Stockholm University

Writing in deaf and hard-of-hearing children

A bimodal bilingual perspective on their written products and writing processes

Moa Gärdenfors

Doctoral Thesis in Linguistics at Stockholm University, Sweden 2023

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Academic dissertation for the Degree of Doctor of Philosophy in Linguistics at Stockholm University to be publicly defended on Friday 12 January 2024 at 13.00 in sal G, Arrheniuslaboratorierna, Svante Arrhenius väg 20 C.

Abstract

This thesis presents unique insights into the written products and writing processes of Swedish deaf and hard-of-hearing (DHH) children using a keystroke logging tool. Writing processes encompass the activities (such as planning or revision) that writers engage in during the production of the written text. The thesis explores how the diverse backgrounds of these children, including age, gender, age of acquisition, hearing degree, and sign language proficiency, may influence their narrative texts. The study includes 58 children and adolescents aged 8–18, with varying degrees of hearing loss and linguistic backgrounds in spoken and written Swedish and Swedish Sign Language.

This research comprises four studies that collectively demonstrate that DHH children using hearing technology produce written products closely resembling those of children of deaf adults (CODA) and hearing children. The only notable exceptions are in terms of lexical density and text length, both of which may be associated with their reduced auditory input. The finding of few other differences is unique from an international perspective and may be attributed to the effectiveness of early interventions in the Swedish context which, for instance, include sign language courses for parents, bilingual schools, early hearing screening, and early cochlear implant operations. Regarding the writing process, DHH children exhibit a "here-and-now" planning strategy similar to same-age hearing peers. However, the DHH group shows distinctive patterns in writing fluency, with a more deliberate pace and a tendency to revise work more frequently. This writing behavior may be attributed to slower lexical retrieval and phonological challenges from their specific auditory backgrounds. Extensive local revisions and repeated spelling attempts, visible in the writing processes in the DHH group, may explain the minor differences between the DHH and the hearing groups in their written products.

When considering background factors, age plays a crucial role. DHH children follow a developmental trajectory similar to their hearing peers, albeit with slight delays, suggesting continuous development. Gender differences are observed, with girls demonstrating higher proficiency in writing. The age of acquisition does not predict writing outcomes, likely due to early linguistic input and support. Hearing loss predicts a higher cognitive load for DHH children in writing. The connection between spoken language and writing is less direct, which may explain why they need more time, effort and strategies to write. DHH children proficient in both sign and spoken languages seem to perform as well as or even better than their non-signing peers in writing tasks, producing more clauses and adjectives. The latter can be interpreted as a transfer from sign languages' inherently descriptive nature. This also indicates that sign language proficiency, along with spoken language, does not hinder written language development.

In summary, this thesis provides a comprehensive understanding of DHH children's written products and writing processes, highlighting the multifaceted effects of age, gender, age of acquisition, hearing degree and sign language proficiency. The thesis offers insights into the writing behavior and the strategies they employ and contributes to areas such as writing and bilingualism. Finally, the results may be of interest to parents, educators, and researchers seeking a deeper understanding of the writing of the DHH group.

Keywords: *DHH, CODA, cochlear implants, hearing aids, sign language, bilingualism, literacy, writing development, keystroke logging, writing fluency, revision, linguistic complexity, lexical density, lexical diversity, spelling, cross-linguistic influence, transfer.*

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My sister, Emmie Gärdenfors, is the talented artist behind the cover painting.
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Writers live twice.

Contents

Definitions

Definitions of important notions and abbreviations that are used throughout the text.

AoA **A**ge **o**f **A**cquisition refers to the age at which individuals learn their first language.

ASL **A**merican **S**ign **L**anguage.

CLI **C**ross-**L**inguistic **I**nfluence, also known as transfer, is a phenomenon in which an individual's knowledge in a language influences another language.

CI A **C**ochlear **I**mplant is a small electronic device that is surgically implanted in the inner ear to provide a sense of hearing to individuals with severe to profound hearing loss. A cochlear implant consists of an external component that captures sound and processes it into electrical signals, which are then transmitted to an internal component implanted in the cochlea. The internal component stimulates the auditory nerve directly, allowing the individual to perceive sound and speech. Cochlear implants are particularly beneficial for individuals who do not benefit sufficiently from hearing aids.

CODA **C**hildren **O**f **D**eaf **A**dults. Hearing children who in most cases use sign language at home with their deaf parents. CODAs are thus often bilinguals in a spoken and a signed language.

Deaf A **Deaf** individual is typically characterized by a complete or partial hearing loss. However, in this thesis, I have specifically defined "deaf" as an individual who not only lacks the ability to comprehend or use spoken Swedish due to insufficient hearing, but also relies on Swedish Sign Language as their primary mode of communication.

DHH **D**eaf and **H**ard-of-**H**earing. An overall definition of the group with any kind of hearing loss, whether if the individual is deaf, hard-of-hearing or a CI-user.

HA A **H**earing **A**id is a small electronic device designed to amplify and enhance sound for individuals with hearing loss. It is worn in or behind the ear and consists of a microphone to capture sound, an amplifier to increase the volume, and a speaker to deliver the amplified sound into the ear. The purpose of a hearing aid is to improve the individual's ability to hear and understand sounds, speech, and other environmental noises.

HoH A **H**ard-**o**f-**H**earing individual refers to these who have a partial hearing loss, which means they have some level of hearing loss but may still have residual hearing and some ability to perceive sounds. Hard-of-hearing individuals may use various forms of hearing technology to enhance their communication and auditory experience. The specific degree of hearing loss can vary among individuals.

HT **H**earing **T**echnology encompasses various technologies designed to enhance hearing, including devices such as hearing aids, cochlear implants, and more. Therefore, when I refer to the definition "DHH with HT" in this thesis, it specifically pertains to DHH children utilizing CI or HA.

STS **S**venskt **T**ecken**S**pråk (Swedish Sign Language).

List of Papers

I. **Gärdenfors M.,** Johansson, V., and Schönström K. (2019) Spelling in Deaf, Hard of Hearing and Hearing Children With Sign Language Knowledge. *Front. Psychol*. 10:2463. doi: 10.3389/fpsyg.2019.02463
(published November 12, 2019)

II. **Gärdenfors, M**. (2021) The Writing Process and the Written Product in Bimodal Bilingual Deaf and Hard of Hearing Children. *Languages* 6:85. doi: 10.3390/languages6020085
(published May 11, 2021)

III. **Gärdenfors, M.** (2023) Writing Development in DHH Students: A Bimodal Bilingual Approach. *The Journal of Deaf Studies and Deaf Education*. doi: 10.1093/deafed/enac045
(published December 14, 2022)

IV. **Gärdenfors M.,** and Johansson V. (2023) Written products and writing processes in Swedish deaf and hard of hearing children: an explorative study on the impact of linguistic background. *Front. Psychol*. 14:1112263. doi: 10.3389/fpsyg.2023.1112263
(published May 9, 2023)

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Acknowledgements

Someone said that the doctoral studies will pass in the blink of an eye. So it did. Still, this period has been the most enlightening years of my life.

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Sundbyberg, December 2023

Sammanfattning på svenska

Syftet med denna avhandling är att undersöka och beskriva de skriftliga produkterna och skrivprocesserna hos döva och hörselskadade barn med hjälp av ett tangentloggningsprogram som registrerar deras skrivbeteende i realtid (programmet kan bl.a. se hur snabbt barnen skriver, hur mycket de reviderar och var i texten de pausar med mera). Det sekundära syftet är att utforska förhållandet mellan barnens skrivfärdigheter och deras bakgrundsfaktorer, vilka inkluderar ålder, kön, ålder vid språkinlärning, hörselbakgrund och teckenspråkskunnighet. Totalt inkluderas 58 barn med olika hörsel- och språkbakgrunder mellan åldrarna 8 och 18 år. Dessa delas i fyra grupper: 1. Döva barn utan hörselhjälpmedel, 2. Döva och hörselskadade barn med hörselhjälpmedel (som använder hörapparat eller cochleaimplantat), 3. CODA-barn (children of deaf adults, dvs. hörande barn med döva föräldrar) och 4. Hörande barn utan teckenspråksfärdigheter.

Denna sammanläggningsavhandling består av fyra publicerade artiklar som tillsammans visar att när det gäller skrivna texter uppvisar gruppen med döva och hörselskadade med hörselhjälpmedel (2) få skillnader jämfört med CODA (3) och hörande jämnåriga (4). Resultaten är anmärkningsvärda när man betraktar dem ur ett internationellt perspektiv där man funnit att skrivande brukar vara mer utmanande för döva och hörselskadade barn.

Däremot skiljer sig texterna i lexikal densitet och textlängd. Att döva och hörselskadade barn (med och utan hörselhjälpmedel) generellt producerar kortare texter och har högre lexikal densitet (dvs. de producerar proportionerligt sett färre grammatiska ord) har påvisats i en rad tidigare studier. I avhandlingen diskuteras detta i termer av att barn med hörselnedsättning får en begränsad språkstimulans från svenskan och att de därför bland annat missar nödvändiga småord, vilket i sin tur ökar den lexikala densiteten i de skrivna texterna.

Den döva gruppen utan hörselhjälpmedel i åldrarna 10–11 (1), vilken bara undersökts i den första studien, skriver dels kortare texter och gör dels andra typer av stavfel än vad hörande barn gör. Vad gäller typerna av stavfelen kan det bero på att de, på grund av sin dövhet, förlitar sig på visuella strategier och ibland resulterar detta i överföringar från svenskt teckenspråk (STS). Bland annat kan ett teckens handform speglas i ett svenskt ord hos den döva gruppen. Ett exempel är att de skriver "rätt" istället för det avsedda ordet "rädd," eftersom tecknet för "rädd" utförs med ett handform som är utformad som ett T.

Dövgruppen har fler utmaningar i sitt skrivande jämfört med sina jämnåriga med hörselhjälpmedel. Trots detta visar den döva gruppen avancerade färdigheter i STS, vilket tyder på mycket etablerade kommunikationsförmågor, men att de ännu inte lärt sig att använda dem fullt ut i skrivandet.

Vad gäller skrivprocessen kan man se att de döva och hörselskadade barnen med hörselhjälpmedel i åldrarna 10–12 (2) har en ”här-och-nu” planeringsförmåga som också är typisk för hörande barn i samma ålder (3 och 4). Detta resulterar ofta i ett linjärt skrivbeteende. Jämfört med de hörande jämnåriga har däremot gruppen döva och hörselskadade barn med hörselhjälpmedel ett långsammare skrivflöde, fler avbrott (de skriver färre tecken- och ordsträngar innan de måste pausa), samt gör fler revisioner. Dessa skillnader kan bero på fonologiska utmaningar och att de tar längre tid på sig att hitta rätt ord, vilket antagligen är en direkt konsekvens av deras hörselnedsättning. Men deras omfattande lokala revideringar leder till något positivt och kan vara en orsak till att deras slutliga texter uppvisar så få skillnader jämfört med texterna hos hörande jämnåriga. Dock innebär ett intensivt revideringsbeteende en kognitiv belastning som ger mindre utrymme för andra skrivprocesser, vilket kan bli tungt i längden.

Gällande de undersökta bakgrundsfaktorerna spelar ålder en avgörande roll, där döva och hörselskadade barn med hörselhjälpmedel (2) uppvisar typiska utvecklingsmönster som påminner om dessa hos hörande (3 och 4), men med små fördröjningar. Detta visar att deras utveckling är kontinuerlig och inte avvikande. Vissa könsskillnader kan observeras, där flickor är skickligare skribenter. Förvånansvärt nog påverkar inte ålder vid språkinlärning skrivresultatet, vilket annars ofta varit ett återkommande resultat i internationella studier. Detta förklaras med att det svenska samhället erbjuder tidig intervention, inklusive tidiga hörselscreeningar, cochleaimplantat-operationer, tidig språkinput i form av teckenspråkskurser, talträning med mera.

Hörselbakgrund är ytterligare en variabel som tydligt påverkar den kognitiva belastningen hos döva och hörselskadade barn vid skrivandet. Ett fullhörande barn får under uppväxten enkelt den nödvändiga, talade språkliga inputen för att förstå ord, prepositioner, grammatik, och mycket mer. För döva och hörselskadade barnen med hörselhjälpmedel är språket inte lika tillgängligt, och de behöver ägna mer tid och ansträngning för att tolka ljuden och lagra språket och senare uttrycka det i skrift.

Samtidigt har STS positiva effekter på skriftspråket (barnen i avhandlingen genomgick ett teckenspråkstest) där teckenspråkiga döva och hörselskadade med hörselhjälpmedel producerar fler satser och adjektiv än deras jämnåriga döva och hörselskadade med hörselhjälpmedel men utan teckenspråkskunskaper. Detta kan bero på en typ av överföring från STS, eftersom teckenspråk ofta är deskriptiva till sin natur. Men eftersom studien också visar att teckenspråkiga och icke-teckenspråkiga döva och hörselskadade barn med hörselhjälpmedel för övrigt skriver likartade texter, tycks teckenspråk tillsammans med talat språk inte hindra skrivutvecklingen hos gruppen. Med tanke på att denna grupp har en hörselnedsättning kan det vara extra fördelaktigt att

de, utöver talat språk, också har goda kunskaper i STS. De kan därigenom luta sig mot teckenspråket när det talade språket inte räcker till. Med andra ord visar denna avhandling att teckenspråk tillsammans med talat språk inte påverkar skrivspråket negativt.

Sammanfattningsvis ger avhandlingen en övergripande förståelse av döva och hörselskadade barns och ungdomars (med och utan hörselhjälpmedel) skrivna texter och skrivprocesser, liksom effekterna av barnens ålder, kön, ålder vid språkinlärning, hörselbakgrund och kunskaper i svenskt teckenspråk.

1 Introduction

This thesis explores the distinct nature of writing among Swedish deaf and hard-of-hearing (henceforth, DHH) children and adolescents. Specifically, it explores their writing in two dimensions by analyzing their written products and investigating their writing processes using a keystroke logging tool. Additionally, the thesis explores the relationship between their writing abilities and various background factors, including proficiency in sign language.

Writing can be studied from a wide range of perspectives (e.g., Bazerman, 2016; MacArthur & Graham; 2016; Leu et al. 2016). For instance, sociocultural perspectives on writing and writing development are concerned with various elements such as writing artefacts (keyboards, pens, pencils, etc.), or the differences in social contexts in which writing is learned and used (classrooms, workplaces, social media, differences between countries and educational systems). This thesis, on the other hand, is interested in writing and writing development from a cognitive perspective, which involves studying aspects of writing that pertain to how the individual writer allocates cognitive resources to various sub-processes of writing. This thesis also has a particular interest in investigating how writing unfolds in real-time. The kind of writing in focus here is the narrow aspect of generating new text. Writing proficiency is further incorporated into the concept of literacy, which, in its fundamental definition, refers to the ability to read and write.

In other words, writing is not simply a linear process that leads to a final product, but rather a complex problem-solving activity that involves various iterative and simultaneous processes, such as planning, translating, and reviewing (Bereiter & Scardamalia, 1987; Hayes & Flower, 1980). This recursive switching between processes becomes more sophisticated with age and practice, which explains why young writers often produce more linear texts that may be experienced as less sophisticated and audience-adapted texts than those of older and skilled writers (Bereiter & Scardamalia, 1987; Chenoweth & Hayes, 2001). Young and second-language learners may also exhibit different writing behaviors compared to adults due to their limited ability to switch between writing processes recursively. These writers have not yet automatized all of the necessary processes required for a well-written text. However, over time, their low-level processes (such as transcribing, spelling, punctuation, grammar, and finding the right key) will become automatized and stored in long-term memory, freeing up space in working memory (Just &

Carpenter, 1992; McCutchen, 1996). Writers who have automatized basic processes can focus more on high-level processes such as planning, reading, and revising, which often lead to more mature texts (Chanquoy, 2001; McCutchen, 1996).

In the realm of writing, extensive research has been conducted. However, there is a missing piece in this puzzle — we know very little about how DHH children and adolescents write. Previous literacy studies on the DHH population has primarily focused on their reading proficiency, leaving a significant gap in our knowledge about their writing. Furthermore, the research landscape pertaining to bilingual DHH children, who are proficient in a sign language alongside a spoken and written language, is still largely unexplored, and when it has been investigated, it has been done with varying methods (see e.g., Bell et al., 2022; Hall & Dills, 2017; Hoffmeister & Caldwell-Harris 2014; Kuntze, 1998; Szarkowski, 2010).

This gap in our knowledge becomes even more pronounced when we consider the unique challenges faced by DHH individuals in acquiring linguistic skills. Their hearing loss influences the development of spoken language as their primary mode of communication (e.g., Traxler, 2000). These challenges are further complicated by access to language in general, specifically exposure to a sign language, which can affect their early language acquisition (e.g., Mayberry, 2006). For example, this effect can be manifested through communication barriers with hearing parents who may not have acquired sign language well enough to effectively communicate, or by insufficient exposure to a rich linguistic environment (e.g., Hall, 2017). Consequently, there is a risk that the development of their writing and reading skills will be delayed, potentially harming an already vulnerable and marginalized group characterized by lifelong delays and affecting not only their linguistic development but also their cognitive and social growth, as highlighted and discussed by numerous studies (Hall, 2017; Kermit, 2010; Mayberry, 1993; Szarkowski, 2018 and more).

Nevertheless, some existing research indicates that developing writing skills might pose greater difficulties for DHH individuals than speaking and reading skills. According to this research, these challenges stem from increased cognitive demands associated with writing tasks, which may hinder their ability to perform as proficiently as their peers in linguistic activities due to their hearing loss (Arfè, 2015; Breland et al., 2022). Some studies have proposed that early exposure to sign language can reduce these challenges and enhance literacy development of DHH children, as sign language does not rely on auditory input (Caselli et al., 2021; Cormier et al., 2012; Mayberry, 2007; Pontecorvo et al., 2023). In additional, research on the relationship between sign language proficiency and literacy in DHH individuals remains limited. Studies in this area vary widely in their methodologies, approaches, measures, and interpretations, with many overlooking the crucial variable of sign language knowledge (Hall & Dills, 2020; Mayer & Trezek, 2018). Consequently,

establishing generalizable implications for this group remains a complex challenge, particularly when considering from a bilingual perspective.

Turning the lens to writing in general, until recently, there was a restricted body of literature that delved into writing processes employing technology (e.g., Juzwik et al., 2006). While research on the effect of sign language on writing is scarce, there is also a limited body of work exploring writing processes using technology (e.g. Juzwik et al., 2006). These that especially include keystroke logging tools can offer crucial insights into individuals' writing behaviors, encompassing elements like writing speed, pause patterns, and revision strategies (Johansson et al., 2023; Wengelin & Johansson, 2023). A systematic review from 2006 to 2019 revealed approximately 200 keystroke logging studies (Lindgren et al., 2019), underscoring the emerging nature of this research area. To the best of my knowledge, only two peer-reviewed studies have employed keystroke logging tools on DHH children (Asker-Árnason et al., 2010; 2012). However, these studies did not incorporate sign language as a variable in their analyses. This underscores the novelty and the substantial potential of employing keystroke logging in writing research, especially when focusing on the DHH population and including sign language proficiency.

This thesis aims to fill gaps in previous research on the literacy development of the DHH population by examining their written products and writing processes. Understanding the complexity of the DHH group's writing, along with the influence of variables like age, gender, age of acquisition, hearing degree, and sign language, is essential for understanding the complex orchestration behind their literacy skills.

The thesis uses a descriptive and data-driven approach, which include bottom-up analysis of the DHH group’s written products and writing processes. This decision is rooted in the selection of diverse theoretical frameworks related to cognitive aspects of writing and bilingualism. The writing models encompass frameworks applicable to DHH, adult and young, experienced and inexperienced writers (Bereiter & Scardamalia, 1987; Chenoweth & Hayes, 2001; Hayes & Berninger, 2014; Hayes & Flower, 1980), alongside working memory theories (Just & Carpenter, 1992; McCutchen, 1996). The bilingual perspective used in this work includes the cross-linguistic influence (CLI) model (Jarvis & Pavlenko, 2008). Notably, the critical period hypothesis as well as age of acquisition (henceforth, AoA) by Lenneberg in 1967 will also be discussed alongside CLI.

The thesis is structured as follows. Chapter 1 presents the introduction, study aims and research questions as well as an overview of the DHH group in Sweden. Chapter 2 describes the theoretical models, including writing models and bilingual perspectives. Chapter 3 gives an overview of the research on writing in the general population. Chapter 4 provides a background of the literacy of the DHH group, encompassing both reading and writing skills. Chapter 5 outlines the methodology used in the thesis. Chapter 6 offers a summary of the papers. Chapter 7 discusses the results of the papers. Chapter 8 serves as the concluding chapter. Chapter 9 shows the references.

1.1 Study aims and research questions

The primary aim of this thesis is to investigate and describe the written products and writing processes of school-aged deaf and hard-of-hearing (DHH) children in Sweden. The secondary aim is to explore the relationship between their writing skills and their background factors, which include *age*, *gender*, *age of acquisition*, *hearing degree* and *sign language proficiency*. The research questions (RQ) are as follows:

1. What are the characteristics of the written products of DHH children in terms of text length, spelling, syntactic complexity and lexicon?

