorough assessment of both intellectual and adaptive functioning. ID is divided into three levels: mild, moderate, and severe. This thesis has investigated mild to moderate ID; thus, the results might not be generalisable to severe ID.

A meta-analysis investigated the prevalence of ID in both developing and industrialised countries, and estimated the prevalence of ID to be 1.04% (CI_{95%} 0.96–1.12) based on 52 studies published between 1980 and 2009 (Maulik et al.,

2011). Maulik and colleague's (2011) results are similar to the 1 % found in studies investigating the prevalence in developed countries (Harris, 2006; King et al., 2009). Further, Maulik et al. (2011), found a higher rate of ID in low- and middle-income countries, studies using psychological assessments or scales (compared to standard diagnostic systems), and studies that focused on children and adolescents rather than adults.

In Sweden, the "Support and Service for Persons with Certain Functional Impairments" act (*Act (1993:387)*) states that individuals with certain disabilities are entitled to special support and services. For instance, the individual can apply for personal assistance, housing that includes access to personnel, and other forms of support to facilitate daily living. The act states that individuals with the diagnosis ID and autism spectrum disorder (ASD) are entitled special support. The act also states that other profound cognitive disabilities (that are not part of natural ageing) are should be entitled support. This means that an individual with ID, by law, has the right to a variety of support and services. The law states that it should be the individual's need for support rather than the individual's diagnosis that merit assistance. However, research has found that a diagnosis is sometimes necessary for the school to give special educational resources (Mattson & Roll-Pettersson, 2007). In Sweden, if a child is not expected to attain the knowledge requirements of the regular school due to ID, the child is offered a place at a compulsory school for pupils with learning disabilities. Thus, all children enrolled in the Swedish compulsory school for pupils with learning disabilities have been diagnosed with ID before admittance.

The Developmental Delay and Difference Models

The literature has explained ID as either being the result of a developmental delay or of individuals with ID having a qualitatively different cognitive profile (Bennett-Gates & Zigler, 1998; Zigler, 1967). Zigler (1967), formulated two models based on these viewpoints: a *developmental delay model* and a *difference model*. The developmental delay model was introduced to address criticisms that the literature was too focused on finding a core deficit of ID. Before Zigler's paper, researchers often compared individuals of the same chronological age (CA) to individuals with ID when investigating deficits in ID. Zigler argued that there were methodological issues with using a CA-matched comparison, as individuals with ID cannot be expected to have the same developmental trajectory as individuals with a typical development. Thus, Zigler argued that rather than having a comparison group matched on CA, the only meaningful comparison group for ID was a group matched on developmental level, namely matched on MA (See Thurstone, 1926 for a description of MA). However, Zigler also criticised the literature's quest to find a core deficit in individuals with ID and argued that the study of individuals with ID has to discriminate between what he called the cultural-familial (or familial) and organic origin of ID. According to Zigler (1967) individuals with familial ID simply represent the lower end of the Gaussian distribution of intelligence in the

population, whereas individuals with an organic ID represent a qualitatively different population. The cause of familial ID would be related to having parents with low IQ, relatives with ID, or low socioeconomic status, whereas the cause for an organic ID is explicitly coupled to a biological cause; such as Down syndrome (DS), Williams syndrome (WS), or that the person has experienced prenatal or perinatal injuries (Bennett-Gates & Zigler, 1998; Zigler, 1967). During the 1990s the theory was expanded, and environmental factors within individuals with both familial and organic ID were considered important aspects of ID (Hodapp et al., 1998).

Zigler's (1967) models and the emphasis on considering the aetiology of the ID has had at least two implications for the study of ID (Burack et al., 2012). First, it is now common to compare individuals with ID to individuals at the same developmental level (i.e. MA). However, the introduction of having MA as a criterion for matching does not come without complications. Even if a person with ID and a person with a typical development share the same MA they will differ in multiple other ways. The person with a typical development would have developed faster and thus be younger than the person with ID who instead would have lived longer and had more life experience than the individual with a typical development (Burack et al., 2012). The consequences of this have not been thoroughly investigated. This thesis investigated if the longer life experience for individuals with ID positively affects their performance in everyday planning tasks. The second implication of Zigler's article is reflected in the increased study of aetiology-specific profiles and their strengths and weaknesses (Burack et al., 2012). However, it is hard to establish if the ID is familial or organic as the origin of ID is often not known, and new aetiologies for ID are constantly found (Burack et al., 2012). Thus, it is hard to be certain that a sample shares the same cause for ID. Furthermore, the terms familial and organic ID have been replaced in the literature. It is now more common to refer to the known cause or diagnosis, or to "non-specific ID" where the cause of is unknown.

Planning

Planning is central to daily life. It includes both short-term planning, such as preparing for dinner, and long-term planning, like career planning or planning for the summer holidays. In addition to engaging cognitive functions, planning requires life experience of how to solve similar planning situations (B. Hayes-Roth & Hayes-Roth, 1979; Kliegel et al., 2007; Ward & Morris, 2005). The definitions of planning have varied over the years. The debate on the definition of planning in the 1960s argued that planning in the human mind is similar to the planning that takes place in a computer program (Miller et al., 1960). Later, research switched to a more cognitive aspect of planning, and recently the focus has shifted to situating the plan in a context; both in a context of cognitive processes, but also in a social and cultural context (Friedman & Scholnick, 2014).

When planning, the planner first constructs a representation of the problem, then constructs a goal state where that problem is solved, and lastly constructs an

anticipatory strategy for how to reach that goal (Friedman & Scholnick, 2014). Thus, individual cognitive processes will affect the outcome of the plan, such as the planner's working memory (WM) and other executive functions (EF) (Miller et al., 1960; Ward & Morris, 2005). However, to construct a correct mental representation of what a planner wants to do, the person requires a representation of the environment where the planner's experience and expertise of the task are crucial. Thus, the planner's knowledge of and familiarity with the task will affect the strategy constructed by the planner (Friedman & Scholnick, 2014; Schank & Abelson, 1977; Ward & Morris, 2005). B. Hayes-Roth and Hayes-Roth stated in 1979 that having a representation of the environment is not enough for forming a plan, the planner must also know how to define and evaluate goals. A skilled planner will take anticipatory actions to build the plan before acting. Anticipatory actions have been seen in both theoretical cognitive planning tasks (Davies, 2005) and motor planning tasks (Domellöf et al., 2020). Davies (2005) discussed the published literature on the role of expert knowledge in relation to the adoption of different planning strategies and Gilhooly (2005) discussed the literature on differences in planning by expert and novice chess players. Domellöf et al. (2020), compared motor planning in children and adults and found that both adults and children were able to complete the task of grasping, transporting, and rotating pegs. However, the adults rotated the peg during transport while the children did so mostly after reaching the goal, meaning that the adults made an anticipatory action before encountering the issue at hand. Similarly, Kliegel et al. (2007) found that older adults performed better than younger adults when making plans in situations that they had experience in. However, the difference between the groups disappeared when the planning situation was novel. Thus, planning should not be considered to be a cognitive function only, but rather a skill that requires both experience and cognitive processing.

This thesis has adopted the two-stage definition of planning proposed by B. Hayes-Roth and Hayes-Roth (1979). First, when formulating the plan, the planner decides a course of actions to reach a goal. Secondly, the planner monitors and guides the execution of the plan. The studies in this thesis have focused on the first of the two stages, namely, the formulation of the plan. During the formulation of a plan, the planner must split up a broad goal, for instance cooking dinner, into smaller sub-goals. Additionally, the planner has to identify the temporal order of the sub-goals (B. Hayes-Roth & Hayes-Roth, 1979; Levine et al., 2000).

External and Internal Support for Planning

Planning ability can be supported by using external or internal support. In this thesis, support is defined as something that facilitates the execution of an everyday planning task. External support refers to something outside the brain such as assistive technology for cognition (ATC), whereas internal support can be a cognitive function, such as EF or life experience and knowledge. Thus, cognitive training might be a support for getting better at everyday planning. Figure 1 presents a schematic illustration of the two stages of planning and how planning can be

supported in terms of the possible influences of EF, life experience, cognitive training, and external support of ATC, all of which are investigated in this thesis.

Figure 1. Schematic illustration of the different stages of planning and the support for planning in terms of assistive technology for cognition and cognitive training. This thesis has investigated the formulation (the green square) of a plan.

Assistive Technology for Cognition

ATC is defined as any technological device assisting or improving cognitive function during task performance (Gillespie et al., 2012). Humans have used ATCs for hundreds of years. Examples of ATCs commonly used are notebooks, calendars, and calculators. An ATC can facilitate everyday life even for a person without a cognitive disability, but the support of an ATC can be vital for a person with ID, ASD, or dementia. Hence, ATCs are common and helpful for individuals with reduced cognitive functioning (Gillespie et al., 2012). However, research has found a gap between the user's cognitive abilities and the cognitive abilities necessary for being able to use the technology. Many ATCs require the very same ability they aim to support (Scherer & Federici, 2015; Wehmeyer et al., 2004). For instance, for an individual to be able to use a timer, s/he must be able to cope with the construct of time to know what a reasonable time to set the timer on for a specific task is. Thus, when developing an ATC, the user's cognitive capacities have to be kept in mind.

Research on ATC has found that individuals with ID use fewer assistive technologies compared to other groups with disabilities (Carey et al., 2005; Chadwick et al., 2013; Mechling, 2011; Stephenson & Limbrick, 2015). Identified barriers include lack of access, lack of training and support, and expense of technologies (Carey et al., 2005; Chadwick et al., 2013). Previously, research has

focused on what type of technology is being used, what the device is being used for, or what external barriers there are to usage (Boot et al., 2018; Stephenson & Limbrick, 2015; Wehmeyer et al., 2004). However, research is missing on how individuals with ID are using ATCs. By analysing how the ATC is used, it might be possible to get more answers on why individuals with ID use fewer ATCs than other disability groups. Thus, Paper I in this thesis used a parental survey to investigate how ATCs were used for everyday planning.

Planning and Difference or Developmental Delay Models

According to the models proposed by Zigler (1967), the study of ID has to separate the study of individuals with specific and non-specific ID, since they represent two different, heterogenous, populations. Zigler states that different aetiologies of ID, such as DS, should be studied as one homogenous group and should manifest similar deficits in their cognitive phenotype profiles. For the developmental delay model to have evidence in the literature, two claims must be verified:

1. Individuals with a non-specific ID should perform according to their developmental level (i.e. on par with a group matched on MA).
2. Individuals with a specific ID should manifest similar strengths and weaknesses when sharing the same aetiology.

Studies in favour of the difference model, on the other hand, should present data where a nuanced picture can be seen even in the non-specific ID group and where individuals with a specific ID (e.g. DS or WS), perform according to their developmental level on all EF measures. Thus, the evidence against the developmental delay model and in favour of the difference model would be results where individuals with familial ID perform lower than individuals with a typical development matched on MA or if individuals with different specific IDs exhibit similar strengths and weaknesses (Bennett-Gates & Zigler, 1998; Zigler, 1967). The literature on planning provides no clear picture of planning and ID. That is, the literature provides support for both the developmental delay model and for the difference model. A study by Danielsson et al. (2010) found that individuals with ID performed on par with their CA-matched peers contrary to Van der Molen (2008) where the ID group performed lower than the CA-matched control. Other research suggests that individuals with non-specific ID perform below both CA-matched and MA-matched peers (Danielsson et al., 2012), while Numminen et al. (2001) and Van der Molen (2009) found that individuals perform according to their MA. The results for individuals with DS are also diverse. A study by Pennington et al. (2003) compared individuals with DS to children with a typical development matched on MA and could not find a difference in planning. Rowe et al. (2006), on the other hand, found that individuals with DS performed lower than individuals with non-specific ID on a planning task. A result also found by Lanfranchi et al. (2010), who found that individuals with DS performed significantly lower on planning measures compared to a group with a typical development matched on MA.

