Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Social and Educational Sciences
Department of Psychology

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Associations of Fine Motor Skills, Visual Processing Abilities, and Psychological Resources with Reading Skills in Young adults - Investigating Gender Differences

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Foreword

This thesis was partly associated with a project in cooperation with Hermundur Sigmundsson, with an aim of investigating the relationship between skills, abilities and psychological resources. I would like to thank my supervisor, Prof. Hermundur Sigmundsson for providing useful insights and advices during the writing of this thesis, as well as essential inspiration and motivation during difficult times. I would also like to thank Adrian Dybfest Erikson for always being available for questions, as well as providing relevant literature.

I want to thank my fantastic family and friends for all the support, giving me the opportunity to relax and enjoy this long process.

I also have to thank my best friend and girlfriend, Marit for all the support throughout this long period. Without the reassuring words, your humor, and your presence, this process would be a lot more difficult.

Finally, thanks to all the participants for contributing to this study.

Abstract

Although gender differences in reading skills is well established in childhood and adolescence, it is unclear whether these differences exist at later ages. Considering the prevalence of gender differences, it is important to investigate possible explanations for why these differences occur. Thus, this study aimed at examining possible associations of fine motor skills, visual processing abilities, grit and mindset with reading skills, as well as whether gender differences within these factors are present in young adults. The sample included 61 Norwegian young adults, and were tested in reading skill, fine motor skill, coherent motion and form thresholds, grit and mindset. Descriptive statistics and independent t-test were conducted to examine gender-related differences. Furthermore, a Pearson correlation, as well as Fisher *r*-to-*z* transformation, was performed to examine the various associations, and whether these associations differed between gender. Results indicated no significant gender differences in the included factors. Furthermore, a significant correlation was only found between fine motor skill and reading skill. Although no significant gender differences were found in the correlation coefficients, several tendencies of stronger correlations among males than females were present, suggesting that females might exhibit more specific reading skills than males. The absence of gender differences in this study lay further emphasis on the importance of experience, suggesting that boys might simply need more reading experience in youth. Possible interventions that might increase boys reading experience are proposed, including developing higher levels of grit and growth mindset. In sum, more research is necessary to examine gender differences in these factors, as well as their associations to reading skills at different groups of age.

Keywords: Gender differences, reading skills, fine motor skills, visual processing abilities, grit, mindset, young adults.

Sammendrag

Til tross for at kjønnsforskjeller i leseferdigheter er godt dokumenter i barndom- og ungdomsåra, er det fortsatt usikkert hvorvidt disse forskjellene er utbredt i voksen alder. På bakgrunn av disse kjønnsforskjellene er det viktig å undersøke mulige forklaringer for hvorfor disse forskjellene oppstår. Denne studien undersøkte derfor mulige assosiasjoner av finmotorikk, visuell prosesseringsevne, grit og mindset med leseferdigheter, og hvorvidt det er kjønnsforskjeller i disse faktorene. Utvalget besto av 61 norske voksne, og ble testet i leseferdighet, finmotorikk, terskel for koherent bevegelse og form, grit og mindset. Deskriptiv statistikk og uavhengig t-test ble gjennomført for å undersøke kjønnsrelaterte forskjeller. Således ble en Pearson korrelasjonsanalyse, samt en Fisher *r*-to-*z* transformasjon utført for å undersøke de ulike assosiasjonene, og hvorvidt disse assosiasjonene varierte mellom kvinner og menn. Resultatene viste ingen signifikante kjønnsforskjeller i de inkluderte faktorene. Videre viste resultatene kun en signifikant korrelasjon mellom finmotorikk og leseferdighet. Selv om det er ikke var signifikante forskjeller mellom kvinner og menns korrelasjonskoeffisienter, var det flere tendenser av sterkere korrelasjoner blant menn enn hos kvinner. Dette kan tyde på at kvinner innehar mer spesifikke leseferdigheter enn menn. Fraværet av kjønnsforskjeller i denne studien gir videre støtte til viktigheten av erfaring, der gutter muligens mangler leseerfaring i yngre alder. Mulige intervensjoner som kan bidra til økt leseerfaring blant gutter er foreslått, som utvikling av grit og growth mindset. Mer forskning er nødvendig for å undersøke kjønnsforskjeller i de ulike faktorene, samt deres assosiasjon til leseferdigheter i ulike aldersgrupper.

Table of Contents

Introduction

Being able to read fluently with understanding is an essential skill in modern society. Specifically, adequate development and learning of reading skills is fundamental for knowledge acquisition, for participating in social and cultural life, for having a successful career, and for further learning (Uusen & Müürsepp, 2012). Statistics from large-scale assessments such as PIRLS (Progress in International Reading Literacy Study) and PISA (Program for International Students Assessment) have shown large gender gaps in reading skills at both 9-10-year-olds and 15-year-olds (Mullis, Martin, Foy, & Hooper, 2017; The Organisation for Economic Co-operation and Development [OECD], 2016). In fact, results from PISA demonstrated that reading is one of the skills with the largest gender difference (OECD, 2016). Although there are differences between countries, 9-10-year-old and 15-year-old girls, on average, performs better than boys in reading across all nations. Noteworthy, Norwegian 15-year-old girls performed better than boys by a total of 39 points (i.e., girls mean score = 533, boys mean score = 494), despite Norway being one of the countries with the highest average reading scores (OCED, 2019). Besides the prevalence of gender differences in reading skills, boys are considered as a risk factor for low reading achievement (Uusen & Müürsepp, 2012). The risk factor of boys can also be reflected by the fact that boys are more frequently reported to be affected by reading disability compared to girls (Rutter et al., 2004). The highlighted differences between girls and boys reading skills can be worrisome, as such differences might persist into adulthood and affect several aspects of everyday life. However, it is unclear whether these differences persist into later ages.

Ultimately, gender differences in reading skills is an important and extensive research area, and by investigating possible explanations for these differences, one could discover interventions that might help close the gender gap in reading skills. For instance, studies have demonstrated that girls read more frequently and have a more positive attitude towards reading than boys (e.g., Coles & Hall, 2002; Logan & Johnston, 2009). Thus, boys might simply be lacking in reading experience compared to girls. Besides adequate reading experience, other trainable skills, underlying abilities and psychological resources has proven to be important on various areas that might be related to reading skills. For instance, fine motor skills have been suggested to be important for school readiness (e.g., Grissmer, Grimm, Aiyer, Muurah, & Steele, 2010). Furthermore, deficits in underlying visual processing abilities has been associated with reading disability (e.g., Stein & Walsh, 1997; Cornelissen, Richardson, Mason, Fowler, & Stein, 1995; Livingstone, Rosen, Drislane, & Galaburda, 1991). Finally, psychological resources such as grit and mindset has been related to success and achievement in various domains (e.g., Duckworth, Peterson, Matthews, & Kelly, 2007; Dweck, 1986; Yeager & Dweck, 2012).

What is the associations of fine motor skills, visual processing abilities, grit and mindset with reading skills? Are they closely related, and do the associations differ between females and males? Finally, are there gender-related differences in reading skills, fine motor skills, visual processing abilities, grit and mindset in young adults? Considering the large gender differences in reading skills among children and adolescents, underpins the importance of investigating gender differences within these factors and their associations with reading skills. This might provide deeper understanding for why gender differences in reading skills exist, as well as alternatives for improving boys' reading skills. The following section will show the background for the study, by presenting each factor of interest and gender differences, and then what former research says about their associations with reading skills.

Individual Differences

Before examining reading skills, fine motor skills, visual processing abilities, grit and mindset, and whether gender differences are present within these factors, it is crucial to have a theoretical framework to understand why individual differences in development and learning exist. For instance, what is it that make some individuals better than others at various skills such as mathematics, reading, or varying sport activities? Similarly, why do females outperform males on reading-related tasks? Questions like these leads back to the debate concerning nature versus nurture. Some experts would say that it was because of physical differences (e.g., our genes differed), while others would point towards the importance of environmental differences (e.g., practice and ways of learning). Today however, there is an overall agreement that it is not genes *or* environment, but an interaction between the two. This idea can be demonstrated by Gottlieb's theory on development, known as the probabilistic epigenesis. Gottlieb's theory stresses that there is always an interaction between genes and environment (Gottlieb. 2007), implying that the developmental outcome is probabilistic determined by both internal and external stimuli (Gottlieb, 1998). This perspective is derived from how the relationship between structure (i.e., structural maturation of the nervous system) and function (i.e., behavior) is perceived. In contrast to the predetermined epigenesis, also known as the maturational theory, the probabilistic epigenesis perceives the relationship between structure and function as bidirectional (i.e., two-way), in which genes, structure, behavior and environment can affect each other. In sum, both internal and external stimuli are highlighted as crucial for development.

In line with Gottlieb's probabilistic epigenesis, Edelman proposed a theory known as the theory of neuronal group selection (TNGS), which further demonstrates the interaction of internal and external stimuli for learning. Specifically, Edelman illustrated this by looking at the presence of group selection within the nervous system, in which synaptic strengths within specific brain regions changes when they are used, choosing those neuronal groups that yields adaptive behavior (Edelman, 1993). In other words, stimuli and practice increases neuronal connections within specific brain regions. For instance, imaging a toddler trying to grasp a ball for the first time of her/his life. Neuronal connections that are involved in arm movements that are perceived as "negative" (i.e., misses the ball) will be weakened, reducing the likelihood that those neuronal connections will be used on later attempts. In contrast, neuronal connections that are involved in arm movements that are perceived as "positive" and adaptive (i.e., reaching and grasping the ball) will be strengthened, increasing the likelihood that those neuronal connections will be used on later attempts. Edelman's theory of neuronal group selection supports the theory of task-specificity, i.e., what is trained develops (Sigmundsson, Trana, Polman, & Haga, 2017). Both Gottlieb's probabilistic epigenesis and Edelman's TNGS emphasizes the importance of experience for individual development and learning, and individual differences can be understood as differences in the reciprocal interaction of internal and external stimuli.

Reading Skills

As previously mentioned, being able to read fluently with understanding is an essential skill. Reading can be understood as a complex cognitive process, and according to Vellutino, Fletcher, Snowling, and Scanlon (2004), reading can be defined "*as the process of extracting and constructing meaning from written text for some purpose*" (p. 5). Besides being a complex cognitive process, reading is also known as a multicomponent task that is generally considered to consist of two different, but related, skills; reading comprehension and word-decoding. Reading comprehension involves being able to derive meaning and interpretations from the text (Hoover & Gough, 1990), and both linguistic comprehension and word-decoding has shown to be important parts of reading comprehension (Tighe & Schatschneider, 2016; Hoover & Gough, 1990). Within a simplistic perspective, reading comprehension can, thus, be said to be a product of both linguistic comprehension and word-decoding (Gough & Tunmer, 1986). Word-decoding, on the other hand, reflects the technical side of reading (Flem & Finbak, 2005), and involves recognizing words by using letter-sound conversion rules (Gough & Tunmer, 1986). Specifically, word-decoding involves processes of translating print into speech by rapidly matching a letter or combination of letters (i.e., graphemes) to their corresponding sounds (i.e., phonemes), and, thus, recognize patterns that make up words. Frith (1985) divided word-decoding into three phases with three types of skills; logographic skill, alphabetic skill, and orthographic skill. The logographic skill refers to fast recognition of words with visual features acting as important cues (Frith, 1985). During the logographic phase, the child's attention is directed toward how the word is written and is only capable of reading known words (Flem & Finbak, 2005). Furthermore, as the child gets more reading experience, the word-decoding skill develops accordingly. The acquisition of the analytical alphabetic skill is a radical change in word-decoding and refers to a stage where the reader uses knowledge about grapheme-phoneme correspondences (Frith, 1985). However, the decoding of grapheme-phoneme correspondences is relatively slow at the beginning and requires a lot of attention. This might affect the child's overall reading comprehension, and a lot of training is, thus, highlighted as important for improving the alphabetic skill (Flem & Finbak, 2005). Normal reading development typically results in precise and automatic decoding. This is known as the orthographic skill and refers to instant retrieval of words without any phonological conversion (Frith, 1985). The automatization of word-decoding is crucial of reading comprehension (Flem & Finbak, 2005). Based on the components of reading comprehension and word-decoding, individual differences in reading skills might originate from differences in word-decoding, comprehension, or both.

Gender Differences

It is often assumed that girls perform better than boys on reading-related tasks, and as demonstrated above, statistics from large-scale assessments indicates that girls are slightly more advanced than boys in reading skills (Mullis et al., 2017; OECD, 2016, 2019). Furthermore, several studies have found gender differences in various aspects of verbal skills, including vocabulary growth (Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991), letter-writing scores (Puranik, Petscher, & Lonigan, 2013) and phonological awareness (Chipere, 2013), all favoring girls. In addition, several studies point towards gender differences in word-decoding (e.g., Verhoeven & van Leeuwe, 2011; Savolainen, Ahonen, Aro, Tolvanen & Holapainen, 2008). Specifically, Savolainen et al. (2008) demonstrated gender differences in 15-year-olds, in which girls performed better than boys on word-decoding tasks (i.e., word-chain test and error finding). Finally, gender differences are also present in reading disability, in which boys are more frequently reported to be affected by reading disability compared to girls (Rutter et al., 2004). Given the fact that dyslexia are often assumed to be a deficit in word-decoding (Vellutino et al., 2004), might further suggest that gender differences in word-decoding exist. As previously highlighted, gender differences in reading skills might be worrisome, as such differences might endure into adulthood and affect several aspects of everyday life. However, whether these differences persist into later ages is unclear. For instance, while some have reported that gender differences in reading skills might be present at later ages (i.e., 16 and older) (Kutner et al., 2007), other studies have found little to no gender differences in 16-24-year-olds reading skills (Solheim & Lundetræ, 2016). Furthermore, Hannon (2014) found no gender differences in adults' word-decoding skill. However, word-decoding was found to be a stronger predictor for reading comprehension among males than females. Overall, more research is necessary to assess whether gender differences in reading skills are present at later ages.

Based on theoretical perspectives of Gottlieb's probabilistic epigenesis and Edelman's TNGS, gender differences in reading skills can be understood as differences in both internal and external stimuli. For instance, there might simply be a lack of reading experience amongst boys, resulting in poorer performance on reading-related skills compared to girls. Furthermore, differences in the reciprocal interaction of internal and external stimuli might lead to differences in brain development and cerebral lateralization, which is considered as important contribution to gender differences in reading skills. For instance, males' brains have been found to facilitate intrahemispheric (i.e., within) cortical connectivity, whereas females' brains show higher interhemispheric (i.e., between) cortical connectivity (Ingalhalikar et al., 2013). In other words, females might use more neuronal resources (i.e., both hemispheres) to achieve the same cognitive outcome. Specifically, this has been demonstrated in language-related tasks, in which males' brains are more left lateralized during phonological tasks (e.g., Shaywitz et al., 1995; Clements et al., 2006).