2. What are the characteristics of the writing processes of DHH children in terms of pauses, writing fluency, and revision behavior, and how can these be related to their written products?

3. What background factors influence the writing DHH children, and do those factors differ from those that influence their hearing writers?

4. Can patterns be observed in terms of transfer of linguistic knowledge from Swedish Sign Language (STS) into the writing of DHH children?

This thesis consists of four papers, each with a unique angle and focus, addressing one or more of the research questions presented above, and some of them may overlap across the papers.

In the first study (Paper I), the research delves into the spelling abilities of deaf as well as DHH children using hearing technology (HT), exploring their spelling attempts and considering the potential influence of their bilingualism and degree of hearing on their spelling skills. This study addresses research questions 1 (by investigating their spelling), 2 (by exploring their spelling behavior), and 3 (by examining the relationship between their backgrounds and spelling proficiency).

The second study (Paper II) focuses on bimodal bilingual children who are DHH with HT and CODA (children of deaf adults). The study controls for background variables to understand how they relate to writing. This study addresses research questions 1 (through an examination of written product), 2 (by investigating their writing process), and 3 (by exploring the relationship between their background variables and their writing).

The third study (Paper III) is a cross-sectional study that delves into the development of written products among the DHH population using HT, aged 8–18. Here, the focus remains on research questions 1 (by analyzing their written products) and 3 (exploring the relationship between their backgrounds, such as age, and their writing). This study enables a comparison of writing development across different age groups.

Lastly, the fourth paper (Paper IV) builds on the findings from Paper II, with a larger participant pool of DHH children using HT, and more in-depth writing process measures. This study provides a comprehensive analysis, examining research questions 1 (by exploring written product measures), 2 (by analyzing writing process measures), and 3 (exploring the relationship between their background variables and their writing).

Research question 4 (which focuses on transfer) aims to investigate the potential impact of STS on the writing skills of DHH children, based on the results from these four papers. By discussing possible patterns found in all the papers, this question seeks to uncover any observations or trends that show whether and how DHH children incorporate their knowledge of STS into their writing.

1.2 Deaf and hard-of-hearing children in Sweden — an overview

At the center of this thesis is the DHH[1] group and the investigation of their writing skills. To better understand the history and conditions for this group in the Swedish context, the thesis begins with an overview of the DHH group from the Swedish perspective, aiming to provide the reader with an approximate idea of how the situation for the DHH in Sweden has looked over the past few decades.

There is no official statistics over the number of DHH individuals in Sweden. However, it is estimated that approximately 1.5 million people have some form of hearing loss, which may range from partial to complete inability to hear sounds in one or both ears, resulting in a continuum of reduced to zero auditory perception (HRF, 2020). Among these are around 10,000 people who are born profoundly deaf, or who have become deaf early in life (SDR, 2022). This equates to 30–40 deaf children being born in Sweden every year (*Barnplantorna*, 2022). This deaf group, thus, belongs to a small minority in Sweden.

Like in other parts of the world, for decades, (many) DHH individuals in Sweden have been reported to face reading and writing challenges. There are

[1] Definitions for three distinct concepts, namely "**DHH**," "**DHH with HT**" (hearing technology), and "**deaf**," are provided here to prevent potential misunderstandings. The term "DHH" (deaf and hard-of-hearing) is a widely accepted term encompassing a diverse group of individuals with varying degrees of hearing loss, ranging from partial to total deafness. The term covers individuals both with and without hearing technology and serves as a central concept in this thesis. When referring to "DHH with HT," these are specifically individuals who are deaf or hard-of-hearing but utilize hearing aids or cochlear implants. They often exhibit varying degrees of proficiency in spoken languages and constitute the group that takes up the most space in this thesis. Finally, the term "deaf" specifically refers to the minority of individuals with profound deafness, often without the use of hearing technology. Typically, this group cannot rely on or comprehend spoken language. This group has also been studied, however, in a more limited scope within this thesis.

documentations about severe delays in reading and writing skills among DHH children from the 1800 to the 1980s, a period when sign language was prohibited in schools as the DHH children also faced a communication barrier with their hearing parents who, due to a lack of awareness, did not learn sign language well enough to effectively communicate with their DHH children (Svartholm, 1983, 2009, 2010). In this period, the DHH children's first contact with a (sign) language was often when they attended a school for the deaf at the age of 7, even if their teachers were instructed to not use sign language with their students in order to focus on their spoken language and comprehension development. Their first contact with sign language was, therefore, when they met older DHH peers at school who signed with them (Svartholm, 1983). The period without language until their schooling started, has led to the Swedish concept "the seven white years" (*de sju vita åren*) which refers to the period of limited language exposure in the years prior to the school start (Svartholm, 1983; 2009). Elderly DHH people in Sweden report in interviews that they experienced the period without language as traumatic. They shared personal stories of observing their parents packing their small clothes into suitcases, and, later, they were abandoned at a train station with no explanation. Other accounts included mothers accompanying them to the school, but then disappearing during dinner, as the teachers or staff advised the parents that a long farewell would be too painful (Jönköping University, 2021).

Ahlgren (1983), a pioneer in the research on the Swedish of DHH children, proposed that prior to the 1980s, more than 90% of Swedish DHH students struggled with learning written Swedish. Below is her account describing how written Swedish could be comprehended by a deaf child:

> Swedish is not sound for a deaf student, it is squiggles. […] If we want to explain that "!" and "I" are different kinds of squiggles while "o" and "b" are of the same kind, we have to do it without referencing to their different sounds. The squiggles are ordered from left to right in rows. Also, they are clumped together into groups that are ordered among themselves sometimes with, sometimes without spaces in between. The squiggles normally have no meaning of their own, but the groups do. There are rules for how the squiggles may be combined in groups. (Ahlgren, 1983, p. 84, my translation)

In contrast to many other countries that faced similar situations regarding their DHH children, much changed in Sweden around the 1980s, when Swedish researchers understood the importance of providing sign language as early as possible to DHH children (Svartholm, 1983). This resulted in an intervention, and a collaboration was initiated between researchers and teachers of a special school for DHH children. The researchers provided sign language classes not only for the children but also for their parents. The parents and children met at Stockholm University every weekend where they were provided sign language. The parents attended sign language classes, while other deaf adults looked after their DHH children in a signing environment. This

resulted in a longitudinal study in which the DHH children were followed by the researchers until their graduation from high school. The results were astounding – the DHH children with early access to STS outperformed their classmates who acquired STS later in life. The breakthrough and the understanding of early sign language proficiency on DHH children's school achievements resulted in a Swedish National Curriculum with a bilingual focus (including both Swedish and STS) in 1983 (Svartholm, 2010). This focus, in turn, had the result that it became more natural and accepted for hearing parents to learn STS to communicate with their DHH children.

From 1980 to the 2000s, almost every deaf child attended a bilingual school for the deaf in Sweden, in which they were educated in STS and written Swedish. In addition, in the 1990s, the parents of DHH children gained the right to attend to STS classes or camps for free while deaf and/or signing adolescents looked after their DHH children. If the parents would need to miss work to attend class, they would be economically compensated through CSN (The Swedish Board of Student Finance, *Centrala studiestödsnämnden*) controlled by the Swedish Government (SOU, 2016:46). This bilingual profile in Sweden became a role model for many other countries (Svartholm, 2010).

While traditional hearing aids, available for decades to assist individuals with residual hearing, are likely familiar to most, they may prove ineffective for those who are deaf or have severely damaged inner ears. In contrast, cochlear implants (CI) may be a better alternative for these people (NIDCD, 2022), enabling medicially deaf individuals to use and comprehend spoken language (SOU, 2016:46). More specifically, a CI is an advanced hearing technology that requires an operation and it consists of two parts: an implant with electrodes that are surgically placed behind the ear and inside the cochlea, and an external processor with a magnetic coil that catches sound and converts it into signals sent through the coil attached to the implant. The implant then sends electrical impulses that stimulate the auditory nerve, which carries the signals to the brain's hearing center, resulting in that the deaf people interpreting the impulses as sound (Akademiska sjukhuset, 2023). The pivotal advancements in CIs occurred around the year 2000 in Sweden.

Currently, about two decades later, more than 95% of Swedish children born deaf receive CIs as early as 5–12 months of age (Karolinska sjukhuset, 2023) so there is a small minority of DHH children who do not receive a CI for various reasons (only 1–2 of 30 deaf born children every year) (SOU, 2016:46). Several Swedish and international pediatric studies have suggested that early implantation (before 9–12 months) is not only associated with better speech outcomes, enabling children to communicate and comprehend spoken language (e.g. Dettman et al., 2016; Karltorp et al., 2019; SOU, 2016:46), but also associated with better reading and writing outcomes than their deaf peers without HT (e.g., Sarant, 2012). This result is probably the reason that implant age has dropped from 3–7 years in 1990–2000 to as early as 5–12 months (Karolinska sjukhuset, 2023). The result of early CI implantation is that the number of students attending a special school for the deaf halved between

2000 and 2013 (SOU, 2016:46). The latest estimate from 2016 was that 80% of all DHH attended mainstream classes, and the remaining 20% attended a special school for the DHH or were in a hard-of-hearing class (SOU, 2016:46).

The growing use of advanced hearing technology and its outcomes has resulted in many parents relying on the hearing technology for supporting their children's linguistic development. As a consequence, parents and families may not take actions to learn and use sign language as an additional or parallel means to communicate, and it has been suggested that many of today's children have no or limited signing skills (SOU, 2016:46). Yet a consequence is that more parents do not need quit or change work to move the whole family to be close to a deaf school, or to move their children alone to school dormitories to a new city so that the DHH child could attend a special school. Now their children are mainstreamed in hearing classes in their home town (Holmström, 2022; Schönström et al., 2021; SOU, 2016:46).

There is no nationwide documentation of the STS knowledge of the DHH students and their parents in Sweden today, however, Holmström (2022) collected survey data from 118 Swedish parents of DHH children with questions about their language backgrounds and language use at home. The majority (86%) reported that they could not sign before they learned that their children had a hearing loss. Holmström named this group "newly-signing parents", and out of this group, 35% of the parents estimated that they had no to limited knowledge of STS, 58% parents estimated that they had above-beginner to good signing knowledge, and the remaining 7% estimated that they had very good STS proficiency. But despite the fact that many parents were mastering sign knowledge, this study showed that spoken Swedish was the most dominant language used at home. Five newly-signing families reported that they used only STS with their DHH children. The other children, though, used spoken Swedish, or spoken Swedish combined with STS or sign-supported Swedish (or with other spoken languages).

Another Swedish study with a focus on the reading and writing abilities of DHH school students showed similar outcomes when the background information was collected from the children from the special school for the DHH. Schönström et al. (2021) collected reading, writing and language background data from 55 children and adolescents from 5th and 9–10th grades from four schools for the deaf or schools for hard-of-hearing children. The parents were provided a background questionnaire that included questions about their children's linguistic and hearing degree, their language use at school and at home, and various other factors. The majority (88%) of the children used some kind of hearing technologies such as CI, BAHA[2] or hearing aids (HA). Regarding language use at home, out of 33 parents, four replied that they used STS home with their DHH children, and seven parents reported using total communication (spoken Swedish supported by signs). The remaining 22 of 33

[2] Bone Anchored Hearing Aid, is a hearing technology that uses bone conduction to assist individuals with hearing loss by transmitting sound vibrations directly to the inner ear.

parents used spoken Swedish or other spoken languages with their DHH children. Eleven of the 33 parents reported that they have learned STS (to put this in context, eight of the signing parents were themselves DHH). Fifteen parents reported that they had learned "some STS", and seven parents had not learned it at all (Schönström et al., 2021). Both studies may indicate how the language situation looks at home in families with DHH children.

Today, the general view is that deaf and DHH children using HT have different starting points regarding their literacy development. A number of studies has suggested that even if both groups show delays, the children with CI or HA demonstrate more similar linguistic features found among hearing peers. These children with HT use more features from spoken languages, such as making phonologically plausible spelling errors (spelling a word as it sounds), producing more grammatically correct sentences as well as a larger vocabulary, while deaf children tend to demonstrate other kinds of spelling caused by visual strategies or sign language, omitting functional/grammatical words and may have a more limited vocabulary in their written texts (Bowers et al., 2016; Holcomb, 2023; Mayer et al., 2016; Singleton et al., 2004).

To summarize, the advancement of hearing technology has given DHH individuals a better opportunity to acquire spoken language, but this opportunity has also led to many of their parents choosing to place their DHH children in their home municipality instead of sending them to a special school for the DHH, or relocating the family to another city so that the DHH child can attend a special school. Another consequence is also that the children and their parents do not always learn sign language (SOU, 2016:46).

2 Theoretical models

This study aims to address gaps in the literature on writing in the DHH population by examining these written products and writing processes from a bilingual perspective. Given the diverse linguistic backgrounds of the children featured in this thesis, many of whom are bilingual in written/spoken Swedish and STS, it is crucial to apply relevant linguistic theoretical frameworks that encompass both writing and the complex backgrounds of DHH individuals.

This chapter centers on two main theoretical frameworks, firstly dealing with writing models and, secondly, dealing with bilingual perspectives. The first part of the chapter presents writing models that describe writing development in adults, and this discussion is followed by a subchapter that explores the significance of working memory in the context of writing. A framework applied to young or inexperienced writers, including DHH children, will be followed. The second part of this chapter deals with the bimodal bilingual perspective of the thesis. Here a particular focus is on the theory of cross-linguistic influence (CLI). In order to comprehensively address and understand the intricate backgrounds of DHH children, this chapter will also briefly touch upon the Critical Period Hypothesis and Age of Acquisition.

2.1 Writing models

Writing, or written language production, is a specific way of expressing oneself linguistically. Both written products (i.e. what readers meet as the result of writing) and writing processes (i.e. the actions the writer takes in order to produce a written text) are important study objects for examining language development. This section focusses on theoretical models describing writing processes. First, the general aspects of the models are addressed, and then models that attend to writing processes in young and/or inexperienced writers, which includes DHH children, will be discussed.

2.1.1 Writing processes in general

I will start with a theoretical framework on writers in general, which often are adult writers. Adults serve as a reference point to understand the unique characteristics in the writing development of young and inexperienced writers, including DHH children.

A seminal model of writing process composition was introduced by Hayes and Flower (1980) who identified three fundamental stages that occur during text production: *planning*, *translating* and *reviewing*. The authors proposed that these processes do not occur sequentially, but recursively or iteratively during the writing activity, that the writers repeatedly shift between these stages during a text composition. These processes are presented in detail in below.

The planning stage is when writers retrieve relevant information from long-term memory and apply it to their writing tasks to outline, organize and set purposes, goals and ideas of how to convey linguistic messages in the text, and plans for how these goals can be achieved.

It has been proposed that pauses are symptoms of planning (Goldman-Eilser, 1968; Hayes and Flower, 1980) which means that the cognitive effort in terms of pauses can indicate that a writer is planning – that is, formulating ideas, organizing content, conveying messages, making decisions regarding word choice and sentence structure, and evaluating the need for revision (Chanquoy, 2001; Matsuhashi, 1981; Spelman-Miller, 2006; Wengelin, 2006). It is however important to be aware of that not all pauses necessarily reflect planning activities, because pauses may also occur when a writer is evaluating the text-so-far, e.g., through reading what has been written. Also, writers can simply be looking away from the screen (e.g., Spelman-Miller, 2006; Van Waes et al., 2016).

Planning can be further divided into different kinds of planning, namely local and global planning. *Local planning* can be defined as "planning what to write next without any sense of the overall picture of the composition to be formed" (Sasaki et al., 2018, p. 294). *Global planning* can be defined as "overall planning of the content of the text to be written" (p. 294). Global planning, which involves a higher level of cognitive engagement, is often a prerequisite for producing more well-developed and audience-adapted written texts. As a result, young and inexperienced writers are more often engaged in local planning, which relies less on cognitive processes than the global planning commonly observed in adult writers. There is no age when young writers have reached this stage as it varies by individuals, but around the mid-adolescence has been suggested (Bereiter & Scardamalia, 1987).

The translating stage is the actual text generation, when letters are being written on paper or on screen, perhaps what a layman will understand as the actual act of writing, when the ideas from the planning stage are transformed to printed words readable for everyone. Hayes and Flower (198, p. 15) write that "[t]he function of the translating process is to take material from memory under guidance of the writing plan and to transform it into acceptable written English sentences." Berninger and Swanson (1994) built on the Hayes and Flower model and adapted the theoretical framework to developing writers, and divided the translation process into two subprocesses, namely text generating and transcription. Text generating is when ideas are transformed into linguistic representations and stored in the working memory. Transcription is

the same as Hayes and Flower's translation – that is, translating the text generates written symbols. But when there are disruptions in the processes, such as slower transition times (average time in seconds between two consecutive keystrokes within a word), or interruptions in writing flow (uninterrupted periods of writing measured in terms of the number of characters or seconds the writer uses to write before pausing or revising), it can mean that disfluency is present, revealing that the writers have not automatized their ability to translate and are possibly also struggling with a higher cognitive load (Chenoweth & Hayes, 2001; Van Waes et al., 2016; Olive & Cislaru, 2015).

The reviewing process is suggested to consist of two subprocesses, namely reading and editing/revising. Reading is an internal reviewing process that means that the writers read, evaluate, and make a decision about whether the text produced so far needs to be edited or not. In other words, some reviewing takes place within our minds before we even start writing. These internal revisions involve changes in our thoughts and ideas as we plan and formulate our intended message. The nature of these internal revisions makes them somewhat challenging to capture effectively. The second subprocess, editing/revising, happens when the writer makes any kind of physical of change to a text. This change can be anything from deleting or inserting a single character, word, sentence, up to and including a whole paragraph. Revisions can be either minor or major, or occur on a local or a global level (e.g., Chanquoy, 2001, 2009). Physical revisions are more readily captured because they involve physical changes that can be documented using tools like keystroke logging (Berninger et al., 1996; Fitzgerald, 1987; Hayes and Flower, 1980).

Taken together, these review and planning processes are suggested to be controlled by external factors such as the writing task, its topic and audience, and what knowledge the writer retrieves from their long-term memory that can be turned into their writing (Hayes & Flower, 1980). Reviewing is a complex and costly activity, as it competes with other cognitive processes, and is proposed to be established last of all the writing processes (Berninger et al., 1996).

2.1.1.1 Working memory

Understanding the importance of working memory is imperative; just as understanding the writing process, the theories surrounding working memory capacity and writing suggest that various cognitive processes compete for limited mental resources. However, a significant insight here is that as certain sub-processes become automatized, and in so doing, they free up cognitive space. This freed-up mental capacity can then be turned to more cognitively demanding writing tasks, potentially offering insights on how to help DHH children enhance their writing skills (Just & Carpenter, 1992; McCutchen, 1994, 1996).

McCutchen (1994) compared working memory capacity during writing to a switchboard operator who handles multiple calls and demands, and at the same time that all these tasks are being performed, all the relevant information

is being converted into transcribed text. With time and training, switchboard operators will automatize their skills and learn how to handle multiple calls and eventually become a skilled worker. However, each skilled switchboard operator was, once upon a time, an uncertain beginner feeling overwhelmed by multiple calls. These novice operators can be equated to young and immature writers learning how to handle all the processes in order to reach a well-written text. When the switch-board operators – or in this case, the writers – become overwhelmed, their workload increases, which may result in pausing during writing. This phenomenon occurs when the cognitive processes involved in the task are not fully automatized, and the cognitive effort required becomes more demanding, leading to a need for extended pauses. In simple terms, when our brains are not accustomed to a task and the mental effort that is required is too big for our working memory capacity, we tend to need breaks or pauses to manage and slowly navigate through the workload (McCutchen, 1994).

When young children are in the process of learning how to spell and transcribe, they may, based on their little orthographical knowledge, put a disproportionate of time and effort into transcribing and spelling a word correctly. This concentration may result in increased cognitive burden, and a consequence could be that the young children cannot continue or finish the writing task, such as making a grammatically correct sentence, so they need to find other solutions, such as choosing other words or drawing pictures (e.g., Baghban, 2007).

Two things that interact with working memory and the writers' writing experience can be thought of as low-level processes and high-level processes. Novice writers who are learning how to write are occupied with low-level processes (transcribing, spelling, punctuation, grammar, finding the right key etc.). But with time and age, the young writers' spelling and transcription ability will be automatized and stored in long-term memory, and they now can quickly and effortlessly retrieve words, which frees up space for them to focus on high-level processes (planning, reading, revising etc.; Chanquoy, 2001; McCutchen, 1996).

Poor transcription skills are a "bottle-neck" phenomenon – these children have a desire to convey linguistic messages, but are stuck because of their weak transcription skills and so they cannot progress in their writing. Having poor transcription skills can metaphorically be seen as a traffic jam on a busy highway. When multiple lanes merge into a single lane, the flow of cars becomes constrained and slower. Similarly, when faced with the writing process, various cognitive tasks (such as generating ideas, organizing thoughts, and composing sentences) converge into a limited capacity, creating a bottleneck that hinders the smooth progression of writing (Alves & Limpo, 2015; Berninger & Swanson, 1994).