For the WS group, however, there might be a syndrome specific profile, as Costanzo et al. (2013), Menghini et al. (2010), and Rhodes et al. (2010) consistently found that the group with WS had relative planning difficulties compared to a MA-matched group of children with a typical development. The contradicting findings on planning in ID might be due to unaccounted moderators explaining some of the variances in the results. The participant's life experience, which has not been investigated in the studies above, could be a candidate for a moderator that can explain differences in the results.

Assessing Planning Ability

The literature often uses tower tests to assess planning. The most common tower tests are the Tower of Hanoi and the Tower of London (Shallice, 1982). The tower test is a look-ahead puzzle where the participant re-stacks a set of blocks and gets them into a specific goal state. To solve the task, the participant has to determine a set of sub-goals and execute them in a specific order for the goal-state to be reached (Shallice, 1982). Thus, the tower tests do not use an everyday situation for assessing planning but rather try to be "contextually clean". However, there has been criticism about how much planning participants actually do when solving the tower tests, and how much that kind of behaviour in the experimental setting transfers to everyday (e.g. Simon, 1975). Depending on how planning is assessed, different cognitive functions may be involved (Burgess et al., 2005; Goel & Grafman, 1995). A clearer picture of planning ability in ID might be obtained when using a task set in an everyday context combined with accounting for life experience. Such a task could facilitate the investigation of the impact of the participant's life experience and knowledge on planning.

Together with the tower tests, errands test are the most common tasks used to assess planning (B. Hayes-Roth & Hayes-Roth, 1979; Kliegel et al., 2007; Scholnick & Friedman, 1993; Shallice, 1982). An errands test is similar to the tower tests in that it encourages the participant to identify the appropriate order for sub-goals to achieve the desired goal state. Contrary to the tower test, however, the errands test is supposed to mimic a real-life situation (Scholnick & Friedman, 1993). In an errands test, the participant is given a set of errands to run with a list of restrictions and limitations which makes it important to consider what errand to run in what order. The errands test can either be done outside of the laboratory, e.g. in a shopping mall (Shallice & Burgess, 1991) or a school setting (Steverson et al., 2017), or it can be performed in a paper and pen fashion in the laboratory (e.g. the party planning test; Burgess et al., 2005; B. Hayes-Roth & Hayes-Roth, 1979). Studies investigating planning abilities in individuals with frontal lobe damage have seen that participants perform well on the tower tests, but that they fail on the errand tests (Burgess et al., 2005). Furthermore, research has shown that a participant is prone to use personal experience that goes beyond the instruction of the task when solving an errands test (Burgess et al., 2005). For instance, in the Shopping Plan test presented in Burgess et al. (2005), the participants tended to consider which errand was most important to perform, a specification which was not included in the initial instruction.

A contextualized planning test can be seen as a test that closely matches (or transfers) to events as they would occur in a natural situation. Burgess et al. (2006) argue that there is a distinction between the theoretical construct and manifested behaviour. The construct can refer to the theoretical construct of, for instance, planning, whereas the behaviour would be an observable behaviour of someone solving a mental problem in several steps. Thereby, if the test does not transfer to a behaviour in a natural situation, the test may miss important aspects of that construct. Since the literature has found that the formulation of a plan in everyday life relies on earlier experience and learned sequences, a test without context might miss important features of an individual's planning in everyday life.

The tower tests have been used for many clinical populations including ID (e.g. Danielsson et al., 2012, 2010; García-Alba et al., 2017; Henry & Winfield, 2010; Masson, Dagnan, & Evans, 2010; Numminen et al., 2001; Van der Molen et al., 2007). However, research shows that many tests of cognitive functioning rely too much on verbal skills or are too hard for individuals with ID, resulting in floor effects (Masson et al., 2010). Masson and colleagues highlighted the need for tests that are adapted for the population with ID. Other literature has also highlighted the need for tests that have higher ecological validity than tower tests to reduce the gap between the lab and the everyday context (Burgess et al., 1998, 2006). Thus, contextually based tests for assessing planning, have become more and more common (e.g. Brown & Hux, 2016; Burgess et al., 1998; Chevignard et al., 2000, 2010). The literature investigating planning in an everyday setting in the general population is sparse, and the literature investigating everyday planning (using, for example, the errands test) in individuals with ID is close to non-existent. For this reason, it is hard to know whether and how individuals with ID make use of their experience when solving planning tasks. Life experience might be a factor that can explain the discrepancy in the results presented above. To determine how an individual functions in everyday life, and how experience and age correlate with the individual's performance, a contextualized planning test seems to be more suitable than the traditional tower test (Burgess et al., 1998, 2006). The errands test might be able to capture the influence of life experience and focus less on problem-solving than the tower tests. Therefore, this thesis used planning tasks that simulated everyday contexts and collected proxy estimates of the participants' life experience.

Executive Functions

EFs are associated with both everyday and academic competencies (Alderman et al., 2003; Bull & Scerif, 2001; Burgess et al., 1998, 2006; Jacobson et al., 2017; Willoughby et al., 2017; Wilson et al., 1998). Research has found associations between EFs and academic readiness in kindergarten (Allan et al., 2014; Willoughby et al., 2017), reading competence (Clark et al., 2002; Jacobson et al., 2017), and mathematics (Bull & Scerif, 2001). Research has also found associations between low executive functioning and everyday life competencies (Alderman et al., 2003; Burgess et al., 1998, 2006; Wilson et al., 1998). Thus, it seems that having

the internal support of relatively high EFs is important for success in extensive areas in a person's life.

Executive functions (EF) is an umbrella term for a set of cognitive functions described as top-down cognitive functions involved in non-automatized behaviours that demand active decisions (Diamond, 2013). The cognitive functions included in the executive framework are often called "frontal lobe"-functions referring to the functions being processed in the frontal parts of the brain (Miyake et al., 2000; Miyake & Friedman, 2012). Even though several cognitive functions can be described as executive functions, the functions inhibition, shifting, and updating are often referred to as the core executive functions (Gilbert & Burgess, 2008; Miyake et al., 2000; Miyake & Friedman, 2012). Other cognitive functions that have been suggested to be a part of EF include planning, decision-making, and fluency, as they are synthesized in guiding behaviour toward a specific goal (Fisk & Sharp, 2004; Jurado & Rosselli, 2007; Pennington & Ozonoff, 1996). However, these cognitive functions are referred to as higher-order EFs, separating them from the core EFs (Miyake et al., 2000). The core functions are proposed to be lower-level functions, and has been defined in a fairly precise manner. Miyake and colleagues (2000) performed a factor analysis on several suggested EFs. Their analysis led to a diversity of three core functions. However, the analysis also showed that the core functions correlated with each other. Thus, they developed a "unity and diversity framework" for EF, meaning that the three core EFs correlate with one another by tapping some common underlying ability, but also show separate, diverse contributions to the concept of EF.

Inhibition is the ability to hinder an irrelevant distraction, behaviour, or thought, and instead focus on a task that is at hand (Diamond, 2013). When performing a task tapping inhibition, the participant has to actively suppress a dominant, automatic, or inappropriate response (Miyake et al., 2000).

Shifting refers to the ease of transitioning from one task to another. The terms shifting and cognitive flexibility are both used in the literature to describe the same underlying construct (Diamond, 2013). Cognitive flexibility is engaged when switching back and forth between multiple tasks, and includes the disengagement of an irrelevant task and actively engaging in a new task (Miyake et al., 2000). Cognitive flexibility is necessary to see things from different perspectives, or to quickly and flexibly adapt to a new situation. For example, to "think outside the box" we need to deactivate our previous mind-set and activate a new, different perspective (Diamond, 2013). This thesis has used the term cognitive flexibility, rather than shifting, due to the task used to measure the ability in the studies using the term cognitive flexibility (Playing Cards, Emslie et al., 2003).

Updating is the ability to temporarily hold and manipulate information in the mind (Diamond, 2013; Miyake et al., 2000). The function goes beyond simple maintenance of information (i.e. short-term memory) and requires monitoring and revising the information held in the mind by replacing information that is no longer relevant with newer information (Miyake et al., 2000). Researchers investigating EFs often refer to WM as the subcomponent updating, whereas researchers

investigating WM often use the term more broadly, resulting in a concept that is more similar to several of the EF subcomponents (Diamond, 2013; McCabe et al., 2010). One of the most common WM models is the model proposed by Baddeley (Baddeley, 2000; Baddeley & Hitch, 1974; Diamond & Ling, 2016; McCabe et al., 2010). Baddeley's working memory model includes a central executive which involves both inhibitory control and cognitive flexibility. An updated version of the model also includes an episodic buffer which involves long-term memory (Baddeley, 2000). Thus, Baddeley's definition of WM goes beyond the EF function updating. However, Diamond (2013) argues that the common denominator of the different WM models described in the literature is the ability to use and manipulate information that is not perceptually present. The result being that WM is virtually the same as updating. Thus, this thesis will use the term WM in the same sense as EF theorists use the term updating. WM can be divided into two separate parts; verbal and visuo-spatial WM (Diamond, 2013). Examples of tasks tapping verbal WM are digit span tasks, where the participant is asked to manipulate digits that are presented verbally. Visuo-spatial WM can be assessed using the Corsi block-tapping task, in which the participant is asked to copy a sequence of movements made by the experimenter in tapping cells in a matrix (Baddeley, 2002).

Executive Functions and Intellectual Disability

Individuals with ID have difficulties in tasks that engage the EFs (e.g. (Danielsson et al., 2012; Pennington & Ozonoff, 1996). The literature is generally consistent in that individuals with ID perform lower than their CA-matched peers (Danielsson et al., 2010, 2012; Henry, 2010; Rhodes et al., 2010; Van der Molen et al., 2007, 2009). However, the literature investigating the EF profile for individuals with ID in terms of a developmental delay or difference model show diverse results. The literature has found support both for the developmental delay model and for the difference model. To avoid a possible bias on whether the observed difference in the literature can be attributed to verbal or visuo-spatial difficulties rather than an EF-specific weakness, it is common to include both a verbal and a visuo-spatial EF task in the study (e.g. Carney et al., 2013; Costanzo et al., 2013; Danielsson et al., 2012; Henry, 2010; Pennington et al., 2003; Rhodes et al., 2010; Stavroussi et al., 2016; Van der Molen et al., 2007). A summary of the literature follows below.