Motor Skills

Motor skills can be defined as "*those skills in which both the movement and the outcome of actions are emphasized*" (Newell, 1991; p. 214), and can include everything from "writing on this keyboard", "playing piano", "dancing", and "painting". Even skills like "reading" and "speaking" requires some forms of motoric movements. When referring to motor skills, the concept of motor competence has been proposed which can be understood as an individual's level of performance when executing different motor acts (Henderson &

Sugden, 1992, in Sigmundsson & Haga 2016). The term motor competence includes both fine and gross motor skills. Fine motor skills, also known as visual-motor skills and/or manual dexterity, involves small muscle movements requiring close eye-hand coordination (Luo, Jose, Huntsinger, & Pigott, 2007), such as “writing”, “cutting”, “opening lunch boxes”, and “tying shoelaces”. Whereas fine motor skills refer to skills including finger dexterity, wrist flexibility, arm and hand steadiness, gross motor skills refer to large whole-body movement skills such as balance, strength and body coordination (Wang, 2004). Noteworthy, gross motor skills are typically distinguished between locomotor skills (e.g., jumping, running, swimming) and object control skills (e.g., throwing, kicking, catching).

Adequate development and learning of motor skills is an important part of children’s development, and the approach of dynamic systems have been the most often used to explain motor development and learning (Thelen & Smith, 1994; in Haga, Pedersen, & Sigmundsson, 2007). This dynamic approach brings together perspectives on how to explain both similarities and variability in motor development and is consistent with perspectives on development as probabilistic determined by both internal and externals stimuli (Gottlieb, 1998, 2007). Based on Edelman’s TNGS (Edelman, 1993), motor skill learning can further be argued to be task specific, in which training specific motor tasks will strengthened those neuronal connections involved in that particular task. Interestingly, motor performance has been found to increase from childhood to young adulthood and decrease from young adulthood to old age (Leversen, Haga, & Sigmundsson, 2012). Furthermore, Leversen et al. (2012) demonstrated that correlations between motor tasks increased with age. In other words, the specificity of motor skills is higher in childhood and decreases with age, and the principle of “use it or lose it” becomes increasingly important in older adults (Leversen et al., 2012).

The importance of adequate development and learning of motor skills can be highlighted in several areas. Overall, motor development and learning are important in infants’ exploration of the environment, i.e., it is through motoric actions that infants construct their knowledge about the world (Piaget, 1952, in Son & Meisels, 2006). Furthermore, several studies have demonstrated the importance of motor skills on different physical- and activity-related areas. For instance, adequate mastery of motor skills has been associated with physical activity (Holfelder & Schott, 2014; Stodden et al., 2008), physical fitness (Haga, 2008) and sport participation (Okely, Booth, & Patterson, 2001), in youth. In addition, mastery of motor skills has been linked with degree of excessive weight and obesity (D’Hondt et al., 2013; Hendrix, Prins, & Dekkers, 2014), as well as subsequent physical activity and fitness (Stodden et al., 2009). More recently, however, motor skills have also been studied in relation to cognitive function and academic performance. In the context of this thesis, associations of fine motor skills with reading skills is especially of great interest in will be further examined later.

Gender Differences

Similar to reading skills, several studies have demonstrated gender differences in motor skills. For instance, in childhood and adolescence, boys have been found to be more proficient than girls in gross motor skills, especially in object control skills such as throwing, catching, or kicking (e.g., Barnett, van Beurden, Morgan, Brooks, & Beard, 2010; Raudsepp & Pääsuke, 1995; Vedul-Kjelsås, Stensdotter, & Sigmundsson, 2013; Valtr, Psotta, & Abdollahipour, 2016). Furthermore, several studies point towards gender differences in fine motor skills. Specifically, girls have been found to perform better than boys at various aspects of fine motor skills in 4-6-year-olds (Sigmundsson & Rostoft, 2003), in 7-8-year-olds (Junaid & Fellowes, 2006), and in 15-16-year-olds (Valtr et al., 2016). Interestingly, however, Vedul-Kjelsås et al. (2013) found no gender differences in fine motor skills in 11-year-olds. Studies of gender differences in fine motor skills at adulthood seems to be mixed and dependent on the task used to measure fine motor skills. For instance, some studies have reported females to perform better than males at peg-moving tasks when using tiny pegs (e..g, Peters, Servos, & Day, 1990), whereas other studies have reported males to perform better than females at peg-moving tasks using thick pegs (e.g., Peters & Campagnaro, 1996). However, when eliminating finger size as a factor, these gender differences disappeared. Thus, when assessing whether gender differences in fine motor skills exist at adulthood, it is important to eliminate any gender advantages. Considering that performance on motor skills increases from childhood to adulthood and then decreases into old age (Leversen et al., 2012), gender differences in motor skills might be related to age. Accordingly, Hands, Larkin and Rose (2013) demonstrated that their findings of gender differences on overall motor performance was dependent on age.

Based on the presented findings, gender differences in motor skills might be present, especially in object control skills and fine motor skills. However, these differences might be argued to depend on age, in which both biological and environmental factors play important roles. Specifically, differences in internal and/or external stimuli might explain why gender differences in motor skills exist. In other words, differences between girls' and boys' performance on object control skills and fine motor skills might be a result of differences in experience, strength/size, or both. More research is necessary to assess whether gender differences are present at young adulthood, in which motor skills are at its peak performance.

Visual Processing Abilities

Although humans only have one pair of eyes, it is widely accepted that the visual system involves two distinct streams. Schneider (1969) was one of the first to challenge the assumption of a single visual system, by proposing an anatomical separation between visual coding for location and identification. Following this proposal, Mishkin and Ungerleider (1982) identified two distinct streams for visual processing from their lesion studies of macaque monkeys. Thus, by applying the model of two visual systems, it is common to distinguish between a visual dorsal and a visual ventral stream for visual processing. The visual dorsal stream projects from primary visual cortex (V1) to the posterior-parietal cortex (PPC), whereas the visual ventral stream projects from V1 to the inferotemporal cortex (IT) (Polanen & Davare, 2015). The distinct streams have also been referred to as “what” and “where”, as the ventral and dorsal stream are associated with object recognition in IT and object localization in PPC (Ungerleider & Mishkin, 1982, in Goodale & Milner, 1992). Goodale and Milner (1992), however, wanted to emphasis the output requirements, and proposed the distinct of “what” and “how” to capture the functional dichotomy between the ventral and dorsal stream. Specifically, the dorsal stream uses information about size, shape and orientation of an object to control motoric actions, whereas the ventral stream uses the same information to identify and describe objects (Goodale & Milner, 1992).

The distinction between a visual dorsal and a visual ventral stream can be traced back to the subdivision of retinal ganglion cells that separates in different layers of the lateral geniculate nucleus (LGN) (Goodale & Milner, 1992). These layers can be illustrated during reading. Once our eyes are focused on a word, neuronal patterns are activated, giving us access to information about the meaning of the word and how it is pronounced (Posner & McCandliss, 1999). Specifically, this process starts with a coded retinal image, and from retina, visual information is sent to distinct layers of LGN in the thalamus, known as the magnocellular and parvocellular layers. These layers are distinguished based on differences in cell size and response properties. The magnocellular layer is composed of large neurons that show high conduct velocity and high sensitivity to movement and rapid stimuli changes (Skottun & Parke, 1999). The parvocellular layer, on the other hand, is composed of small neurons that are sensitive to color and fine details. Furthermore, the magno- and parvocellular layers terminate in different strata within 4C of V1; axons from magnocells terminate in the upper part of 4C, while axons from the parvocells terminate in the lower part of 4C ("Central visual pathways", 2012). Based on differences in cell size and response properties, magno- and parvocells process different types of visual information, and the dorsal and ventral stream each receive inputs from magno- and parvocellular pathways (Goodale & Milner, 1992). While the anatomical separation between magno- and parvocellular pathways is maintained in the input layers (i.e., LGN), the information from magno- and parvocells are increasingly mixed beyond this point (Cornelissen, Hansen, Hutton, Evangelinou, & Stein, 1998). For instance, V5/MT seems to be heavily dominated by magnocellular input, while both V1 and V4 seems to have mixed input from both magno- and parvocellular pathways.

Gender Differences

In addition to having a larger brain (Breedlove, 1994), males also tend to have a larger visual cortex than females (Vanston & Strother, 2016), and this might suggest that gender differences in underlying visual processing abilities exist. In fact, several studies have demonstrated gender differences in basic visual processing abilities, including contrast sensitivity (e.g., Brabyn & McGuinness, 1979; Abramov, Gordon, Feldman, & Chavarga, 2012) and visual acuity (e.g., McGuinness, 1976; Abramov et al., 2012). Furthermore, some studies also suggest that gender differences might exist in the two distinct streams (i.e., visual dorsal and visual ventral stream). When examining the properties of these two streams, motion and form thresholds have often been examined (e.g., Johnston, Pitchford, Roach, & Ledgeway, 2016; Billino, Bremmer, & Gegenfurtner, 2008; Englund & Palomares, 2012). The motion task often includes a random-dot-kinematogram, whereas the form task often includes either a glass or static line segments, and the thresholds are measured similarly (i.e., minimum properties of dots/lines needed to reliably detect coherent dots/geometric patterns) (Johnston, Pitchford, Roach, & Ledgeway, 2017). Interestingly, Johnston et al. (2016) found females' coherent motion thresholds to be significantly higher than those of males in a random-dot-kinematogram (i.e., males = 16.80 vs. females = 21.89). These findings were consistent with previous studies demonstrating higher motion thresholds among females compared to males (e.g., Billino et al., 2008; Snowden & Kavanagh, 2006). On the other hand, Johnston et al. (2016) found no differences between males and females' performance on the coherent form threshold task. Gender differences in visual processing abilities might be considered in the context of laterality. Given the fact that there might be gender differences in laterality of face recognition (Zoccolotti & Pizzamiglio, 1986) and the relationship between face- and word recognition (Behrmann & Plaut, 2013), differences in the laterality of visual word recognition might exist. Furthermore, post-mortem studies demonstrating anatomical differences in motion processing areas (Amunts et al, 2007), might further indicate that laterality of visual processing abilities exist.

Grit

Grit is a relatively new construct defined "*as the perseverance and passion for long-term goals*" and is divided in two components: 1) perseverance of effort, and 2) consistency of interest over time (Duckworth et al., 2007; Duckworth & Quinn, 2009). 'Gritty' individuals are typically characterized by working hard toward challenges while maintaining effort and interest over a long period, despite failure, adversity, and plateaus. Duckworth et al. (2007) initially proposed grit as an explanation for why some individuals accomplish more than others of equal intelligence and showed that grit predicted achievement in challenging domains over and beyond measure of talent. Specifically, they found that grit predicted retainment in the U.S. Military Academy, West Point, higher levels of educations, fewer career changes, higher GPAs, and better performance in the Scripps National Spelling Bee. Furthermore, grit accounted for significant more variance than IQ and for Big Five Conscientiousness. Interestingly, grit was not positively related to IQ (either orthogonal or slightly inversely correlated) but was highly correlated with Big Five Conscientiousness. In line with Duckworth et al. (2007), several other studies have shown grit to be predictive to success in various settings. For instance, Eskreis-Winkler, Shulman, Beal, and Duckworth (2014) found grit to predict retention in military, workplace, high-school, and marriage. Interestingly, this effect was higher than normal context-specific predictors of retention (e.g., intelligence, physical aptitude, Big Five personality traits, job tenure) and demographic variables in each setting. Grit has also shown to be a strong predictor of students' success in school and life (Duckworth, Kirby, Tsukayama, Berstein, & Ericsson, 2011).

The idea behind grit has roots all the way back to the earliest days of psychology. Already in 1869, Galton proposed "self-denial" as an essential factor, in addition to talent, of high achievers – namely "*zeal [and] the capacity of hard labor* (Galton, 1869, in Duckworth & Gross, 2014). What Galton termed "self-denial" is now referred to as "self-control" which involves both inhibiting undesirable impulses and activating desirable impulses (Duckworth & Gross, 2014). Today, self-control, one of the facets of Big Five Conscientiousness, and grit are often used interchangeably. Although they are closely related, it is proposed that grit differs from self-control in its emphasis on stamina (Duckworth et al., 2007; Duckworth & Gross, 2014). In other words, grit can be said to be an extreme form of self-discipline

(Mulcahy-Dunn, King, Nordstrum, Newton, & Batchelder, 2018). An individual high in self-control, but moderate in grit may, for example, effectively control his or her temper and stick to his or her diet, yet often change careers. Grit also differs from need for achievement. Whereas individuals high in need for achievement pursue goals that are neither too easy nor too hard, individuals high in grit deliberately set for themselves extremely long-term objectives and do not stray away from them, even in the absence of positive feedback (Duckworth & Quinn, 2009).

During the study of Duckworth et al. (2007), they identified a two-factor structure with 12 items in the self-report measure of grit (Grit-O), a structure comprising stamina in both perseverance of effort and interest over time (Duckworth & Quinn, 2009). However, as Duckworth and Quinn (2009) highlights, the differential predictive validity of these factors for various outcomes was not explored. Thus, Duckworth and Quinn (2009) undertook an investigating to validate a more efficient measure of grit. They examined the self-report measure of grit in a similar sample as Duckworth et al. (2007). During this investigating, they ended up with the Short Grit Scale (Grit-S). Grit-S retains the two-factor structure of the Grit-O (Duckworth et al., 2007), but has 4 fewer items and improved psychometric properties. Duckworth and Quinn’s (2009) findings demonstrated that; among adults, Grit-S was associated with educational attainment and fewer career changes; among adolescents, Grit-S longitudinally predicted GPA and, inversely, hours of watching television; among cadets at the U.S. Military Academy, West Point, Grit-S predicted retention; and among Scripps National Spelling Bee Competitors, Grit-S predicted final round attained, a relationship mediated by lifetime spelling practice. Finally, Duckworth and Quinn (2009) presents evidence for the Grit-S internal consistency, test-retest stability, consensual-validity, and predictive validity.

Gender Differences

There seem to be some inconsistency regarding whether gender differences in grit exist. For instance, Duckworth and Quinn (2009) found Grit-S scores to not differ significantly by gender but were significantly associated with age. However, these findings were weakened by an unbalanced sample of females and males. In another study with equal distribution of females and males, Christensen and Knezek (2014) found significant gender differences in grit scores, in which females were found to be significantly higher in levels of grit than males. In a similar vein, gender differences in grit have also been found in first-year engineering students, with females having higher levels of grit compared to males (Jaeger, Freeman, Whalen, & Payne, 2010). In contrast, and in line with Duckworth and Quinn (2009), Bazelais, Lemay and Doleck (2016) found no gender differences in grit at first-year college physics students. Given the importance of grit in various domains, and the inconsistency of gender differences, suggest that more research is necessary to assess whether gender differences in grit exist.