Working memory plays a crucial role in various complex cognitive processes, including reasoning, problem-solving, and language comprehension. Just and Carpenter (1992) developed a capacity theory of language

acquisition, emphasizing the significance of working memory capacity size. The size varies among individuals, and a person's language understanding ability is influenced by their working memory capacity.

For individuals with a smaller working memory capacity, writing becomes a challenge because they can only focus on a limited amount of information at once, often neglecting other essential details necessary for completing the task effectively. This limitation can result in difficulties in remembering and comprehending content because these writers overload their working memory by processing linguistic information at the expense of understanding the non-linguistic message. Conversely, individuals with a larger working memory capacity find it easier to remember and manage multiple linguistic and non-linguistic information. Their expanded working memory capacity provides more space to process and retain information effectively.

2.1.2 Writing in inexperienced writers

While the original model of Hayes and Flower is based on the study of writing processes in adults with no reading or writing difficulties, Hayes and Berninger's (2014) model takes a more comprehensive approach, considering how various aspects of writing competence evolve over time, from childhood to adulthood. This recognition of the developmental trajectory in writing is a key feature of their framework, offering a detailed description of the writing process that includes several underlying processes and mechanisms that affect one's writing ability. In contrast to the original Hayes and Flower model, Hayes and Berninger's framework accommodates the distinct needs of various groups, including individuals with hearing loss, speech, or language disabilities, as well as both experienced and inexperienced writers.

Hayes and Berninger's (2014) model builds upon Chenoweth and Hayes' (2001) writing production model, and consists of three key levels, namely the *resource level*, the *process level*, and the *control level* (Figure 1). These provide a comprehensive framework for understanding and studying diverse writing behaviors.

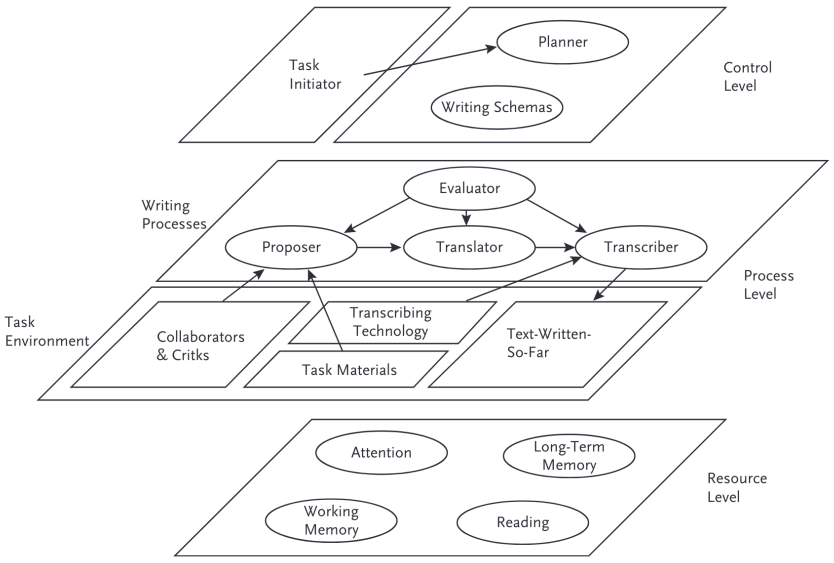

Figure 1. The three levels of writing production adapted from Hayes and Berninger's (2014) model of writing production (which is an expansion of the Chenoweth and Hayes (2001) model). *Borrowed with permission from Hayes and Berninger (2014), 'Cognitive Processes in Writing: A Framework.' The copyright notice included in the Licensed Material is hereby reproduced. This reproduction is conducted with permission from The Licensor through PLSclear. The license can be viewed at https://osf.io/jcrpw [retrieved 231017].*

The resource level in writing relies on the writer's attention, working memory, long-term memory, and reading skills. *Attention*, the ability to stay focused despite distractions, improves from childhood to adulthood, playing a crucial role in prioritizing writing tasks. *Long-term memory* stores essential knowledge, including events, facts, motor skills, and language abilities, all of which affect writing. *Working memory* stores task-relevant information but overloading it can reduce writing fluency and text quality. *Reading* and re-reading one's own text is a fundamental language skill for writers, especially in the revision process, so that one can judge the need for editing or revision.

The process level, the second part in this model, complements the resource level and can be divided into two components: the *writing process* and the *task environment*. Within the *writing process*, there are four sub-processes: the *proposer*, *translator*, *transcriber*, and *evaluator*. The proposer conveys ideas sourced from long-term memory, the task environment, the planner, or the existing text. These ideas are then transformed into language strings by the translator, and finally, the transcriber converts these strings into written text. The evaluator assesses the adequacy of these processes and may request revisions, dismiss ideas, or reject translated language strings. The translator's capacity is dependent on the writer's previous linguistic experience, and if it is

not sufficient, the writer may rely heavily on other sources such as dictionaries, or may decide to rephrase the text, resulting in a disfluency in writing. The translator's ability to apply grammar fully or produce longer linguistic strings will, thus, be limited if the writer is struggling with word retrieval and grammar, and such a struggle may impede the available cognitive resources, all of which can result in a writer trying to compensate a poor text with many revisions (see also Chenoweth & Hayes, 2001).

The second component of the process level is the *task environment,* which encompasses external factors like collaborators, critics (such as teachers and colleagues), task materials (e.g., dictionaries and writing assessment sheets), transcribing technology (handwriting or typing on a keyboard), and the existing written text.

The control level, the third process, comprises sub-processes *task initiation, planning,* and *writing schemas. The task initiator* can be a teacher, colleague, or the writers themselves, requesting the creation of a text. *The planner's* role is to set goals and generate ideas for the text. The final sub-process, *writing schema*, encompasses a writer's goals for the text, including genre knowledge and strategic knowledge. These schemas evolve as writers grow older and gain maturity, varying from one writer to another. The strategies within these schemas dictate the selection of writing processes, their functions, and their interaction with the context of the writing task.

There is no particular order to these processes, and how they progress can vary depending on the writers, their previous linguistic experience, and the task environment. However, an ability to repeatedly switch among the processes improves with the more linguistic knowledge.

Various factors should, however, be taken into account when it comes to DHH writers. Hayes and Berninger (2014) suggested that the resource level of DHH writers should cover the age at which their hearing loss was identified and the timing of interventions they received, such as learning sign language, having speech therapy, or receiving cochlear implants. These factors play a significant role in shaping their language development, which in turn has a profound impact on their vocabulary and syntactic complexity skills. Furthermore, the authors argued that the onset of deafness and the age at which hearing loss is identified can have a direct influence on the working memory system of DHH children. This working memory system is a critical component for writing at both the word and sentence levels. Therefore, it is essential to recognize that these factors constitute vital aspects of the resource levels of these children.

2.1.2.1 Knowledge-telling and knowledge-transformer strategies

This section presents an alternative view of the writing process, namely the *knowledge-telling* and *knowledge*-transformer strategies proposed by Bereiter and Scardamalia (1987) in their developmental model of writing, emphasizing the shift from passive knowledge sharing to active knowledge construction.

Young and inexperienced writers commonly exhibit a "think it, say it" behavior, a strategy known as the *knowledge-telling* approach, and this approach is especially beneficial for inexperienced writers. This method allows them to produce written text even when their linguistic abilities are not fully developed, and is particularly helpful for children in the early stages of writing development (as noted by McCutchen, 1996). In the knowledge-telling strategy, young writers primarily focus on what they want to express, often neglecting considerations like the perspective of their audience. This approach typically results in a linear process, reflecting the writers' initial phase of development. At this stage, their interest lies in topic and content, and although they may have ideas, their ability to organize and articulate them is limited due to incomplete skill automatization.

After the writers have acquired basic knowledge-telling strategies, they will free up cognitive space for more global and advanced writing activities, enabling them to proceed to the next strategy of *knowledge-transformer*, which is a more advanced strategy and usually used by experienced, often adult writers. This strategy is generally mirrored in longer writing time because it covers more advanced activities such as planning, organizing, and reviewing what has been written. More mature writers have thus learned to go beyond local revisions (such as spelling, grammatical correct words, correct punctuation, etc.) to revise globally (far from the inscription point) with the goal to reach formulations that meet their rhetorical and pragmatic goals. Unlike knowledge-tellers, knowledge-transformers understand what their written text actually says to the reader, and these writer can therefore improve their content (Bereiter & Scardamalia, 1987).

2.2 Bilingual perspectives

We now turn to language acquisition research, and theories about bilingualism and the significance of early language exposure in order to comprehend factors underlying language acquisition in DHH children, including theories of Cross-Linguistic Influence (CLI) and Critical Period Hypothesis/Age of Acquisition (AoA).

2.2.1 Cross-Linguistic Influence (CLI) and transfer

Cross-Linguistic Influence (CLI), also known as transfer, is a phenomenon in which a person's first language (L1) influences their second language (L2) during language acquisition. CLI operates on various linguistic levels, including phonology, orthography, lexicon, semantics, morphology, and syntax, as well as discoursal, pragmatic, and sociolinguistic levels. It is suggested that transfers can take place in multiple directions, from L1 to L2, L2 to L1, L2 to L3, and so on. The nature and occurrence of these transfers are highly

individualistic and influenced by the learner's prior language knowledge (Ringbom, 2007; Jarvis & Pavlenko, 2008).

When considering the transfer of patterns between similar languages, it becomes challenging to differentiate between the influence of L1 and L2. Second language learners often prioritize identifying similarities between their languages rather than differences, particularly in the early stages of learning. Similarity of languages influences the transfer process, where learners draw from their previous linguistic knowledge. For example, Finnish speakers whose language is more distantly related to English than Swedish is to English may leverage their knowledge of Swedish when learning English (Jarvis & Pavlenko, 2008).

However, comparing a sign language to a written/spoken language, more differences than similarities emerge. Sign languages rely on visual communication through gestures and facial expressions, while spoken languages are primarily auditory-visual. These differences can lead to omissions and substitutions in spoken language by bilinguals who know both sign and spoken languages. Deaf individuals with prior sign language proficiency find it easier to learn new sign languages due to shared fundamental characteristics among sign languages (Schönström & Holmström, 2022).

In sum, CLI operates on various linguistic levels and is more identifiable when languages are dissimilar. Its occurrence is highly individual and influenced by unpredictable factors.

2.2.2 Critical Period Hypothesis and Age of Acquisition

One background factor that plays a significant role in literacy development among DHH children is the critical period hypothesis, however, as measured through age of acquisition (AoA) (Lenneberg, 1967).

Language development, like other biological processes, is thought to have critical periods, which denote specific windows of time in early development when the brain is most receptive to language acquisition (Lenneberg, 1967). Lenneberg argued that language is an innate ability controlled by biological factors (particularly brain maturation) during specific developmental windows, typically from infancy to early puberty. During this time, children acquire language rapidly and effortlessly without explicit instruction, and follow similar developmental milestones regardless of their language background. This pattern suggests that language development is primarily driven by biological factors rather than environmental influences. The critical period hypothesis is closely linked to AoA which refers to the age at which the children learned their *first* language. If a child learns a language from birth, their AoA is 0 years, and if they start learning their first language later, such as at age 6, their AoA for that language is 6 years (Lenneberg, 1967). This thesis uses AoA as one of the variables to predict the writing outcomes.

Most previous research has focused on age of acquisition of a *second* language and report that age of acquisition matters and that there is a critical

period for age of acquisition; the earlier acquisition of the second language, the more native-like the individual will be (Birdsong & Molis, 2001; Johnson & Newport, 1989).

It has been suggested that the critical period for L2 acquisition may start in infancy and end in early childhood. During this period, the brain is highly plastic and optimized for language acquisition, allowing children to acquire language skills easily and naturally. Children who are exposed to a second language during this critical period are more likely to achieve native-like proficiency (Birdsong & Molis, 2001; Johnson & Newport, 1989).

But when the AoA of language learning is delayed, which is often the case for many deaf children who are not exposed to sign language or spoken language within the critical period, often due to the fact that their parents cannot sign, language development will be jeopardized (Glickman & Hall, 2018). The timing of cochlear implantation or advanced hearing technology is also critical. Early implantation provides a better chance for appropriate development of the neural pathways for auditory processing, leading to improved speech and language development. This explains why children receiving cochlear implants as early as 6 months have better results than those receiving them at age 1 or later (e.g., Colletti et al., 2012; Karltorp et al., 2019).

In sum, the Critical Period Hypothesis and AoA suggest that there is a specific window during early childhood when the brain is most receptive to language acquisition. If language exposure does not occur during this critical period, children's language development may be negatively affected.

3 Writing development

Continuing from the of theoretical models presented in the previous chapter, the upcoming first part of this chapter provides a research overview of writing in the general population. Subsequently, the following part of this chapter will outline the body of research specific to the DHH population. The reason for beginning with writing studies of the general population is simply because research on hearing children is more extensive. This approach allows for a fundamental understanding of writing processes and outcomes in the general population, which will serve as a crucial reference point when exploring the writing of DHH children.

3.1 Studying writing through the written product

In the realm of writing, we distinguish between two fundamental elements: *written products* and *writing processes*. Written products encompass the final, visible outcomes of writing, such as essays, articles, and reports. These products can, for example, offer insights into writing development, illustrating how texts become more complex as writers grow older. In contrast, writing processes involve the dynamic journey of planning, drafting, revising, and editing. Traditionally, scholarly focus has predominantly centered on written products rather than writing processes. One significant reason for this emphasis lies in accessibility of written products. Not everyone is able to study the writing process, which requires advanced technological tools such as keystroke logging tools.

The next sections will introduce syntactic complexity (including text length) and lexical development that are some areas than can be studied through a written product.

3.1.1 Syntactic complexity

Syntactic complexity is indicated by text length, which includes the number of words, characters, clauses, and T-units (defined below). Increasing the length of a written text is a prominent feature of age-related writing development, often accompanied by the use of longer words, phrases, clauses and T-units (Berman & Verhoeven, 2002; Johansson, 2009; Löhndorf, 2021; to mention some studies). A T-unit, a concept introduced by Hunt in 1966, comprises a

main clause and any attached subordinate clauses, phrases, or modifiers. It represents a complete thought, while clauses are categorized as independent or dependent. The number of clauses within T-units estimates the subordination index (Hunt, 1966).

Research on syntactic complexity in individuals aged 11–16 is relatively limited compared to research on younger children and adults (Myhill, 2009), as can be seen in Juzwik et al.'s (2006) review of over 1,500 writing studies, which primarily involved adults. This focus on (very) early writing experiences or preparing older teenagers for higher education or employment leaves a gap in research on individuals during the middle school years. There are, however, a few Swedish studies that have shown inconsistent developmental patterns in text length and vocabulary growth among children aged 10–12, which was attributed to significant variations in linguistic skills in this age span. It was also suggested that there is a developmental leap after the 7th grade, around age 14, among hearing children, followed by a plateau after age 17 (Johansson, 2009; Löhndorf, 2021; Berman & Verhoeven, 2002).

3.1.2 Lexical development

Lexical development can be assessed through various measures, including counting spelling errors per number of words, and examining lexical density and lexical diversity. These measures provide insights into children's spelling proficiency and the richness of their vocabulary (e.g., Johansson, 2009; Löhndorf, 2021; Malvern et al., 2004).

The development of *spelling skills* in school children typically follows a consistent pattern, with improvements occurring over time as they enhance their language proficiency and writing abilities. In the initial years of schooling, as children learn to spell words correctly, it is common to observe numerous spelling errors. These errors often result from phonetic strategies, meaning that students attempt to spell words based on their sounds. As students progress into middle school, their spelling continues to advance, and they begin to employ orthographical strategies. With further exposure in the more advanced grades and advanced linguistic training, one can expect their spelling to become notably more accurate (e.g., Nauclér, 1989, 2004).

Another measure for describing lexical development is *lexical density*, which measures the proportion of content words, with greater density suggesting a more compact and information-rich text. Lexical density is typically calculated by dividing the number of content words (nouns, verbs, adjectives, and lexical adverbs) by the total number of words in a text. Dense texts are often perceived as more mature, precise, and detailed, as individuals prioritize conveying meaning over using function words (Halliday, 1985). However, the opposite has also been suggested; that high lexical density can indicate a less developed grammar, characterized by the use of fewer grammatical words (see Asker-Árnason et al., 2010). Generally, lexical density has been suggested to

be higher in written language than in spoken language and to increase with age (Johansson, 2009).

Lexical diversity measures the variety of words used in an individual's text, providing insights into the richness of their vocabulary. With increased age and exposure to various linguistic contexts, individuals' lexical diversity naturally expands (e.g., Berman & Verhoeven, 2002; Johansson, 2009; Löhndorf, 2021; Malvern et al., 2004). In early childhood, vocabulary is limited, but exposure to school, social interactions, reading, and media broaden linguistic proficiency (e.g., Biemiller, 2003; Kamil et al., 2011). Some studies have suggested that hearing bilinguals may have smaller vocabularies due to shared input from both languages (Bialystok et al., 2008; 2009).

3.2 Studying writing through the writing process

While writing has traditionally been analyzed primarily through the lens of written products, there is more to discover beyond the final text. An alternative approach to understanding writing is to examine the writing processes that lead to these products, and these processes be studied using technology like keystroke logging tools. Studying the writing process itself allows for a deeper exploration of how specific writing behaviors and strategies are used during writing. In next sections, an overview of the measures *pauses, fluency* and *revision* will be presented.

3.2.1 Pauses

Recognizing that pauses often serve as indicators of the planning process (e.g., Goldman-Eisler, 1967; Hayes & Flower, 1980), we can leverage pauses to observe potential planning behavior, and the length of any given pause provides an insight into the cognitive effort used by writers (Wengelin, 2006). It is worth noting that the duration of pauses can be influenced by other factors, such as spelling confidence and more. Research suggests that younger, less experienced writers tend to have longer pauses during word production due to their limited spelling abilities. Conversely, a decrease in the duration of pauses within and between words produced indicates the automation of orthographical and transcription skills. If an adolescent or adult inserts frequent pauses before or between letters, *within* a word it may suggest uncertainty in spelling, in word selection, or a lack of automation in low-level processes (e.g., Matsuhashi, 1981; Spelman-Miller, 2006; Van Waes et al., 2016; Wengelin, 2002).

Moreover, there is a hierarchy in the placement of the longest pauses during the writing process. The longest pauses happen predominantly between sentences and paragraphs, functioning as natural breaks during which writers assess their written content, consider revisions, and plan their next steps. This pattern is consistent among both typical writers and those who have writing and reading difficulties (e.g., Spelman-Miller, 2006).

While pauses can suggest that a writer is engaged in planning, pauses do not provide direct insight into the writer's actual planning in terms of thoughts and intentions. For a more profound understanding of the planning process, additional methods, such as self-reported techniques like think-aloud methods, become essential. These methodologies enable writers to vocalize their thoughts and intentions, granting researchers deeper insights into the cognitive processes involved in the writing planning phase (Johansson, 2009).

Research in this domain has unveiled distinct planning behaviors exhibited by various groups, including children, L2 learners, adult writers, and L1 learners as they progress through different developmental stages (Bereiter & Scardamalia, 1987; McCutchen, 1994; Sasaki et al., 2018). Younger writers tend to engage more in local planning, relying less on high-level cognitive processes than do adult writers, who predominantly use global planning. As mentioned earlier, global planning is characterized by increased cognitive involvement, that often is a prerequisite for producing well-developed and audience-adapted written texts.

A longitudinal study conducted by Sasaki and colleagues (2018) examined the development of different language (L2) writing strategies, including local and global planning, among high and low L2 Japanese university learners of English. Local planning strategies showed no change in usage over time, and all participants, regardless of their L2 proficiency, employed this strategy regularly. On the other hand, strategies related to global planning increased as the L2 writing ability of participants improved. Those with higher L2 writing ability also used global planning strategies more frequently, as they had automated several of their low-level processes. These findings underscore the dynamic nature of writing strategies and their association with L2 proficiency and writing ability.

3.2.2 Fluency

Being fluent in writing is important because fluency enables writers to be effective, translating ideas into words before they forget them (Chenoweth & Hayes, 2001). Fluency is thus a way to examine the degree of automaticity of translating. It may be easier to understand what fluency is by considering its opposite, *dis*fluency, which Van Waes and colleagues (2016, p. 411) defined as "writing…characterized by pauses and revisions, or a combination of both" (Van Waes et al., 2016); see also Chenoweth & Hayes, 2001).

A crucial aspect to fluency is something called a *burst*, which is an uninterrupted period of writing measured by the number of characters or seconds the writer uses for writing before pausing or revising (Olive & Cislaru, 2015, p. 1). If a writer experiences many bursts in their writing process, it may indicate disfluency, because the writer frequently needs to pause and evaluate, spell correctly, find suitable words, or revise their work. Interrupted writing behavior indicates that the writer is struggling with a higher cognitive load (Chenoweth & Hayes, 2001; Van Waes et al., 2016).