EF and the Developmental Delay Model

The EF literature supporting the developmental delay model generally show results where individuals with ID (both in samples with a non-specific and a mixed or unknown origin of ID) perform according to their developmental level (Henry, 2010; Van der Molen et al., 2007; Willner et al., 2010). Van der Molen and colleagues (2007), tested individuals with non-specific ID with an extensive battery of EFs, including both verbal and non-verbal measures, and compared performance to a MA-matched control group. The authors found that individuals with ID performed on par with the control group on virtually all measures (except for one measure of WM) including visuo-spatial WM, verbal WM, and verbal fluency. A similar pattern has been found for category fluency (Henry, 2010). Further, Willner et al. (2010) used a broad assessment to investigate the sub-components of EF in

individuals with mild ID with mixed aetiologies. He compared their scores to a standardised score of the population with a typical development. Their results showed no differences between the groups, and they concluded that the structure of EF in people with ID resembles the model of EF in the population at large. These studies are in line with a developmental delay model, where individuals with non-specific ID perform as expected for their developmental level.

According to the developmental delay model, individuals, where the biological reason behind the ID is known, should show a more specific EF profile compared to the non-specific ID. The participants with specific ID should then perform either higher or lower than MA-matched peers with a typical development, or MA-matched peers with non-specific ID. Indeed, studies investigating DS and WS have found specific profiles for specific syndromes (Borella et al., 2013; Carney et al., 2013; Costanzo et al., 2013; Menghini et al., 2010; Rhodes et al., 2010; Rowe et al., 2006; Stavroussi et al., 2016; Traverso et al., 2018). A review of the literature showing syndrome specific profiles for DS and WS follows below.

In general, individuals with DS tend to have more difficulties with verbal than non-verbal WM, and individuals with WS tend to have relatively good verbal abilities but have more difficulties with non-verbal processing (Danielsson et al., 2016; Farran & Jarrold, 2003; Jarrold et al., 1999; Laws & Bishop, 2004; Menghini et al., 2010; Vicari et al., 2004). Research comparing individuals with DS to a group of children with a typical development matched on MA found that the DS group performed less well in verbal WM (Borella et al., 2013; Carney et al., 2013; Lanfranchi et al., 2010), visuo-spatial WM (Carney et al., 2013; Lanfranchi et al., 2010), inhibition (Borella et al., 2013; Lanfranchi et al., 2010), and verbal cognitive flexibility (Carney et al., 2013; Lanfranchi et al., 2010), but not in tasks assessing fluency (Lanfranchi et al., 2010). Stavroussi et al. (2016) compared adults with DS to adults with non-specific ID matched on receptive language and CA and found that both groups performed similarly on verbal fluency and verbal WM (which was similar to the results from Lanfranchi et al., 2010). The results suggest a broad impairment in EF in adolescents with DS, and indicate a general EF deficit as a characteristic of DS.

However, some studies contradict the results above. Rowe et al. (2006), found that individuals with DS performed lower than individuals with non-specific ID on cognitive flexibility, but not on verbal WM, inhibition, and fluency. However, in this study, the groups were not matched on MA, making it difficult to establish what differences were syndrome specific and what results were related to the participants' MA. Furthermore, Carney et al. (2013) investigated modality-specific difficulties in individuals with DS compared to a MA-matched group of individuals with a typical development and found modality-specific EF difficulties for verbal cognitive flexibility in individuals with DS, but no modality-specific difficulties in the other executive areas. Costanzo et al. (2013) found that individuals with DS had lower verbal and visuo-spatial WM, verbal and visuo-spatial cognitive flexibility, and verbal inhibition, but had preserved visual inhibition. A proposed explanation for the differences in the results on some cognitive measures (e.g. inhibition) is that the CA of the comparison group might influence the results (Traverso et al., 2018).

Traverso et al. (2018), compared inhibition in individuals with DS to two groups comprising of children with a typical development and with a CA of five and six years, respectively. All three groups were matched on MA. The authors found no difference in inhibition between the group of individuals with a typical development aged five, but the group of individuals with a typical development aged six outperformed the DS group. This result indicates that the CA of the comparison group might influence the results even if the groups are matched on MA. In sum, the literature on DS is relatively consistent in reporting that individuals with DS have a lower ability on fluency and verbal cognitive flexibility, but there are mixed results on verbal WM and inhibition when compared to either children with a typical development matched on MA or individuals with ID matched on MA.

Rhodes et al. (2010) compared individuals with WS to children with a typical development matched on verbal MA, and found that the WS group performed lower on visuo-spatial cognitive flexibility, and total errors in the visuo-spatial WM task, however, no difference in the strategy used on the visuo-spatial WM task was found. A study by Menghini et al. (2010) compared individuals with WS to a MA-matched group of children with a typical development and found that the group with WS had deficits in both verbal and visuospatial WM, and verbal and visuo-spatial cognitive flexibility, but mixed results on the inhibition tasks. Carney et al. (2013) investigated modality-specific difficulties in WS compared to a MA-matched group of individuals with a typical development and found that individuals with WS had modality-specific visuo-spatial difficulties for WM and fluency. Verbal cognitive flexibility and verbal- and visuo-spatial inhibition was impaired. Costanzo et al. (2013) found that individuals with WS performed lower than MA-matched individuals with ID on verbal and visuo-spatial WM, but had preserved visuo-spatial and verbal inhibition, and visuo-spatial and verbal cognitive flexibility. In sum, the literature on WS consistently show that individuals with WS perform lower than their MA-matched TD or ID controls on verbal WM, but show mixed results in terms of performance on visuo-spatial WM, verbal and visuo-spatial cognitive flexibility, and inhibition. Thus, the results from the studies investigating DS and WS promote the developmental delay model, which distinguishes non-specific ID from a specific ID.

EF and the Difference Model

Several studies show less unified results for non-specific ID matched on a developmental level. Schuchardt, et al. (2010) investigated EF in individuals with a mixed aetiology of ID and found a general deficit in verbal WM. For visuo-spatial WM, the groups showed increasing difficulties with increasing severity of the ID. Their results suggest that visuo-spatial WM and especially verbal WM is impaired in the ID group. On the contrary, Henry and Winfield, (2010) demonstrated that participants with non-specific ID performed on par with the MA-matched group of individuals with a typical development on visuo-spatial WM tasks, but lower on verbal WM tasks. Van der Molen et al. (2009) compared individuals with non-specific ID to a MA-matched group of children with a typical development, and found that the group with ID performed lower on verbal WM, but not on visuo-spatial WM. Danielsson et al. (2012) found that individuals with ID performed

lower than MA-matched individuals with a typical development on visuo-spatial WM, inhibition, and verbal letter fluency, but not lower on verbal WM, verbal and non-verbal cognitive flexibility, verbal category fluency, and non-verbal fluency. Carretti, et al. (2010) investigated verbal WM in individuals with unknown ID compared to a group of individuals with a typical development matched on MA and found that the individuals with ID performed significantly more poorly on the more complex WM tasks. Similarly, Numminen, et al. (2001), compared individuals with non-specific ID to children with a typical development matched on MA, and found no difference between ID and the comparison group on visuo-spatial or verbal WM, however, individuals with ID performed lower than the comparison group on a more complex WM task. Thus, the literature on WM indicates that individuals with non-specific ID tend to perform lower than their developmental level on more complex WM tasks but not on simple ones. Furthermore, research investigating inhibition has found that individuals with ID perform lower than their MA peers. Ikeda, et al. (2014) compared inhibition in a group of children with an ID of unknown aetiology to children with a typical development matched for MA and found that inhibitory control is impaired in children with ID relative to the comparison group. A meta-analysis aggregated 28 effect sizes for inhibition in individuals with non-specific ID and found the same result as Ikeda et. al, namely that ID is characterised by a medium to large inhibition deficit (Bexkens et al., 2014). Thus, research supports a deficit in inhibition, where individuals with ID have a relative weakness in inhibition but a relative strength (relative to their MA) in cognitive flexibility and fluency. However, cognitive flexibility is not as well studied as WM and inhibition.

In the literature relating to specific ID, there is evidence both for and against the developmental delay model. A study by Pennington et al. (2003) compared individuals with DS to children with a typical development matched on MA and could not find a difference on any of the measured executive tasks, including verbal and non-verbal fluency, inhibition, visuo-spatial and verbal WM. They concluded that there is no evidence for an overall executive deficit in the group with DS (Pennington et al., 2003). Memisevic and Sinanovic (2014) examined inhibition, cognitive flexibility, and WM in relation to the aetiology of ID. The authors investigated possible differences between children with DS, children with ID resulting from another biological aetiology (i.e. not DS), and children with non-specific ID. The only significant difference they found was on the cognitive flexibility measure, where children with DS and other biologic aetiologies had more difficulties compared to individuals with non-specific ID. No difference between DS and other biological aetiologies was found. Thus, their study cannot provide a clear EF profile for different types of ID. Further, a recent meta-analysis found that individuals with ID in general, regardless of non-specific or specific ID, perform lower than participants matched on MA on EF tasks (Spaniol & Danielsson, 2019).

There are several methodological limitations in the studies presented above. Many of the studies have small sample sizes, with some studies having fewer than 20 participants in each group (e.g. Ikeda et al., 2014; Lanfranchi et al., 2010; Menghini et al., 2010; Rhodes et al., 2010; Stavroussi et al., 2016). Thus, many studies are

underpowered, leading to unreliable results. Another limitation is that the authors have used different tests for measuring EF, with some studies that distinguished verbal from visuo-spatial tests, and others that did not. Further, the studies vary in choice of comparison group, with some having a comparison group of children with a typical development matched on MA (Carretti et al., 2010; Ikeda et al., 2014; Menghini et al., 2010; Traverso et al., 2018; Van der Molen et al., 2007), and others having a comparison group of another disability group, sometimes matched on MA (Borella et al., 2013; Carney et al., 2013; Costanzo et al., 2013), and sometimes not (Rowe et al., 2006; Stavroussi et al., 2016). In other studies, another comparison group is used (e.g. matched on verbal ability; Rhodes et al., 2010). Another limitation is that the studies are not consistent in whether they report and discriminate between the aetiology of ID (Henry, 2010; Henry & Winfield, 2010; Van der Molen et al., 2007, 2009) or not (Carretti et al., 2010; Ikeda et al., 2014; Willner et al., 2010). Thus, due to these methodological weaknesses, it is hard to conclude whether the developmental delay or the difference model applies in the case of EF for individuals with a non-specific or specific ID.

According to Zigler (1967), the study of ID has to separate the study of individuals with specific and non-specific ID. However, research has suggested that the varying profiles of relative strengths and weaknesses differ with regard to the studied domain (Burack et al., 2001). Jaswal et al. (2016) emphasised the importance of the context of the phenomena that are studied. For instance, a review of the literature on attention in individuals with ASD showed that their abilities can vary dramatically depending on how they are assessed, and the authors argue that researchers should study "how" individuals with an atypical development perform rather than "how well" they perform, including how the ability manifests in everyday life (Burack et al., 2016). Thus, future studies should not try to generalise based on the origin of ID, but rather focus on building theory in the studied domain. That is, rather than trying to falsify either model, research should investigate which model best applies to various cognitive areas.

Previous studies have evaluated similarities and differences on cognitive performance by comparing group means (e.g. Danielsson et al., 2012; Danielsson, Henry, Rönnerberg, & Nilsson, 2010; Henry, 2010; Rhodes, Riby, Park, Fraser, & Campbell, 2010; Van der Molen, Van Luit, Jongmans, & Van der Molen, 2007, 2009). However, the studies have not accounted for the fact that individuals with ID have had a longer life experience. Both of which could influence how to build a theory of ID. Thus, this thesis investigated the different models in relation to everyday planning by measuring both cognitive functions and life experience. Additionally, this thesis went beyond comparing the groups on mean scores, and investigated whether the same cognitive functions were involved in both individuals with ID and without ID when solving planning tasks.