Mindset

Before understanding what mindset is, it is important to note that there are several conceptualizations of the term. For instance, in cognitive psychology, a mindset can be understood as the sum of active cognitive processes during a given task, whereas in social psychology, a mindset can be understood as cognitive filters (French, 2016). In this thesis, however, mindset will be viewed from positive psychology. Mindset, or implicit theories, can be defined "*as a set of beliefs of our own attributes*" (Dweck, 2012). The popularized term of mindsets originates from the seminal paper of Dweck and Leggett (1988) where they introduced implicit theories of intelligence and implicit theories of personality as conceptual terms. Today, publications often use the term mindset instead of or interchangeably with implicit theories. Mindset (or implicit theories) are people's lay beliefs about the nature of human attributes, such as intelligence or personality (Dweck, 2012). Some individuals have a fixed mindset (or an entity theory) and believe that human attributes are simply fixed traits. In contrast, individuals that hold a growth mindset (or an incremental theory) believe that all people, no matter who you are, can become substantially more intelligence through effort and practice. Research has demonstrated that people's mindset plays a key role in both motivation and achievement. For instance, having a growth mindset has been linked with mastery-oriented responses to challenges and well-being (Dweck, 1986; Dweck, Chiu, & Hong, 1995; Howell, 2016), whereas having a fixed mindset has been linked with helplessness and vulnerability to negative feedback (Dweck, 1986; Dweck et al., 1995; Mangels, Butterfield, Lamb, Good, & Dweck, 2006). Furthermore, research has demonstrated a link between people's mindset and resilience to academic and social challenges, in which people with a growth mindset tend to view challenges as an opportunity for learning, whereas people with a fixed mindset tends to avoid challenges. Yeager and Dweck (2012) found that students with a growth mindset showed higher achievement across challenging school transitions and greater completion rates in challenging math courses.

When assessing people's mindset, research has been using the so-called Implicit Theories of Intelligence Scale (ITIS). This scale consists of several subscales with items rated on a 6-point Likert-type scale, from 1 (*Strongly Agree*) to 6 (*Strongly Disagree*). In the original version, only 3 items were included in the ITIS (Dweck et al., 1995). Today however, the 6- and 8-item ITIS are the most commonly used in the research literature concerning mindset. The items included differ between those associated with an entity theory (i.e., fixed mindset) and those associated with an incremental theory (i.e., growth mindset). For instance, an entity theory item can be "*You have a certain amount of intelligence and you really can't do much to change it*", whereas an incremental theory item can be "*You can always substantially change how intelligent you are*". To get a meaningful score that indicates which mindset the participant holds, the incremental scale items are reversed. As a result, when all items are summed, the higher average score indicates a greater amount of incremental beliefs about intelligence. The ITIS has demonstrated good internal consistency (α = .80 to .82), as well as good construct validity with scores predicting meaningful relationships with several variables (Dweck et al., 1995). Furthermore, the scale shows good discriminant validity against a range of variables (e.g., social desirability, intellectual ability, social-political attitudes, self-esteem). Finally, the Norwegian version of ITIS has also shown to be reliable, with Cronbach's α of .86 for entity items and .88 for the incremental items (Bråten & Strømsø, 2004).

Gender Differences

There appear to be few previous studies examining gender differences in mindset (or implicit theories). However, findings from an adult sample showed a small, but significant positive correlation with incremental theory of intelligence (i.e., growth mindset) for females (Spinath, Spinath, Riemann, & Angletiner, 2003). In other words, females were found to associate more strongly to a growth mindset than males. In contrast, Diseth, Meland and Breidablik (2014) found higher levels of growth mindset among boys compared to girls, but not in fixed mindset in both 11 and 13-year-old students. Interestingly, gender differences in mindset might also be examined in context of specific areas. For instance, studies have demonstrated that gender differences in math achievement exist among fixed mindset students. Specifically, Dar-Nimrod and Heine (2006) demonstrated that girls' mindset significantly affected the performance on a challenging math task. This was demonstrated by giving one of two explanations for the gender differences in math achievement to college females. One group was given a fixed mindset explanation, whereas the other group was given a growth mindset explanation. In both experiments, females who had received a fixed mindset explanation performed significantly worse than those who had received a growth mindset explanation. These studies suggested that females, in the context of match achievement, might be influenced by a fixed mindset. An interesting though is whether this also could be applied to gender differences in reading skills, and whether males' poor performance on reading skills compared to females might be influenced by a fixed mindset.

Relationship Between the Factors

As demonstrated above, several studies have demonstrated that gender differences might be present in reading skills, fine motor skills, visual processing abilities, grit and mindset. Considering these gender differences, this section will further investigate associations of fine motor skill, visual processing abilities, grit and mindset with reading skills.

Reading Skills and Motor Skills

Given that both reading and motor skills is trainable and follow the task-specificity principles of skill development and learning (Gottlieb, 1998, 2007; Edelman, 1993; Leversen et al., 2012; Sigmundsson et al., 2017), one might expect that the relationship between them is low. However, several studies have demonstrated associations of motor skills with reading skills. For instance, Sigmundsson, Englund and Haga (2017) examined the associations of motor competence and physical fitness with reading skills in children aged 9 to 12 years. Overall, they found low correlations between motor competence and reading, and low correlations between physical fitness and reading, in both age groups. Although some associations of motor competence and reading skills were present, the low correlations are consistent with the task-specificity principle of motor tasks (e.g., Haga et al., 2007; Leversen et al., 2012). Thus, Sigmundsson et al. (2017) argue that the low correlations further support the task-specificity principle of learning, i.e., what is trained develops (Sigmundsson et al., 2017). Furthermore, several findings suggest that there might exist a relationship between fine motor skills and reading skills. As previously mentioned, fine motor skills generally thought to be important for school readiness (Grissmer et al., 2010). However, findings from Son & Meisels (2006) demonstrated an association of early fine motor skills with both math and reading performance at the end of first grade. Furthermore, Cameron et al. (2012) examined the associations of various fine motor skills and executive functioning with kindergarten reading achievement. They found several fine motor skills to correlate with early reading achievement (e.g., phonemic awareness, reading comprehension and word-decoding). Interestingly, the fine motor task of symbol copying correlated more highly with word-decoding than with phonemic awareness and reading comprehension. Explanations for why a relationship between fine motor skills and reading skills exit is unclear. Suggate, Pufke and Stoeger (2019) proposed three possible explanations; 1) shared developmental and cognitive variables, 2) functionalism, and 3) shared internalized motor processes. On the other hand, this relationship can be understood from the fact that both skills are trainable and, thus, might relate to each other because of practice. In other words, individuals that practice reading skills might also practice fine motor skills, or vica versa. Nevertheless, more research is necessary to examine whether the relationship between fine motor skills and reading skills is also present at later ages. Considering the fact that task-specificity decreases with age (e.g., Haga et al., 2007; Leversen et al., 2012), one might argue that the relationship between fine motor skills and reading skills to increase with age. Finally, given the mentioned gender differences in fine motor skills, it would be interesting to examine whether the relationship between fine motor skills and reading skills differ between gender.

Reading Skills and Visual Processing Abilities

Based on Gottlieb's probabilistic epigenesis and Edelman's TNGS, the importance of practice is highlighted. Besides sufficient practice, however, the integrity of underlying abilities such as the visual system might be important for development and learning of reading skills. As previously demonstrated, visual processing abilities can be understood as visual dorsal and visual ventral functions. The importance of visual processing abilities can mainly be illustrated in the context of reading disability. Dyslexia are generally defined as "*a deficit in word-decoding*" (Vellutino et al., 2004), and the most common precursor to dyslexia is a deficit in phonological awareness. By appealing to the importance of grapheme-phoneme correspondence in word-decoding, the phonological deficit theory suggest that dyslexics have poorly specified phonological representations (Ramus et al., 2003). Specifically, if sounds are poorly represented, learning of grapheme-phoneme conversion (i.e., the alphabetic skill) will be affected. In support of this theory, dyslexic individuals show poor performance on tasks requiring phonological awareness. In addition, interventions focusing on the phonological skill have shown to be the most effective treatment for dyslexic children (Vellutino et al., 2004). However, the phonological deficit theory suffers from its inability to explain observation of both sensory and motor deficits in dyslexic individuals (Ramus et al., 2003), suggesting that deficits in phonological awareness might not be the only cause of reading difficulties.

Studies have demonstrated that poor reading skills in both typical and reading disabled individuals are associated with poor performance on coherent motion detection and other dorsal stream tasks (e.g., Livingstone, et al., 1991; Conlon, Sanders, & Zapart, 2004; Cornelissen et al., 1998). This had led to the influential, however, controversial, magnocellular dorsal deficit theory. The magnocellular-dorsal deficit theory deals with the assumption that reading disabled individuals are associated with impaired magnocellular-dorsal function. Specifically, Stein and Walsh (1997) argued that abnormal development of magnocellular-dorsal function lead to visual impairments through the dorsal stream connections with PPC, as PPC is involved in eye-movement control, visuospatial attention, and peripheral vision which should be important during reading. As previously mentioned, tasks of coherent motion thresholds are often used when examining the visual dorsal stream (Englund & Palomares, 2012). The use of motion detection can be supported by the fact that moving stimuli, including coherent motion, has shown to activate a subcortical region of the dorsal stream that are dominated by magnocells (i.e., V5/MT) (Skottun & Skoyles, 2006). In addition, lesion to V5/MT can lead to akinetopsia (i.e., inability to see movements) (Cornelissen et al., 1998). Although the relationship between magnocellular-dorsal functions and reading skills are mainly demonstrated in poor readers and reading disabled individuals, some studies has pointed towards a continuum of performance relating variation in magnocellular-dorsal function to variation in reading behavior (e.g., Cornelissen et al., 1998; Talcott et al., 2002).

Besides the relationship between visual dorsal functions and reading skills, the visual ventral stream has also shown to be important during reading. Specifically, IT cortex is widely accepted to involve areas in which visual word recognition takes place. Studies have demonstrated a region particularly responsive to visual words in the left fusiform gyrus, known as the Visual Word Form Area (McCandliss, Cohen, & Dehaene, 2003; Dehaene & Cohen, 2011). In contrast to studies using coherent motion detection when examining visual dorsal functions, other studies has also used coherent form detection when examining visual ventral functions (e.g., Englund & Palomares, 2012; Kevan & Pammer, 2008). For instance, Englund and Palomares (2012) demonstrated that both coherent motion thresholds and coherent form thresholds correlated with components of reading fluency. Specifically, they demonstrated that coherent motion thresholds correlated with reading rate and accuracy, which both improved with chronological age. However, when controlling for non-verbal abilities and age, reading accuracy significantly correlated with coherent form thresholds but not coherent motion thresholds in typically developing children. Kevan and Pammer (2008), on the other hand, demonstrated that children at risk for dyslexia had deficits in coherent motion thresholds, whereas no corresponding deficits were found in visual coherent form thresholds. In sum, more research is necessary to assess the importance of visual processing abilities (i.e., visual dorsal and visual ventral stream) to reading skills, especially at the whole spectrum of normal readers.

Considering gender differences in cerebral laterality (e.g., Shaywitz et al., 1995; Clements et al., 2006) in language-related tasks, and gender differences in visual processing, including motion thresholds (Johnston et al., 2016; Billino et al., 2008; Snowden & Kavanagh, 2006), one could argue that males and females might differ in the relationship between visual processing abilities and reading skills. Whether females and males differ with respect of the relationship between motion and form thresholds with reading is unclear. However, there is some studies that indicate differences in associations of visual stimuli with reading. For instance, Burman, Bitan, and Booth (2008) demonstrated differences between boys' and girls' dependency on sensory stimuli during language judgments. They found that girls language judgments depended on a common language network regardless of sensory stimuli, whereas boys depended more on a modality-specific network (Burman et al., 2008). Furthermore, to examine whether boys are more likely to handle reading based on visual modality, Huestegge, Heim, Zettelmeyer, and Lang-Kuttner (2011) assessed reading skills, visual-short-term memory, visual-long-term memory for details, and general non-verbal cognitive ability in primary school children. Surprisingly, there was no reading performance gap that favored the girls. In fact, boys performed better than girls in this study (Huestegge et al., 2011). However, several visual, non-verbal processes was associated with reading performance in boys, whereas this pattern was not observed in the girls (Huestegge et al., 2011). The presented findings suggest that gender differences in visual processing abilities exist, as well as in the association of visual processing with reading performance. Specifically, boys' reading performance seems to be more dependent on visual stimuli compared to girls. It would be interesting to examine whether there are gender differences in the association of visual dorsal and visual ventral functions with reading skills in young adults.

Reading Skills and Grit

As previously mentioned, several studies have demonstrated grit to be an important contributor to success in various domains, including academic achievements. For instance, in a study by Mulcahy-Dunn et al. (2018), both grit and self-control were found to be significant predictors of reading and mathematics performance. Specifically, grit was found to have a stronger association with reading performance than socioeconomic status, even after controlling for sex, region, and age. Furthermore, research has shown grit, as well as other "soft-skills" (e.g., self-control, self-confidence), to play a key role in determining students' success in school and beyond (Heckman & Kautz, 2012). The importance of grit regarding reading performance can also be understood as indirect. For instance, in Duckworth et al. (2011) study, they found deliberate practice (i.e., studying and memorizing words while alone) to better predict performance in the National Spelling Bee than being quizzed by others or reading for pleasure. Interestingly, however, grit was also found to significantly correlate positively with deliberate practice. Thus, they argue that perseverance and passion for long-term goals enables individuals to persist with practice activities that are less intrinsically rewarding, but more effective, than other types of preparation. Overall, there seem to be few studies examining the importance of grit at various reading skills, an whether the importance of grit on reading performance might differ between boys and girls. Considering that girls seem to read more and have a more positive attitude than boys (e.g., Coles & Hall, 2002; Logan & Johnston, 2009), and perform better than boys in reading-related tasks (Mullis et al., 2017; OECD, 2016), one could expect girls to have higher levels of grit than boys in the context of practicing reading skills in childhood and adolescence. Thus, examining whether females and males differ with respect to the relationship between grit and reading skills is of great interest.

Reading Skills and Mindset

As highlighted throughout this thesis, the influences of individual differences in reading skills is wide reaching in scope, including differences in both internal and external stimuli. However, as highlighted above, the relative new construct of grit might explain why some individuals practice more than others. In a similar vein, there has been more focus into the potential of implicit theories of intelligence and ability might have on academic outcomes (e.g., Blackwell, Trzesniewski, & Dweck, 2007). For instance, Petscher, Otaiba, Wanzek, Rivas, and Jones (2017) examined the dimensionality of general and reading-specific mindset. They found a global growth mindset that describes mindset connected to both general and reading skills. Furthermore, specific factors also emerged, including a general mindset regarding basic abilities, intelligence, and talents, and a reading-specific mindset regarding reading learning and achievement. Noteworthy, they found that students' global growth mindset and reading mindset were positively and significantly related to their achievement in reading comprehension and word-reading skill. In addition, global growth mindset and reading mindset were significantly related to reading comprehension over and above students' word-reading achievement. This was one of the first studies to demonstrate a unique relation of mindset and content-specific mindset to standardized, reading-specific measures. Moreover, Petscher et al. (2017) also examined whether the relation between mindset and reading achievement differed according to students' levels of reading skills. Specifically, they found that the relation between reading mindset and reading achievement was stronger for students with higher reading comprehension, whereas the relation between global mindset and reading comprehension was stronger among students with lower reading comprehension (Petscher et al., 2017). Thus, they argue that, for the lowest performing students, a stronger global growth mindset regarding their skills may be necessary to have the grit and perseverance needed to persist when progress in reading is challenging. On the other hand, at higher levels of reading achievement, a stronger reading-specific mindset may be needed for motivation and further improvement.