Studies have shown that the length of bursts in writing is influenced by a writer's linguistic experience and is a predictor of their proficiency levels. Children and second language (L2) learners tend to produce shorter bursts than their adult and L1 peers (Barrot & Agdeppa, 2021), which can be attributed to their limited working memory resources and the fact that they only can produce a shorter string of words at once. Experienced L1 writers have been found to produce bursts of around 10–12 words, whereas less experienced writers, such as L2 writers, tend to produce bursts in the range of 5-6 words (Kaufer et al., 1986).

Chenoweth and Hayes (2001) studied the impact of linguistic backgrounds on the writing fluency of L1 and L2 writers. Thirteen undergraduate students, native English speakers who had studied French and German as L2 for three or five semesters, wrote essays in English and their L2 while providing think-aloud protocols. The findings showed that linguistic experience significantly affected writing fluency. Less experienced L2 writers produced fewer words per minute, shorter P-bursts (repeatedly pausing after writing few words), and shorter R-bursts (frequent revisions). When writing in their L2, they had a higher percentage of revision bursts compared to their L1 (on average 26% vs. 13%). Students with more L2 experience wrote more fluently. Experienced writers had longer P-bursts, fewer R-bursts, and a smaller gap between think-aloud and final text word count, indicating better alignment between their thoughts and their written expression.

Lindgren et al. (2008) explored disfluency in writing for L1 and L2 writers. Swedish 15-year-old students wrote essays in both Swedish (L1) and English (L2) while their writing was monitored using a keystroke logging tool. The results revealed that writing fluency suffered more when the students composed in their L2 than it did when they wrote their L1. They exhibited extended writing times, more pauses, engaged in local revisions, and had slower overall fluency characterized by more bursts. These findings suggested that the students were experiencing a greater cognitive load when writing in their L2. Surprisingly, the L2 texts were better quality, which was interpreted as L2 writers compensating for that cognitive load by dedicating more time to their writing.

In sum, translating (in terms of fluency) is influenced by linguistic experience. More experienced writers demonstrate increased fluency, which is reflected in longer bursts of writing as a result of greater automatization. Automatization enables a more coherent writing process without the need for frequent pauses or revisions. In contrast, less experienced writers with limited cognitive processes and lexical retrieval struggle more, leading to more need for revision in order to effectively convey their intended meaning.

3.2.3 Revision

Measuring revision offers insights into how writers revise and review to enhance the clarity and coherence of their written texts. Reviewing is thought to

be a complex and cognitively costly activity as it competes with other cognitive processes like planning and translating, and has been proposed to be the last established part of the processes (Berninger et al., 1996).

Chanquoy (2001) conducted an experimental study involving French students from the 3rd, 4th, and 5th grades. They were instructed to write about a personal experience using two pencils, one in blue for writing and one in green for revising. The experiment encompassed three scenarios. In the first scenario, R1, students engaged in online revision, which meant they wrote and revised during the same writing session. In R2, children were asked to write a draft, later revise it afterwards, and finally rewrite the text within the same writing session. Finally, in R3, the children postponed revision, writing a draft on one day and revising it the next day. R3 proved to be the most effective in terms of revision performance, which was attributed to the fact that in R3, the children did not have to split their cognitive resources between transcription and revision, as they had had to in R1 (online writing). An interesting observation was that 3rd graders tended to focus more on surface revisions, while older students showed a greater inclination toward making meaning revisions.

Global revisions (that is when the writer attends to the full text and makes revisions, as opposed to 'local revisions' when writers make changes in close connection to the inscription point) often emerge only after several years of writing. A study conducted a revision changes model that could be roughly divided into local revisions and global revisions (with further subcategories that would categorize whether a revision was on a formal change level, a meaning preserving level, a microstructure level, or a macrostructure level) and tested this model by carrying a study on three older groups with varying writing experiences. The groups consisted of six inexperienced university students, six advanced student writers, and six expert adult writers. The writers were asked to perform three writing tasks, and the analyses showed that the inexperienced students did mostly surface changes, while the more experienced writers produced considerably more meaning changes than the inexperienced writers. Interestingly, the advanced students produced more revisions than the expert adult writers, and the authors hypothesized that these adults may have developed a mental text and revised this in their mind before realizing this in written text. They wrote that “[s]uccessful revision results not from the number of changes a writer makes but from the degree to which revision changes bring a text closer to fitting the demands of the situation” (Faigley & Witte, 1981, p. 411).

4 DHH and literacy

This chapter will explore previous research on literacy in DHH individuals. It is essential to recognize the limited research in this area, especially with regard of writing studies, which has presented challenges in illuminating writing as a fundamental aspect of communication and language development for DHH individuals. To address this gap, this chapter broadens the understanding by exploring related fields and studies that offer insights into the reading and writing, as well as other contributing factors that can influence their literacy. This chapter ends with a short section about of the CODA group.

4.1 DHH and reading

The ability to read is crucial as it affects an individual's education, career, and social growth. For children who are DHH, mastering this skill can be challenging. The combination of hearing loss, unfamiliarity with reading strategies, language deprivation, and language delays (and more) can cause that DHH children start school with limited communicative skills (e.g., Hall, 2017; Marschark, 2007; Williams & Mayer, 2015). Since learning how to read generally takes time, effort, and explicit instructional support, it is essential that this process occurs in a shared language that both the children and teachers are proficient in, which is often not the case (Marschark, 2007). This combination of factors previously mentioned has likely made it more difficult for DHH children to learn both reading and writing (e.g., Hall, 2017; Hoffmeister & Caldwell-Harris, 2014; Marschark, 2007; Paul et al., 2020). These challenges may have contributed to a claim that half of all DHH 18-year-old students leave high school with inadequate literacy skills. A textbook reviewing the education of deaf children in the US (where the most reading studies have been performed in the field of DHH education) described the situation like this:

> Current data indicate that, on average, 18-year-old deaf students leaving high school have reached only a fourth to sixth grade level in reading skills. Only about 3 percent of those 18 years old read at the same level as the average 18-year-old hearing reader, and more than 30 percent of deaf students leave school functionally illiterate. (Marschark et al., 2002, p. 157)

Furthermore, only 10% of American DHH students achieve literacy results beyond those of an eighth-grade hearing student (Traxler, 2000). The current situation in Sweden seems to be better, thanks to early intervention, sign language courses, and bilingual schools, as discussed in the introduction, and Swedish DHH students leave school with considerably better results than their American peers. Svartholm (2009, p. 9) writes:

> About half or even more of those who leave the special school for the deaf receive a grade of Pass or higher in the subject Swedish, i.e., they can read at a level equivalent to hearing leaving students, which is good, very good in an international perspective. That around 40% of our special school students also get grades in a third language, English, is surprising and sometimes seems almost improbable for many outside Sweden's borders. (my translation)

While it seems that Swedish DHH children have advantages compared to many of their foreign peers, they still often do not reach the proficiency levels of their Swedish L1 peers (Asker-Árnason et al., 2010, 2012; Bell et al., 2022).

Researchers have commonly posited that a strong foundation in phonological coding and awareness (PCA), which is the ability to recognize and manipulate sounds in words, is essential for learning to read (Anthony & Francis, 2005). It is likely that this belief contributed to the assumption among many professionals that DHH children struggle with reading because they cannot manipulate sounds into words (Miller & Clark, 2011; Musselman, 2000; Petitto et al., 2016). Of course, as mentioned earlier, it has been shown that approximately 10% of deaf students in the US read beyond an eighth-grade level (Traxler, 2000), indicating that deaf individuals *can* become skilled readers. This suggests that there are alternative methods for learning to read that go beyond the traditional focus on PCA.

Mayberry et al. (2011) conducted a comprehensive review of 57 studies involving over 2000 DHH participants aged between 4 and 62, examining the relationship between reading and PCA in the DHH population. Half of the studies analyzed in the review yielded statistically significant evidence for PCA skills, while the other half did not. The review also found that PCA skills have a moderate predictive impact on reading achievement in deaf individuals, but their influence is less than other factors, such as language ability, which has a more significant impact on reading development.

This finding is consistent with research conducted on the hearing population that has suggested that developing good reading skills does not solely rely on phonological awareness (e.g., Artelt et al. 2001; Becker et al., 2010). This observation may explain why some deaf individuals manage to develop strong reading skills despite having poor phonological awareness. A sole focus on phonological awareness when considering the reading ability of the DHH group is too narrow, as PCA is not the only factor contributing to reading achievement. Rather, it is crucial to adopt a more holistic perspective when examining how DHH children acquire reading abilities.

Other abilities and factors that have been thought to promote reading skills include general language ability (Guldenoglu et al., 2014; Kargin et al., 2012; Mayberry et al., 2011), orthographic knowledge, syntactic awareness, and metacognitive skills (Miller & Clark, 2011). Additionally, lip-reading, fingerspelling, and sign language (Musselman, 2000; Padden & Hanson, 2000) have been suggested to increase reading skills, as these methods utilize visual representations for the DHH population. Musselman (2000) suggested that there is no definitive understanding of how DHH children learn to read, but it appears they employ multiple encoding strategies.

In conclusion, research on the learning of reading and writing among children with hearing loss has been ongoing for some time, yet there is still no consensus on how to address the reading delays that result in DHH children not achieving the same developmental levels as their hearing peers. Unfortunately, this group has often been unfairly labeled as having a deviant language. The reason for this label is that the way these children learn to read and write is based on the methods used by hearing children, who have entirely different starting points (Roos, 2008).

4.2 DHH and writing

This section will firstly present the DHH group's written products, followed by the DHH group's writing processes and various factors that influence DHH literacy. This chapter will end with a short section about CODA children and their language development.

4.2.1 Written products of DHH individuals

The first part of this chapter will concentrate on the written products of the DHH group. The focus will then shift towards an examination of the writing products of deaf individuals. Finally, a short passage will be presented about the CODA group's language development. By examining these groups, this section aims to gain a comprehensive understanding of the writing abilities and experiences within the broader DHH group.

4.2.1.1 Written products of DHH individuals with hearing technology

A disparity between reading and writing studies is exemplified in a review conducted by Mayer and Trezek (2018), which examined 21 studies involving DHH children aged 5–18 who use cochlear implants. None of the reviewed papers exclusively focused on writing, and only three studies included writing in addition to reading. These studies indicated that the writing outcomes for DHH children were not strong and suggested that this group faces greater challenges in developing writing skills than it does in developing reading skills.

The authors also highlighted the need for more longitudinal research on the DHH population.

One aspect of concern is suggested to be the lower lexical diversity in writing. Studies have suggested that DHH children tend to rely on a smaller pool of words, which leads to repetitive word usage, especially of content words, which can affect the overall quality and richness of their writing. Consequently, the low-diversity writing of DHH children may result in a high lexical density, characterized by a lower proportion of function (grammatical) words and a higher presence of content words (e.g., Arfè, 2015; Asker-Árnason et al., 2010, 2012; Breland et al., 2022; Geers & Hayes, 2011; Mayer & Trezek, 2018). The writing strengths of DHH children have been suggested to be spelling, punctuation, story construction, organization, and planning, presumably because these aspects do not rely on writing ability (e.g., Alamargot et al., 2007; Antia et al., 2005; Marschark, 2007).

A review by Bell et al. (2022) emphasized that DHH children who use cochlear implants (CIs) constitute a diverse group with varying degrees of language development. However, the findings consistently indicated that the use of CIs generally results in improved language acquisition for these children. Despite these improvements, DHH children using CIs still tend to fall behind their hearing peers in terms of literacy development. The authors called for further longitudinal studies on the writing skills of this specific group to gain a deeper understanding of their literacy development.

Asker-Árnason and colleagues (2012) conducted a study in Sweden that explored the spoken and written narratives of 20 children and adolescents aged 10–18 who had varying degrees of hearing loss, ranging from moderate to severe, all of whom used hearing aids. Their performance was compared with 63 hearing controls in the same age range. In general, the results were heterogeneous, with participants with hearing loss having poorer outcomes than their hearing peers. However, one trend was that participants with greater hearing loss had higher lexical density and lower lexical diversity than those with more moderate hearing loss in their written narratives.

Arfè (2015) examined the narrative abilities of 42 Italian DHH participants aged 7–15 in both spoken and written language. The study focused on spoken and written narratives of stories based on the well-known children's fable "Frog, where are you?" and compared their narratives to those of 48 hearing controls. The findings revealed that the DHH group produced more clauses in their speech narratives but did not significantly differ from the hearing participants in terms of the number of words spoken. However, in the realm of writing, the DHH group produced significantly fewer words compared to their hearing peers, even though they had an equivalent number of clauses. The author concluded that the DHH group has greater difficulties in the written modality compared to the speech modality, even though their performance in both modalities was poorer than their hearing peers.

A study by Breland et al. (2022) compared the morphosyntactic complexity and global narrative features of 46 adolescents with cochlear implants (CI)

in the US in the eighth grade, and 52 hearing adolescents who served as controls. The results demonstrated that the DHH group performed similarly to their hearing peers in terms of spoken language skills, but encountered difficulties in their writing performance. Both groups showed similar proficiency in their oral narratives, but the adolescents with CI faced greater challenges in their written narratives. Notably, their writing narratives were less complex than their oral narratives, indicating a difficulty in transferring complex morphosyntactic patterns from oral to written language. The authors suggested that while individuals using CI may have developed adequate oral narrative skills, they encounter a disparity in their proficiency in written language.

The studies mentioned above provide insights into the language development of DHH children who use HT. While these studies indicate that DHH children with HT have a language advantage over their deaf peers, it is important to note that they still face challenges in writing.

One common characteristic observed in DHH writing is the tendency to produce shorter texts with fewer words and clauses, which suggests difficulties in generating longer and more complex sentences. DHH children also often seems to have challenges in grammatical and syntactical complexity, leading to errors or inconsistencies in sentence structure (e.g., Asker-Árnason et al. 2010, 2012; Bowers et al., 2016; Grenner et al., 2022; Sarant, 2012).

The existing research on how sign language proficiency affects the writing of DHH individuals using HT is extremely limited, which is why I aim to provide a comprehensive overview of writing skills exhibited by deaf children, with some perspectives of how sign language affects their writing.

4.2.1.2 Written products of deaf writers

Similar to the limited research conducted on the writing abilities of the DHH population using HT, there are also few comprehensive studies focusing on the writing skills of deaf children and adults without hearing technology; these few are presented below.

Williams and Mayer (2015) conducted a literacy overview of 17 papers published between 1990 and 2012 on writing development in young deaf children between 3 and 8 years old. This review showed that the majority of the studies had a particular focus on reading ability rather than writing ability. The few writing studies that were conducted focused on spelling or individual words, rather than on comprehensive levels such as grammar or syntax, concepts that the deaf group often struggled with. The authors argued that there is a need for multi-year longitudinal studies that focus on the overall writing development of deaf children.

Wengelin (2002) found that lexical diversity in writing Swedish was lower among deaf Swedish adults than their hearing peers, and this result was suggested to be due to a limited second-language vocabulary. However, in contrast to other studies, Wengelin found that the lexical density of these two groups did not differ. This finding is at odds with other studies on DHH populations, which generally suggest that DHH individuals have higher lexical

density in writing (compare with the findings of Arfè, 2015 and Asker-Árnason et al., 2012 reviewed above; see also Singleton et al., 2004; Svartholm, 1984). One explanation she offers for this discrepancy in results is simply a function of the sample size – the sample of deaf adults in Wengelin's study was small and therefore it was difficult to apply statistics to assess significance. However, Wengelin noted that deaf adults tended to use nouns (which are content words) more often than pronouns (which are function words). For example, instead of using "he", the deaf adults would repeat the word "boy". This pattern was also observed in the deaf group's frequently used words, with only three out of the top 20 most frequent words being function words. Wengelin suggested that the deaf adults' use of STS contributes to their higher use of content words in written Swedish, as STS (like other sign languages) is known for its high density.

In Schönström's studies in Sweden (2010; 2014), written and signed narratives were collected from 38 deaf students in either 5th or 10th grade attending a special school for the deaf. These narratives were analyzed using the Processability Theory developed by Pienemann (1998), which proposes that second language learners acquire grammatical structures in a particular order. Schönström also found that there was a developmental trend with age, in that older deaf students performed more advanced grammatical structures than their younger peers. He further found the expected increase of developmental levels in accordance with processability theory, confirming that this L2 developmental theory was also applicable to the deaf L2 learners of written Swedish. Schönström also noted a possible positive relationship between STS knowledge and written proficiency.

Wolbers et al. (2014) investigated the relationship between ASL and written English in 29 deaf students attending a residential school in the US. They reported that ASL transfer in some form was observable in most students' writing regardless of whether they belonged to a high or low achieving group, explaining why they applied a Strategic Interactive Writing Instruction (SIWI) on the students. The idea with SIWI is its "language zone" that encourages deaf students to express their thoughts and ideas in their first language (often ASL) while, under guidance of a teacher, they learn how to transfer those ideas into English, through learning about the languages' similarities and differences. After a year of instruction using SIWI, all students' percentages of ASL transfer to English decreased, showing improvements in their English. The authors concluded that SIWI can significantly reduce ASL features in writing and that bilingual literacy programs emphasizing ASL and metalinguistic knowledge can support deaf students in developing written English.

Singleton et al. (2004) compared the written English vocabulary of 72 deaf elementary school students with varying levels of proficiency in ASL with 60 hearing English as a second-language (ESL) speakers and 61 hearing monolingual English speakers of similar age. The students were asked to rewrite the fable of "The Tortoise and the Hare". Word count, redundancy, and lexical density were examined in the written narratives. The study found that

all deaf writers used significantly fewer function words than their hearing peers. Low-ASL-proficient students displayed a formulaic writing style using high-frequency words and repetitive use of few function words. On the other hand, deaf students who were moderately or highly proficient in ASL showed more varied writing styles and incorporated novel, low-frequency vocabulary to express their thoughts. These findings challenged previous research on deaf writers which seemed to show that their vocabulary use was generally are more limited.

A study by Bowers et al. (2016) analyzed spelling errors in writing samples collected from 29 middle school DHH students at the beginning, middle, and end of a year-long writing instructional approach. Through a linguistic analysis, the researchers assessed the students' understanding of various rules related to phonology, morphology, orthography, semantics, and visual imagery in written language. The results provided a descriptive analysis of the different types of spelling errors made by middle school DHH students. They observed that deaf children had a greater tendency to base their English words (incorrectly) on the handshape of a sign, such as spelling "funeral" as "vorival" because the sign for FUNERAL is expressed with the handshape V. They emphasized the need to directly address spelling during writing lessons.

Recently, Holcomb (2023) investigated the writing development of three deaf siblings who were bilingual in ASL and written English and who used all of their linguistic resources in both languages to express themselves effectively. The study analyzed a data set of 28 written expressions collected over a ten-year period, starting from the ages of three to ten. The author could see the siblings demonstrating unique characteristics in their written English, reflecting their use of ASL at various linguistic levels. For instance, the five-year-old used numbers and letters that shared phonemes with ASL signs to represent them in their written expressions. An example is that this child expressed the number 8 as "PREFER" because both signs share the same handshape. These findings suggest that the youngest children in the study were using their knowledge of ASL to influence their written English at all linguistic levels. Specifically, they were utilizing phonological and syntactical aspects of ASL to convey meaning in written English. Another example is that shown when a six-year-old wrote "I want to be only" but she meant "alone". The signs for "ONLY" and "ALONE" are almost homonyms in ASL.

Holcomb also discussed the difficulty in identifying true equivalences between ASL and English. To accurately convey the spatial and facial features of ASL into English, a higher level of metalinguistic awareness in both languages is needed. One example of such awareness was observed in a ten-year-old who wrote a descriptive story about a lonely mountain that was waiting for a friend, which demonstrated a greater use of descriptive and figurative language in English that appeared to be equivalent to the unique features found in ASL. Holcomb also concluded that using ASL can facilitate the development of written English, and that as proficiency in English increases, ASL

features in written English eventually decrease, resulting in written expressions that resemble those of hearing monolinguals.

4.2.2 The writing processes of DHH individuals

Probably the first study that examined the writing process of DHH *children* using a keystroke logging was conducted by Asker-Árnason and colleagues fairly recently, in 2010. The authors examined the writing of narrative texts using a keystroke logging tool from 18 DHH children aged 11–19 with severe or profound hearing loss who had received cochlear implants (CI) and compared their process to a group of age-matched hearing controls. Nine of the DHH children had prelingual deafness and the other nine had progressive hearing loss. The DHH participants were divided into two groups based on age at implantation and age at the time of the study. The authors found that the DHH children had a significantly higher lexical density, and their percentage of pause time was greater (at least for children older than 13 years). The children who received CI later than age 5 performed similarly to their hearing peers, which the authors thought might have resulted from early exposure to spoken language (these children became deaf after that exposure). The authors also suggested that DHH children with CI had some limitations in their linguistic and cognitive processing compared to their hearing peers.