Cognitive Training

In the definition of ATCs, cognitive training programs are explicitly excluded (O'Neill & Gillespie, 2015). However, computer-based training programs aim to support similar cognitive functions as the ATCs, and thus the challenges seen in the

usage of ATCs might be similar to those observed in relation to computer-based training programs. There are many advantages of using digital programs over analogue ATCs, giving computer-based programs aimed at improving everyday chores the potential to be a suitable complement to the traditional hardware ATCs. The software can easily be distributed online, and computers are getting cheaper and cheaper, which facilitates distribution and accessibility. Furthermore, the software can assist and support individual needs in an adaptive way which might not be feasible for an analogue ATC.

Literature has identified inadequate assessment as a barrier to using ATC (Boot et al., 2018; Scherer et al., 2005). A common way to assess the effect of the ATC and training interventions is evaluation of the impact after a training period (Boot et al., 2018; Lanfranchi et al., 2017; Söderqvist et al., 2012; Stephenson & Limbrick, 2015; Wehmeyer et al., 2004). However, this type of assessment limits the study of when and how learning changes during the training period, which is an important aspect when studying planning in ID. Using a training program enables the possibility to study the learning process, as well as when and how behaviour changes. Paper III in this thesis investigates how learning in a training program changes over time in a group with ID compared to MA-matched children with a typical development.

Generally, two types of cognitive training can be identified in the literature, process-based and strategy-based (e.g. Sandberg et al., 2014). The process-based cognitive training usually targets a specific cognitive domain (such as WM, inhibition, attention) and often consists of repetitive computer-based exercises, whereas strategy-based training teaches a strategy (Mowszowski et al., 2016). Strategy-based training typically encourages both internal strategies (structured heuristics for goal-directed behaviour) and external strategies (using calendars or checklists) and involves active guidance by a facilitator (Mowszowski et al., 2016). The taught strategies should be contextually relevant and target more than a single cognitive domain. The effects achieved in strategy-based training tend to last over time, but they also tend to be rather tasks-specific and do not easily transfer to other contexts (Derwinger et al., 2003; Stigsdotter Neely & Backman, 1993). An example of a strategy-based training is memory training based on mnemonic strategy training (Derwinger et al., 2003; Li et al., 2016; Scruggs et al., 2010).

The process-based cognitive training, on the other hand, has been claimed to be more effective in inducing transfer effects due to the possibility of improving the underlying cognitive functions needed to solve the task, whereas the strategy-based cognitive training lowers the demand on the cognitive functions (Brom & Kliegel, 2014). Research has long found a positive relationship between cognitive ability and real-world performance and success, thus the argument is that improving those cognitive abilities would also improve performance on daily tasks, and in the long term improve people's lives (Simons et al., 2016). Neural plasticity is often mentioned as a possible mechanism for the transfer of improvement in a core cognitive function to an improvement on any other task where that cognitive function is involved (Dahlin et al., 2008; Gathercole et al., 2019; Rapport et al., 2013; Simons et al., 2016).

For cognitive training to be beneficial for the participants, the effect should generalize to other, untrained, tasks that the individual encounters in everyday life. For example, the goal of training WM tasks is not that the participants get better at remembering the specific WM tasks trained, but rather that the improvement transfers to other, untrained situations, such as scholarly outcomes (Kirk et al., 2015; Melby-Lervåg & Hulme, 2013; Rapport et al., 2013; Shipstead et al., 2012; Simons et al., 2016). Some studies have been able to show promising results concerning transfer to other, untrained tasks (e.g. Dahlin et al., 2008; Mowszowski et al., 2016; Sitzler et al., 2006; Spencer-Smith & Klingberg, 2015).

However, a near transfer effect is more common than a far transfer effect (e.g. Lampit et al., 2014; Sandberg et al., 2014; Thorell et al., 2009) and it has not been established if, how, and when a far transfer effect occurs. The debate if and how transfer occurs is very much alive in the literature (see Au et al., 2016; Gathercole et al., 2012; Melby-Lervåg et al., 2016; Melby-Lervåg & Hulme, 2013). In a comprehensive review by Simons et al. (2016), the authors conclude that there is not sufficient evidence for transfer effects from cognitive training to justify the claim that brain training is an effective tool for enhancing real-world cognition, and that the evidence of benefits from cognitive brain training is inadequate in terms of methodological limitations in the studies. Nonetheless, the literature seems to agree that the participant does get better at what was being trained, and that some near to moderate transfer can be achieved (Gathercole et al., 2012; Simons et al., 2016). Such a result might best be called a training effect, demonstrating that you get better at anything you do repetitively. Simply put, generic learning.

Thus, the challenge for cognitive training is to identify crucial factors for how to construct the training to be beneficial for a person's everyday life. Paper IV in this thesis used a training program for everyday planning that aimed to represent planning as it is performed in real life to achieve transfer to untrained everyday planning tasks on both near and far transfer levels.

Training Everyday Planning in Individuals with ID

Several different cognitive training programs have been investigated for individuals with ID, including programs aiming to improve EF and WM (Danielsson et al., 2015; Diamond & Lee, 2011; Kirk et al., 2015; Lanfranchi et al., 2017).

Considering the cognitive difficulties manifested in ID, cognitive training could be of particular benefit to the group. Söderqvist et al. (2012) investigated cognitive training for WM and non-verbal reasoning in children with ID. Their results showed that cognitive training was feasible and yielded cognitive improvement for this group. Further, Lanfranchi et al. (2017) examined the feasibility and efficacy of a computer-based spatial-simultaneous WM training program for individuals with DS. The study had both an active and a passive control group, and found significant, direct effects for the experimental group on spatial-simultaneous WM, near transfer effects on spatial-sequential and verbal WM, and also far transfer effects to parental reports on situations in everyday life that require visuo-spatial WM. In general, the study found specific significant effects on near and far transfer to untrained WM

tasks, but not to the tasks that did not rely on WM. Thus, results suggest that an effective training program should aim to train the specific components that are involved in the task where the transfer effect is desired.

A meta-analysis on the effectiveness of WM training for individuals with ID found that effectiveness of the training-program depended on the type of training (Danielsson et al., 2015). The authors found a significant medium effect for a mixed-training approach, including both verbal and visuo-spatial WM components, and no significant effect for only visuo-spatial WM training. Their findings, in combination with Söderqvist et al. (2012) and Lanfranchi et al. (2017), suggest that cognitive functions can be trained in individuals with ID, but they also emphasise the importance of the type of training. Thus, the literature holds promise for developing a training program involving more complex cognitive functions, such as planning.

The first step in an intervention for cognitive training for everyday planning is to investigate if the training program is feasible for individuals with ID. Paper III evaluated a computer-based training program for everyday planning, which mimicked planning tasks from an everyday planning setting. That is, Paper III did not aim to answer whether the learned skill in the program generalises or transfers to an untrained, cognitively demanding task, but rather whether it could be a feasible tool for interventions in a school setting. Paper IV focuses on the training effects and the possible transfer effects to other tasks.

To conclude, research might be beneficial for individuals with ID when training specific EFs, such as WM, and several studies have investigated the feasibility of cognitive training programs for individuals with ID with promising results (Danielsson et al., 2015; Lanfranchi et al., 2017; Söderqvist et al., 2012). Papers III and IV build upon these results and investigate the feasibility and effectiveness of a training program aimed at improving everyday planning. Papers III and IV aimed to investigate both the behaviour during the training period, as well as the results from the training period. This enables an investigation of how behaviour changes and evolves during training, and it also contributes to the literature as to how individuals with ID can use technology without an intermediary user.

Summary

Children and adolescents with ID show difficulties in EFs and when coping with everyday planning tasks. However, the literature cannot explain if individuals with ID will perform in accordance with their developmental level or not (i.e. according to their MA). Thus, the literature cannot provide clear evidence for either the developmental delay model or the difference model of ID. Rather, the picture seems to be more complex, where individuals with both non-specific and specific ID sometimes perform according to their developmental level and sometimes not. There is literature indicating that one reason for the difference in results might be due to differences in life experience. This thesis investigated if life experience could be an influential factor.

Planning performance can be improved by either using external or internal support. The literature has not investigated how ATCs are being used in everyday planning situations. Cognitive abilities and life experience are examples of internal support. Cognitive functions and EFs are correlated with both academic and everyday life competencies. Thus, this thesis explored whether cognitive abilities and life experience correlate with planning in individuals with ID, and whether this internal support can be trained using a cognitive training program for everyday planning.

General Aims and Study Rational

The overall aim of this thesis was to investigate external and internal support in everyday planning in adolescents with intellectual disability (ID). Specifically, Paper I explored the external support of ATC-usage in an everyday planning situation. Paper II investigated how cognitive abilities in combination with life experience explained planning ability in everyday planning in relation to the developmental delay model and the difference model of ID. Paper III evaluated a computer-based cognitive training program, that aimed to improve everyday planning, in terms of its feasibility, and Paper IV investigated transfer effects to untrained planning tasks.

General Method

The thesis includes two large studies. The first study used an online survey which was analysed in Paper I. The second study was a cognitive training intervention study with three time points; before the training (pre), directly after (post), and 6-months after completed training (follow-up). Log data from the training was also collected. The data collected from the intervention were analysed and presented in Papers II (pre-tests only), III (data from the training program), and IV (pre, post, and follow-up).

Disability Research

This thesis is positioned in the field of disability research, a field where the individual's health is viewed as a complex interaction between health condition, environmental, and personal factors, within the scope of the bio-psycho-social model (Engel, 1977; Shakespeare & Watson, 2001). The model was formulated as a reaction to the medical sciences being too focused on the person's biological functions to determine a person's health. Both Engel (1977) and Shakespeare & Watson, (2001) argue that the health of a person has to be defined on more aspects of the individual's life. The bio-psycho-social model states that a person's functioning must be studied in context, and that all three levels of biological, psychological, and social aspects must be studied together. If the levels are separated and studied in isolation, the researcher will miss important aspects and valuable information about the individual's health (Shakespeare & Watson, 2001).

The International Classification of Functioning, Disability and Health (ICF) is a classification of the health components of functioning and disability. The purpose of the ICF is to acknowledge that the functioning and disability of a person are results of the interaction between health conditions and the environment. ICF was developed by the World Health Organization (World Health Organization, 2001), in accordance with the bio-psycho-social model. The model covers both biological, psychological, and social functions for an individual with a disability. It is structured around the individual's body functions and structure, the individual's activities and participation in a social situation, and several environmental factors. The model regards disability as a complex interaction between all these factors and postulates that a person's health can only be completely assessed when all these aspects are considered.

Figure 2. The ICF Model showing the interaction between the different components of ICF for everyday planning for individuals with intellectual disability.

This thesis can be visualised in the ICF model. The thesis has used methods to assess the complexity of everyday planning on both psychological and social aspects in the individual with ID's life. The activity of everyday planning has been investigated in the health condition ID. The thesis investigated body functions and structures (cognitive abilities) in Paper II and Paper IV, participation in independence and involvement in Paper I, Paper III, and Paper IV. Environmental factors are investigated in Paper I, and personal factors (age and life experience) are investigated in Paper II. Figure 2 has a schematic representation of how the ICF framework can be adopted in relation to ID and everyday planning, and the internal and external support that is included in this thesis.