The relationship between mindsets and reading performance can also be examined in the context of reading interventions. For instance, Andersen and Nielsen (2016) showed that children of parents with fixed mindsets had lower reading skills, even when controlling for the child's previous skills and parents' socioeconomic status. Furthermore, they demonstrated that a reading intervention with a growth mindset approach increased children's reading and writing achievements and that this effect was strongest among children with parents who had a fixed mindset before the intervention. before the intervention had a fixed mindset (Andersen & Nielsen, 2016).

The Aim of the Current Study

In the current study, 61 Norwegian young adults were tested in reading skill, fine motor skill, visual processing abilities, and psychological resources. As evident in the presented research findings, several gender differences have been found in reading skills, fine motor skills, visual processing abilities, grit and mindset. Furthermore, several studies point towards associations of fine motor skills, visual processing abilities, grit and mindset with reading skills. Considering the possibility of existing gender differences in these factors, more research is needed to assess these relationships, as well as whether the relationships differ between gender. Thus, on the basis on previous findings, two research questions for the current study is proposed:

1. Whether gender differences in reading skills, fine motor skills, visual processing abilities, grit and mindset are present in young adults.
2. What is the associations of fine motor skills, visual processing abilities, grit and mindset with reading skills, and do these associations differ between gender.

Method

Participants

The sample consisted of 61 Norwegian young adults. The young adults mean age was 21.70 (*SD* = 2.40), and the overall range was 19 to 33 years. 47 females and 14 males participated. The females' mean age was 21.64 (*SD* = 2.52), and the males' mean age was 21.93 (*SD* = 2.06). All participants had Norwegian as their first language. Considering that this study aimed to assess a typical group of young adults, reading disabilities were not an exclusion criterion because such conditions are quite common in the population. In addition, all participants had normal or corrected-to-normal vision.

Procedure

Due to limited time and resources, a convenience sampling method was used when recruiting participants. This was mainly done by sending out registration forms in lectures and seminars at the Norwegian University of Science and Technology. Participants met up at the location for testing at a time and date suitable for the participants. Before testing, the participants were presented with an information sheet and consent agreement (see Appendix A), stating that that the participation was voluntary. They were also informed that it was anonymous and that they could refrain from answering or withdraw from the study at any point. The participants were tested in reading skill, fine motor skill, visual processing abilities, grit and mindset. To minimize any effects of order, the order of the tests was randomized as much as possible. The first thirty to participate in this study received a gift card of 100 NOK, whereas the rest received cookies and fruits as thanks for participating in the study.

Tests

Reading Skill

Reading skill was measured using the word-chain test (WCT) (Høien & Tønnesen, 1997). The WCT is a quick way of measuring speed and accuracy of word-recognition (Miller-Guron & Lundberg, 2000), and is a valid and reliable screening test of word-decoding skill (Gabrielsen & Lundetræ, 2013). Although the WCT is not a diagnostic test, a poor result on this test suggest further diagnostic testing.

The test includes 90 word-chains, where each chain consists of four familiar words, e.g., *brunkomsynalt* (browncamesighteverything), *mergjortbeinfrø* (moredonelegseed), *treoverlivse* (treeoverlifesee). During the WCT, participants are instructed to set three lines in each word-chain to divide them into four words (e.g., *brun | kom | syn | alt*), within the allocated time of four minutes. The words included are nouns, verbs, adjectives, adverbs, prepositions, or numerals. The participants score is equal to the amount of correctly marked word-chains, a maximum of 90.

Fine Motor Skill

To measure participants fine motor skill, one of the fine motor tasks from the Test of Motor Competence (TMC) battery was used (Sigmundsson et al., 2016), called *placing bricks*. For this test, one plastic board (i.e., Duplo plate 6x12) and 18 plastic bricks (i.e., Duplo Bricks 2x2) is required. The participants sit comfortably with the equipment arranged in from of her/him at the table. The plastic bricks are positioned in three horizontal lines next to the preferred hand and the plastic board is held on the table with the other hand. The participants were verbally instructed to hold duplo board with one hand and put the other hand next to the duplo bricks. At the signal, the participant picks up the bricks, one at a time, and places them at the board as quickly as possible. The time count start when the participant starts the movement of the first brick and stop when the last brick is placed on the motherboard. Although starting with the preferred hand, both hands are tested. The overall score was equal to the mean score when combining the time used with both hands.

Visual Processing Abilitijes

In measuring participants visual processing abilities, a computerized test, known as the Magno application (Wold, 2016), was used. This computerized test includes a coherent motion detection and a coherent form detection. As previously mentioned, motion and form thresholds are suggested to measure the visual dorsal and visual ventral stream (Englund & Palomares, 2012). The computer was placed in a calm environment at a place and time suitable for the participants. The participants were seated approximately 30 cm from the computer screen.

The coherent motion detection test displayed two patches, each containing 300 randomly placed dots. These patches were displayed in intervals. At each interval, one of the patches were randomly chosen to contain a coherent motion target. In the coherent motion patch, a percentage of dots would either move leftwards or rightwards, reversing every 0.57 seconds. The dots not moving coherently, will move at random, changing direction when colliding with other dots. To prevent the participants from following a single dot, 10% of the dots are destroyed after 0.086 seconds (Wold, 2016). The participants had to identify the patch with the coherent moving target during 5 seconds of animation. After the dots disappear, the participants can click on the patch they believe contained the coherent motion target, taking a guess if needed. Correct answer reduces the coherence (i.e., making the task harder), whereas wrong answer increases the coherence (i.e., making the task easier).

Similar with the coherent motion detection test, the coherent form detection also includes two patches. In the coherent form detection test, each patch contained 600 lined segments. They are oriented in concentric circles and in random orientations. The line segments forming circles are placed at the tangent of an imaging circle. As with the coherent motion detection test, one patch holds the target (i.e., circles) and noise, while the other patch only consists of noise. Which patch that contained the circle was random for each interval. The patches with stimuli had a animation time of 4 seconds

Grit

A Norwegian version of an 8-item short grit scale (Grit-S) (see Appendix B) developed by Duckworth and Quinn (2009) was used. The Grit-S was originally devised from a longer, 12-item scale (Grit-O) (Duckworth et al., 2007). Duckworth and Quinn (2009) recommended the short Grit-S over the longer Grit-O due to superior psychometric properties and simplicity. The scale consists of two subscales, Perseverance of Effort and Consistency of Interest. The Consistency of Interest subscale has demonstrated acceptable internal consistency with Cronbach's alpha ranging from .73 to .79, whereas the internal consistency is lower for the Perseverance of Effort subscale, with Cronbach's alpha ranging from questionable ($\alpha = .60$) to acceptable ($\alpha = .78$) (Duckworth & Quinn, 2009). Grit-S and Grit-O have previously been translated to Norwegian by sending (2014), using a parallel blind technique. Sending (2014) found a strong correlation ($r = .89$) between the Norwegian and English responses for bilingual respondents. Mean grit scores were also similar to those found in Duckworth and Quinn (2009). In addition, the relationship between Grit-S and the Grit-O remained the same in the Norwegian and English ($r = .96$).

Items on the Norwegian Grit-S are rated on a 5-point Likert-type scale, from 1 "*Ikke meg i det hele tatt*" (Not me at all) to 5 "*Veldig typisk meg*" (Very typical me), and include sentences such as "*Jeg mister ikke motet ved tilbakeslag/motgang*" (Setbacks don't discourage me) and "*Jeg setter meg ofte et mål, men bestemmer meg så for et annet i stedet*" (I often set a goal but later choose to pursue a different one). The participants scores were calculated such that higher score indicated higher levels of grit.

Mindset

A Norwegian version of Implicit Theories of Intelligence Scale (ITIS-8) was used to measure participants' mindset (see Appendix B). The four items used to measure participants' entity theory (i.e., fixed mindset) concerned the believe that intelligence is a fixed trait and something that cannot be changes, e.g., "*Du har en bestemt mengde intelligens, og du kan egentlig ikke gjøre mye for å endre den*" (You have a certain amount of intelligence and you really can't do much do change it). The four items used to measure participants incremental theory (i.e., growth mindset) focused on the belief that intelligence is controllable, that is, that individuals can become more intelligent trough effort, e.g., "*Hvor intelligent du er, er noe du alltid kan endre betraktelig*" (You can always substantially change how intelligent you are). The items focusing on either an entity or an incremental theory of intelligence were presented in a mixed order in the ITIS-8, and each item is rated on a 6-point Likert-type scale, from 1 "*Svært enig*" (Strongly agree) to 6 "*Svært uenig*" (Strongly disagree). To get a meaningful score that indicated which mindset the participants holds, the incremental scale items were reversed. As a result, when all items are summed, the higher scores indicate a greater amount of incremental beliefs about intelligence (i.e., growth mindset).

Statistical Analysis

For the statistical analysis, SPSS version 25.0 for Windows was used. Descriptive statistics and independent t-test was conducted to examine gender differences in reading skill, fine motor skill, coherent motion and form thresholds, grit and mindset. Furthermore, a Pearson product-moment correlation was used to investigate possible associations of fine motor skill, coherent motion and form thresholds, grit and mindset with reading skill. To analyze gender differences between the correlation coefficient, Fisher *r*-to-*z* was used. Statistical significance was set to $p < .05$

Results

Gender Differences

Descriptive statistics were derived for the whole sample, as well as for both females and males, to examine whether gender-related differences were present in the included factors (see Table 1). As previously mentioned, score on the WCT was measured as the number of solved word-chains, whereas placing bricks was measured as the average time used to fill out the duplo board with both hands. Furthermore, coherent motion and form thresholds was measured with the Magno application. Finally, grit and mindset were measured with a Norwegian version of Grit-S and ITIS-8, in which higher score indicated higher levels of grit and mindset. Descriptive statistics revealed that females performed slightly better at reading skill, fine motor skill, coherent form thresholds, grit and mindset, whereas males performed slightly better at coherent motion threshold. Further investigation with an independent t-test demonstrated that these differences were not significant (see Table 1 for significance level of mean differences between females and males).

Table 1

Number of participants (N) and means and standard deviations on the Word-Chain test (WCT), Placing Bricks (PB), the Coherent Motion and Form Thresholds (CMT & CFT), Grit-S (GS) and ITIS-8 (MS). P = Sig. (2-tailed) Independent t-test

Variables	Total (*n* = 61)		Female (*n* = 47)		Male (*n* = 14)		P
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	
WCT	63.54	10.77	63.81	10.24	62.64	12.77	.758
PB	21.18	2.10	21.17	2.13	21.23	2.05	.919
CMT	20.60	8.25	20.61	8.50	20.55	7.64	.978
CFT	6.12	1.59	6.04	1.59	6.39	1.61	.488
GS	3.50	0.54	3.55	0.55	3.34	0.50	.185
MS	3.97	1.04	4.05	1.00	3.71	1.16	.328

Relationship Between the Factors

A Pearson's (two-tailed) was conducted to examine the association of fine motor skill, coherent motion and form thresholds, grit and mindset with reading skill in the whole sample, in females, and in males. The correlation (Pearson's two-tailed) between fine motor skill (PB), coherent motion threshold (CMT), coherent form threshold (CFT), Grit-S (GS), ITIS-8 (MS) and Word-Chain Test (WCT) for the whole sample, for females, and for males are presented in Table 2.

When examining the correlations for the whole sample, for females and for males, the results of the Pearson correlation indicated that there was a significant negative association between performance on PB and WCT for the whole sample (r = -.390, n = 61, p = .002) and for females (r = -.364, n = 47, p = .012). Although not significant, the correlation was strongest among males (r = -.474, n = 14, p = .087).

Furthermore, there was no significant correlation between CMT and WCT in the entire group (r = .090, n = 61, p = .488), for females (r = .035, n = 47, p = .814), and for males (r = .268, n = 14, p = .354), as well no significant correlation between CFT and WCT in the entire group (r = .034, n = 61, p = 796), for females (r = -.035, n = 61, p = .843) and for males (r = .229, n = 14, p = .431).

In addition, the results found no significant correlation between GS and WCT in the entire group (r = .095, n = 61, p = .465), in females (r = .054, n = 61, p = .718) and in males (r = .200, n = 14, p = .494), and between MS and WCT in the entire group (r = -.106, n = 61, p = 4.17), in females (r = -.118, n = 61, p = .430) and in males (r = -.103, n = 14, p = .725).

Overall, there was a medium-to-large correlation between performance on the fine motor skill and reading skill in the whole sample, in females and in males. In other words, faster time used to complete the placing bricks task associated with more correctly solved word-chains. Furthermore, coherent motion and form thresholds, grit and mindset had low correlations with performance on WCT in the whole sample, in females and in males. Noteworthy, males demonstrated stronger associations of fine motor skill, coherent motion and form thresholds, and grit with reading skill. However, the Fisher r-to-z transformation found no significant differences between the correlation coefficients for females and males.

Table 2

Correlation (Pearson's Two-Tailed) Between CMT, CFT, GS, MS and WCT for the Whole Sample (N = 61), for Females (N = 47) and for Males (N = 14).

	WCT		
	Overall	Females	Males
PB	**-.**390*****	-.364*	-.474
CMT	.090	.035	.268
CFT	.034	-.030	.229
GS	.095	.054	.200
MS	-.106	-.118	-.103

Note. PB = Placing Bricks; CMT = Coherent Motion Threshold; CFT = Coherent Form Treshold; GS = Grit Score; MS = Mindset Score; WCT = Word-Chain Test.

Correlation is significant at the .05 level (p < .05, two-tailed)

Discussion

This study looked at gender differences in reading skill, fine motor skill, visual processing abilities, grit and mindset in young adults. Furthermore, this study also examined associations of fine motor skill, visual processing abilities, grit and mindset with reading skill, as well as whether these associations differed between females and males. The results found no significant gender differences in any of the included factors. However, as a result of an unbalanced sample of females and males, this were not surprising. Furthermore, only fine motor skill correlated significantly with reading skill, whereas the other factors had low correlations with reading skill. Interestingly, males demonstrated several correlations that were stronger than those of females and will be further investigated. Finally, because the current study used a correlational analysis on the data, the unique contribution of the factors onto reading skill are unknown.