Wengelin (2002) was, however, the first researcher who analyzed the written products and the writing processes of *deaf adults* by using a keystroke logging tool. She collected data from three Swedish groups consisting of nine deaf adults, eleven adults with reading and writing difficulties, and ten hearing controls. The adults performed different tasks which included for instance written production in different genres. In regard to their writing process behavior, Wengelin reported that the deaf group were fluent and fast writers but exhibited a non-planning behavior, mirrored in a linear writing process.

These adults also struggled with grammatical errors that often remained unnoticed, as their problem-solving strategies were limited. Unlike the hearing controls who demonstrated a more global writing behavior, reflected in more coherent texts, the writing behavior of the deaf adults seemed to be more forward-oriented and local. Wengelin posited three possible explanations. First, the deaf subjects may not have realized that they have trouble with spelling. Second, they might not have been as concerned as the other groups about making writing mistakes. Third, their writing habits could have been influenced by a culture of texting and using cell phones to communicate with each other.

Another study by Alamargot et al. (2007) focused on the writing composition of deaf children without a keystroke logging tool. This study compared the written composition of 15 signing deaf and 15 hearing middle school students in France and explored how their writing skills may be connected to their working memory. The researchers employed Kellogg's (1996) text production model (reminiscent of Hayes and Flower's (1980) model) to analyze various text production processes. The study examined the quality of written

descriptive texts and investigated the impact of phonological (the ability to remember and recall strings of phonemes in correct order), visuospatial (the ability to process and store visual and spatial information), graphomotor (the ability to physically write or type out text) and executive (central executive components of working memory that control and coordinate the cognitive processes involved in a writing process) capacities on the writing skills of the two groups.

The study suggested that the deaf students had no problems with graphomotor and planning processes, which may be due to their preserved and fully functional visuospatial capacities which could help them plan texts that are well-organized as those of hearing students. The deaf students instead faced difficulties with the phonological component because of their deafness, which burdens their working memory and consequently leads to disfluency in their formulation process, reflected in longer and more pauses, shorter texts, more spelling errors, syntactic complexity, and grammatical errors. The deaf students also exhibited a sequential writing process behavior, meaning that they dealt with processes separately and not recursively.

4.3 Factors influencing DHH literacy

The following sections present a set of key variables that play a crucial role in the literacy development of DHH children. According to research, these factors can include *age*, *gender*, *age of acquisition*, *hearing degree* and *sign language proficiency*. These variables can significantly affect the development of language and communication skills, which are integral to the overall literacy development of the DHH community.

4.3.1 Age

Age remains a significant influence on writing development. Literature reviews focusing on the DHH population have underscored a noticeable absence of longitudinal studies in this domain, highlighting a critical gap in our comprehension of the writing development of this group (Bell et al., 2022; Mayer & Trezek, 2018; Williams & Mayer, 2015). This gap motivates this brief overview of how various linguistic proficiencies evolve over time in the general population.

In early childhood (ages 3–6), children typically start developing pre-writing skills like scribbling and drawing. They may also begin experimenting with writing letters and simple words, often with letters inverted. Writing at this stage is mostly focused on self-expression, without much consideration for conventional writing rules or structures (Schickedanz & Casbergue, 2009; Yang & Noel, 2006).

In elementary school (age 7–11), children start practicing low-level processes like transcription, spelling, punctuation, and grammar, all of which are

basic writing skills. They tend to follow a "think it, say it" approach, reflecting a linear writing process (Bereiter & Scardamalia, 1987; McCutchen, 1996; Schickedanz & Casbergue, 2009).

During adolescence, around age of 12 and older, writers have typically automated their low-level writing processes, allowing them to progress to using more sophisticated and complex writing styles, including developing a wider vocabulary, using language more proficiently, and varying the content of their writing more freely. They also begin using macro processes such as planning and reviewing on higher levels, and considering factors like audience, purpose, and genre. These skills are crucial for higher-level writing (Bereiter & Scardamalia, 1987; Hayes & Flower, 1980; Löhndorf, 2021; Myhill, 2009).

The simultaneous emergence of multiple processes and skills during the ages of 10–13, coupled with significant individual differences, makes it challenging to pinpoint specific developmental trends in text length and vocabulary at this time in life (e.g., Johansson, 2009). Some studies have proposed that rather than a linear progression, development in these areas may follow a stepwise pattern, with a significant leap occurring between the ages of 13 and 17 (Berman & Verhoeven, 2002; Johansson, 2009; Löhndorf, 2021).

4.3.2 Gender

Gender is another factor that may play a role in literacy development. Gender aspects of writing development are complex and varied even within the general population, and there are some studies that show that boys and girls perform similarly in writing with few differences (e.g., Jones & Myhill, 2007). However, most studies suggest that girls outperform boys in both L1 writing (e.g. Kanaris, 1999; Reynolds et al., 2015) and L2 writing (e.g., Saeed et al., 2011). An Australian study by Kanaris (1999) showed that 9-year-old girls generally wrote longer and more complex texts with a wider range of adjectives and verbs compared to their boy peers.

Many studies suggest that girls may have advantages in writing skills, including greater vocabulary, syntactic complexity, fluency, editing capacity, and text quality compared to boys. Gender differences in writing performance have been observed across different age groups and in different countries.

Gender differences have not only been reported regarding written product studies but also writing process studies. Zhang et al. (2019) examined fluency in writing using keystroke logging with children in grades 6–9 in the US, and found that girls were more fluent, engaged more in both local and global editing, and paused less during text production. Berninger and Fuller (1992) examined writing and speech fluency in 300 children in first, second and third grades, and found that boys performed better in speech fluency, while girls performed in written fluency. Girls consistently outperformed boys in terms of the number of words and clauses produced in both narrative and expository composition.

Another study by Al-Saadi (2020) examined gender differences in writing fluency and text quality among Omani undergraduate students proficient in Arabic as L1 and English as L2. Females outperformed males in writing fluency and text quality in both languages, with their superiority linked to higher English proficiency. Writing fluency in English was identified as a significant factor contributing to females' superior text quality. The findings highlight the importance of considering gender differences in writing performance and language proficiency when designing writing instruction.

Given the limited research on writing in DHH individuals overall, it is not surprising that gender differences in writing in this population have been studied only rarely. The existing studies that consider both gender and literacy skills in DHH individuals have produced mixed results.

Some studies, like Kluwin and Kelly (1992), suggest that there are no significant gender differences in the writing abilities of DHH individuals. However, other research, including studies conducted by Antia et al. (2005), Hassanzadeh and Nikkhoo (2019), and Musselman and Szanto (1998) indicate that DHH girls may outperform DHH boys in writing.

A recent study by Grenner et al. (2022) sought to investigate the impact of various factors on narrative text quality among Swedish students with hearing loss. This study included eleven DHH students using HT in grades 5/6 and 7/8, aged 12–15, who participated in a writing intervention program over a six-month period. Trained evaluators assessed the quality of the texts, and the researchers analyzed factors such as working memory capacity, language comprehension, reading comprehension, school grade, gender, and the impact of the writing intervention using a mixed-effects regression model. The study's findings revealed a significant gender difference in narrative text quality. Specifically, over the course of the study, texts authored by female students in grade 7/8 received the highest ratings, while those written by male students in the same grade received the lowest ratings. This outcome highlights the importance of considering gender differences in literacy development in DHH individuals, as gender may have implications for designing effective interventions and support systems.

4.3.3 Age of acquisition

There are a few studies exploring the age of acquisition (AoA) of L1 in the DHH population. Thanks to these studies, we have learned that deaf individuals worldwide, in several cases, are not born into a language-rich environment comparable to that of hearing children.

Mayberry's (1993) study examined potential differences between first-language age of acquisition and second-language age of acquisition in deaf adults. The study included 36 participants with a variety of language acquisition histories in English and American Sign Language (henceforth, ASL). Twenty-seven participants were born deaf and acquired ASL as their first language (L1) during infancy to late childhood. The remaining nine participants

were born hearing but became deaf later in childhood and acquired spoken English as their L1 from birth, with ASL acquired as their second language (L2) later in childhood. Mayberry tested the participants' short-term memory by asking them to recall long and complex sentences in ASL. The results showed that those who acquired ASL as their L2 (but who had been exposed to speech early) outperformed their deaf peers who had acquired ASL as their L1 at the same age that the first group of students had acquired ASL as L2. Mayberry concluded that an early AoA in an L1 supports L2 acquisition, and that a normally developed L2 is better than a delayed L1.

Boudreault and Mayberry (2006) explored the affect of AoA on ASL using a timed grammatical judgement task on 30 deaf adults. These participants had AoAs ranging from birth to 13 years old. ASL syntactic structures, including simple, negative, agreement verb, wh-question, relative clause, and classifier sentences, were used as stimuli. Results showed that delays in first language exposure were associated with decreased accuracy in grammatical judgement, regardless of the syntactic structure. Signers who acquired ASL later in life or had delayed language acquisition were less accurate and slower in responding to ungrammatical stimuli than native learners. These findings support previous research indicating that the age of first language acquisition has a lasting impact on syntactic knowledge in subsequent language acquisition, including ASL.

Cormier and colleagues (2012) obtained similar results when investigating the effects of late AoA on first language (L1) development in British Sign Language (BSL) using a grammaticality judgment task. The study included 30 deaf participants, with 10 native signers of BSL (from deaf families), 10 early learners of BSL (between 2 and 8 years), and 10 who had learned BSL between the ages of 8 and 18. The findings revealed that a later AoA was associated with decreased accuracy on the BSL grammaticality judgment task until around the age of 8, but no effects were observed with acquisition later than that age. This result was interpreted as suggesting that participants with a late AoA of BSL may have acquired some English, which could have served as a scaffold for learning BSL as a second language (L2), as also suggested by Lenneberg (1967).

To summarize, L1 acquisition differs from L2 acquisition, and the long-term effect of a learning an L1 later in life is greater than learning an L2 later in life. Full and early access to an L1 will thus provide opportunities to learn further languages (L2, L3 and so on), and a late L1 acquisition will affect the life-long language learning negatively, and many years of exposure to sign language later in life (as L1) will not compensate for that delay.

4.3.3.1 Language deprivation

Research has suggested that deaf individuals with delayed age of acquisition are *language deprived*. Language deprivation can have serious and long-lasting consequences for deaf children, and without early and consistent exposure to a language, this group may experience delays in literacy, cognitive,

social, and emotional development (Glickman & Hall, 2018; Hall et al., 2019; Mayberry, 1993).

Hall (2017) wrote a commentary about the risks associated with language deprivation. He emphasized that early exposure to an accessible language (in this case, a sign language) is fundamental for DHH children's further linguistic and cognitive development. Language deprivation can result in a range of negative outcomes — not only linguistic delays, but also mental health issues, isolation, and fewer job opportunities as these people become adults. Hall called for awareness and understanding of the fundamentality of early access to sign language for DHH children, including these using cochlea implants. An additional issue is that community resources such as doctors, teachers, researchers, ministers, or other professionals may not always possess sufficient knowledge or understanding of the importance of early and complete language access. This access eventually facilitates the cognitive and brain development of DHH individuals.

Koulidobrova and Pichler (2021) also discuss the concept of language deprivation, agreeing that it seems to be a common assumption that many DHH children are completely language deprived until they acquire a sign and/or spoken language later in life, but they maintain that the DHH group's language development is not necessarily nonexistent. DHH children often have some linguistic experiences before acquiring their first natural language, which Koulidobrova and Pichler call this the *initial system* (family-specific 'home-signs', some elements of spoken language, or other *ad hoc* ways to communicate). They further argue that when the language input is limited, children still have a desire to communicate, which means that they will develop linguistic solutions such as multimodal tools like gestures, texts, pictures, and signs. Koulidobrova and Chen-Pichler further argue that these initial systems should be considered the DHH group's first language, and that their first acquisition of a natural language (such as a sign language) should therefore be considered as their L2 and not as a delayed L1.

Having an initial system is common for the DHH population, but the systems themselves may look different depending on what and how much input they include. An argument against the notion of initial systems is that this *ad hoc* system cannot be considered an L1 because it is not a shared or a conventional language, and has no natural linguistic ground. But Koulidobrova and Pichler counterargue that an initial system is 'language-like' and serves the function of being communicative. They further argue that many cross-linguistic studies assume that only natural languages (languages that are spontaneously developed, culturally transmitted systems of human communication, like English and Swedish) can influence another language, which explains why there are few studies exploring possible transfers from initial systems (home-signs) to natural languages. They referred to a study by Morford and Goldin-Meadow (1997) which reported transfers in a deaf boy from his home-sign to ASL who showed severe delays in his development of both ASL and English. Koulidobrova and Pichler further argued that an initial system, if it

would be considered as a DHH individual's L1, it still does not provide learners the foundation that is necessary for typical language acquisition.

The DHH's AoA situation described above has been characteristic over the centuries in many countries, and Sweden was no exception (e.g., Glickman & Hall, 2018; Svartholm, 1983). As mentioned in the introduction, in Swedish education there is a concept of "the seven white years" (*de sju vita åren*), which refers to that fact that many DHH children had no language until they attended a school for the deaf at age seven, and many of those people experienced this period as very traumatic (Jönköping University, 2021; Svartholm, 1983). Fortunately, AoA in Swedish DHH children has decreased over the past few decades because of early hearing screenings, CI operations, parental sign language classes, bilingual schools, and more.

4.3.4 Hearing degree

Hearing degree and how much sound DHH children can comprehend is suggested to be another crucial factor that can significantly affect their literacy development, as children with different degrees of hearing loss will have different starting points when it comes to learning language and literacy. It has been suggested that about 20–30% of all school children with hearing loss have language learning problems (Briscoe et al., 2001; Geers et al., 2011).

It is important to note that approximately 90–95% of DHH children are born into hearing families (at least in the U.S) (Mitchell & Karchmer, 2004), which means that DHH children with greater residual hearing will have more opportunities to intercept linguistic input (particularly in spoken language from their hearing families) than a completely deaf child (e.g., Sharma et al., 2020; Tomblin et al., 2014). In connection with the advancement of hearing technology such as digital hearing aids (HA) and cochlear implants (CI), profoundly deaf children have received new opportunities to intercept sound and develop literacy by using sounds, and research has suggested that these children using new technologies function as a hard-of-hearing individuals (e.g., Marschark et al., 2012). CI technology in particular has greatly improved the auditory abilities of DHH children by providing access to sound, and the earlier that the operations are carried out, the better the outcomes. Children who have received CIs at a very young age (6–9 months of age) have been thought to develop listening and spoken language skills similar to their hearing peers, at least within their first years of life, but there is still a need for longitudinal studies that explore lifelong outcomes on this group (Colletti et al., 2012; Karltorp et al., 2019). Although hearing technologies offer several advantages, studies have generally found that these children with CI continue to struggle with literacy development (e.g., Arfè et al., 2016; Breland et al., 2022).

What literacy looks like in DHH children using advanced hearing technology such as HA or CI can vary based on several factors such as early identification of hearing loss (Fitzpatrick et al., 2017; Yoshinaga-Itano, 2003; Yoshinaga-Itano et al., 1998), age of implantation (Colletti et al., 2012;

Karltorp et al., 2019), language input (Houston, 2022), language input before a CI operation (Hassanzadeh, 2012), and the listening effort needed due to background noise (Brännström et al., 2022). It is important to emphasize that hearing ability itself is not the sole determining factor of literacy, but rather literacy is influenced by many factors, including the amount of training the children have received, the kind of hearing technology, and the effectiveness of those technologies. If we consider a group of DHH children who have similar levels of hearing loss, some children will benefit more from residual hearing in the context of intensive speech rehabilitation, while others will not respond as well the the same support (e.g., Lederberg et al., 2013).

A Norwegian study by Wie and colleagues (2020) conducted a longitudinal study observing the language development of DHH children who received bilateral CIs between 5 and 18 months of age. The aim was to understand their language trajectories and identify factors influencing language outcomes. The study included 21 children with CIs and 21 children with normal hearing, matched for age, sex, and maternal education. Language skills were assessed at ten time points over six years after implantation using parent reports and standardized measures. In the first four years after implantation, children with CIs gradually narrowed the gap in general language abilities that they had initially had compared to their hearing counterparts. However, between four and six years post-implantation, challenges were observed in expressive grammar and receptive vocabulary. Language outcomes six years after implantation were predicted by speech recognition skills, age at CI activation, and maternal education. These findings emphasized the importance of long-term language intervention and suggested extending studies beyond the four-year mark to support the ongoing language development of children with CIs.

4.3.5 Sign language proficiency

There are numerous sign languages worldwide, but historically, they have not always received widespread recognition and acceptance as valid means of communication, with Sweden being no exception (Svartholm, 2009, 2010). Sign languages have been the subject of continual debate as to their legitimacy, resulting in limited research, as most research (even within the field of DHH studies) has not considered sign language as a variable (e.g., Hall & Dills, 2020). Today, however, we know that early and consistent sign language proficiency is a strong predictor of literacy skills in deaf children, and several studies have shown the positive impact of early sign language knowledge on later reading and writing outcomes (e.g., Dostal & Wolbers, 2014; Hall et al., 2019, 2019; Hoffmeister, 2000; Kuntze, 1998; Scott & Hoffmeister, 2017; Svartholm, 2010; Wolbers et al., 2014). This finding aligns with Cummins' (1996) interdependence principle, which suggested that proficiency in one language can positively influence proficiency in another language. Although Cummins was writing about spoken languages, it seems clear

that DHH children can eventually use their metalinguistic knowledge from sign language to transfer pattern into writing and speaking other languages.

Some researchers have called for more evidence of the impact of sign language effect on literacy in DHH children who use HT (Fitzpatrick et al., 2012; Mayer & Trezek, 2018), as the number of DHH children using sign language has decreased, making it hard to properly investigate this small group (Szarkowski, 2018). There are also calls for more studies on the writing of DHH individuals who use HT (Bell et al., 2022; Mayer & Trezek, 2018; Williams & Mayer, 2015), as the few studies to date have mainly explored the relationship between sign language and reading, not with writing.

A study conducted by Hoffmeister (2000) examined fifty deaf children from the US who used ASL and printed English. Of these, twenty-one were native signers and twenty-nine were non-native signers (that is, they learned ASL later in life). Standardized reading comprehension tests were administered to all participants, and it was found that the native signers performed better than their non-native signing peers in reading comprehension. Additionally, knowledge of synonyms, antonyms, and plurals in ASL was found to be positively correlated with reading comprehension in English. The study also showed a strong correlation between proper ASL syntax and proper English syntax. These findings led Hoffmeister to conclude that signing knowledge is essential if deaf individuals are to achieve literacy. To validate the findings of the 2000 study, Hoffmeister and colleagues repeated the study in 2021 (Hoffmeister et al., 2021), including a larger dataset of 517 deaf children aged 8 to 18, with 34% identified as native signers and 66% as non-native signers. The results showed a strikingly similar correlation between ASL vocabulary and English reading comprehension as the original study. Moreover, the positive correlation between good ASL proficiency and good English syntax was even stronger in the more recent study, providing further support for the relationship between ASL and English literacy among the deaf population.

As mentioned before, research that has examined DHH children with HT who use both spoken and signed languages is limited. One reason is that most hearing parents choose to use only spoken language with their DHH children, which means that studying signing DHH children will be harder simply because there are fewer of them (e.g., Szarkowski, 2018). The few studies that have been conducted have demonstrated mixed results (e.g., Fitzpatrick et al., 2016; Kermit, 2010; Mayer & Trezek, 2018). Some studies demonstrate that DHH children using spoken language perform better than their peers who use sign language (e.g., Geers & Hayes, 2011; Peterson et al., 2010), while others suggest the opposite, that is, that signing and speaking DHH children outperform their peers who only use spoken languages (Amraei et al., 2017; Davidson et al., 2014; Goodwin & Lillo-Martin, 2019; Hassanzadeh, 2012; Pontecorvo et al., 2023). Some studies suggest that total communication yields the best outcomes for the children (Jiménez et al., 2009). The variable outcomes have been suggested to be due to the inconsistent definition or dichotomous

categorization of the true language proficiency of DHH children (Hall & Dills, 2020; Szarkowski, 2018).

Guiberson (2014) examined the language skills of 51 Spanish DHH children and adolescents aged 3–18, and included both monolingual and bilingual participants, although the specific languages in which they were bilingual were not explicitly addressed. The primary focus of the study was on assessing their proficiency in their first language (L1) and potential abilities in a second language (L2). Background information, such as details on the participants' hearing loss, oral language proficiency, bilingual background, and exposure to a second language (L2), was provided by the parents of the DHH participants. Guiberson observed that the bilingual group more frequently used an oral and sign mode, whereas the monolingual group predominantly relied on cued speech. The results showed that DHH bilingual children exhibited stronger L1 skills than their monolingual DHH peers. Even if they displayed varying levels of L2 proficiency, most parents reported that their children's L2 skills either met or exceeded their expectations. The study discussed the concept of cross-linguistic transfer, highlighting the ability of DHH children to effectively manage and transfer knowledge between two languages. These results align with previous research suggesting that DHH children can successfully become bilingual.