ICF gives the researcher a framework to study the functioning of an individual on medical, psychological, and social levels. It also includes the context in which the individual operates. ICF has provided a framework where both the individual's cognitive abilities and her environment can be studied. This provides a broader picture of where the difficulties arise when it comes to everyday planning. The thesis has found that the issues that arise in everyday planning are not diagnosis-specific (Paper I). Further, the connection between cognitive functioning, life experience, and everyday planning was studied, and it was found that even though individuals with ID and their MA peers perform equally well, they use different strategies to reach complete the task (Paper II and III). Future research is encouraged to also adopt the ICF framework to further investigate the intertwined connection between cognitive abilities and social context.

Ethics

Participation in all studies was voluntary. For all studies, the participants were given an information letter about the study. The letter included information on data confidentiality, and that data would be analysed at group-level. The studies included in this thesis were approved by the regional ethical board in Linköping (Paper I (ST 2014-016; Papers II, III, IV (2015/119-31). All caregivers signed an informed

consent before participation and the participants gave oral consent at the beginning of the test sessions for. The participants were informed that they could withdraw their consent (without stating a reason) at any time. The test leader was particularly careful when testing the participants with an ID to ensure that they understood the conditions of their participation.

Participants

The participants for Paper I were recruited online using social media (see Paper I for more details). The participants in Paper I consisted of parents of at least one child with either TD (comparison group), a diagnosis of ADHD or ADD (referred to as the disability group in Paper I), or ID or ASD (referred to as the habilitation group in Paper I).

In Papers II-IV, 143 participants were recruited. The participants comprised of adolescents with an ID, and a comparison group of younger children with a typical development. The participants were recruited from towns and cities in the south of Sweden. The participants with ID attended classes for children with special needs, and the comparison group attended the regular school curriculum. The sizes of the towns and cities varied substantially between around 4000 and 800 000 citizens. All children enrolled in the Swedish compulsory school for pupils with learning disabilities have been diagnosed with ID before admittance. Participants were matched on MA in Paper II and Paper III.

Procedure for Paper II-IV

All participants were tested in their school environment. The participants were tested individually with a test leader. For those tests that were done more than once, an equivalent test was used to reduce the test-retest effect (more information under Material). All tests were taken in one session apart from a few sessions that had to be split either due to the participants need for a break or logistical reasons.

Materials

ATC Survey

The survey used in Paper I was developed by the research team and was based on the results from a Master's thesis by Rönmark (2014). The survey was based on categories that emerged from interviews with adolescents with ID in combination with categories found in a literature review. The survey can be found in the supplemental material for Paper I here:

<https://doi.org/10.1080/10400435.2018.1522523>

Plan Some More – A Tablet-Based Training Program

To investigate the aims of this thesis, a training program called Plan Some More was developed to improve everyday planning.

Universal Design

The program was developed based on *The 7 Principles of Universal Design*. These guidelines were developed by a group of architects, product designers, engineers and environmental design researchers, led by the North Carolina State University in 1997. The guidelines were created to increase the usability of products, without the need for adaptation or specialized design (Connell et al., 1997). In short, the guidelines encourage the design of products that are easy to use for people with diverse abilities and individual preferences. The product should be simple and intuitive to use, regardless of previous experience or knowledge. It should be error-tolerant and minimize negative effects of accidental or unintended actions. The product should require low physical effort and have perceptible information. The aim of this thesis was not to evaluate how well the program fulfilled these guidelines, rather they were used to guide the design of the program.

Learning-By-Teaching

The program has an agent, an alien named Hensi, that asks the user to help them learn how to plan. This agent acts as the tutee of the user and is inspired by the pedagogical paradigm *learning-by-teaching* (Bargh & Schul, 1980). The paradigm lets the tutee become the tutor as the students are asked to teach another student. The research shows a promising learning outcome for the paradigm (Fiorella & Mayer, 2016). Another positive effect of the learning-by-teaching paradigm is that it supports the student's self-efficacy, that is a person's belief in his or her ability to carry out a certain task successfully, which in turn protects the tutee from blaming themselves for mistakes (Tärning et al., 2019). The paradigm has also been investigated in computer-based pedagogical agents with successful results (e.g. Biswas et al., 2005).

Principles for Training

The goal of the training was (1) for the training effect to last for a long time and (2) for what is learned to transfer to related but untrained tasks. To achieve this, the program included an algorithm for continuously adapting the difficulty level based on the performance of the participant, so that the participant is training at an optimal level throughout the training period (Holmes et al., 2009; Klingberg et al., 2002, 2005; Schmidt & Bjork, 1992). Further, recall rather than recognition for solving tasks was implemented by not using, for instance, multiple choice answers. Research has found that recall is better for learning than recognition (Rowland, 2014; Schmidt & Bjork, 1992). A meta-analytic review suggested that a reason for this was that effortful processing was a contributor to the testing effect (Rowland, 2014).

The Planning Strategy

Based on the advantages of the strategy-based training being more prone to produce long-lasting results, and the process-based training being better at inducing transfer, a mixed type of training was adopted in the training program. The program was based on the definition depicted in Figure 1, planning as the formulation of a plan

to achieve a future goal. In the program, the planner visually identified the sub-goals of a larger goal, and then placed the sub-goals in the appropriate temporal order. The program encouraged the user to first think about "what items do you need, and in what order would you use these items when performing the task?". The participant trained by themselves, in their classroom, and they did not get active guidance from a facilitator.

Narrative and Setting

The narrative for the program was that an alien named Hensi (Figure 3) had crash-landed on earth and could not go back home because the rocket had broken down. Thus, the user was asked to help Hensi understand the ways of life on earth, by teaching Hensi how to plan.

The program consisted of two different settings, a house and a rocket (Figure 4, top left). The house contained the different planning tasks and the rocket functioned as a reward where the user collected items that were received after solving tasks. The house consisted of four different rooms, a kitchen, a bedroom, a bathroom, and a hall (Figure 4). In the beginning, only one room was open. Thereafter, new rooms were opened one by one with 15-minute intervals (Figure 4, top right). The program was installed on Lenovo TAB 2 A10-30F ZA0C with OS Android 5.1.

Figure 3. Hensi, the main character in Plan Some More.

Interaction

The program was user-driven, meaning that the user initiated the actions in the program (e.g. to receive a task, the user clicked on Hensi). The program used drag-and-drop to solve the tasks. The user dragged the different items in the room from where they were placed into a specified area on the screen. After the correct items were identified, the user was prompted to drag the items and place them in the correct order (Figure 5). To reduce the possible impact of the user's working memory capacity, the user could click on Hensi to repeat the instruction as many times as the user wanted.

Levels of Difficulty

The training program consisted of three different levels of difficulty and an introductory level. In the introductory level, the tasks introduced how to navigate in the program by asking the planner to only fetch different items from the room (i.e. no planning was required). The purpose of this level was to introduce the user to how the program works; how to interact with the program, how to move items, how to check if the answer was correct, and what type of feedback that was given. This level was not developed for training planning, and the results on this level were not included in the analysis when analysing planning improvement in the program. The rest of the levels, levels 2, 3, and 4, all consisted of a planning component where the task was to plan for different events. The levels increased in difficulty by introducing more and more advanced plans. In level 2, the plan required two items to be complete, in level 3, the plan required 3 items and in level 4, the plan required four or more items (maximum of 6 items for the most complex task).

Planning Tasks

In the training program, the user was asked to help the alien (Hensi), to make everyday plans for tasks in one of the four rooms in the house (hall, bathroom, bedroom, and kitchen), e.g. “Help me plan how to make toast”. The user was asked to first identify the different items needed for the plan (e.g. a toaster, some bread, some butter, and a knife for spreading the butter onto the toast) and then identify the temporal order in which the items should be used (e.g. 1. toast, 2. toaster, 3. knife, and 4. butter). Due to the nature of the tasks, several different orders could be correct with some restrictions (e.g. the user must toast the bread before spreading the butter). An example of the Level 3 task “Prepare toast”, can be seen in Figure 5.

Control Group Training Program

The control program was visually similar to the training program. However, at the beginning of the training, only one item was present in each room (e.g. only an apple in the fridge). Every ten minute, a new item appeared in the room. Instead of solving tasks, Hensi encouraged the participants to move the items around and re-furnish the room. When the user was satisfied with the new arrangement of the items, the user clicked on the green play button. The user then got the same positive feedback as in the training program, and the items went back to their original position, and the user started over. The same rewards were given in terms of items added in the rocket every ten minutes.

Figure 4. Top left: the start screen when opening the program. Top right: an overview of the four different rooms, only the kitchen (illustrated by an apple) is open in the beginning of the game, the other rooms are locked (illustrated by a padlock). Middle left: the kitchen. Middle right: the bathroom. Bottom left: the bedroom. Bottom right: the hall.

Behavioural Tests

The participants were individually tested by a test leader (Figure 6). The behavioural tests were used in study II and study IV (RCPM were also used in study III) to assess planning ability and cognitive function. The tests are presented in detail in Table 1. The tests were adapted so that they would not be too hard for the sample with ID. Instructions were made shorter and were presented both verbally and in written form. No tests required the participant to be able to read or write. Planning tests 1, 2, and 3 used a combination of both text and pictures to improve understandability. For all pictures, Widgit Go SE© was used with permission from Hargdata AB. The test leader made sure that the participant had understood the instructions before the test started. Planning tests 1- 4 captured near- to far transfer. Planning test 1 was considered the least complex task with the nearest transfer to the tasks that were being trained, and Planning test 4 was considered the most

Figure 5. A walkthrough of the task "Help me plan how to make toast". Picture 1: Hensi gives the user the task. Picture 2: The user opens the cabinet doors to look for the appropriate items. Picture 3: The user places the items in the cloud at the bottom of the screen and clicks on the green play button in the top right corner. Picture 4: If the appropriate items have been placed in the cloud, the user goes to the second stage of the planning and is prompted to place the items in the appropriate order for the planning to be correct. Picture 5: The user places the items in the temporal order in which the items are supposed to be used and then clicks on the green play button. Picture 6: If the order is correct, Hensi gives a positive verbal feedback and a star is shown. Every 10 minutes, the user also gets a new item for Hensi's rocket (here a mobile phone).