Gender Differences

Reading Skill

The results from this study demonstrated no significant differences between females and males' reading skill in young adults, although females scored slightly better than males (i.e., females WCT = 63.81 vs. males WCT = 62.64). These findings are inconsistent with previous studies demonstrating gender differences in word-decoding and other aspects of reading skills at childhood and adolescence (e.g., Verhoeven & van Leeuwe, 2011; Savolainen et al., 2008; Mullis et al., 2017; OECD, 2016). On the other hand, these findings are supported by studies demonstrating little to no gender differences in young adulthood (e.g., Solheim & Lundetræ, 2016). Specifically, the absence of gender differences in young adults' word-decoding in the current study are in line with Hannon (2014), who also demonstrated no gender differences in adults' word-decoding skill. Noteworthy, Hannon (2014) found word-decoding to be more predictive of reading comprehension for males than females. Overall, the findings of this study further support the notion that gender differences in reading skills decreases or even disappear into young adulthood. Some explanations for why gender differences are so apparent in childhood and adolescence, but absent at later ages have been proposed. According to Solheim and Lundetræ (2016), the large-scale assessments (e.g., PIRLS and PISA) that are used to measure reading skills of children and adolescents, might be designed in a way that favors girls. Regardless whether PIRLS and PISA are designed in a way that favors girls, several studies have demonstrated gender differences in various reading- and verbal-related skills (e.g., Verhoeven & van Leeuwe, 2011; Savolainen et al., 2008; Huttenlocher et al., 1991; Puranik et al., 2013; Chipere, 2013). Thus, other explanations for why these differences decreases into young adulthood is needed. As previously mentioned, theoretical perspectives on development and learning (e.g., Gottlieb, 1998, 2007; Edelman, 1993) highlights the importance of experience. Bearing that in mind, gender differences in reading skills can be explained by differences in reading experience. In other words, boys might simply be lacking in reading experience compared to girls. This assumption is supported by studies demonstrating that girls read more frequently and have a more positive attitude towards reading than boys (e.g., Coles & Hall, 2002; Logan & Johnston, 2009). Thus, the absence of gender differences in young adults' reading skill, demonstrated in this study, might be a result of increased reading experience among males at later ages. In sum, these findings provide a positive outlook on gender differences in reading skills, illustrating that with adequate reading experience, both females and males exhibit the same possibilities of performance on reading skills.

Fine Motor Skill

Although females scored slightly better than males at fine motor skill (i.e., females PB = 21.17 vs. males PB = 21.23), these differences were not significant. This is contrary to previous studies demonstrating gender differences in various aspects of fine motor skills at both childhood and adolescence (e.g., Sigmundsson & Rostoft, 2003; Junaid & Fellowes, 2006; Valtr et al., 2016). On the other hand, these results are partly supported by studies demonstrating no gender differences in fine motor skills at adulthood when controlling for finger size (e.g., Peters & Campagnaro, 1996; Peters et al., 1990). These findings support the notion that gender differences in fine motor skills might be dependent on age (Hands et al., 2013), in which internal (e.g., strength and/or size) and external (e.g., experience) factors play important roles (Gottlieb, 1998, 2007; Edelman, 1993). Similar to gender differences in reading skills, differences between females and males' fine motor skills seems to be present at childhood and adolescence but decreases or even disappear into later ages. Thus, gender differences in fine motor skills might decrease into young adulthood as a result of more experiences with fine motor skills among males. Finally, the small gender differences in fine motor skills might also be understood from the fact that young adulthood is a period of life where motor skills are at its peak performance (Leversen et al., 2012; Sigmundsson et al., 2016).

Visual Processing Abilities

In addition, no significant differences were found in both coherent motion thresholds (CMT = 20.61, males CMT = 20.55) and coherent form thresholds (males CFT = 6.39, females CFT = 6.04). The absence of gender differences in coherent motion and form thresholds are both consistent and inconsistent with previous findings. For instance, these findings are similar to studies demonstrating no gender differences in coherent form thresholds (e.g., Johnston et al., 2016). In contrast, however, several studies have demonstrated gender differences in coherent motion thresholds (e.g., Johnston et al., 2016; Billino et al., 2008; Snowden & Kavanagh, 2006). Important implications have been suggested by studies demonstrating higher coherent motion thresholds among females than males have. For instance, these differences might provide explanations for one of the most common criticism regarding the association of visual deficit with reading disability, i.e., not all dyslexics demonstrate a visual deficit (Skottun & Skoyles, 2004). In other words, studies that find no associations of visual deficits with reading disability might not have taken gender into account. Explanations for gender differences in coherent motion thresholds can be viewed from post-mortem studies. Specifically, Amunts et al. (2007) demonstrated that a brain region known as hOc5, which is related to V5/MT, was significantly smaller in the left hemisphere of females than males. Thus, it is argued that left-right asymmetry might provide males with more neuronal resources for processing visual stimuli. Nevertheless, findings from this study demonstrated no gender differences in underlying visual processing abilities, including both coherent motion and form thresholds. A possible reason for the inconsistency between this study and previous findings demonstrating gender differences in coherent motion thresholds, is sample differences. For instance, Johnston et al. (2016) included a large number of dyslexics in their study, whereas both Billino et al. (2008) and Snowden and Kavanagh (2006) included a broad range of age, both young and old individuals. Thus, it might be possible that gender differences in visual processing abilities is related to age. Accordingly, Atchley and Andersen (1998) demonstrated that motion processes, as well as gender differences in motion processes differed as a function of age. Furthermore, Snowden and Kavanagh (2008) demonstrated that coherent motion thresholds increased with age. Thus, the current study’s small gender differences in coherent motion and form thresholds might be a consequence of the participants age.

Grit

Regarding gender differences in grit, the research literature is rather scarce, as well as inconsistent. The result from this study demonstrated no significant differences between females and males' levels of grit, although females had slightly higher grit scores than males (females GS = 3.55, males GS = 3.34). This is in line with previous studies that have indicated no gender differences in grit (e.g., Duckworth & Quinn, 2009; Bazelais et al., 2016). On the other hand, these findings are in contrast to studies demonstrating significant higher levels of grit among females compared to males (e.g., Christensen & Knezek, 2014, Jaeger et al., 2010). Similar to Duckworth and Quinn (2009), a major weakness of this study was the unbalanced sample of females and males. Interestingly, the mean differences between females and males' levels of grit in this study (i.e., mean difference = 0.22) mirrored the mean difference found in Christensen and Knezek (2014) study (i.e., mean difference = 0.20), which had an equal distribution of females and males. Thus, although not significant, some tendencies of gender differences in grit were present in this study, indicating that females might exhibit greater perseverance and passion for long-term goals. This might have important implications, as grit has shown to play a key role in determining students' success in school and beyond (Heckman & Kautz, 2012). Specifically, if females exhibit greater levels of perseverance and passion for long-term goals, this might explain why girls read more and have a more positive attitude towards reading than boys (Cole & Hall, 2002; Logan & Johnston, 2009) and, as a result, outperform boys on reading-related skills.

Mindset

Similar to grit, the research literature is rather scarce and inconsistent regarding gender differences in mindset. Inconsistent with previous studies demonstrating gender differences in mindset (e.g., Spinath et al., 2003; Diseth et al., 2014), this study found no significant differences between females' and males' mindset score. However, some tendencies were present. Specifically, females had a higher average mindset score compared to males (females MS = 4.05, males MS = 3.71). In other words, the results indicated some trends that females might possess a higher growth mindset than males, suggesting that females might perceive their own attributes as more malleable compared to males. These trends are consistent with Spinath et al. (2003) which demonstrated a relationship between growth mindset and women. On the other hand, these trends are inconsistent with studies demonstrating higher levels of growth mindset among boys than girls, but not in fixed mindset, in both 11- and 13-year-olds (Diseth et al., 2014).

Relationship Between the Factors

Reading Skill and Fine Motor Skill

The results from this study suggest a relationship between fine motor skill and reading skill in young adults for both females and males. More specifically, the correlation between placing bricks and word-chain test was significant in the whole sample (r = -.390) and for females (r = -.364), but not for males (r = -.474). Interestingly, however, the relationship between fine motor skill and reading skill was stronger among males than females. These findings are partly supported by previous studies that have found associations of motor skills and reading skills (e.g., Sigmundsson et al., 2017), and studies demonstrating associations of fine motor skills and reading skills (e.g., Son & Meisels, 2006; Cameron et al., 2012 et al., Suggate, Pufke, & Stoeger, 2016; Suggate et al., 2019). However, it is difficult to compare these findings across studies because of the diverse measurements used to assess the different factors. Given the task-specificity within cognitive and motor skills (e.g., Sigmundsson, Polman, & Lorås, 2013; Haga et al., 2007; Leversen et al., 2012), one could expect the relationship between fine motor skill and reading skill to be low. However, the relationship between fine motor skill and reading skill was medium-to-large in the whole sample, in females and in males. This is contrary to the low relationship between motor skills and reading skills found in Sigmundsson et al. (2017). Noteworthy, Sigmundsson et al. (2017) investigated this relationship in 9 and 12-year-olds. Thus, these results might further support the assumption that task-specificity decreases with age (Leversen et al., 2012).

Explanations for why a relationship between fine motor skills and reading skills exist is unclear. One possible understanding can be viewed from the fact that both fine motor skills and reading skills is trainable and requires adequate experience. In other words, experience with fine motor skills might associate with experience in reading skills. Specifically, Suggate et al. (2019) highlighted the functionalism of fine motor skill and argued that having greater fine motor skills might lead to more engagement in graphomotor activities (e.g., drawing and handwriting), which further increases reading experiences. Another explanation of the relationship can be viewed from shared development and cognitive functions. It has been suggested that there is a lot of evidence linking fine motor skills with cognitive functions, and that many of these cognitive functions are related to early reading development (Suggate et al., 2019). Furthermore, the relationship between fine motor skills and reading skills might exist because of shared internalized motor processes, which is supported by studies demonstrating that by involving fine motor skills with word-decoding skills improve word-decoding acquisition (Suggate et al., 2016, 2019). Findings demonstrating that word-decoding is a stronger predictor of reading comprehension among males than females (Hannon, 2014), and findings demonstrating that fine motor skills improve word-decoding acquisitions (Suggate et al., 2016), might describe why males had a stronger association of placing bricks and word-chain test in this study. Consequently, it could be possible that boys' poorer performance on fine motor skills compared to girls at childhood and adolescence (e.g., Sigmundsson & Rostoft, 2003; Junaid & Fellowes, 2006; Valtr et al., 2016) influence the acquisition of word-decoding skills, which is essential for reading comprehension.

Another contribution to the relationship between fine motor skills and reading skills might be shared underlying abilities, namely the visual system. As previously mentioned, visual magnocellular-dorsal function has been linked with reading skills, especially in reading disabled individuals (e.g., Livingstone et al., 1991; Cornelissen et al., 1995; Talcott et al., 2002). However, the visual dorsal stream is also important to carry out motoric actions (Goodale & Milner, 1992), and several studies have pointed out the importance of visual magnocellular-dorsal function with motor skills. For instance, Chakraborty et al. (2017) found associations of coherent motion thresholds with visual motor integration, motor coordination, gross motor and total motor scores, whereby lower coherent motion thresholds were associated with higher motor scores. Similar to studies demonstrating a magnocellular-dorsal deficit among reading disabled (e.g., Livingstone et al., 1991; Cornelissen et al., 1995, 1998), developmental coordination disorder (DCD) has been associated with visual deficits for both coherent motion and form detection (e.g., Sigmundsson, Hansen, & Talcott, 2003). Thus, it could be possible that the relationship between fine motor skills and reading skills is mediated by more underlying visual processing abilities.

In sum, to assess whether unique links between fine motor skills and reading skills exist, research needs to control for several variables, including shared developmental and cognitive variables, as well as graphomotor and handwriting skills. It is also worth mentioning that the measurements of fine motor skills and reading skills used in this study might share some similarities. Specifically, because the WCT requires the use of a pencil, this test involves forms of graphomotor skill. Thus, the strong relationship between fine motor skill and reading skill might simply be a result of the fact that both tasks requires aspects of fine motor skills. More research is necessary to examine the relationship between fine motor skills and reading skills, while also controlling for possible mediating factors.

Reading Skills and Visual Processing Abilities

Findings from this study demonstrated low relationships between visual processing abilities and reading skills. Specifically, the association of both coherent motion and form thresholds with WCT were low for the whole sample (CMT: r = .090, CFT: r = .034). These findings are inconsistent with assumption that reading performances increases with lower thresholds. Regarding the coherent motion threshold, these findings are inconsistent with previous studies demonstrating associations of coherent motion thresholds and reading skills in both normal readers (e.g., Conlon et al., 2004; Cornelissen et al., 1998; Englund & Palomares, 2012; Talcott et al., 2002) and in reading disabled (e.g., Cornelissen et al., 1995, 1998; Kevan & Pammer, 2008; Pellicano & Gibson, 2008). In context of coherent form thresholds, reflecting the visual ventral stream, these findings are inconsistent with previous studies demonstrating associations of coherent form thresholds with reading skills (e.g., Englund & Palomares, 2012). It is worth mentioning that there is no consensus about the causality of the relationship between visual processing abilities. However, the association seems to be more apparent and stronger when comparing poor readers with good readers (e.g., Conlon et al., 2004) or reading disabled with normal readers (e.g., Cornelissen et al., 1995). Thus, the absence of associations of visual processing abilities with reading skills in the current study might be a result of including the whole spectrum, and not comparing poor and good readers. Consequently, it might be possible that the relationship between visual processing abilities and reading skills is most apparent when comparing good vs. poor readers and reading disabled with normal readers, further supporting the assumption that reading difficulties is associated with visual deficits. Noteworthy, however, Cornelissen et al. (1998) demonstrated that the major effects of motion detection persisted even when removing reading disabled children. Thus, they argue that there is a continuum of performance relating variation in magnocellular-dorsal function to variation in reading skill. This is further supported by studies demonstrating that motion sensitivity is a predictor of orthographic skills (Talcott et al., 2002). Considering the fact that the findings of a continuum of visual processing abilities and reading skills (e.g., Cornelissen et al., 1998; Talcott et al., 2002) have been demonstrated in childhood, the current study might indicate that these associations decreases with age. In other words, young adults' reading skills is well-developed, and, thus, might not depend on visual stimuli as much as it does in childhood.

As previously mentioned, the prevalence of gender differences in visual processing abilities, especially in coherent motion thresholds (e.g., Johnston et al., 2016; Billino et al., 2008; Snowden & Kavanagh, 2006), might suggest that studies failing to find a link between visual processing abilities and reading skills have not taken gender into account. Similarly, the low association of coherent motion and form thresholds with reading skill in the whole sample might be explained by differences between females and males. Accordingly, the results demonstrated some tendencies that females and males differed in their associations of both coherent motion and form thresholds with WCT. Specifically, males demonstrated both stronger association of coherent motion and form thresholds with WCT (CMT: r = .268, CFT: r = .229) compared to females (CMT: r = .035, CFT: r = -.030). Most interesting, males demonstrated that performance on WCT associated with higher motion and form threshold, i.e., higher threshold for detecting motion and form correlated with higher performance on WCT. Again, these findings might be due to the participants age, in which both females and males reading skills is well-developed and does not necessarily associate with lower coherent motion and form thresholds. Nevertheless, the differences between females and males' associations of visual processing abilities with reading skills is interesting, indicating that males reading skills might be more dependent on visual stimuli compared to females.