Kermit (2010) highlighted an important ethical concern about advice provided to parents regarding their children with CIs, which he called the "Precautionary principle". In 2008, an announcement Oslo University Hospital, Rikshospitalet in Norway advised hearing parents to prioritize auditory training for their DHH children using HT, and sign language was recommended only as a secondary option if their DHH children failed to develop speech. Kermit points out that it is ethically problematic for professionals to encourage parents to focus solely on a monolingual approach because it is impossible to predict which implanted children will successfully acquire spoken language. Kermit gives an example of parents who were advised to use only spoken language with their child with CIs and avoid sign language. When the child did not develop speech as expected, the parents eventually introduced sign language, and the child began to show linguistic and communicative development. The parents felt deceived and believed that, because of the advice they received, they had delayed their child's language development.

Kermit acknowledges that the outcomes of a bilingual approach are still unexplored, but he considers it is preferable than to focus only on spoken language. Taking a bilingual approach in spoken and sign language is a precautionary measure that should help natural language development for all children with CIs, and lessen the risk that any given child who fails to acquire speech will then be language-deprived.

Szarkowski (2018) highlighted similar issues to Kermit from a psychologist's perspective. She argued that it is impossible to predict which children will succeed and which will not. She shares stories of parents of children with

CIs were were advised to minimize the use of visual cues to enhance their children's' auditory and speech development. However, these children did not develop as expected and instead became language-deprived.

Szarkowski also questioned the definition of "successful cases" among children with CIs who might perform well on discrete listening or single-word understanding tests. She argued that these tests have their limitations and do not accurately reflect real-world communication complexities. In everyday situations, communication involves longer segments of language, like paragraphs rather than single words. Moreover, communication includes dealing with various distractions not present in controlled testing environments, such as background noise and social behavior. Szarkowski emphasizes that many professionals tend to overlook these limitations and underestimate the risks of significant language difficulties in children with CIs. Therefore, it is essential to consider the full range of abilities and limitations within the implanted group rather than rely solely on a few language measures conducted in a testing room. This comprehensive view is crucial for a more accurate assessment of the communication skills and needs of children with implants.

Szarkowski also highlights the risk of papers reporting that one group performs better than another group, such as suggesting that speaking DHH children outperform signing DHH children or that children with HT have better results than their deaf peers, for the following reason:

> It is quite easy to read that one particular group demonstrated better outcomes than another group without realizing that both groups performed poorly. (Szarkowski, 2018, p. 248)

Szarkowski gives an the example from a highly criticized paper by Geers et al. (2017), which concluded that the speech-only DHH children outperformed their signing peers. However, in realty both groups performed below average, compared to hearing peers; in reality, nearly half of the speech-only children performed poorly and below average.

Szarkowski (2018, p. 248) warned against pitting groups against each other and categorizing them into a "signing group" and a "non-signing group" when their language backgrounds are often much more complex in reality. Here, her views align with those of Hall and Dills (2020), who also argued that children's modes of communication are frequently misinterpreted and inappropriately categorized, which can ultimately be more harmful than beneficial.

Hall and Dills (2020) emphasized the problematic nature of research on language competence and choice of communication mode (spoken language vs. sign language) in DHH individuals. They re-examined three review studies, which collectively encompassed 82 literacy studies involving DHH children. The overarching conclusion drawn from these three review studies was that there was no definitive recommendation regarding the most suitable "mode of communication" for the DHH population.

Hall and Dills identified several shortcomings in these 82 studies comprising the three reviews and argued that the conclusions they presented could potentially have adverse consequences for many DHH children. The findings could be interpreted as suggesting that the choice of language made by parents for their DHH children does not significantly impact the children's development, given the lack of supporting evidence.

Hall and Dills argued that the absence of a clear connection between language input (i.e., the mode of communication) and language outcomes (language skills) in the 82 studies may be primarily attributed to issues with how the way of communication is defined. They noted that there is no standardized method for measuring the communication style of the DHH group, leading to variations in how language proficiency is assessed in different studies.

For instance, it is not uncommon for studies to categorize DHH children's communication styles on a scale of 1–6 (ranging from sign-only language to speech, sign with support, etc.) or to divide several manual systems into dichotomous categories, such as spoken language with sign support or SEE (Signing Exact English), despite the fact that these systems have completely different grammars and linguistic structures. These papers often fail to consider the complexity of the children's language proficiency, which can be multifaceted, change over time, and depend on factors like input and age of acquisition.

Some DHH children may have initially been exposed to sign language but later transitioned to using speech (or vice versa) and it is important to note that children who use speech fluently may still be proficient in sign language (and vice versa). Hall and Dills argued that many papers, for the empirical reasons mentioned above, have generated incorrect results and conclusions regarding DHH children. Therefore, there is a significant need to accurately represent and highlight the linguistic complexity of DHH children in academic papers.

Hall and Dills also pointed out that many papers used standardized tests to assess the writing and reading skills of DHH children. The problem with these standardized tests is that they often have a pre-defined range that includes a lower and upper limit (+/-1 SD). If DHH children's scores fall in the lower part of this range, they are still considered to be within the range. This can lead to misleading results, as the entire DHH group may fall, for example, in the 17th to 20th percentile, while a normative control group may fall in the 17th to the 84th percentile. Clinically, the DHH group is still considered to be within the "normal range," even though they may actually be severely language delayed.

However, one cannot deny that there are challenges associated with providing early sign language input to DHH children. It is not uncommon for parents to be unfamiliar with sign language or to have misconceptions about its impact on their child's development. Maintaining a consistent sign language environment can be particularly challenging for families who live far from a deaf or signing community. These challenges can lead to delays or

missed opportunities in introducing sign language as a primary means of communication (Kermit, 2010; Mitchell & Karchmer, 2004; SOU, 2016:46).

There has been an ongoing debate about whether hearing parents of DHH children should attempt to learn sign language to communicate with their children. Some argue that hearing parents may not offer the same language-rich environment as deaf parents because they need to learn sign language alongside their DHH children (e.g., Geers et al., 2017). However, a recent study by Caselli et al. (2021) challenges this notion and suggests parents still provide valuable input even if they are not 'fluent' (as a deaf parent is) in a sign language. The study examined the English vocabulary of 78 DHH children (of hearing parents) who were exposed to ASL (American Sign Language) early. The study distinguished between those exposed to ASL before reaching 6 months and those exposed between 6 and 36 months. The findings revealed that children introduced to ASL within the first 6 months of life, even if their parents did not become fluent in it, exhibited typical age-expected vocabulary growth. Children who experienced a short delay in ASL exposure (between 6 and 36 months) had smaller expressive vocabulary sizes but made rapid gains thereafter.

The study concludes that hearing parents of deaf children can learn ASL alongside their children and expose them to the language during infancy. This early exposure to ASL enables DHH children to develop age-appropriate vocabulary skills at a similar rate to native signers, which will subsequently support their further development. The authors suggest that hearing parents of deaf children should make efforts to learn and use ASL in their everyday interactions to support their children's language development and overall success.

A subsequent study conducted by Pontecorvo et al. (2023) examined the relationship between learning ASL and spoken English skills in a sample of DHH children (of hearing parents) who were bilingual in ASL and English. This cross-sectional study included 56 DHH children aged 8 to 60 months who were learning both ASL and spoken English with hearing parents. Vocabulary size in ASL and spoken English was assessed independently through parent report checklists.

The results revealed a positive correlation between ASL vocabulary size and spoken English vocabulary size. The spoken English vocabulary sizes of the ASL-English bilingual DHH children in this study were comparable to those of monolingual DHH children who were learning only English. Moreover, the combined vocabulary (ASL and English) of the bilingual DHH children was found to be equivalent to that of same-age hearing monolingual children. Additionally, children with larger ASL vocabularies were more likely to have spoken English vocabularies within the average range based on norms for hearing monolingual children.

These findings contradict previous predictions suggesting that the acquisition of sign language hinders spoken vocabulary development. The authors concluded that there is no support for the recommendations that families with

DHH children should avoid learning sign language. On the contrary, early exposure to ASL allows children to develop age-appropriate vocabulary skills in both ASL and spoken English.

To summarize this section, early sign language proficiency seems to have a positive impact on later literacy skills in deaf children. However, more studies are needed to fully investigate the relationship between sign language and reading/writing outcomes for DHH children using HT.

4.4 CODA and their language development

While the primary focus of the thesis is on the DHH group, another group of interest from a bimodal bilingual perspective is the CODA (Children of Deaf Adults) group. CODAs refer to hearing children raised bimodally bilingually with both sign and spoken languages by deaf parent(s). This group acquires and uses the same languages as bimodal bilingual DHH children, making them an appropriate comparative group compared to bilingual hearing children of two spoken/written languages, explaining their inclusion in this chapter. This section delves into research that centers on CODA's language development, specifically examining their acquisition and use of both spoken and signed languages.

A study by Brackenbury et al. (2005) examined how CODA children learn words incidentally in both ASL and spoken English without direct instruction. The study examined the expressive vocabulary and incidental word-learning of a hearing child raised by deaf parents and learning both ASL and spoken English. Despite minimal spoken English input (the amount of time during a day that they were exposed to spoken English) which was around 20%, the CODA child's expressive vocabulary at 16 and 20 months matched their monolingual peers. At 16 months, these children showed better proficiency in learning ASL signs incidentally. By 20 months, the children showed signs of incidental word learning in both languages, supporting the view that these CODAs can acquire typical vocabulary levels, even when their exposure to one of the languages is limited, and that the progression of incidental word learning mirrors a comparable path in both ASL and spoken English.

A study by Larsson (2015) examined the development of grammatical intuition in 29 adult CODA in STS and Swedish. Grammatical intuition was assessed using two versions of a grammatical judgement tests (written and auditory) and a cloze test (filling in missing words based on context). The results indicate that the average grammatical intuition in spoken Swedish among CODA native signers is comparable to that of early L2 learners of Swedish but significantly different from that of native Swedish speakers. This finding suggests that, for some native signers, Swedish may have been acquired successively rather than as a first language.

Yet a qualitative case study by Hofmann and Chilla (2014) in Germany explores the language development of hearing children of deaf adults

(CODAs) using a bimodal bilingual language acquisition model. Six CODAs (aged 3 years 10 months to 6 years 4 months) were assessed using standardized tests for spoken language competence, and their overall abilities in both spoken and sign language were measured. The CODAs performed similarly to monolingual children in German sentence structure and vocabulary, but exhibited deviations in verb and preposition production. Some CODAs displayed below-average performance in certain grammatical subtests, suggesting a simultaneous acquisition of both languages (spoken and signed German) for some, while others exhibited patterns resembling successive language acquisition seen in (migrant) children acquiring German as an early second language.

A study by Bishop and Hicks (2005) explores CODA children's bimodal bilingualism. The study, based on emails from a forum for hearing individuals with deaf parents, reveals strong grammatical influence from ASL in written communication. Unique structures, such as nonstandard verb inflections and syntactic calquing, highlight the distinctive linguistic features of bimodal bilinguals. Additionally, there is a notable tendency to use English to describe ASL signs, emphasizing visual representations over lexical equivalents. The findings contribute to the understanding of bilingualism, offering a valuable perspective on language use in the context of bimodal bilingualism.

In summary, there is a notable absence of research on writing within the CODA group, and our understanding of their language development from various perspectives remains limited.

5 Methodology

This methodology chapter presents various critical elements, that are overviewed and discussed in sections that address the thesis' study design, the participant recruitment, an overview of the participants, material, procedure, ethical considerations, analyses, and statistical analyses.

5.1 Study design

This thesis has a descriptive bottom-up approach as its starting point, offering a contextual understanding of DHH writing by considering various factors. For example, variables like *age*, *gender*, *age of acquisition, hearing degree*, and *sign language proficiency*, are all taken into account, which may shed light on the interaction and effects of these variables on writing in DHH children. This comprehensive approach allows investigation of the nuances and complexities of this population's writing.

Another advantage of the bottom-up approach is that it can inform professionals in research, education, and interventions about how DHH children perform in writing. The insights gained from a descriptive bottom-up study can have practical implications for interventions and instructional strategies aimed at understanding the complexity and unique needs of the DHH group. By identifying specific challenges to or strengths in DHH children's writing, the study findings can guide and improve our understanding of this group's needs, and propose concrete interventions should such be needed.

5.2 Participant recruitment

Data were collected from written texts from 58 children, including those who are deaf, hard-of-hearing, and hearing. The subsequent sections will delve into the recruitment process.

5.2.1 Recruitment through cochlear implant teams

Before this study started, four Swedish cochlear implant (CI) teams were asked if they would help recruit informants by conveying information about my research project to their patients. Two of the four CI-teams replied and

appointments were initiated with those teams. At the meetings, the inclusion criteria for the study (see section 5.3) were presented. The first CI-team could convey information to 13 patients, and the second CI- team to 109 patients. Patient lists are strictly confidential, and so we agreed that the first CI-team would add information about the research project in their yearly appointment letters to the patients. From the two teams combined, only nine of 122 patients agreed to participate, which is a response rate of 6.5%.

5.2.2 Recruitment through the deaf community

Data collection from the deaf community was approached through personal contacts, such as friends, acquaintances (friends of friends), Facebook, networking and special schools.

Of the 40 members in the deaf community who were contacted, 37 agreed to participate (including both DHH and CODA children), corresponding to a rate of 92.5% agreement. However, seven of these 37 had to cancel before the testing sessions (due to illness, other commitments, or exclusions for various reasons), resulting in a final participation rate of 75%. Appointments were arranged with the participants and their parents, and their teachers and rectors provided rooms for the testing sessions within a few days or weeks.

5.2.3 Recruitment through networking

The remaining hearing children were contacted through both acquaintances and with help of a family friend who worked as a teacher at a school for hearing students in a small village in southern Sweden.

5.2.3.1 Regarding recruitment

A notable discrepancy in response rates emerged between CI teams (6.5%) and the deaf community approached directly (initially at 92.5%, later reduced to 75% for actual participants). It is crucial to underscore potential factors that could have contributed to this variation. While data collection and engagement with the deaf community were easily conducted, collecting data from the CI-teams was more challenging. Discussions with the CI-teams revealed that the DHH group is a relatively small but highly sought-after population for research. Many CI-users and their parents may feel overwhelmed by the number of researchers interested in including them in various research projects, leading to a sense of being overanalyzed. Additionally, patients at the CI-teams often undergo multiple tests during their annual appointments that contribute to research, which may make them hesitant to participate in yet another study. These factors could explain the lower response rate from the CI-teams.

Another factor that may have influenced the response rate is the participants' lack of signing knowledge. The letter sent to parents mentioned that their children would undergo a STS test in addition to the written task,

regardless of their proficiency in sign language. This addition might have intimidated potential participants, especially considering that many of them primarily use spoken Swedish and/or are mainstreamed into hearing society and/or have little to no proficiency in sign language. Considering the limited frequency of sign language proficiency among DHH children in general (SOU, 2016:46), it is likely that those with cochlear implants from the CI-teams felt uncertain about participating in a test that would include a language of which they have little or no knowledge.

5.3 Overview of participants

When recruitment started, the following inclusion criteria were applied:

- No further disabilities other than the hearing loss.
- If the child has CI, s/he should have received it at the latest at the age of 3.0.
- The DHH child was deaf before the age of 2.
- Other children with varying hearing and linguistic backgrounds would also be included in the collection, such as deaf, hard-of-hearing and hearing children. The hearing children were either monolinguals, bimodal bilinguals (including CODA) or unimodal bilinguals.

These criteria led to the inclusion of 58 participants. The age group spanned 8 to 18 years, encompassing 32 children with varying degrees of hearing loss, including 7 deaf, 12 hard-of-hearing, and 13 CI-users. The remaining 24 participants were hearing children, comprising 10 signing CODAs and 14 hearing children with no prior exposure to STS. See Table 1 for more details.

	Deaf	HoH	CI-users	CODA	Hearing
n	7	12	13	10	14
Mean Age	10.5	12.0	13.1	11.4	10.9

Table 1. An overview of the distribution of the participants.

It is important to note that sometimes a given participant appears in more than one of my research papers, but not always. There are three reasons for this. Firstly, participants were still being recruited after some papers were under review or already published. Secondly, the papers used differently aged participants; for instance, Paper I includes participants aged 10–11 while Paper III includes those aged 8–18. Thirdly, the deaf (that is individuals without HT) children participated only in Paper I and were not included in subsequent papers, because the later papers had a specific focus on DHH children using HT, which did not apply to deaf children without HT.

5.3.1 Deaf participants

The deaf children were profoundly deaf, which means that they did not use HT and did not use or comprehend spoken language. They have STS as their primary language. Each deaf participant had at least one deaf parent, which explains why the deaf children had at least a parent with full signing knowledge. The deaf children were attending a special school for the DHH with a bilingual focus on written Swedish and STS. Table 2 shows the metadata of the deaf children, including their number of words and SignRepL2 points. Note again that these deaf children only appear in Paper I.

Age	Gender	Signing parent(s)	School	Number of words	SignRepL2 (max 4.0)	Paper participation
9.9	Girl	Yes	Special school	168	3.88	Paper I
10.0	Girl	Yes	Special school	105	3.88	Paper I
10.0	Girl	Yes	Special school	244	3.96	Paper I
10.5	Boy	Yes	Special school	128	3.86	Paper I
10.7	Boy	Yes	Special school	282	3.90	Paper I
10.8	Girl	Yes	Special school	139	3.98	Paper I
11.3	Girl	Yes	Special school	164	3.92	Paper I
10.5				**175.6**	**3.9**	

Table 2. Metadata of the deaf participants. The columns display information regarding the participants' age, gender, parental signing status, school choice, word count in their texts, STS test scores, and the specific papers in which they participated.

5.3.2 Hard-of-hearing participants

The hard-of-hearing children in this study used traditional hearing aids and used and comprehended spoken Swedish. The majority of these hard-of-hearing children used STS on a daily basis, as the very majority of their parents were fluent in it.

An 8-year-old boy was excluded from the analysis as he could not complete the writing task due to uncertainty about his written Swedish, leaving twelve remaining hard-of-hearing participants. Of these twelve, eleven had deaf and signing parents and one had hearing parents with limited signing skills. Six hard-of-hearing children were attending a special school for DHH with a bilingual focus in spoken Swedish and STS. Two participants were attending a public school for hard-of-hearing. The remaining four children were attending a mainstream school. Table 3 shows the metadata of the hard-of-hearing children, including their number of words, SignRepL2 points, and which papers they appear in.

Age	Gender	Signing parent(s)	School choice	Number of words	SignRepL2 (max 4.0)	Paper participation
8.7	Girl	Yes	School for HoH	294	3.9	Paper III
9.2	Girl	Yes	Mainstreamed	324	2.78	Paper III
10.7	Boy	Yes	Special school	240	3.88	Paper I, II, III, IV
11.2	Boy	Yes	Special school	134	3.38	Paper I, II, III, IV
11.6	Boy	Yes	Special school	300	3.84	Paper I, II, III, IV
12.0	Girl	Yes	Special school	322	3.98	Paper III, IV
12.7	Boy	Limited	School for HoH	291	3.68	Paper III, IV
12.8	Girl	Yes	Special school	360	3.98	Paper III, IV
12.8	Girl	Yes	Special school	395	3.96	Paper III, IV
12.9	Girl	Yes	Mainstreamed	293	3.92	Paper III, IV
14.7	Girl	Yes	Mainstreamed	530	3.92	Paper III
15.0	Girl	Yes	Mainstreamed	412	3.86	Paper III
12.0				**324.6**	**3.8**	

Table 3. Metadata of the hard-of-hearing (HoH) participants. The columns display information regarding the participants' age, gender, parental signing status, school choice, word count in their texts, STS test scores, and the specific papers in which they participated.

5.3.3 Cochlear implant users

Cochlear implant (CI) users are individuals with cochlear implants, enabling them to use and comprehend spoken Swedish. Their proficiency in STS varied, influenced by factors such as having signing parents or the absence thereof.

One CI participant initially recruited was excluded because it turned out that she had only lived in Sweden for a few years. Out of the thirteen CI-users initially recruited, two had deaf parents and the other 11 had hearing parents. Out of these 11 hearing families, three families (parents) have learnt sign language fluently. Table 4 shows the CI-users' number of words, SignRepL2 points, and the papers they appear in.

Age	Gender	Signing parent(s)	School choice	Number of words	SignRepL2 (max 4.0)	Paper participation
8.7	Girl	Yes	Mainstreamed	215	2.14	Paper III
9.4	Girl	No	Mainstreamed	225	1.84	Paper III
10.7	Girl	Limited	Mainstreamed	174	2.44	Paper I, II, III, IV
11.0	Girl	Yes	Mainstreamed	270	3.54	Paper I, II, III, IV
11.1	Girl	Yes	Mainstreamed	318	3.88	Paper I, II, III, IV
11.3	Girl	Yes	Special school	374	3.78	Paper I, II, III, IV
11.4	Girl	Yes	Mainstreamed	353	3.80	Paper I, II, III, IV
13.8	Girl	Limited	Mainstreamed	228	2.80	Paper III
14.1	Boy	No	Mainstreamed	315	2.02	Paper III
14.6	Boy	Limited	Mainstreamed	339	2.74	Paper III
17.6	Girl	No	Mainstreamed	550	2.24	Paper III
18.1	Boy	Limited	School for HoH	692	3.28	Paper III
18.7	Girl	Yes	School for HoH	580	3.96	Paper III
13.1				**356.4**	**3.0**	

Table 4. Metadata of CI-users. The columns display information regarding the participants' age, gender, parental signing status, school choice, word count in their texts, STS test scores, and the specific papers in which they participated.