Figure 6. The test set-up in the schools for the pre, post, and follow-up tests (Papers II-IV).

complex planning task, with the furthest transfer to trained planning tasks. The tests used were:

- Planning test 1: Order-your-task (OYT)
- Planning test 2: Multiple Errands Test (MET; Shallice & Burgess, 1991; Steverson et al., 2017)
- Planning test 3: Children's Kitchen Task Assessment (CKTA; Chevignard et al., 2010)
- Planning test 4: Zoo map 2 from BADS-C (Emslie et al., 2003)
- Working memory: Backwards Corsi span using the software Pebl© (Mueller & Piper, 2014)
- Reasoning: Raven's Coloured Progressive Matrices, RCPM (Raven, 2003). Also used for assessing mental age
- Flexibility: Playing Cards from BADS-C (Emslie et al., 2003)
- Fluency: Semantic category fluency from Delis-Kaplan (Baldo et al., 2001)
- Activity Experience, items used: 1-6, 9-12, 15-17, 19-21, 29-34 (Arvidsson 2020, <https://doi.org/10.6084/m9.figshare.11968419.v1>)

Table 1

<i>Descriptions of the tests included in the study. Table reprinted with permission from Palmqvist et al., (2020), i.e. Paper I.</i>
Planning task 1: Order-your-task   The Order-your-task (OYT) test was developed for this project to assess the participant’s ability to temporally organise a task into sub-tasks (e.g. for the task “Help me plan how to make toast” the user has to identify the order of the sub-tasks: 1. <i>Toast bread</i>, 2. <i>Spread butter onto toast</i>, and 3. <i>Eat toast</i>. The participant got one point per correct task. There were 10 tasks, resulting in a maximum score of 10. The dependent variable was the total correct tasks combined with the time to completion.
Planning task 2: Multiple errand task   The multiple errand task (MET) was developed by Shallice and Burgess (1991) to capture difficulties with everyday tasks in individuals with acquired brain injuries and have been adapted for individuals with ID (Steverson et al., 2017). In the original task, the participant is asked to execute a set of errands in a real-life setting (in a shopping mall; Shallice & Burgess, 1991). However, the present study aimed to investigate the <i>formulation</i> rather than the <i>execution</i> of the plan, thus, the task was modified into a pen-and-paper task. The participants were given a list of seven tasks to perform while following a series of rules. The setting was a school environment, and the tasks included everyday school activities such as, “draw a sun”, “getting a pen”, “playing football”, and “finding out what’s for lunch”. The rules included finding the appropriate room to visit (e.g. go to the schoolyard for playing football), not to enter the same room twice, and doing the task in the appropriate order (e.g. fetching the pen before drawing the sun). One point was given per correct matched pair of rooms and tasks, 1.25 points were given if the tasks were performed in an appropriate order, and one minus was given if the participant entered the same room twice. The maximum score was 8.25. The dependent variable was the total correct tasks combined with the time to completion.
Planning task 3: Children’s Kitchen Task Assessment   Chevignard et al. (2010) developed an assessment of everyday planning called Children’s Kitchen Task Assessment (CKTA). The CKTA was modified into a pen-and-paper task. The participant was asked to identify the correct steps in a recipe, the maximum score was eight. The dependent variable was the total correct tasks combined with the time to completion.
Planning task 4: Zoo map   The Zoo map 1 (from here on referred to as Zoo Map) is a sub-test in the test battery BADS-C (Emslie et al., 2003). The Zoo map assesses the participant’s own ability to identify the sub-goals and arrange them appropriately to achieve a goal. The participant is asked to visit eight places in a zoo (e.g. the restaurant or the bears) using a paper map of the zoo. The participant may only use certain roads once and must start and end in specified places. The participant is prompted to draw a line with a pen showing what places they visited and in which order. The participant got one score per correct visited animal. The score was then deducted by one each time the participant: used a forbidden path more than once, deviated from the path, failed to make a continuous line, or made an inappropriate visit. The maximum score was eight. The dependent variable was the total correct tasks combined with the time to completion.
Working memory

Non-verbal working memory capacity (WM) was measured using a backwards Corsi span using the software Pebl (Mueller & Piper, 2014). The test consisted of a grid of 3x3 squares. The squares lit up, one by one in a sequence, and the participants were asked to remember the correct reversed order. The participant was then asked to click on the squares in the correct pattern using a computer mouse. The test started with a sequence of two squares and increased by one square every second sequence. The test ended when a participant made two errors in a row. The participant was given a test trial consisting of three supervised 3-item-spans. The participant was verbally reminded that the task was to remember the sequence backwards to avoid floor effects due to forgetting the instructions. The score was calculated by taking the minimum list length, adding the total number correct, and then dividing the number of lists at each length. This results in the participant's mean span which corresponds to the participant's working memory capacity. The dependent variable was the participant's working memory span.

Reasoning

The participants' non-verbal inductive reasoning was measured using Raven's Coloured Progressive Matrices (Raven, 2003). The total number of correct was calculated. The maximum score was 36. The dependent variable was the total score.

Flexibility

To test cognitive flexibility, Playing Cards in BADS-C was used (Emslie et al., 2003). The participant was asked to reply yes or no according to a pre-specified rule. The test was performed two times, with different rules. If the participants successfully switched to the new rule (i.e. no rule breaks) they were given a score on 1 and if they failed (i.e. one or more rule breaks) the participant was given a 0. That is, the dependent variable was binary (1 or 0).

Fluency

The semantic category fluency task was used to measure verbal fluency (Baldo et al., 2001). The participants were asked to name as many items as possible in two given categories (animals and boy names) for 2*60 seconds. The category test was used rather than the letter fluency task (e.g. FAS) to reduce the influence on the participants reading skills. The total number of uniquely named items was calculated and used as the dependent variable.

Activity Experience

Activity experience was measured using a short version of a questionnaire developed by Arvidsson and Granlund (2018) for individuals with ID. The questionnaire was originally developed to measure the individual's participation in society, however, only the component that captured how often an individual did a certain activity was used, thus capturing activity experience (e.g. "How often do you take the bus to school?", "How often do you shop in stores?", and "How often do you visit a café/restaurant"). The questionnaire is a structured interview where the participant rate how often they perform everyday activities (2 = often, 1 = sometimes, 0 = seldom/never). The questionnaire included 22 items representing a selection of categories from the ICF domains of the activity/participation component (World Health Organization, 2001). The original questionnaire did not include any questions regarding how often the participant baked. Since one of the planning measured used recipes, this question was added to the questionnaire. The dependent variable of the activity experience was the sum of the scores on the 23 items (max 46).

Data Treatment and Statistical Considerations

The data from Paper I were analysed using a mixed-methods approach including statistical analysis of the use of ATCs followed by an inductive thematic text analysis. The thematic text analysis was performed according to the guidelines presented by Braun and Clarke (2006), and trustworthiness and credibility were assessed as described in Nowell, et al. (2017).

Type of statistical analysis was chosen based on what was best suited to the characteristics of the data (in terms of normality, level of measurement, and other statistical assumptions). Non-parametric analyses were adopted when appropriate. The planning measures presented in Paper II and Paper IV were calculated by combining time and accuracy using the balanced integration score, presented in Liesefeld and Janczyk (2019). The balanced integration score was chosen as it integrates speed and accuracy with equal weights making it relatively insensitive to speed-accuracy trade-offs.

Summary of the Papers

Paper I

Paper I investigated how ATC was employed as external support by children with and without disabilities. The aim was to explore how ATCs were used to form plans in an everyday context. Since research has found that access to support can differ depending on diagnosis (e.g. Mattson & Roll-Pettersson, 2007), the study investigated three groups: 1) children qualifying for Swedish habilitation centres (ID/ASD), 2) children with disability not qualifying for habilitation service (ADHD), and 3) children with a typical development. The study used a parental survey (n = 192) and answers were analysed with statistical tests and inductive thematic text analysis. Results showed that all groups used ATC, the habilitation group used the most ATCs and the group of individuals with a typical development used the fewest ATCs. According to parents, ATC supported cognitive functions in all groups, but it became evident that the parents were responsible for planning by setting up the ATC, while the children merely executed the plans. This was linked to several limitations, for example, the design was not appropriately adapted for these groups. Thus, external support in terms of ATCs was used in planning situations. However, the developers of ATC need to ensure that the devices can be independently used by adolescents with ID.

Paper II

Paper II investigated internal support and the extent to which cognitive abilities and life experience can explain planning ability in tasks that simulate everyday planning in individuals with ID, and whether planning ability differs from a MA-matched control group. In addition, the study investigated whether the results from everyday planning support the developmental delay model or the difference model of ID. One hundred and thirty-three participants were included in the study; 71 adolescents with ID and 62 children matched on MA. The results found that adolescents with ID scored on par with the MA matched group on planning ability, verbal fluency, cognitive flexibility and activity experience but performed lower in the WM task. Regression analyses showed that the predictors of planning differed between the groups. The cognitive measures could predict planning in both groups, but life experience contributed positively to planning only in the MA group, whereas chronological age was negatively correlated with successful planning in the ID group. The difference in WM and predictors support the difference model of ID. Further, the results show that both groups used their internal support of cognitive abilities, but only the MA group used their life experience.

Paper III

Paper III evaluated how behaviour changes during training, and whether individuals with ID can use the training program independently. 33 adolescents with ID and 30 younger children with a typical development were included. The participants were instructed to train in school for a total of 300 minutes. Both groups made fewer errors per task at the end compared to the beginning. Individuals with ID started off making fewer attempts per task and increased their activity during the training. This pattern was not seen in the comparison group. Both groups used the program without adult supervision. However, for some individuals in the ID group, the program might not have been feasible as they did not train for the training time criteria. Only 16% of the participants trained for all 300 minutes. Participants in the MA group trained for a longer time than the ID group. The ID group increased their activity during the training which might mirror a strategy development in how to use the program. The change in behaviour can be interpreted as individuals with ID needing a longer time to get familiarised with the technology. Tablet-based training programs are feasible for individuals with ID, but it is necessary to follow up on usage-time. Thus, it seems as it is possible to train everyday planning, and thus to increase the internal support for both individuals with ID and TD. The next step is to investigate if there were any transfer effects to untrained tasks.

Paper IV

Paper IV investigated a computerized everyday planning program. The study included four groups, two with ID and two comparison groups with a typical development. The ID group and the group of individuals with a typical development were either part of an intervention group or an active control group. The paper included four groups with a total of 143 participants. It was a 2x2x3 design, with two training groups; ID ($n = 33$) and a comparison with a typical development ($n = 31$), and two groups serving as an active comparison; ID ($n = 47$) and TD ($n = 32$). Results showed that performance on the planning tests improved over time, but the results did not differ between the control and the intervention groups. Thus, only training effects were observed, and no transfer effects were obtained. The literature has not yet come up with how to best design cognitive training to achieve transfer effects. Thus, research should consider other types of interventions for individuals with ID.

General Discussion

In the present thesis, external and internal support for everyday planning was investigated in adolescents with ID. The new knowledge gained from the results from this thesis includes the discovery that the children and adolescents did not formulate the plans themselves, but rather their parents set up the ATC. A second discovery is that cognitive abilities explained planning ability in both individuals with ID and children with a typical development. However, only in the group of individuals with a typical development could life experience explain a higher planning ability. Further, it was found that the individuals with ID could learn as much as their MA matched peers in a planning program, but that individuals with ID needed a longer time to get used to the program, and used a somewhat different strategy when learning the program. Unfortunately, no transfer effects to untrained planning tasks were found. The theoretical implications of the results of this thesis are discussed below.

Parents are Intermediary Users

The results from Paper I in the thesis showed that ATCs for everyday planning are useful, but that they can be better. The ATCs were used in daily living. Parents reported that they were happy with the ATCs, and that the devices provided more independence for their child to some extent. However, the ATCs had a limitation in that they needed an intermediary user for the ATC to be useful for the child or adolescent with a disability. By asking questions on how the ATC was used in its everyday context, Paper I was able to determine that the parents, rather than the children, were formulating the plan. This result complements earlier research that has found that ATCs often are left unused, but have not been able to provide a comprehensive explanation as to why (Dawe, 2006; Scherer & Federici, 2015; Wessels et al., 2004). The need for an intermediary user could be a contributing reason, as it makes planning time- and energy-consuming for the parents, which the parents reported as a drawback of the ATCs.