Explanations for such differences might be considered in the context of laterality. As mentioned earlier, the fact that females have decreased laterality compared to males has led to the idea that males' brains are more optimized for intrahemispheric connectivity, whereas females' brains are betters suited for interhemispheric connectivity (Ingalhalikar et al., 2013). Specifically, this has been shown in language-related tasks, in which males' brain are more left lateralized during phonological tasks (e.g., Shaywitz et al., 1995; Clements et al., 2006). However, it is also possible that there are gender differences in lateralization within the visual system as well (Vanston & Strother, 2016). This can further be supported by Amunts et al. (2007) which demonstrated left-right asymmetry that might provide males with additional neuronal resources when processing visual stimuli. Considering the mentioned gender differences in brain development, cerebral laterality, and visual processing abilities, one could argue that males and females might depend on different brain regions during reading. Accordingly, the result from this study show a much stronger relationship between visual processing abilities and reading among males than females. This is consistent with previous studies demonstrating gender differences in the dependency of sensory stimuli during language judgments (e.g., Burman et al., 2008; Huestegge et al., 2001), and further supports the importance of visual stimuli during males' reading. Overall, the relationship between coherent motion and form thresholds and reading skills from the whole sample were surprising. However, when examining differences between females and males, males demonstrated stronger associations of both coherent motion and form threshold than females, in which both higher motion and form threshold correlated with higher performance on WCT. Considering these gender differences in associations of visual processing abilities, it could be argued that reading skills is more specific among females because of differences in brain development and lateralization, whereas males reading skills is less specific and more dependent on other factors such as visual processing abilities. If males' reading performance is more dependent on visual stimuli compared to females, gender differences in reading skills could be explained by influences of underlying visual processing abilities on males' reading skills.

Reading Skill and Grit

The results suggest that the relationship between grit and reading skill in young adults are low for both females and males. Given that grit might have importance on skills such as reading in terms of motivation and consistent practice and rehearsal, one could expect a relationship between grit and reading skills to be present. Thus, these results were surprising, as well as inconsistent with previous studies demonstrating associations of grit with academic success and reading performance (Duckworth et al., 2007; Eskreis-Winkler et al., 2014; Duckworth et al., 2011; Mulcahy-Dunn et al., 2018). A possible reason for the low relationship between grit and reading skill might be due to the relatively high average grit score in the whole sample (GS = 3.50). Thus, it could be argued that the participants in this study demonstrated a high level of perseverance and passion for long-term goals in general, making it difficult to determine whether grit is related to reading skill.

Although not significant, some tendencies of gender differences in the association of grit with reading skill were found. Specifically, males' performance on WCT were more strongly associated with levels of grit (r = .200), whereas this relationship was low among females (r = .054). In other words, males' reading skill increased more strongly with higher levels of grit, whereas this was low among females. These findings are interesting, suggesting that males reading skills might relate to their levels of grit, and could provide explanations for gender differences in reading skills. Considering boys poorer performance in reading skills compared to girls in childhood and adolescence, one might think that low levels of grit among boys could make it difficult for them to practice and engage in reading-related activities. Specifically, gender differences in reading skills at childhood and adolescence might be a result of low levels of grit among boys. Furthermore, the absence of gender differences in young adults' reading skill could be a result of males developing higher levels of grit, and, thus, having more motivation and perseverance to engage in reading activities. The fact that females demonstrated a low relationship between grit and reading skill might further indicate that females' reading skills is more specific and independent of other factors such as grit. In sum, more research investigating gender differences in grit and its association to reading skills at childhood and adolescence could provide useful insights into the prevalence of gender differences in reading skills.

Reading Skill and Mindset

Finally, the results found a low relationship between mindset and reading skill. In fact, mindset was negatively associated with performance on the reading skill. In other words, results from this study demonstrated that with higher levels of growth mindset, the poorer the participants did on the reading skill. This is surprising, and inconsistent with previous studies demonstrating associations of growth mindset with academic achievement and reading performance (e.g., Yeager & Dweck, 2012; Blackwell et al., 2007; Petscher et al., 2017). However, as previously mentioned, Petscher et al. (2017) used both general and reading-specific mindset when assessing the relationship between mindset and reading performance. Specifically, they found a global growth mindset that describes mindsets connected to both general and reading skills. Furthermore, they found specific factors, including a general mindset of basic abilities, intelligence, and talents, and reading-specific mindset in context of reading learning and achievement. In contrast, the current study measured a general mindset of intelligence. Thus, the negative and low relationship between mindset and reading skill might be a result of lacking specificity towards reading skill. Noteworthy, Petscher et al. (2017) argued that low performers in reading skills might benefit more strongly from a global growth mindset, whereas high performers in readings might benefit more strongly from a reading-specific mindset when reading is challenging. Thus, the high average score in WCT in the current study (WCT = 63.54) might explain why a general growth mindset did not relate to reading skill, and a more reading-specific mindset would be more fruitful to determine the relationship between mindset and reading skills. Future research examining the relationship between mindset and reading skill in young adults is, thus, recommended to use more reading-specific mindset.

No apparent gender differences in the association of mindset and reading skill were found, whereby females had slightly stronger association than males (females MS: $r = -.118$, males MS: $r = -.103$). However, given the fact that previous studies have demonstrated the importance of mindset interventions of several domains included gender differences (e.g., Dar-Nimrod et al., 2006), it would be interesting to investigate whether gender differences in mindset exist at childhood and adolescence, and whether boys are influenced by a fixed mindset regarding their reading skills.

Limitations in the Current Study

This study does not go without some limitations. The main weakness of this study is the small sample size and the unbalanced sample of females and males. With the aim of investigating gender differences, this study originally planned on having a close or equal number of females and males. However, this proved to be difficult in the process of collecting participants, whereby several failed to show up for testing or canceling for varying reasons. As a result, findings of gender differences in this study is difficult to interpret and generalize. Another limitation of the sample included in this study, is the fact that many of the participants were psychology students. As a result, some of the participants might exhibit theoretical knowledge about the current study. Furthermore, this study did not control for amount of reading experience and other demographic variables such as socioeconomic status. Finally, the fact that this study used a correlational analysis, this study cannot determine the unique contributions of fine motor skill, visual processing abilities, grit and mindset onto reading skill.

Conclusion

As illustrated, although gender differences in reading skills in childhood and adolescence is well established (Mullis et al., 2017; OECD, 2016), it is unclear whether these differences are present in young adulthood. Based on theoretical perspectives on development and learning (Gottlieb, 1998, 2007; Edelman, 1993), differences between girls' and boys' reading skills can be understood as differences in internal and/or external stimuli. Accordingly, several studies have demonstrated that girls read more frequently and have a more positive attitude towards reading than boys (e.g., Coles & Hall, 2002; Logan & Johnston, 2009). However, fine motor skills, visual processing abilities, and psychological resources such as grit and mindset has proven to be important on various areas that might be related to reading skills (e.g., school readiness, dyslexia, success, and academic achievements). Thus, this study aimed at investigating possible associations of fine motor skills, visual processing abilities, grit and mindset with young adults' reading skill, as well as whether there are gender differences within these factors.

Although several studies point towards gender differences in the included factors at various groups of age, this study found no significant gender difference in young adults' reading skill, fine motor skill, visual processing abilities, grit and mindset. In the context of reading skills and fine motor skills, these findings provide further support to the importance of adequate reading experience. More specifically, gender differences in both reading skills and fine motor skills might decrease or even disappear with age as a result of more experience with either reading- and fine motor activities among males. Furthermore, this study found no gender differences in visual processing abilities. Considering previous studies demonstrating that females and males might differ in visual processing abilities when examining wide age groups, the current findings might suggest that these gender differences are dependent on age. Thus, it would be interesting to investigate whether gender differences in visual processing abilities exist at different groups of age, including childhood, adolescence, adulthood, and old age. Although the differences between females and males grit and mindset score was not significant, some important tendencies were present, whereby females exhibit higher levels of both grit and mindset. These tendencies are highlighted as important as they might entail several implications for gender differences in reading skills.

Furthermore, the most prominent findings were the strong association of fine motor skill with reading skill. However, the causality of this relationship is difficult to determine, and several explanations has been proposed. Interestingly, the large relationship between fine motor skill and reading skill, especially among males, further supports the idea that task-specificity might decrease with age (Leversen et al., 2012). Moreover, low associations of coherent motion and form thresholds, grit and mindset with reading skill were found. Interestingly, however, males' reading skill were more strongly related to coherent motion and form thresholds and grit. Consequently, this might indicate that females reading skills is more specific than those of males. In sum, this study highlights several interesting tendencies that needs further elaboration, e.g., to which extent fine motor skills affect reading skills, differences between females and males' dependency on visual processing abilities during reading, and the importance of psychological resources such as grit and mindset on reading skills. The lack of gender differences in this study of young adults emphasizes the importance of experience (e.g., practice and rehearsal), suggesting that boys might simply need more reading experience in youth. Thus, the next question concerns how to increase boys' reading experience. Given the fact that grit and a growth mindset can provide individuals the motivation to persist with practice and rehearsal when faced with challenges, it could be fruitful to incorporate the construct of grit and mindset in teaching methods, whereby teachers can help children develop grit and growth mindset to improve their reading skills.

References

Abramov, I., Gordon, J., Feldman, O., & Chavarga, A. (2012). Sex & vision I: Spatio-temporal resolution. *Biology of Sex Differences*, *3*(20), 1-14. doi: 10.1186/2042-6410-3-20

Amunts, K., Armstrong, E., Malikovic, A., Hömke, L., Mohlberg, H., Schleicher, A., & Zilles, K. (2007). Gender-Specific Left-Right Asymmetries in Human Visual Cortex. *Journal of Neuroscience, 27*(6), 1356-1364. doi: 10.1523/JNEUROSCI.4753-06.2007

Andersen, S. C., & Nielsen, H. S. (2016). Reading intervention with a growth mindset approach improves children's skills. *PNAS*, *113*(43), 12111-12113. doi: 10.1073/pnas.1607946113

Atchley, P., & Andersen, G. J. (1998). The effect of age, retinal eccentricity, and speed on the detection of optic flow components. *Psychology and Aging*, *13*(2), 297-308. doi:10.1037/0882-7974.13.2.297

Barnett, L. M., van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2010). Gender Differences in Motor Skill Proficiency From Childhood to Adolescence. *Research Quarterly for Exercise and Sport*, *81*(2), 162-170, doi: 10.1080/02701367.2010.10599663

Bazelais, P., Lemay, D. J., & Doleck, T. (2016). How does grit impact college students' academic achievement in science? *European Journal of Science and Mathematics Education*, *4*(1), 33-43.

Behrmann, M., & Plaut, D. C. (2013). Distributed circuits, not circumscribed centers, mediate visual recognition. *Trends in Cognitive Sciences*, *17*(5), 210-219. doi: 10.1016/j.tics.2013.03.007

Billino, J., Bremmer, F., & Gegenfurtner, K. R. (2008). Differential aging of motion processing mechanisms: Evidence against general perceptual decline. *Vision Research*, *48*(10), 1254-1261, doi: 10.1016/j.visres.2008.02.014

Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit Theories of Intelligence Predict Achievement Across an Adolescent Transition: A Longitudinal Study and an Intervention. *Child Development*, *78*(1), 246-263. doi: 10.1111/j.1467-8624.2007.00995.x

Brabyn, L. B., & McGuinness, D. (1979). Gender differences in response to spatial frequency and stimulus orientation. *Perception & Psychophysics*, *26*(4), 319-324. doi: 0031-5117/79/100319·06$00.85/0

Breedlove, S. M. (1994). Sexual differentiation of the human nervous system. *Annual Review of Psychology*, *45*, 389-418. doi: 0066-4308/94/0201-0389$05.00

Bråten, I., & Strømsø, H. I. (2004). Epistemological beliefs and implicit theories of intelligence as predictors of achievement goals. *Contemporary Educational Psychology*, *29*(4), 371-388. doi: 10.1016/j.cedpsych.2003.10.001

Burman, D. D., Bitan, T., & Booth, J. R. (2008). Sex differences in neural processing of language among children. *Neuropsychologia*, *46*(5), 1349-1362. doi: 10.1016/j.neuropsychologia.2007.12.021

Cameron, C. E., Brock, L. L., Murrah, W. M., Bell, L. H., Worzalla, S. L., Grissmer, D., & Morrison, F. J. (2012). Fine Motor Skills and Executive Function Both Contribute to Kindergarten Achievement. *Child Development*, *83*(4), 1229-1244. doi: 10.1111/j.1467-8624.2012.01768.x

Central visual pathways. (2012). In: Purves, D., Augustine, G. J., Fitzpatrick, D., Hall, W. C., LaMantia, A., & White, L. E. (Eds), *Neuroscience*, pp. 257-274. Sunderland: Sinauer Associates, Inc.

Clements, A. M., Rimrodt, S. L., Abel, J. R., Blankner, J. G., Mostofsky, S. H., Pekar, J. J., Denckla, M. B., & Cutting, L. E. (2006). Sex differences in cerebral laterality of language and visuospatial processing. *Brain and Language*, *98*(2), 150-158. doi: 10.1016/j.bandl.2006.04.007

Chakraborty, A., Anstice, N. S., Jacobs, R. J., Paudel, N., LaGasse, L.L., Lester, B. M., … Thompson, B. (2017). Global motion perception is related to motor function in 4.5-year-old children born at risk of abnormal development. *Vision Research*, *135*, 16-25. doi: 10.1016/j.visres.2017.04.005

Chipere, N. (2013). Sex differences in phonological awareness and reading ability. *Language Awareness*, *23*(3), 275-289. doi: 10.1080/09658416.2013.774007

Christensen, R., & Knezek, G. (2014). Comparative Measures of Grit, Tenacity and Perseverance. International Journal of Learning. *Teaching and Eduational Research*, *8*(1), 16-30.