5.3.4 CODA participants

The CODA (children of deaf adults) are hearing, but have deaf parents and have therefore brought up in a signing environment. They are bilinguals in spoken Swedish and STS. No CODA child was excluded from data collection. Table 5 shows the CODA participants' number of words, SignRepL2 points, and the papers they appear in.

Age	Gender	Signing parent(s)	Number of words	SignRepL2 (max 4.0)	Paper participation
10.9	Girl	Yes	290	3.92	Paper I, II, IV
11.0	Boy	Yes	227	3.70	Paper II, IV
11.0	Boy	Yes	225	3.78	Paper I, II, IV
11.0	Boy	Yes	408	3.92	Paper II, IV
11.2	Girl	Yes	402	3.84	Paper I, II, IV
11.3	Girl	Yes	345	3.62	Paper I, II, IV
11.4	Girl	Yes	522	3.44	Paper I, II, IV
11.6	Girl	Yes	432	3.76	Paper I, II, IV
11.7	Girl	Yes	1155	3.46	Paper II, IV
12.5	Girl	Yes	335	3.52	Paper II, IV
11.4			**434.1**	**3.7**	

Table 5. Metadata of the CODA participants. The columns display information regarding the participants' age, gender, parental signing status, word count in their texts, STS test scores, and the specific papers in which they participated.

5.3.5 Hearing participants

Data was collected from fourteen hearing children without previous knowledge of STS, although five of them were exposed to other languages in the home environments beyond Swedish (Danish, Dutch, Kurdish, and Thai). This distribution of hearing children should therefore correspond to a typical class in Sweden. One hearing child was excluded from the analysis because she had writing and reading difficulties, which was only found out about after data collection. See Table 6 for more detailed meta information about the hearing participants and the papers they appear in.

Age	Gender	Languages	Number of words	SignRepL2 (max 4.0)	Paper participation
10.3	Girl	Monolingual	262	1.96	Paper I, IV
10.3	Girl	Monolingual	277	1.76	Paper I, IV
10.4	Girl	Monolingual	450	2.38	Paper I, IV
10.5	Girl	Monolingual	276	2.02	Paper I, IV
10.6	Girl	Monolingual	183	2.06	Paper I, IV
10.6	Girl	Monolingual	236	2.2	Paper I, IV
10.7	Boy	Monolingual	175	1.94	Paper I, IV
10.8	Boy	Bilingual	174	2.06	Paper I, IV
10.9	Boy	Monolingual	252	2.08	Paper I, IV
11.1	Girl	Bilingual	483	2.58	Paper I, IV
11.2	Boy	Bilingual	422	2.2	Paper I, IV
11.4	Girl	Bilingual	445	1.98	Paper I, IV
11.5	Girl	Monolingual	314	2.24	Paper I, IV
11.6	Boy	Bilingual	208	2.1	Paper I, IV
10.9			**296.9**	**2.1**	

Table 6. Metadata of the hearing participants. The columns display information regarding the participants' age, gender, word count in their texts, STS test scores, and the specific papers in which they participated.

5.3.5.1 Regarding sampling limitations

It is crucial to acknowledge that the sample size in this study is relatively small, which may raise concerns about the generalizability of the findings. However, the significance of this study lies in its focus on DHH children in Sweden who have sign language proficiency. In Sweden, approximately 30–40 children are born deaf each year (Barnplantorna, 2022), most of whom have hearing parents who typically prioritize implants and spoken language as their primary means of communication (Karltorp et al. 2019; Mitchell & Karchmer, 2004; SOU, 2016:46). The result of those priorities is that there is only a limited number of DHH children who use STS in this country. To put the numbers in context, this thesis includes a sample of 33 DHH children, in which the majority of them have mastered STS. Given the intensive data collection from this small bimodal bilingual group, this sample should provide a comprehensive understanding of the unique linguistic background of this population, especially considering the small number of signing DHH children in Sweden.

5.3.5.2 Regarding age

I did not want to exclude any children or adolescents who might have been at the extremes of the most appropriate age range, and I included all who were willing to participate. While most participants fell in the range of 10 to 12 years old, those with CIs had a broader age range and a higher mean age because they were recruited through CI-teams who sent a request to all patients between the age of 8 and 18. Even though the number of participants at the lower and upper levels of the age range of this group was few, I wanted to ensure that their data was not collected in vain. Therefore, I included participants across the entire age spectrum (ages 8 to 18) in Paper 3.

5.4 Material

The materials used in this study include a keystroke logging tool, a writing stimulus, an STS test, and a background questionnaire designed to collect information about the participants' backgrounds. These components will be presented in the following sections.

5.4.1 Keystroke logging tool

The measures from Table 8 were generated from a *keystroke logging tool*, which is a non-intrusive software installed on a computer. The idea behind this tool is to record and track every keyboard activity (and sometimes mouse movements) while a person is actively writing on the computer (Johansson et al. 2023). A keystroke logging tool can register a writer's activities and record information about the writers' writing behavior such as how fast they type, when and where they pause, delete, their writing time, writing speed, writing

fluency and much more. It is, however, important to note that a keystroke logging tool only shows *what* that happens during writing, not *why* those events happen. To get a deeper insight into *why* writers write the way they do, additional methods such as self-reports, think-aloud methods (verbalizing one's thoughts and decision-making processes while writing), or retrospective interviews should be considered (Johansson et al. 2023).

There are many of different keystroke logging software that can be used for various specific purposes. For my research, I used ScriptLog for data collection and ScriptLog and its sister program Inputlog (Leijten et al. 2013) for extracting analysis files for further exploration (Johansson et al., 2023). ScriptLog consists of a screen with a start and end button (Figure 2).

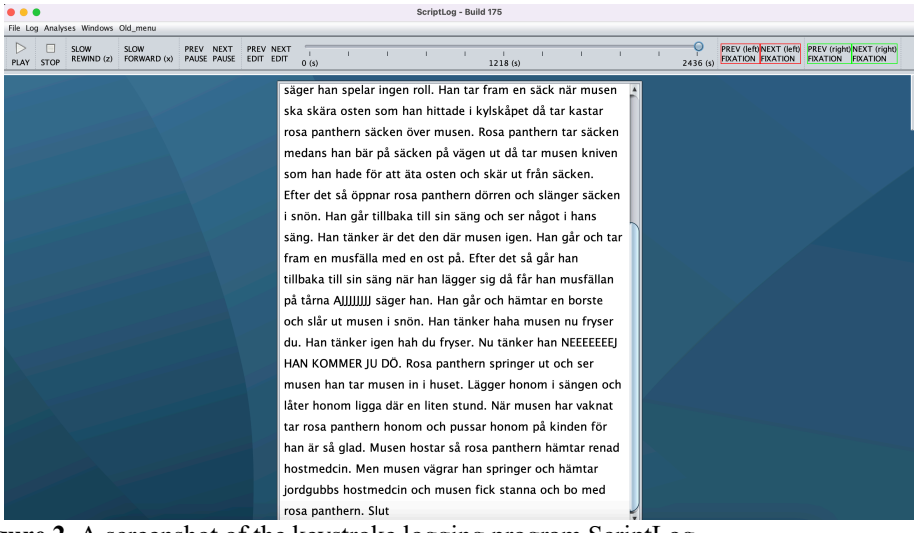

Figure 2. A screenshot of the keystroke logging program ScriptLog.

When recording is finished, several files can automatically be generated – the final text, the raw file representing the writing process including pauses and revisions, detailed writing statistics such as writing time, total pause time, pauses before, within or after words, punctuation, spaces, capital letters and more. The statistics will of course change depending various settings. For instance, a pause criterion could in theory be set to 0 seconds, in which case *all* pauses during writing, regardless of length, would be captured, including the micro-pauses it takes to move between two keys. These micro-pauses are not relevant in the context of this research. If the pause criterion is set to 2 seconds, ScriptLog will only extract pauses equal to or longer than 2 seconds. Table 7 shows ScriptLog output for a sample phrase (the phrase is Swedish for “once upon a time”).

0 s criterium	2 s criterium
<72.963>d<0.000><0.179>e<0.000><0.509>t<0.000> <0.314><0.000><0.345>v<0.000><1.043>a<0.000> <0.100>r<0.000><1.085><0.000<0.586>e<0.000> <0.219>n<0.000><0.209><0.000><1.266>g<0.000> <0.608>å<0.000><0.410>n<0.000><0.418>g<2.542>	<72.963>det var en gång<2.542>

Table 7. Comparison of ScriptLog output from pauses of 0 s and 2 s. When the 0 s criteria is used, any pause, no matter how short, is captured, including the movement between two keys within a word.

After a writing task has been completed, the following information can be generated through the statistics output from ScriptLog, see Table 8.

Definition in ScriptLog	Outcome	Explanation
Character tokens in final text	1677	Including letters, spaces and punctuation marks.
Character tokens in linear text	2197	The writer typed 2197 characters during the whole writing process (which means that the writer deleted 23% of the characters).
Total recording time	2436.4	The time in seconds between pressing the start and end button (here, 40.6 minutes).
Time until first key press	72.9	The time it took for the writer to start writing (or observe the cartoon, to plan, etc.)
Total typing time	2347.6	The time in seconds the writers wrote (here, 39 minutes).
Pause criteria (s)	2.000	User-determined pause criterion in seconds.
Number of pauses	173	The number of pauses that were equal to or longer than 2 seconds.
Total pause time	1086.3	The total time in seconds the writer paused (here, 18 minutes, which is 46% of the total typing time).
Mean pause length	6.3	Statistical mean average of all pauses that met the pause criterion.
Median pause length	6.9	Statistical median average of all pauses that met the pause criterion.
SD pause length	3.8	Standard deviation of pause lengths.
Transition time median	0.364	The median amount of time it took for the writer to find the next key.

Table 8. A sample of writing process measures generated automatically by ScriptLog. The output in this table is based on a writing task of a DHH child from Paper IV.

The keystroke logs that were recorded in ScriptLog were later exported to another keystroke logging program, Inputlog, to take advantage of the additional analysis options provided in that program (Leijten et al., 2013). Output from both ScriptLog and Inputlog was occasionally further processed in Excel.

5.4.2 Writing stimuli

This thesis used a cartoon stimulus featuring a narrative with the Pink Panther, an animated character known for his misadventures and comedic behaviors. This stimulus, which includes 31 pictures distributed across two pages, is detailed in Gärdenfors (2016)[3]. The story can be summarized as follows:

> The Pink Panther sleeps in his bed and wakes up because he hears something. He checks it out and sees footprints, follows them, and finds a mouse in the bed. The Pink Panther throws out the mouse. The Pink Panther discovers new footprints, finds the mouse near the refrigerator, and catches the mouse with a sack. The mouse cuts itself out of the sack before the Pink Panther can throw it out and hides in the bed. The Pink Panther sets a mouse trap and sneaks to the bed and lies down but ends up getting his foot caught in the mouse trap. The Pink Panther throws out the mouse with a broom, but later feels guilty and lets the mouse back in.

The story lacks speech bubbles or any other accompanying text and therefore requires the writers to produce their own narratives using their own language skills without relying on possible word clues from the stimulus. The cartoon about the Pink Panther is appealing to participants of a wide age range (e.g., Berman & Slobin, 2016), so it was thought to be appropriate for the writers here who were between 8 and 18 years old. An advantage of using this stimulus, as opposed to free-writing, is that this stimulus provides equal starting points for all participants, and enables comparable data across age and participant group (or participant backgrounds) for linguistic comparison of how various linguistic problems are solved, such as writing beyond a word they cannot spell.

5.4.2.1 Regarding writing stimuli

The children's proficiency in written Swedish was not assessed based on standardized tests; rather, the analyses of the written Swedish proficiency lies in the written narratives generated by the participants. Analysis of written texts allows the gathering of essential information such as spelling, text length, lexical and syntactical complexity, etc., and analysis of both the data themselves and the processes that produced it. A vast body of research has demonstrated

[3] Unfortunately, I am unable to show the cartoon in the appendix because I never got a response regarding copyright permissions from the current rights holder, and ownership has changed since the last contact.

that using picture-elected narratives is successful for generating comparable linguistic data (cf. for instance Berman & Slobin, 2016, in which ”Frog where are you” was used for cross-linguistic comparisons). The Pink Panther writing stimulus specifically used here has previously been used in other studies involving DHH children (Gärdenfors, 2016; Schönström, 2010; Schönström et al., 2021). The participants also confirmed that they were familiar with the Pink Panther, which means that they all had equal prior knowledge about this main character.

Given the limited research on writing in Swedish DHH children, especially from an international perspective, reusing the Pink Panther stimulus allows for replication of previous writing studies on Swedish DHH children.

5.4.2.2 Regarding a Swedish vocabulary test

While the participants' proficiency of STS was examined, their proficiency in written Swedish was not evaluated through standardized tests. This poses a limitation, particularly considering the bilingual nature of the study. Integrating standardized Swedish proficiency tests, such as evaluations of reading comprehension or spelling, could have provided insights into the participants' overall language skills in Swedish. For example, details about the Swedish proficiency of the hearing and CODA groups (whether unusually strong or weak) might have influenced the conclusions drawn about the writing abilities of these distinct groups. The exclusion of these tests may render it more challenging to arrive at definitive conclusions about their actual proficiency in written Swedish. Nevertheless, the reasoning behind this choice is that a substantial amount of information about their written Swedish proficiency was derived from the written narratives, offering an overall depiction of their written Swedish.

The decision to omit standardized tests was motivated by ethical considerations (see also 5.6 for further discussion). Given that the DHH community is a minority often subjected to research, many individuals have previously engaged in research and school projects. The risk of 'over-researching' may have resulted in research fatigue and resistance to additional testing. I consciously opted to prioritize the number of participants and their testing experience over the inclusion of supplementary tests.

5.4.3 The SignRepL2 test

STS proficiency of the participants was measured using the first version of an sentence repetition test called SignRepL2 (Holmström et al., 2023; Schönström & Holmström, 2017). In this test, fifty sentences in STS were shown to the participants on a computer, and the participants were asked to recall the sentences exactly as presented during recording. The difficulty of the sentences increased from simple single-sign items to three-sign sentences.

More specifically, SignRepL2 consists of a 10 minute video including 50 short video-clips (30 clips with one sign, 10 clips with two signs and 10 clips

with three signs) of increasing difficulty. The video clips included both lexical signs and advanced features such as syntactic and non-manual features required for reaching higher points.

Each correctly copied sentence would give 4 points, so the maximum possible number of points was 200 (4 points x 50 sentences = 200 points). Whether the sentences were correct or not was judged based primarily on the sign(s)' phonological features such as handshapes, movements, placements and mouthings. For example, the STS sign for LEDSEN [SORRY] (Swedish Sign Language Dictionary, ID 00185) is carried through a flat hand placed on the chest with a circulating movement, and a mouthing imitating the Swedish word "ledsen". If a participant imitated one phonological feature incorrectly (for example using a jumping movement instead of a circulating one), the total points for this particular sentence would be 3 points. If the participant failed to imitate two features out of four, 2 points would be given, and so on.

When the sentences increased to two or three signs, additional aspects such as morphology and syntax would also be considered. For example, the sentence "BLÅ ÖGON" [BLUE EYES] is not only considered lexically, but also morphologically and syntactically. This sentence starts with an initial pause before the sign BLÅ which adds the morphological information that the eyes are very blue. The test, thus, also measures the participants' proficiency in producing the more advanced features associated with STS such as initial pauses, non-manual signals, sign order, fingerspelling and so forth. For the example "BLÅ ÖGON", six features were considered (handshape, movement, placement, mouthing, syntax and morphology). So if a participant was able to copy 6 out of 6 features, the maximum points would still be 4. But if the participant only copied 3 of 6 features, they would be given 2 points (see Holmström et al. 2023 for further details).

Having to produce these non-manual signals, fingerspelling and so forth clearly advantages L1 STS speakers, who typically handle these components automatically, over L2 STS learners, who primarily focus on mastering lexical signs. L2 learners may overlook important grammatical features that are characteristic of sign languages, and will therefore probably achieve lower scores that L1s.

5.4.3.1 Regarding SignRepL2

One concern about the STS test SignRepL2 is that it is primarily intended for L2 learners, which mean that there was a potential ceiling effect since several participants in this study had STS as their L1, often alongside another language (spoken or written). This fact raises the issue that there is currently no test available that covers the range of zero knowledge to full proficiency in STS.

There is an alternative test called STS-SRT that was designed for adult L1 learners (Schönström, 2014), but it was not used in this study. Previous studies using STS-SRT reported difficulties faced by several young participants who had STS as L2, leading to test cancellations. In addition, children with STS as

their L1 scored lower than their adult counterparts with STS as L1 (Schönström & Hauser, 2021; Schönström et al., 2021). For these reasons, SignRepL2 was chosen for these studies as it has a better scoring system, considering each correctly expressed sub-part of a sign or a sentence.

In addition, the scoring systems of SSL-SRT and SignRepL2 are quite different. SSL-SRT takes a binary approach, and any given sentence has a score of either 0 or 1 point. A score of 0 results even if only a single sign out of seven possible is produced incorrectly. Thus, the SSL-SRT scoring method does not account for phonological or morphological nuances in signing. SignRepL2 scoring system (outlined in the previous section) is more nuanced, attributing points for each correctly produced phonological part of a sign. This approach takes into consideration the participants' individual and nuanced understanding of STS, allowing for a more comprehensive assessment of their proficiency.

5.4.4 Background questionnaire

Questionnaires about the backgrounds of the participants were filled out by the participants' parents (or by participants themselves if they were 18 years old). The questionnaires comprised forty questions divided into five sections and including important demographic variables such as age, age of acquisition, hearing degree, gender, etc.

The first section included general questions (name, age, family background) and whether a child had any other known disabilities (and if so what). The second section focused on the child's degree of hearing, including when their deafness had been identified, if and when they received a cochlear implant (CI), their hearing level with and without CI or hearing aids, and similar information. The third section covered questions about the child's school choice, such as whether they attended a mainstream class or a class for DHH children, and other relevant details. The fourth section addressed the child's linguistic background, including that child's primary communication method at home with parents, any changes in their communication methods over time (e.g., transitioning from STS to spoken Swedish or vice versa), when they started learning STS, when they started speaking, reading, and writing in Swedish, and their reading habits. This section also covered the parents' proficiency in STS (whether they had learned STS and if so to what extent). The fifth section focused on the family's socioeconomic background, including the educational level and occupations of the parents.

5.4.4.1 Regarding the background questionnaire

The information acquired in the background questionnaire was not exhaustive, and could perhaps have been used more to interpret the empirical data. Factors such as age of acquisition and spoken language acquisition will be discussed below.

I discovered there was an issue with the question regarding children's AoA. The question asked, "*When did your child learn spoken Swedish/sign language? Please reply in years and months.*" The responses received from parents were quite diverse, ranging from "from birth", "0 year" to "1 year". The problem is that children cannot communicate in spoken Swedish or STS from day one. Instead, what should have been asked is when the children received their first linguistic input, which is a crucial factor in language acquisition (Lenneberg, 1967).

A notable limitation of the study lies in the fact that, despite the DHH children using HT demonstrating well-developed proficiency and comprehension in spoken Swedish during the testing sessions and engaging in age-appropriate conversations, their proficiency in spoken Swedish comprehension was not formally assessed. This limitation can be problematic because proficiency in spoken Swedish comprehension is a crucial variable for linguistic development in the DHH population (e.g., Karltorp et al., 2019; Wie et al., 2020). The lack of proficiency testing in spoken Swedish comprehension limits a comprehensive understanding of the participants' language abilities. By assessing spoken Swedish comprehension, we would have gained insights into the participants' language skills and their overall language development. This information would have allowed for a more robust analysis and a clearer understanding of the factors influencing language acquisition in this population.

This work encountered a significant challenge when it came to collecting essential auditory and linguistic background information for the participants. Initially, agreements were in place with two CI-teams to administer standardized tests, including audiograms, vocabulary assessments, and spoken comprehension tests in both calm and noisy environments. These tests would have furnished auditory insights crucial for comprehending the language abilities and bimodal bilingualism of the participants. Unfortunately, the participation rate from the CI-teams turned out to be quite low, leaving a substantial gap in the auditory information available for the majority of the recruited participants from the deaf community.

It would be beneficial if future research could incorporate additional tests (like the audio tests) and ask for some additional background information to compensate for potential limitations in data availability.