As found in Paper III, individuals with a disability did have the capacity to learn to use a technical device. It might be tempting to blame the user for being unable to learn the technology. Instead, one should consider that the ATCs might not be designed for individuals with ID's strengths and weaknesses and it is thus a design fault that is causing the non-use rather than a limitation of the user. For instance, to use a timer as an ATC, the planner must understand the concept of time to understand what a reasonable time for getting dressed is, yet it is known that time management is hard for individuals with ID (e.g. A. L. Owen & Wilson, 2006),

To ensure that individuals with ID can operate the ATCs themselves and to reduce the need for an intermediary user, developers of ATC might benefit from consulting the guidelines of universal design and user-centred system design (USD) when developing new ATCs (Connell et al., 1997; Gulliksen et al., 2010; Norman & Draper, 1986). The guidelines for universal design provide suggestions for how to make the design as accessible for as many as possible in as many situations as possible. This could contribute to the development of a more flexible ATC that can be used by different people in different situations. User-centred system design is an iterative design process in which developers focus on the users and their needs in each phase of the design process (Norman & Draper, 1986). User-centred system design advocates involving users throughout the product development via several different research techniques to create highly usable and accessible products for the users (Gulliksen et al., 2010). User-centred system design has successfully been applied in several groups with disabilities including visual impairment (Magnusson et al., 2017) and severe ID (Hedvall et al., 2013). By employing the method of USD, the user can provide useful information as to where difficulties with the device arise, which in turn should reduce the dependency of intermediary users.

The reason for the intermediary usage might not only be that the adolescents with ID have reduced planning abilities. Research has found that adolescents with a typical development do not tend to formulate plans themselves either. The studies investigated plan formulation and found that adolescents with a typical development lacked motivation to plan, not the skill itself (Chalmers & Lawrence, 1993; Kliegel et al., 2007). Furthermore, models on planning have added motivation as an important factor for successful planning together with life experience and cognitive abilities (Friedman & Scholnick, 2014; B. Hayes-Roth & Hayes-Roth, 1979; Scholnick & Friedman, 1987; Zigler, 1967). Thus, if the dependency of an intermediary user should be reduced, it must be ensured that adolescents are motivated to learn how to plan.

Together with ensuring motivation in the adolescents with ID, it is also necessary to ensure the motivation of the adults in the individual's life and that they are motivated to enable training as that will influence how often an individual with ID plans. Research has found that staff motivation and attitudes influence the use of ATCs (Adolfsson et al., 2015). Parents and other adults might think that it is easier and less time consuming to finish the plan themselves, without the help of the individual with a disability. However, Paper I found that parents were asking for off-loading and more support in everyday life. Thus, if the parents were given the right ATCs to support their child to get better at formulating a plan, their motivation to allow the child to plan for themselves might increase.

Independence and participation are central in the United Nations' *convention on rights of persons with disabilities* (United Nations, 2006). The convention states in their general principles that a person with disabilities has the right to individual autonomy. Furthermore, the model in ICF has participation as a central concept for enabling health (World Health Organization, 2001). A review investigating the everyday life of adults with ID found that individuals with ID strive to be heard in their everyday life, but are experiencing that they lack choice and control (Gjermestad et al., 2017). This experienced neglect violates the convention on rights of persons with disabilities and it underlines the difficulties individuals with ID face in being active citizens. The review further highlights

that, not only do individuals with ID have the right to their independence, but it is something that they want and strive for. Research has found that ATC has the potential to increase both independence and participation for individuals with ID (Beyer & Perry, 2013; Gillespie et al., 2012; Söderström et al., 2019; Wennberg & Kjellberg, 2010). Wennberg and Kjellberg (2010) observed that young adults with mild ID increased their participation in everyday activities, experienced greater control, and gained health-related benefits when using ATC in their daily lives. However, the intermediary usage found in Paper I constitutes a barrier to gaining full independence. Beyer and Perry (2013) evaluated assistive technology in social care services and its impact on the quality of life and independence for people with ID. They concluded that personnel needed better awareness and knowledge of how assistive technology can increase independence and autonomy for the individual with ID. Furthermore, the authors emphasised the importance of the ATC being individually tailored, and that the person's physical or mental impairments, ways of communication, patterns of activity, behavioural issues, privacy, safety, etc. must be incorporated in the ATC.

Life Experience and Cognitive Functions in Planning

Planning theories suggest that life experience together with cognitive functions is associated with planning ability (Friedman & Scholnick, 2014; B. Hayes-Roth & Hayes-Roth, 1979; Kliegel et al., 2007; Scholnick & Friedman, 1993; Ward & Morris, 2005). Previous research has only investigated this association among adults (Kliegel et al., 2007). Paper II found an association with life experience in the group of children with a typical development, where both age and activity experience could predict planning ability. Even with a small age range in the group of individuals with a typical development (± 3 years), age was a significant predictor. Thus, the study provides support that experience is important for planning not only in adults but also for children.

In the introduction of the thesis, it was proposed that the different results found in the literature, regarding whether individuals with ID perform according to or lower than their developmental level, might be explained by differences in life experience. Thus, it was expected that planning ability would be predicted by life experience in the ID group, and that they might even perform better than the MA group due to them having a longer life experience (due to the difference in CA). However, the results from Paper II did not support this. Rather, the opposite was found as life experience was more important for the group that had lived a shorter time. Whether the difference is due to the difference in time lived or due to the ID is not something this research can answer. Research should further investigate life experience and ways to assess life experience in different populations to scrutinize the influence of life experience on planning in the population with ID. A suggestion is to include a group with a typical development matched on chronological age to explore if the prediction pattern resembles one of the adolescents with ID or not.

The only life experience variable associated with planning in the ID group was age, which had a negative association with planning. The younger the participants were, the better they were at planning. This relationship was also the strongest, in terms of beta-values,

of the included predictors in the model. The reason for this negative relationship is not known, however, the ID group had a negative correlation to age on all measured variables (including RCPM). One reason for this might be that the younger participants in the ID sample included in the study had a higher cognitive level than the older participants. Another explanation for the negative relationship could be that in 2011 Sweden adopted a new curriculum for the compulsory school for pupils with learning disabilities (*Läroplan (Lsär11) För Grundsärskolan*, 2011). This new curriculum has a high focus on the theoretical subjects (in contrast to a more care/nursing perspective of the old school form) where assessments and grading have become more equal to the regular school form (Eriksson-Gustavsson, 2014). Thus, the negative effect of age in study II might be an effect of some of the older students have had the old curriculum for a longer time than the younger students. This, in turn, would mean that the younger students have had a more theoretical curriculum, which might be reflected in better planning ability. To our knowledge, no evaluation of the effect of the new curriculum on the students' knowledge has been performed.

The results from Paper I indicate that the children are not involved in the formulation of the planning process, thus they might not get enough training to gain enough life experience to apply. This lack of everyday planning training might result in that the symptoms become greater with age. This has been observed in children with ASD (Hansen et al., 2008; Matson & Kozlowski, 2010), but not been found in individuals with ID before. Perhaps there is a similar increase in symptoms in the population with ID. Individuals with ID and ASD were included in study II, however, subgroup analysis did not find that the negative correlation was driven by the group with the additional ASD diagnosis. Regardless of the reasons for the negative correlation, one might need to consider that younger individuals perform better than older ones. Thus, interventions should be implemented as early as possible.

Fluency was associated with planning in both groups in Paper II. The relationship between planning and verbal fluency has been found before in both adolescents with a typical development and individuals with ID (Ashman & Das, 1980). For solving planning tasks, the individual needs to evaluate different possible outcomes and scenarios (Friedman & Scholnick, 2014). Verbal fluency has been suggested to assess vocabulary retrieval and verbal ability (Henry et al., 2015; Sauzéon et al., 2004; Shao et al., 2014). Thus, the association between verbal fluency and planning might indicate that verbal ability and the skill to quickly access the vocabulary is important for planning.

Visuo-spatial WM predicted planning in the ID group but not in the group of individuals with a typical development. However, WM was strongly correlated with planning ability in the MA group as well as the ID group. According to Gilhooly (2005), when formulating a plan the planner mentally generates, represents, stores, evaluates, and selects possible actions. All of which puts high demands on WM. For WM, there was a group difference, such that the individuals with ID had a lower WM than the MA group, replicating Danielsson et al. (2012). This difference could have influenced the group difference in predictor variables for planning ability. Perhaps the high WM capacity in the MA reduced the WM load in the planning tasks, whereas individuals with ID had a higher load on their WM for planning. Additionally, the MA group might have benefitted from using their life experience which in turn reduced the need to engage their WM when planning. Since the

individuals with ID could not make use of their life experience, the demand for WM was higher (Gilhooly, 2005).

For the group of individuals with a typical development, reasoning predicted planning. Reasoning was not included in the regression model for planning in the ID group, however, reasoning was correlated with planning in the ID group. For solving the reasoning matrix task, the individual must figure out the relation between the displayed patterns, and then infer that relation to determine which pattern is the correct one. This strategy might also be successful for planning since the different outcomes of the plan must be inferred from the overall goal, possible restrictions, and prerequisites for the plan. However, this does not explain the difference in the groups, and the results do not indicate that the individuals with ID instead used their experience of performing different activities for solving the planning tasks. As the groups did not differ on reasoning or planning, a possible difference in those abilities cannot explain the difference. However, perhaps it is not the absolute difference in reasoning score that is the essence of planning. The groups differed in WM capacity, and reasoning and WM are highly correlated (Harrison et al., 2015; Kane et al., 2004; Kyllonen & Christal, 1990; Süß et al., 2002). Thus, further studies should investigate if the difference in WM capacity can be a mediator for why reasoning was a significant predictor for the ID group but not for the MA group. An additional explanation might be that individuals with ID have a deficit in reasoning ability as a core symptom of their diagnosis (American Psychiatric Association, 2013). Having a deficit in reasoning might make it more difficult to utilize that ability in other problem-solving tasks. However, this hypothesis must be tested in a future study to be validated.

The Difference Model and Planning

This thesis studied predictors of everyday planning (Paper II) and behaviour *during* everyday planning training (Paper III) and captured differences on a group-level and in strategy use in the groups. This way of analysing behavioural data provided new ways of testing for the difference and developmental delay models, complementing the studies that have focused on group differences only (i.e. mean comparison). Over the years there has been a theoretical shift from finding a singular deficit to a more fine-tuned understanding of ID (Burack et al., 2012). The results from studies in this thesis can contribute to this understanding of ID.

The results from the papers in this thesis do not support the notion of the developmental delay model, which predicts individuals with non-specific ID to perform on the same level as MA-matched peers. Even though some researchers have found support for this model (Henry, 2010; Van der Molen et al., 2007; Willner et al., 2010), other researchers have been unable to confirm this model when investigating EF in individuals with ID (Bexkens et al., 2014; Carretti et al., 2010; Danielsson et al., 2012; Henry & Winfield, 2010; Ikeda et al., 2014; Numminen et al., 2001; Schuchardt et al., 2010; Van der Molen et al., 2009). The literature investigating planning has also been unable to confirm the model (Danielsson et al., 2010, 2012; Numminen et al., 2001; Van der Molen, 2009). This discrepancy in the literature disputes the notion that ID can simply be explained by being at a lower developmental level than peers with the same CA. The results from Paper II

and Paper III further corroborate this notion. The ID group and the group of individuals with a typical development performed equally on the planning tasks (Paper II) and learned equally as much when training everyday planning (Paper III). However, the ID group had a lower visuo-spatial WM capacity compared to the group matched on MA (Paper II) in line with Danielsson et al. (2012) and Schuchardt et al. (2010). Furthermore, different cognitive factors predicted everyday planning (Paper II), and the groups had different strategies for learning the training program (Paper III).