Coles, M., & Hall, C. (2002). Gendered readings: learning from children's reading choices. *Journal of Research in Reading*, *25*(1), 96-108. doi: 10.1111/1467-9817.00161

Conlon, E., Sanders, M., & Zapart, S. (2004). Temporal processing in poor adult readers. *Neuropsychologia*, *42*(2), 142-157. doi: 10.1016/j.neuropsychologia.2003.07.004

Cornelissen, P., Richardson, A., Mason, A., Fowler, S., & Stein, J. (1995). Contrast sensitivity and coherent motion detection measured at photopic luminance levels in dyslexics and controls. *Vision Research*, *35*(10), 1483-1494. doi: 10.1016/0042-6989(95)98728-R

Cornelissen, P. L., Hansen, P. C., Hutton, J. L., Evangelinou, V., & Stein, J. F. (1998). Magnocellular visual function and children's single word reading. *Vision Research*, *38*(3), 471-482. doi: 10.1016/S0042-6989(97)00199-5

Dar-Nimrod, I., & Heine, S. J. (2006). Exposure to Scientific Theories Affects Women's Math Performance. *Science*, *314*(5798), 435. doi: 10.1126/science.1131100

Dehaene, S., & Cohen, L. (2011). The unique role of the visual word form area in reading. *Trends in Cognitive Sciences*, *15*(6), 254-262. doi: 10.1016/j.tics.2011.04.003

D'Hondt, E., Deforche, B., Gentier, I., De Bourdeaudhuji, I., Vaeyens, R., Philippaerts, R., & Lenoir, M. (2013). A longitudinal analysis of gross motor coordination in overweight and obese children versus normal-weight peers. *International Journal of Obesity*, *37*, 61-67, doi:10.1038/ijo.2012.55

Diseth, Å., Meland, E., & Breidablik, H. J. (2014). Self-beliefs among students: Grade level and gender differences in self-esteem, self-efficiency and implicit theories of intelligence. *Learning and Individual Differences*, *35*, 1-8. doi: 10.1016/j.lindif.2014.06.003

Duckworth, A. L., & Gross, J. J. (2014). Self-Control and Grit: Related but Separable Determinants of Success. *Current Directions in Psychology Science*, *23*(5), 319-325, doi: 10.1177/0963721414541462

Duckworth, A. L., Kirby, T. A., Tsukayama, E., Berstein, H., & Ericsson, K. A. (2011). Deliberate Practice Spells Success: Why Grittier Competitors Triumph at the National Spelling Bee, Social Psychological and Personality Science, *2*(2), 174-181, doi: 10.1177/1948550610385872

Duckworth, A. L., Peterson, C., Matthews, M. D., & Kelly, D. R. (2007). Grit: Perseverance and Passion for Long-Term Goals. *Journal of Personality and Social Psychology*, *92*(6), 1087-1101. doi: 0.1037/0022-3514.92.6.1087

Duckworth, A. L., & Quinn, P. D. (2009). Development and Validation of the Short Grit Scale (Grit-S). *Journal of Personality Assessment*, *91*(2), 166-174, doi: 10.1080/00223890802634290

Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist*, *41*(10), 1040-1048. doi: 10.1037/0003-066X.41.10.1040

Dweck, C. S. (2012). Mindsets and human nature: Promoting change in the Middle East, the schoolyard, the racial divide, and willpower. *American Psychologist, 67*(8), 614-622. doi: 10.1037/a0029783

Dweck, C. S., Chiu, C., & Hong, Y. (1995). Implicit theories and their role in judgments and reactions: A word from two perspectives. *Psychological Inquiry, 6*(4), 267-285. doi: 10.1207/s15327965pli0604_1

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review*, *95*(2), 256-273. doi: 10.1037/0033-295X.95.2.256

Edelman, G. M. (1993). Neural Darwinism: Selection and reentrant signaling in higher brain function. *Neuron, 10*(2), 115-125. doi: 10.1016/0896-6273(93)90304-A

Englund, J. A., & Palomares, M. (2012). The relationship of global form and motion detection to reading fluency. *Vision Research*, *67,* 14-21. doi: 10.1016/j.visres.2012.06.020

Eskreis-Winkler, L., Shulman, E. P., Beal, S. A., & Duckworth, A. L. (2014). The grit effect: predicting retention in the military, the workplace, school and marriage. *Frontiers in psychology*, *5*(36), 1-12, doi: 10.3389/fpsyg.2014.00036

Flem, A., & Finbak, L. (2005). Skriftspråklige ferdigheter: lesing og skriving. In: Sigmundsson, H., & Haga, M. (Eds), *Ferdighetsutvikling – Grunnbok i utvikling av grunnleggende ferdigheter*, pp. 97-115. Oslo: Universitetsforlaget.

French, R. P. (2016). The fuzziness of mindsets: Divergent conceptualizations and characterizations of mindset theory and praxis. *International Journal of Organizational Analysis*, *24*(4), 673-691. doi: 10.1108/IJOA-09-2014-0797

Frith, U. (1985). Beneath the Surface of Developmental Dyslexia. In: Patterson, K., Marshall, J. C., & Coltheart, M. (Eds), *Surface Dyslexia*, pp. 301-330. London. Lawrence Erlbaum Associates.

Goodale, M. A., & Milner, A. D. (1992). Separate visual pathways for perception and action. *Trends in Neurosciences, 15*(1*),* 20-25. doi: 10.1016/0166-2236(92)90344-8

Gottlieb, G. (1998). Normally Occurring Environmental and Behavioral Influences on Gene Activity: From Central Dogma to Probabilistic Epigenesis. *Psychological Review, 105*(4), 792-802. doi: 10.1037/0033-295X.105.4.792-802

Gottlieb, G. (2007). Probabilistic epigenesis. *Developmental Science*, *10*(1), 1-11. doi: 10.1111/j.1467-7687.2007.00556.x

Gough, P. B., & Tunmer, W. E. (1986). Decoding, Reading, and Reading Disability. *Remedial and Special Educations, 7*(1), 6-10. doi: 10.1177/074193258600700104

Grissmer, D., Grimm, K. J., Aiyer, S. M., Murrah, W. M., & Steele, J. S. (2010). Fine motor skills and early comprehension of the world: Two new school readiness indicators. *Developmental Psychology, 46*(5), 1008-1017. doi:10.1037/a0020104

Haga, M. (2008). The relationship between physical fitness and motor competence in children. *Child: Care, Health and Development*, *34*(3), doi: 10.1111/j.1365-2214.2008.00814.x

Haga, M., Pedersen, A. V., & Sigmundsson, H. (2007). Interrelationship among selected measures of motor skills. *Child: care, health and development*, *34*(2), 245-248, doi: 10.1111/j.1365-2214.2007.00793.x

Hands, B., Larkin, D., & Rose, E. (2013). Reprint of 'The psychometric properties of the McGarron Assessment of Neuromuscular Development as a longitudinal measure with Australian youth'. *Human Movement Science*, *32*(5), 1163-1175. doi: 10.1016/j.humov.2013.08.003

Hannon, B. (2014). Are there gender differences in the cognitive components of adult reading comprehension? *Learning and Individual Differences 32*, 69-79. doi: 10.1016/j.lindif.2014.03.017

Heckman, J. J., & Kautz, T. (2012). Hard evidence of soft skills. *Labour Economics*, *19*(4), 451-464. doi: 10.1016/j.labeco.2012.05.014

Hendrix, C. G., Prins, M. R., & Dekkers, H. (2014). Developmental coordination disorder and overweight and obesity in children: a systematic review. *Obesity Reviews*, *15*(5), 408-423, doi: 10.1111/obr.1213

Holfelder, B., & Schott, N. (2014). Relationship of fundamental movement skills and physical activity in children and adolescents: A systematic review. *Psychology of Sport and Exercise*, *15*(4), 382-391, doi: 10.1016/j.psychsport.2014.03.005

Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading and Writing*, *2*(2), 127-160. doi: 10.1007/BF00401799

Howell, A. J. (2016). Implicit theories of personal and social attributes: Fundamental mindsets for a science of wellbeing. *International Journal of Wellbeing*, *6*(3), 113-130. doi: 10.5502/ijw.v6i3.529

Huestegge, L., Heim, S., Zettelmeyer, E., & Lange-Kuttner, C. (2011). Gender-specific contribution of a visual cognition network to reading abilities. *British Journal of Psychology, 103*(1), 117-128. doi: 10.1111/j.2044-8295.2011.02050.x

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991). Early Vocabulary Growth: Relation to Language Input and Gender. *Developmental Psychology*, *27*(2), 236-248. doi: 10.1044/1092-4388(2010/09-0216)

Høien, T., & Tønnesen, G. (1997). Håndbok til ordkjedetesten. *Stavanger, Norway: Stiftelsen, Dysleksiforskning*

Ingalhalikar, M., Smith, A., Parker, D., Satterthwaite, T. D., Elliott, M. A., Ruparel, K., … Verma, R. (2014). Sex differences in the structural connectome of the human brain. *PNAS*, *111*(2), 823-828. doi: 10.1073/pnas.1316909110.

Jaeger, B., Freeman, S., Whalen, R., & Payne, R. (2010). *Successful students: Smart or though?* Paper presented at 2010 Annual Conference and Exposition: Research on the First Year. American Society of Engineering Education.

Johnston, R., Pitchford, N. J., Roach, N. W., & Ledgeway, T. (2016). Why is the processing of global motion impaired in adults with developmental dyslexia? *Brain and Cognition*, *108*, 20-31, doi: 10.1016/j.bandc.2016.07.004

Johnston, R., Pitchford, N. J., Roach, N. W., & Ledgeway, T. (2017). New insights into the role of motion and form vision in neurodevelopmental disorders. *Neuroscience and Biobehavioral Reviews*, *83*, 32-45, doi: 10.1016/j.neubiorev.2017.09.031

Junaid, K. A., & Fellowes, S. (2006). Gender Differences in the Attainment of Motor Skills on the Movement Assessment Battery for Children. *Physical & Occupational Therapy In Pediatrics*, *26*(1-2), 5-11, doi: 10.1080/J006v26n01_02

Kevan, A., & Pammer, K. (2008). Visual deficits in pre-readers at familial risk for dyslexia. *Vision Research*, *48*(28), 2835-2839. doi: 10.1016/j.visres.2008.09.022

Kutner, M., Greenberg, E., Jin, Y., Boyle, B., Hsu, Y.C., & Dunleavy, E. (2007). *Literacy in Everyday Life. Results From the 2003 National Assessment of Adult Literacy* (NCES 2007-480). Washinton DC: U.S. Department of Education, National Center for Education Statistics. Retrieved 29 april from: https://nces.ed.gov/Pubs2007/2007480_1.pdf

Leversen, J. S. R., Haga, M., & Sigmundsson, H. (2012). From Children to Adults: Motor Performance across the Life-Span. *PloS ONE*, *7*(6), e38830, doi: 10.1371/journal.pone.0038830

Livingstone, M. S., Rosen, G. D., Drislane, F. W., & Galaburda, A. M. (1991). Psychological and anatomical evidence for a magnocellular defect in developmental dyslexia. *Proc Natl Acad Sci, 88*(18), 7943-7947. doi: 10.1073/pnas.88.18.7943

Logan, S., & Johnston, R. (2009). Gender differences in reading ability and attitudes: examining where these differences lie. *Journal of Research in Reading, 32*(2), 199-214. doi: 10.1111/j.1467-9817.2008.01389.x

Luo, Z., Jose, P. E., Huntsinger, C. S., & Pigott, T. D. (2007). Fine motor skills and mathematics achievement in East Asian American and European American kindergartners and first graders. *British Journal of Developmental Psychology*, *25*, 595-614, doi: 10.1348/026151007X185329

Mangels, J. A., Butterfield, B., Lamb, J., Good, C., & Dweck, C. S. (2006). Why do beliefs about intelligence influence learning success? A social cognitive neuroscience model. *Social Cognitive and Affective Neuroscience*, *1*(2), 75-86. doi: 10.1093/scan/nsl013

McGuinness, D. (1976). Away from a Unisex Psychology: Individual Differences in Visual Sensory and Perceptual Processes. *Perception, 5*, 279-294. doi: 10.1068/p050279

McCandliss, B. D., Cohen, L., & Dehaene, S. (2003). The visual word form area: expertise for reading in the fusiform gyrus. *Trends in Cognitive Science, 7*(7), 293-299. doi: 10.1016/S1364-6613(03)00134-7

Miller-Guron, L., & Lundberg, I. (2000). Dyslexia and second language reading: A second bite at the apple. *Reading and Writing: An interdisciplinary Journal*, 12(1-2), 41-61.

Mishkin, M., & Ungerleider, L. G. (1982). Contribution of striate inputs to the visuospatial functions of parieto-preoccipital cortex cortex in monkeys. *Behavioural Brain Research, 6*(1), 57-77. doi: 10.1016/0166-4328(82)90081-X

Mulcahy-Dunn, A., King, S. J., Nordstrum, L. E., Newton, E. O., & Batchelder, K. (2018). The relationship between grit, self-control, and early reading: a trail measuring soft skills in rural Tanzania. *Educational Psychology, 38*(8), 997-1009, doi: 10.1080/01443410.2018.1475628

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2017) *PIRLS 2016 International Results in Reading*. Retrieved from Boston College, TIMSS & PIRLS International Study Center website: http://timssandpirls.bc.edu/pirls2016/international-results/

Newell, K. M. (1991) Motor skill acquisition. *Annu. Rev. Psychol*, *42*, 213-237, doi: 0066-4308/91/0201-0213$02.00

OECD. (2016). *PISA 2015 Results (Volume I): Excellence and Equity in Education*, PISA, OECD Publishing, Paris. doi: 10.1787/9789264266490-en

OECD (2019), Reading performance (PISA) (indicator). doi: 10.1787/79913c69-en (Accessed on 29 April 2019)

Okely, A. D., Booth, M. L., & Patterson, J. W. (2001). Relationship of physical activity to movement skills among adolescents. *Medicine and Science in Sports and Exercise*, *33*(11), 1899-1904, doi: 10.1097/00005768-200111000-00015

Pellicano, E., & Gibson, L. Y. (2008). Investigating the functional integrity of the dorsal visual pathway in autism and dyslexia. *Neuropsychologia*, *46*(10), 2593-2596. doi: 10.1016/j.neuropsychologia.2008.04.008

Petscher, Y., Otaiba, S. A., Wanzek, J., Rivas, B., & Jones, F. (2017). The Relation Between Global and Specific Mindset with Reading Outcomes for Elementary School Students. *Scientific Studies of Reading*, *21*(5), 376-391. doi: 10.1080/10888438.2017.1313846

Peters, M., & Campagnaro, P. (1996). Do women really excel over men in manual dexterity? *Journal of Experimental Psychology: Human Perception and Performance*, *22*(5), 1107-1112. doi: 10.1037/0096-1523.22.5.1107

Peters, M., Servos, P., & Day, R. (1990). Marked sex differences on a fine motor skill task disappear when finger size is used as covariate. *Journal of Applied Psychology*, *75*(1), 87-90. doi: 10.1037/0021-9010.75.1.87

Polanen, V. V., & Davare, M. (2015). Interactions between dorsal and ventral streams for controlling skilled grasp. *Neuropsychologia*, *79(Part B)*, 186-191. doi: 10.1016/j.neuropsychologia.2015.07.010

Posner, M. I., & McCandliss, B. D. (1999). Brain circuitry during reading. In: Klein, R. M., & McMullen, P. (Eds) *Converging Methods for Understanding Reading and Dyslexia*. Massachusetts Institute of Technology.