The results do not support the second claim in the developmental delay model of ID either, the individuals with a specific ID did not manifest a similar behavioural pattern even when they shared the same genetic background for their ID. The sample in the thesis consisted of adolescents with mixed aetiology, however, only 11 of 71 included participants had a specific ID, and sub-group analyses could not find any systematic differences in this group. Nor could the differences be explained by additional diagnoses (e.g. ADHD or ASD). Thus, even though the sample in this thesis had a mixed aetiology, the results support the difference rather than the developmental delay model of ID, at least in relation to everyday planning.

In sum, the results from this thesis, suggest that even though the groups were matched on MA, individuals with ID and TD differed qualitatively from each other in how they approached the tasks, which is in line with the difference model (Bennett-Gates & Zigler, 1998). Individuals with ID showed a different qualitative profile rather than sharing a cognitive profile with individuals matched on MA. As discussed in the introduction, WM is considered a core executive function (Gilbert & Burgess, 2008; Miyake et al., 2000; Miyake & Friedman, 2012). Thus, WM could be a core deficit in individuals with ID. Additionally, the ID group used different strategies compared to the MA-matched group of children with a typical development. The group of individuals with a typical development in Paper II used both cognitive abilities and life experience for solving planning tasks, whereas the ID group only seemed to engage their cognitive abilities. In Paper III, the groups once again were similar in outcome in terms of having learnt planning tasks in the training program, but differed in how they adopted these skills. Thus, in addition to confirming the difference model for everyday planning and WM, future research should focus on strategies employed in the setting studied.

Planning and Executive Functioning Assessment

A limitation regarding the assessment of planning is reliability of the planning tests. The reliability of the planning tests (especially for CKTA) was relatively low (see Paper II for a reliability analysis). The thesis has modified both the MET and the CKTA, which could have affected the reliability of the tests. However, Zoo map 2 was not modified and still, low reliability was observed. Nonetheless, only MET was modified for assessing everyday planning by individuals with ID, and no tests were developed for use as a pen-and-paper version. Thus, the modification was necessary for this thesis. However, future studies should further investigate, evaluate, and improve reliability for tests assessing everyday planning in a pen-and-paper fashion.

Training Everyday Planning

Paper III found that the training program offered a feasible intervention for teaching everyday planning to adolescents with ID. However, it is important to ensure the participants train for the right amount of time. The outcomes of the study suggested that a tablet-based training program can be beneficial for adolescents with ID, as the groups did not differ on how much planning they learned in the training program as their MA peers. Furthermore, the study found that individuals with ID needed more time to get used to the program, indicating that it is important to consider the time-spent-on-task when assessing digital support for this group. Since both groups were able to use and learn the training program, and manipulate the tablet without the help of another adult, Paper III provides support that individuals with ID can learn and manipulate technology, thus an inability to learn advanced technology cannot be the reason for why the intermediary usage was found in Paper I. Thus, to increase the feasibility of a technological device, the individual with ID has to be given enough time to get used to the technology, but if they do, they have the potential to learn equally much as their MA-matched peers.

Paper IV controlled for several potential confounders. The groups were carefully matched on mental age to minimise the possibility that the differences between the two samples were due to developmental differences rather than differences connected to the ID. The intervention had an active control to avoid unwanted effects such as test-retest, regression to the mean, placebo, or natural development due to the participants getting older. The two groups also went through the same methodological procedure as the intervention group. As earlier literature has stated that achieving transfer is one of cognitive training's biggest challenges (Melby-Lervåg et al., 2016), the training program included daily tasks to reduce the gap between what was being trained and the untrained situation. The study also included a vast range of tests to assess possible improvement, and included measures to capture near to far transfer. Nonetheless, the study could not find an effect of training. Earlier studies on cognitive training that have reported successful transfer effects have often investigated elderly adults, while meta-analyses focusing on interventions for children and adolescents often show less transfer to untrained tasks (e.g. Mowszowski et al., 2016). Perhaps there is a difference between trying to restore or maintain cognitive functions compared to trying to improve performance on a skill that has always been low due to ID. The null result from Paper IV in this thesis goes hand in hand with other computerised training programs for training different cognitive abilities, showing no or little effects on untrained tasks (Melby-Lervåg & Hulme, 2013; A. M. Owen et al., 2010; Simons et al., 2016). As stated in the introduction, it is common that research on ID has small samples which result in low power. This thesis aimed to have higher power, and 143 participants were recruited, of which 80 participants had an ID. Thus, the null result regarding transfer effects cannot be explained due to low power. Thus, perhaps the reason for the missing effects is simply due to the computerised intervention not working for training tasks other than the task that is being trained.

Gathercole et al. (2019), found that transfer was greater for children with higher cognitive capacities, suggesting that perhaps cognitive training is not beneficial for individuals with ID. However, Paper IV did not find transfer effects for the group with a typical development either, suggesting that the ID is not the only explanation for the absence of

transfer effects. Furthermore, Gathercole et al. (2019) suggest another mechanism for achieving transfer effects, namely that the trained and the transfer tasks should share a common, unfamiliar paradigm and routine. A transfer effect can thus only occur in an untrained task if a cognitive routine is learned during the training that can be directly applied to the transfer task. For instance, WM training using serial recall, complex span, or backward span could only induce transfer in untrained tasks that shared the same WM component. A weaker transfer occurred in untrained tasks for serial recall of verbal material. Training strategy competencies for the shared underlying routine in everyday planning may be a possible way forward for everyday planning training for individuals with ID.

Strategy Competencies in Individuals with ID

Individuals with ID and MA-matched children with a typical development differed in terms of predictors for planning ability, even when both the cognitive measures and life experience difference were accounted for (Paper II). Individuals with ID could not make use of their longer life experience, contrary to the children matched on MA (Paper II). A reason for this might be that they do not know how to employ their previous experience in the planning situation. The groups also differed in how they used an everyday planning training program, with the ID group increasing their activity during the training. The change in behaviour in the training program was interpreted as showing that individuals with ID needed a longer time to get familiarised with the training program (Paper III). The differences between the groups might indicate that the ID group was not using a successful strategy. Previous research has found that individuals with ID used strategies for solving tasks (Watanabe, 2006), but to a lesser extent than individuals with a typical development (Bebko & Luhaorg, 1998; Bray et al., 1997; Poloczek et al., 2016). Furthermore, Bray et al. (1997) found that they use qualitatively different strategies compared to individuals with a typical development.

The literature presents promising effects on strategy training for individuals with ID. Luwel, et al. (2011), investigated the role of intelligence on strategy competence training in the context of a numerosity judgement task. They compared children with low-, average-, and high- intelligence. They found that there were large differences in the three groups on the pre-tests, however, the differences disappeared at the post-test, mainly due to the low intelligence group showing strong improvement. Thus, the authors conclude that intelligence plays an important role in the strategy used among children. Furthermore, their results suggest that training strategy feedback can be an efficient intervention, especially for children with low intelligence (Luwel et al., 2011). Another recent study has found promising effects on using strategy training as an intervention for individuals with ID. Karabulut and Özmen (2018), conducted a single-case study investigating the effect of training a strategy for improving and maintaining mathematical skills in three children with ID. Their results show that not only did the students get better at solving tasks for one-step addition and subtraction, but they also maintained their skills up to eight weeks after the training, and generalized their skills to different problem types. Thus, interventions aimed for individuals with ID might benefit from focusing on instructing the participants on how to make use of their previous knowledge and apply this to the new situation.

External and Internal Support

This thesis has found that ATCs are useful external support for planning for families with children with ID. However, to increase independence, ATCs need to be adapted to the abilities of individuals with ID. Support for the use of internal support was found in both the group of individuals with ID and in the group of individuals with a typical development. However, the group of individuals with a typical development seemed to be able to make use of their life experience more than the ID group did. Thus, individuals with ID might benefit from increasing the internal support. However, training on how to apply life experience to novel planning situations might be more efficient in terms of planning improvement compared to using a cognitive training program.

Clinical Implications

ATC prescribers need to keep in mind the abilities of the user, and give the user enough time to train with the device. Practitioners should explicitly tell the individual with ID to use strategies. They should also encourage planning formulation to increase experience. Furthermore, it is important to be patient with the individual with ID and to give them enough time to get familiarised with the program or the technological device. Practitioners should also enable and actively support a schedule so that training is not forgotten. Lastly, practitioners should be cautious when introducing cognitive interventions if the transfer gap is too large.

Future Directions

Development of new ATCs should consider including the user in the design process, either in the entire development or at least when evaluating the efficacy of the ATC before placing the product on the market. Developers, prescribers, and researchers need to map the individual with ID's strengths and weaknesses to facilitate ATC usage without the need for an intermediary user. Furthermore, the reasons for the need of an intermediary user should be further investigated, together with how to increase independence for individuals with ID.

Even though many participants did not train as much as intended, both groups were able to display learning in the task, and both groups were able to navigate in the program without the help of another adult or teacher. This result is promising with regards to using tablet-based training programs for interventions for individuals with ID, but also highlights the importance of monitoring that the training is carried out. The next step is to investigate the potential to train the individuals' proficiency in formulating everyday plans. This could increase their independence and reduce the role of intermediary users.

The results emphasise the importance of bearing in mind the familiarisation period when assessing and evaluating the efficacy of a cognitive support and intervention programs, such that an ATC or intervention is not discarded before the individual has had enough time to get used to it.

Future research should expand the concept of life experience and include more domains than activity experience and age. It seems more plausible to enhance life experience rather

than cognitive abilities, thus future research could investigate whether individuals with ID can benefit from an intervention on how to apply previous experience in novel situations.

A limitation of this thesis is that socioeconomic status was not included in the studies. Studies have found that socioeconomic status is important for several areas in life in both individuals with a disability as well as without (Emerson et al., 2014; Ritchie et al., 2015; von Stumm & Plomin, 2015). A parental survey for collecting socioeconomic status was sent out, but only approximately half of the parents replied, and the measure had to be excluded. Thus, future studies should try to develop a robust way of collecting socioeconomic status to study the possible impact of socioeconomic status for everyday planning.

Concluding Remarks

This thesis argues that ID cannot simply be thought of as a developmental delay. Rather the strengths and weaknesses seen in ID seem to be more complex, where MA appropriate performance can be observed in some situations and not in others, regardless of aetiology of the ID. Both external and internal support are used for everyday planning by adolescents with ID. ATCs and intervention programs need to be designed and prescribed in a way that increases independence. Rather than trying to come up with a “quick fix” in a cognitive training program, ATCs and other planning enhancing interventions must be thoroughly developed and assessed. The appropriate training needs to be provided for each individual, and usage must be followed up. When the individual with ID is enabled to formulate plans for themselves, then perhaps there will also be a correlation with planning proficiency and experience, and the demand on cognitive abilities will be smaller.

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