Puranik, C. S., Petscher, Y., & Lonigan, C. J. (2013). Dimensionality and reliability of letter writing in 3- to 5-year-old preschool children. *Learning and Individual Differences, 28*, 133-141. doi: 10.1016/j.lindif.2012.06.011

Ramus, F., Rosen, S., Dakin, S. C., Day, B. L., Castellote, J. M., White, S., & Frith, U. (2003). Theories of developmental dyslexia: insights from a multiple case study of dyslexic adults. *Brain*, *126*(4), 841-865. doi: 10.1093/brain/awg076

Raudsepp, L., & Pääsuke, L. (1995). Gender Differences in Fundamental Movement Patterns, Motor Performance, and Strength Measurements of Prepubertal Children. *Pediatric Exercise Science*, *7*(3), 294-304, doi: 10.1123/pes.7.3.294

Rutter, M., Caspi, A., Fergusson, D., Horwood, L. J., Goodman, R., Maughan, B., … Carroll, J. (2004). Sex Differences in Developmental Reading Disability: New Findings from 4 Epidemiological Studies. *JAMA*, *291*(16), 2007-2012. doi: 10.1001/jama.291.16.2007

Savolainen, H., Ahonen, T., Aro, M., Tolvanen, A., & Holopainen, L. (2008). Reading comprehension, word reading and spelling as predictors of school achievement and choise of secondary education. Learning and Instruction, 18(2), 201-210, doi: 10.1016/j.learninstruc.2007.09.017

Schneider, G. E. (1969). Two visual systems. *Science, 163*(3870), 895-902. doi: 10.1126/science.163.3870.895

Shaywitz, B. A., Shaywitz, S. E., Pugh, K. R., Constable, R. T., Skudlarski, P., Fulbright, R. K., Bronen, R. A., Fletcher, J. M., Shankweiler, D. P., Katz, L., & Gore, J. C. (1995). Sex differences in the functional organization of the brain for language. *Nataure*, *373*, 607-609. doi: 10.1038/373607a0

Sigmundsson, H., Englund, K., & Haga, M. (2017). Associations of Physical Fitness and Motor Competence With Reading Skills in 9- and 12-Year-Old Children: A Longitudinal Study. *Research Article*, *7*(2), 1-10. doi: 10.1177/2158244017712769

Sigmundsson, H., & Haga, M. (2016). Motor competence is associated with physical fitness in four- to six-year-old preschool children. *European Early Childhood Education Research Journal*, *24*(3), 477-488, doi: 10.1080/1350293X.2016.1164411

Sigmundsson, H., Hansen, P. C., & Talcott, J. B. (2003). Do 'clumsy' children have visual deficits. *Behavioural Brain Research*, *139*(1-2), 123-129. doi: 10.1016/S0166-4328(02)00110-9

Sigmundsson, H., Lorås, H., & Haga, M. (2016). Assessment of Motor Competence Across the Life Span: Aspects of Reliability and Validity of a New Test Battery. *Article*, 6(1), 1-10, doi: 10.1177/2158244016633273

Sigmundsson, H., & Rostoft, M. S. (2003). Motor Development: Exploring the motor competence of 4-year-old Norewegian children. *Scandinavian Journal of Educational Research*, *47*(4), 451-459, doi: 10.1080/00313830308588

Sigmundsson, H., Polman, R. C. J., & Lorås, H. (2013). Exploring Individual Differences in Children's Mathematical Skills: A Correlational and Dimensional Approach. *Psychological Reports: Mental & Physical Health*, *113*(1), 23-30. doi: 10.2466/04.10.PR0.113x12z2

Sigmundsson, H., Trana, L., Polman, R., & Haga, M. (2017). What is Trained Develops! Theoretical Perspective on Skill Learning. Sport, 5(2), 1-11, doi: 10.3390/sports5020038

Sinding, V. (2014). *Thinking Success, Behavior Sucessfully: The Relation between Hypothetical Thinking Strategies, Effort towards Goal Attainment and Grit* (Master, UIT). Sending, V., Tromsø

Snowden, R. J., & Kavanagh, E. (2006). Motion Perception in the Ageing Visual System: Minimum Motion, Motion Coherence, and Speed Discrimination Thresholds. *Perception*, *35*(1), 9-24, doi: 10.1068/p5399

Skottun, B. C., & Parke, L. A. (1999). The Possible Relationship Between Visual Deficits and Dyslexia. *Journal of Learning Disabilities*, *32*(1), 2-5. doi: 10.1177/002221949903200101

Skottun, B. C., & Skoyles, J. R. (2006). Is coherent motion detection an appropriate test for magnocellular sensitivity? *Brain and Cognition*, *61*(2), 172-180. doi: 10.1016/j.bandc.2005.12.004

Skoyles, J., & Skottun, B. C. (2004). On the prevalence of magnocellular deficits in the visual system of non-dyslexic individuals. *Brain and Language*, *88*(1), 79-82. doi: 10.1016/S0093-934X(03)00162-7

Spinath, B., Spinath, F. M., Riemann, R., & Angleitner, A. (2003). Implicit theories about personality and intelligence and their relationship to actual personality and intelligence. *Personality and Individual Differences*, *35*(4), 939-951. doi: 10.1016/S0191-8869(02)00310-0

Solheim, O, J., & Lundetræ, K. (2016). Can test construction account for varying gender differences in international reading achievement tests of children, adolescents and young adults? – A study based on Nordic results in PIRLS, PISA and PIAAC. Assessment in Education: Principles, Policy & Practice, 25(1), 107-126, doi: 10.1080/0969594X.2016.1239612

Son, S-H., & Meisels, S. J. (2006). The Relationship of Young Children's Motor Skills to Later Reading and Math Achievement. *Merrill-Palmer Quarterly*, 52(4), 755-778.

Stein, J., & Walsh, V. (1997). To see but not to read; the magnocellular theory of dyslexia. *Trends in Neuroscience*, *20*(4), 147-152. doi: 10.1016/S0166-2236(96)01005-3

Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Roberton, M. A., Rudisill, M. E., Garcia, C., & Garcia, L. E. (2008). A Developmental Perspective on the Role of Motor Skill Competence in Physical Activity: An Emergent Relationship. *Quest*, *60*(2), 290-306, doi: 10.1080/00336297.2008.10483582

Suggate, S., Pufke, E., & Stoeger, H. (2016) Do fine motor skills contribute to early reading development? *Journal of Research in Reading*, 41(1), 1-19, doi: 10.1111/1467-9817.12081

Suggate, S., Pufke, E., & Stoeger, H. (2019). Children's fine motor skills in kindergarten predict reading in grade 1. *Early Childhood Research Quarterly*, *47*, 248-258. doi: 10.1016/j.ecresq.2018.12.015

Talcott, J. B, Witton, C., Hebb, G. S., Stoodley, C. J., Westwood, E. A., France, S. J., Hansen, P. C., & Stein, J. F. (2002) On the relationship between dynamic visual and auditory processing and literacy skills; results from a large primary-school study. *Dyslexia*, 8, 204-225, doi: 0.1002/dys.224

Tighe, E. L., & Schatschneider, C. (2016). Examining the Relationships of Component Reading Skills to Reading Comprehension in Struggling Adult Readers: A Meta-Analysis. Journal of learning disabilities, 49(4), 395-409. doi: 10.1177/0022219414555415

Uusen, A., & Müürsepp, M. (2012). Gender differences in reading habits among boys and girls of basic school in Estonia. *Procedia – Social and Behavioral Sciences, 69*, 1795-1804. doi: 10.1016/j.sbspro.2012.12.129

Valtr, L., Psotta, R., & Abdollahipour, R. (2016). Gender differences in performance of the Movement Assessment Battery for Children – 2nd edition test in adolescents. *Acta Gymnica*, *46*(4), 155-161, doi: 10.5507/ag.2016.017

Vanston, J. E., & Strother, L. (2016). Sex Differences in the Human Visual System. *Journal of Neuroscience Research, 95*(1-2), 617-625. doi: 10.1002/jnr.23895

Vedul-Kjelsås, V., Stensdotter, A., & Sigmundsson, H. (2013). Motor Competence in 11-Year-Old Boys and Girls. *Scandinavian Journal of Educational Research*, *57*(5), 561-570, doi: 10.1080/00313831.2012.732603

Vellutino, F. R., Fletcher, J. M., Snowling, M. J., & Scanlon, D. M. (2004). Specific reading disability (dyslexia): what have we learned in the past four decades? *Journal of Child Psychology and Psychiatry, 45*(1), 2-40. doi: 10.1046/j.0021-9630.2003.00305.x

Verhoeven, L., & van Leeuwe, J. (2011). Role of gender and linguistic diversity in word decoding development. Learning and Individual Differences, 21(4), 359-367, doi: 10.1016/j.lindif.2011.02.004

Wang, J. H-T. (2004). A Study on Gross Motor Skills of Preschool Children. *Journal of Research in Childhood Education, 19*(1), 32-43, doi: 10.1080/02568540409595052

Wold, B. H. (2016). *App for Early Detection of Dyslexia* (Master, NTNU). Wold, B. H., Trondheim.

Yeager, D. S., & Dweck, C. S. (2012). Mindsets that promote resilience: When students believe that personal characteristics can be developed. *Educational Psychologist*, *47*(4), 302-314. doi: 10.1080/00461520.2012.722805

Zoccolotti, P., & Pizzamiglio, L. (1986). Lateral Differences in Face Processing: Effects of Sex and Cognitive Style. In: Bruyer, R. (Ed) *The Neuropsychology of Face Perception and Facial Expression*, pp. 201-220. Lawrence Erlbaum Associates, Inc.

Appendix A: Information sheet and consent agreement

Norges teknisk-
naturvitenskapelig universitet
NTNU – Trondheim

Forespørsel om deltakelse i forskningsprosjekt:

Forholdet mellom lese- (ordavkoding) og motoriske (fin motorikk) ferdigheter med visuell prosesseringsevne, grit, og mindset i forhold til kjønn.

Vi gjennomfører et prosjekt som omhandler kjønnsforskjeller i ulike ferdigheter, og betydningen av underliggende evner, lidenskap, utholdenhet, og tankesett. Vi ønsker derfor å undersøke menn og kvinners lese- og motoriske ferdigheter, samt visuell prosesseringsevne, lidenskap, utholdenhet, og tankesett.

Deltakelsen innebærer å gjennomføre forskjellige tester. For testing av leseferdighet vil du/dere gjennomføre en ordkjedetest, som måler din ferdighet innenfor ordavkoding. Når det gjelder motorisk ferdighet, vil du/dere gjennomføre en fin motorisk test der dere skal plassere duploklosser på en overflate så fort som mulig. Test av visuell prosesseringsevne vil bli gjennomført på PC, og de som trenger linser eller briller må bruke det under denne testen. Mer informasjon angående testene vil bli gitt og demonstrert på testdagen.

Prosjektet er basert på frivillig deltakelse og du/dere kan når som helst trekke dere underveis og be om å få slettet deres data uten spørsmål, med mindre data er analysert og publisert. Innsamlede data vil bli behandlet konfidensielt og kun av de som er med på prosjektet. Data vil anonymiseres slik at det ikke er mulig å føre ting tilbake til dere som personer. Demografisk informasjon som du/dere vil bli spurt om inneholder alder og kjønn.

På grunn av begrenset tilgang til ressurser, blir det tilbudt et midtby gavekort på 100 kr til de 30 første deltakerne. De resterende vil bli servert kaffe og bolle.

Testene vil bli gjennomført på Dragvoll rom 12-483D og vil ta ca. 30 min, på en tid passende for deg.

Samtykkeerklæring

Prosjekttittel: Forholdet mellom lese- (ordavkoding) og motoriske (fin motorikk) ferdigheter med visuell prosesseringsevne, grit, og mindset i forhold til kjønn.

Jeg har lest informasjonsskrivet og er villig til å delta i prosjektet

………………….. …………. ……………………………

Sted Dato Underskrift

Appendix B: Grit-S and ITIS-8

1 Kjønn: ______________

2 Alder: ______________

3 Hva beskriver deg best:

◯ **Annet** ◯ **Forelder til elev eller student** ◯ **Ungdomsskolelev** ◯ **VGS-elev** ◯ **Student**

Grit –S (8-items):

Nå kommer det noen enkle spørsmål hvor du skal vurdere om det er ´typisk deg´ eller ´ikke i det hele tatt´

1 Noen ganger distraherer nye ideer og prosjekter meg fra tidligere prosjekter.

◯ **Veldig typisk meg**

◯ **Ganske typisk meg**

◯ **Litt typisk meg**

◯ **Ikke typisk meg**

◯ **Ikke meg i det hele tatt**

2 Jeg mister ikke motet ved tilbakegang/motgang.

◯ **Veldig typisk meg**

◯ **Ganske typisk meg**

- Litt typisk meg
- Ikke typisk meg
- Ikke meg i det hele tatt

3 Jeg har vært besatt av en bestemt ide eller prosjekt i en kort periode, men har seinere mistet interessen.

- Veldig typisk meg
- Ganske typisk meg
- Litt typisk meg
- Ikke typisk meg
- Ikke meg i det hele tatt

4 Jeg er arbeidsom.

- Veldig typisk meg
- Ganske typisk meg
- Litt typisk meg
- Ikke typisk meg
- Ikke meg i det hele tatt

5 Jeg setter meg ofte et mål, men bestemmer meg så for et annet isteden.

- Veldig typisk meg
- Ganske typisk meg

○ Litt typisk meg

○ Ikke typisk meg

○ Ikke meg i det hele tatt

6 Jeg har vanker med å beholde fokus på prosjekter som tar mer enn et par måneder å fullføre.

○ Veldig typisk meg

○ Ganske typisk meg

○ Litt typisk meg

○ Ikke typisk meg

○ Ikke meg i det hele tatt

7 Jeg fullfører alt jeg påbegynner.

○ Veldig typisk meg

○ Ganske typisk meg

○ Litt typisk meg

○ Ikke typisk meg

○ Ikke meg i det hele tatt

8 Jeg er flittig.

○ Veldig typisk meg

○ Ganske typisk meg

○ Litt typisk meg

- ◯ **Ikke typisk meg**
- ◯ **Ikke meg i det hele tatt**

ITIS (8-items)

Her kommer åtte uttrykk som du skal vurdere om du er enig eller uenig i. Svar så godt du kan. Det er ingen rette eller gale svar, vi er bare interessert i hva du mener

1 Du har en bestemt mengde intelligens, og du kan egentlig ikke gjøre mye for å endre den.

- ◯ **1- Svært enig**
- ◯ **2- Enig**
- ◯ **3- Stort sett enig**
- ◯ **4- Stort sett uenig**
- ◯ **5- Uenig**
- ◯ **6-Svært uenig**

2 Intelligensen din er noe ved deg som du ikke kan endre særlig mye.

- ◯ **1- Svært enig**
- ◯ **2- Enig**
- ◯ **3- Stort sett enig**
- ◯ **4- Stort sett uenig**
- ◯ **5- Uenig**
- ◯ **6-Svært uenig**

3 Uansett hvem du er, så kan du endre intelligensnivået ditt i betydelig grad.

- 1- Svært enig
- 2- Enig
- 3- Stort sett enig
- 4- Stort sett uenig
- 5- Uenig
- 6-Svært uenig

4 For å være ærlig, så kan du egentlig ikke endre hvor intelligent du er.

- 1- Svært enig
- 2- Enig
- 3- Stort sett enig
- 4- Stort sett uenig
- 5- Uenig
- 6-Svært uenig

5 Hvor intelligent du er, er noe du alltid kan endre betraktelig.

- 1- Svært enig
- 2- Enig
- 3- Stort sett enig
- 4- Stort sett uenig
- 5- Uenig

- 6-Svært uenig

6 Du kan lære nye ting, men du kan egentlig ikke endre din grunnleggende intelligens.

- 1- Svært enig
- 2- Enig
- 3- Stort sett enig
- 4- Stort sett uenig
- 5- Uenig
- 6-Svært uenig

7 Uansett hvor mye intelligens du har, så kan du alltid endre den en hel del.

- 1- Svært enig
- 2- Enig
- 3- Stort sett enig
- 4- Stort sett uenig
- 5- Uenig
- 6-Svært uenig

8 Selv ditt grunnleggende intelligensnivå kan du endre betraktelig

- 1- Svært enig
- 2- Enig

- ◯ **3- Stort sett enig**
- ◯ **4- Stort sett uenig**
- ◯ **5- Uenig**
- ◯ **6-Svært uenig**

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