5.5 Procedure

Once the participants and their parents had agreed to take part in the research project, individuals aged 18 and above and the parents of participants under 18 submitted written consent for participating. Parents and participants were informed that they had the option to withdraw from the research at any time. Written consent forms were either collected during the testing sessions or sent by mail. Most testing sessions were conducted in pre-scheduled appointments

at schools. However, some testing sessions occurred in participants' homes or in spaces arranged by CI-teams. Regardless of the location, a consistent approach was maintained during the testing sessions.

Data collection took part in a quiet room. In most cases, it started with some small talk before the research project was introduced. Participants were thanked for their participation, and then given overall instructions, which was they would be asked to complete two tasks: a written task and a sign language test.

For the writing task, participants were presented with a picture series of a narrative with the Pink Panther and were asked if they were familiar with this character. All said that they had seen him on TV or in a cartoon, which means that they had equal prior knowledge about the character. The participants were then requested to study the picture series. I explained that the cartoon consisted of two pages, front and back, and instructed them to sit in front of a laptop and write a story about the cartoon they were observing. The participants were informed that they could look at the pictures throughout the writing session and that I would be sitting slightly behind them the whole time, but that they were not allowed to ask for help and needed to complete the writing task independently, with no time limit. Once the participants finished the writing task, I clicked on the "end" button and informed them that their writing processes had been recorded. If they were curious, I replayed the recording so they could see their own writing process. In all cases, the participants found it "cool". All the children, regardless of their backgrounds, were able to comprehend the writing stimuli and created similar outlines, which included the main characters, the beginning, the most significant events, and concluding remarks. On average, the writing task took approximately 30 minutes.

Prior to conducting the STS test SignRepL2, I explained to the participants that I would also be assessing their sign language skills, regardless of whether they had any prior knowledge in sign language or not. The participants were first provided with an introduction video featuring a woman explaining how the test would be conducted. This introduction was both explained through spoken and written Swedish (it was captioned).

In the instructional video, participants were briefed on the testing procedure. They were informed that during the test session, they would observe a man demonstrating signing sentences on the screen. Afterward, there would be a brief period with a blank gray screen, allowing them to mimic the signs as accurately as possible. These copying of sentences would then be recorded through the computer's camera.

Participants were instructed not to use their own preferred sign variations. For instance, if the sign for "SOVA" [SLEEP] was demonstrated in the video with a flat hand on the cheek (Swedish Sign Language Dictionary, ID 00049), they were asked to repeat that word back, even if they personally were accustomed to using an alternative sign for "SOVA" (Swedish Sign Language Dictionary, ID 03253), in which the hand is placed at the eye.

Participants were advised that if they felt the video clips were progressing too quickly for them, they had the option to pause the video between signs during the gray screen intervals, but not in the middle of a sentence or sign demonstration. The instructions were immediately followed by four exercise examples so that the participant could try out how the test worked. After these initial exercises, the participants performed the test. During the whole testing sessions, I was present, sitting slightly behind the participants and ensured that everything proceeded according to the instructions.

5.6 Ethical considerations

The ethical consideration was accepted by *Etikprövningsnämnden* (Ethics Committee in Stockholm) 2018-06-19), diary number (2018/1033-31/5). *Etikprövningsnämnden* approved the initial application with few complements that a formulation needed to be changed so that parents/caregivers could sign the written consent (not only a parent).

To ensure data security, all collected data and background questionnaires were stored on an external hard disk that was securely kept in a lockable case accessible only to me and my supervisors. An important ethical consideration was anonymization of the data. Recoding the written data and the participants' background information into ID numbers posed no issues. However, ensuring anonymity for the SignRepL2 tests recorded on video required several additional steps as the participants' recordings could not be fully anonymized. The additional steps included scoring their SignRepL2 tests on the same day that the recordings were made, allowing the raw scores to be quickly transferred to an Excel document, storing the video files on a separate hard disk, and erasing the original video files from my laptop. The raw scores were then merged with participants' unique ID numbers, guaranteeing that it would be impossible to identify individuals from the Excel file.

Another ethical consideration concerns to the limitations associated with testing. In this thesis, one notable limitation was the absence of standardized tests to assess the children's proficiency in Swedish and their hearing abilities (see discussion in section 5.4.2.2 for further details). This omission was driven by ethical concerns regarding the well-being of the DHH minority, which has been extensively studied in previous research and school projects. As discussed in section 5.4.2.2, it was thought that it would have been unfair to subject the participants to an excessive number of tests, potentially leading to research fatigue and resistance among some individuals. Equivalent information was collected through the background questionnaire that was filled by the parents in an effort to divide the work.

Another related aspect to consider is that some of the DHH children had either no or limited knowledge in STS, yet they still underwent the STS test (they were informed that they could stop the STS test at any time, but no one did). This fact too raises ethical concerns about subjecting them to a test that

they might not perform well in, which might make them unwilling to participate in future research projects.

5.7 Analyses

This work considers several written products and writing process measures. This section presents an overview of how these products and process measures were analyzed, what data they contributed, and which research papers used which products/measures.

5.7.1 Analyzing the written product

Table 9 gives an overview and explanation of the various measures used to analyze the written products, include text length, vocabulary, syntactic complexity, and the overall quality of the text. These measures together offer a comprehensive perspective on the writing capabilities and product quality of the DHH children.

Measure	Definition	Paper(s) using this measure
Number of words	A word is defined as a string of letters separated by spaces (or punctuation). The number of words were obtained through Microsoft Word's word count.	Paper I Paper II Paper III Paper IV
Word length	Word length is defined as the number of characters. The measure was calculated by Computerized Language ANalysis (CLAN) (MacWhinney, 2000). The measure is an average length for all words in the text.	Paper IV
Proportion of spelling errors	Spelling errors in the final texts were identified and coded manually by one of the authors, and then extracted/calculated manually. To compare the proportion of spelling errors among participants, the number of spelling errors in the final texts were divided by the number of words in the final texts.	Paper I Paper II Paper IV
Lexical diversity	Measures of lexical diversity indicate the lexical variation in a text, i.e., the more unique words that are used, the higher the lexical diversity. In this study we used the measure "VocD" (Malvern et al., 2004), which is incorporated in the CLAN programs (MacWhinney, 2000). This measure is automatically calculated by CLAN.	Paper II Paper III Paper IV

Lexical density	Measures of lexical density indicate what proportion of the text consists of lexical words (nouns, verbs, adjectives, and lexical adverbs). We used a measure of lexical density where the number of lexical words was divided by the total number of words (Halliday, 1985; Johansson, 2009). The distribution of lexical and function words was manually recoded by me, and CLAN was then used to calculate the number of function words and lexical words.	Paper II Paper III Paper IV
Number of T-units	Number of T-units per text. Each text was segmented into T-units as the shortest grammatically allowable sentences: a T-unit is defined as a main clause and its subordinated clause(s) or non-clausal structures that are embedded or attached to it.	Paper III
Number of clauses	The number of clauses per text encompasses both main clauses and subordinate clauses. These clauses were first manually coded and subsequently automatically extracted using CLAN.	Paper III
Words per T-unit	The measure of words per T-unit (Hunt, 1966) refers to the average number of words within each T-unit. T-units are manually coded and then the count of words per T-unit was automatically calculated using CLAN.	Paper III
Clause per T-units	The measure of clauses per T-unit (Hunt, 1966) refers to the average number of clauses within each T-unit. T-units and clauses were first manually coded and then the count of clauses per T-unit was automatically calculated using CLAN.	Paper III
Words per clause	The measure of words per clause (Hunt, 1966) refers to the average number of words within each clause. Clauses were manually coded, and then the count of words per clause was automatically calculated using CLAN.	Paper III

Table 9. Overview of written product measures and the papers they were used in.

5.7.2 Analyzing the writing process

Tables 10 and 11 gives an overview of metrics used to analyze writing behavior and the writing process, including pauses, fluency, and revisions. These distinct insights shed light on cognitive effort and fluency within a writing process.

Analysis	Definition	Paper(s) using this measure
Writing time	Writing time was defined as total time on task in minutes, seconds, and milliseconds. This information was automatically extracted by ScriptLog.	Paper I Paper II Paper IV
Number of characters linear text	The number of characters was determined by calculating the total count of characters produced during the whole writing process including these that were later deleted. This calculation was performed by ScriptLog.	Paper II
Writing flow (offline)	Offline writing flow refers to the ratio of the amount of text (measured in the number of characters) in the final text to the writing time in seconds. The number of characters, including letters, numbers, punctuation, and spaces, was automatically calculated by ScriptLog.	Paper II Paper IV
Writing flow (online)	Online writing flow is determined by the amount of text (measured in the number of characters) in the linear text divided by the total writing time in seconds. The number of characters, including letters, numbers, punctuation, and spaces, was automatically calculated by ScriptLog.	Paper II Paper IV
Transition time	The transition time between letters within a word has frequently been used as an indicator of a writer's typing proficiency or transcription skills (Wengelin, 2006). In this thesis, the median transition time (measured in seconds) between two consecutive keystrokes within a word was used, and was automatically extracted by ScriptLog.	Paper II Paper IV
Pause percentage	Pauses are defined as periods of inactivity during typing. Two pause criteria were used to capture different processes in this thesis. Inactivity for 1 second or longer was used to examine low-level processes, such as transcription skills and spelling, while inactivity lasting 4 seconds or longer was used to explore higher-level processes connected to planning and revision. Pauses and pause time were automatically extracted by ScriptLog, and the pause percentage, or the proportion of pause time to the total writing time, was obtained manually by dividing the pause time by the total writing time.	Paper I Paper II Paper IV
Pauses before words	This measure indicates the frequency of pauses occurring before a word and was automatically extracted using Inputlog or ScriptLog.	Paper I Paper II
Pauses within words	This measure indicates the frequency of pauses occurring within a word, specifically between the letters within a word and was automatically extracted using Inputlog or ScriptLog.	Paper I Paper II
Pauses after words	This measure indicates the frequency of pauses occurring after a word. This information was automatically extracted using Inputlog or ScriptLog.	Paper I
Pauses between words	This measure indicates the frequency of pauses occurring between words and was automatically extracted by Inputlog.	Paper IV
Pauses between sentences	This measure indicates the frequency of pauses occurring between sentences and was automatically extracted by Inputlog.	Paper IV

P-bursts in characters (mean)	A P-burst, also referred to as a 'pause burst,' defines a sequence of typed characters between pauses of a specific duration, serving as a measure to assess writing fluency. This measure quantifies the number of characters produced before the next pause (meeting the defined length) took place, providing insights into the length of each burst. The selection of pause criteria influences the number of characters in each burst. Inputlog automatically extracts P-bursts in characters.	Paper IV
P-bursts in seconds (mean)	A P-burst can also be counted in seconds, representing a time of fluent writing before it is interrupted by a pause of a specific length. This measure quantifies the amount of continuous writing time before the next pause occurs. P-bursts in seconds were automatically extracted using Inputlog.	Paper IV

Table 10. Writing process measures and the papers they were used in.

R-bursts in seconds	An R-burst in seconds is defined as the duration of text production, in seconds, that takes place between revisions. This measure is automatically extracted by Inputlog.	Paper IV
R-bursts in characters	An R-burst, also known as a "revision burst," refers to a continuous sequence of typed characters produced between revisions, such as when the backspace or delete keys are pressed. This measure is used to represent fluency and is automatically extracted by Inputlog	Paper IV
Removed characters	The total number of removed characters is divided by the total number of produced characters, and this calculation is automatically extracted by Inputlog.	Paper I Paper IV
Inserted characters	The total number of inserted characters are divided by the total number of produced characters (in the linear text). Automatically extracted by Inputlog	Paper IV
Bigger revisions	The categorization of revisions into smaller and bigger revisions is defined ad hoc, where revisions shorter than five characters are considered smaller revisions, and revisions longer than five characters are considered bigger revisions. This categorization is automatically extracted by Inputlog, and later the separation of smaller and bigger revisions is accomplished through manual coding.	Paper IV
Global revisions	Revision location is *ad hoc* divided into two categories. Local revisions occur at the inscription point. Global revisions are those made further away from the inscription point, that is when the writer had used the mouse or arrow keys to move away from the inscription point to revise something. Automatically extracted by Inputlog.	Paper IV

Table 11. Revision measures and the papers in which they were used in.

5.8 Statistical analyses

Three statistical models were employed in this research, specifically multiple regression analysis, the T-test, and correlation analysis, all implemented using R. These methods will be elaborated upon in the following sections.

Multiple regression analysis was used in three papers (Paper I, III, and IV). This method was chosen because it provides insights into the factors that affect the writing development of DHH children and the relationships between the variables. In addition to offering information on the strengths and directions of predictors, multiple regression analysis can also identify the predictors that have a significant influence on the outcomes.

Another reason this statistical analysis was chosen is that it can handle multiple predictors simultaneously. This feature is particularly useful when analyzing complex phenomena with multiple factors that affect the outcomes. By considering multiple predictors at once, multiple regression analysis can help identify which factors have the strongest influence on the outcome while controlling for the influence of other factors. Another advantage of multiple regression analysis is that it allows for the examination of children with different linguistic and hearing degree as a whole unit, without dividing them into distinct groups. This approach ensures that unique experiences and backgrounds are not missed as potential predictors.

The T-test was used in one paper (Paper II) because it is a relatively simple and straightforward statistical test that also is robust and performs well even with small sample sizes.

Correlation analysis was also used in three papers (Paper II, III and IV). This test enables us to examine the strength and direction of the relationship between two variables, which is a suitable choice considering that the point of my research is to examine how written products and writing processes are related to each other. Correlation analysis can also help generate hypotheses and identify potential relationships for further investigation.

6 Summary of the studies

This chapter provides a comprehensive summary and overview of the findings from the four studies that underpin this thesis. Table 12 summarizes these four studies, including authorship, journal sources, empirical focus, measures utilized, participant characteristics, age range, research objectives, statistical models or predictors employed, primary findings, and doi numbers. Subsequently each study will be summarized.

This series of four articles constitutes a coherent investigation of the written language development and writing processes of DHH children, with a specific focus on the bimodal bilingual context. The studies build on each other and together provide an in-depth understanding of how sign language proficiency and hearing status affect the writing skills of these children.

	Paper I (2019)	**Paper II (2021)**	**Paper III (2023a)**	**Paper IV (2023b)**
Author(s)	Gärdenfors, M., Johansson, V., and Schönström, K.	Gärdenfors, M.	Gärdenfors, M.	Gärdenfors, M., and Johansson, V.
Journal	Frontiers in Psychology	Languages	Journal of Deaf Studies and Deaf Education	Frontiers in Psychology
Empirical focus	Written product and writing process	Written product and writing process	Written product	Written product and writing process
Focus	Spelling	The relationship between written product and writing process	Lexical and syntactical development	The relationship between written product and writing process
Purpose	To explore how various background variables of the deaf and DHH children using HT (together and separately) may contribute to their spelling skills.	To explore how bimodal bilingualism is related to the writing outcomes in DHH children using HT and CODA children with similar	To explore the factors that, from a bilingual view, may influence the lexical and syntactical development in DHH children using HT.	To explore how the written product can be related to the writing processes in DHH children using HT, and how that relationship compares to the

		linguistic backgrounds in spoken Swedish and STS.		relationship between those factors in their hearing peers.
Participants	5 deaf, 4 HoH, 4 CI-users, 6 CODA and 9 hearing children	10 DHH with HT and 10 CODA	24 participants with CI or HA	12 DHH using HT, 10 CODA, and 14 hearing children
Age span	10–11 years	10–12 years	8–18 years	10–12 years
Measures	- Text length - Spelling categories - Spelling behavior - Fluency	- Text length - Syntactic complexity - Lexicon - Fluency	- Text length - Syntactic complexity - Lexicon - Language complexity	- Text length - Syntactic complexity - Lexicon - Fluency - Revision
Statistical model/ Predictors	Multiple regression analysis on predictors STS, hearing loss, deafness and bilingualism	Correlation test and T-test	Multiple regression analysis on the predictors STS, gender, AoA, and age	Correlation analysis and multiple regression analysis on the predictors STS, gender, age and hearing
Main findings	Deaf children's spelling differed from their DHH peers using HT and hearing peers. They seem to use more visual strategies and transfer from STS than their DHH with HT, and hearing peers who relied more on sounding strategies.	Few differences between the groups after their language backgrounds were controlled for. DHH children using HT exhibits higher lexical density and deleted more characters.	Age was the only factor that significantly predicted the complex writing. STS showed a tendency to predict adjective density and number of clauses.	Age predicts writing fluency, longer texts, and an advanced lexicon, confirming theories on cognitive capacity and writing development. The DHH group using HT shows slower fluency, higher lexical density, and frequent revisions.

Table 12. A summary of the research papers upon which this thesis is based.

6.1 Paper I

Spelling in Deaf, Hard-of-hearing and Hearing Children With Sign Language Knowledge (2019)

Published in Frontiers in Psychology, November 12th, 2019.
Authors: Moa Gärdenfors, Victoria Johansson and Krister Schönström

Previous research has shown that DHH children make different spelling errors than their hearing peers (e.g., Bowers et al., 2016). They tend to produce fewer phonologically plausible errors, suggesting limitations in sounding out words due to their hearing loss (Bell et al., 2019; Daigle et al., 2020; Nauclér, 1989). Instead, DHH children rely on alternative spelling strategies, such as visual representations, which can result in phonologically implausible errors.

This study aimed to explore and describe the spelling errors of 10- to 11-year-old deaf and DHH children using HT6 while considering the role of STS knowledge and varying degrees of hearing loss. Narratives were collected from 19 bimodal bilingual deaf, DHH children using HT, CODA with knowledge in STS and written and/or spoken Swedish, and from 14 hearing children without STS knowledge (some of whom knew other spoken languages). Four predictors were used to analyze different spelling error categories: *bilingualism, STS knowledge, hearing loss,* and *deafness*. The children's written narratives were collected using a keystroke logging tool, and the spelling errors were categorized into eight spelling categories.

Deafness emerged as the most influential variable, indicating that the deaf group produced spelling errors due to their limited use of auditory/phonological strategies. This paper discussed how the deaf children used visual representations and clues from STS to spell Swedish words. Examples showed that relying on visual similarity of two words could lead to semantically incorrect choices, that handshapes of a word could be mirroring into a word, and the borrowing of mouth movements from STS could result in reduced mouthings of Swedish words. In contrast, other signing DHH children using HT and CODA groups demonstrated more typical spelling errors without distinct signs of STS transfer, suggesting that an auditive strategy might be superior to a visual strategy for these children who can take advantage of their hearing. Bilingualism, STS knowledge, and hearing loss were weak predictors of all writing measures. The study found no significant differences in the overall number of spelling errors made by each the various groups. However, the hearing children in the study appeared to be superior spellers for their age group according to their teacher. Comparing the results to previous studies on hearing monolinguals, all children in this study, including the signing children, produced approximately half as many spelling errors. This result was discussed in terms of early and consistent exposure to STS, which may have allowed the signing children to use additional spelling strategies, such as

fingerspelling with a signing adult, due to the transparent relationship between STS fingerspelling and Swedish words.

6.2 Paper II

The Writing Process and the Written Product in Bimodal Bilingual Deaf and Hard-of-hearing Children (2021)
Published in Languages, May 11th, 2021
Author: Moa Gärdenfors

Recent studies have suggested that DHH children generally exhibit slower writing fluency and perform more differently on writing product measures compared to their hearing peers. However, no keystroke logging studies have considered the linguistic profiles of the DHH children. This study aimed to examine the relationship between writing product and the writing process from a bimodal bilingual perspective. The study included ten DHH children using HT and ten CODA children with equal linguistic backgrounds in spoken Swedish and STS. Written narratives were collected, and both the written product measures (e.g., *number of words, spelling errors, lexical diversity, lexical density*) and writing process measures (e.g., *writing time, number of characters in total, deleted characters, offline text flow, online text flow, transition time, pauses before words, pauses within words, number of pauses within words*) were analyzed. This study revealed only two significant distinctions between the DHH children using HT and CODA groups, and this, in itself, stands as one of the most noteworthy findings of the study. When background variables are controlled for both groups, the writing of the DHH group using HT closely resembles that of their hearing peers.

The two differences are that the DHH group showed significantly higher lexical density and deleted significantly more characters during the writing process compared to the CODA group. Another difference (though it was not statistically significant) was that the DHH group using HT produced fewer spelling errors than their CODA peers. The higher lexical density in the DHH group using HT was attributed to their hearing loss, which may increase the use of content words. Correlation analysis showed a significant relationship between lexical density and hearing degree rather than between lexical density and STS knowledge. The finding that the DHH group using HT deleted more characters suggests a more conscious writing behavior, which may be attributed to the cognitive demands of producing longer words and considering their content. The analysis indicated that the written product and writing process measures had few correlations, suggesting varying writing behaviors among the children.

In conclusion, the study contributes unique insights into the impact of bimodal bilingualism on writing and emphasizes the importance of including control groups with similar linguistic backgrounds. The study highlights that

the observed few differences between the DHH children using HT and CODA groups can be primarily explained by their varying hearing degrees rather than by their sign language proficiency. This finding underscores the need to compare DHH children with appropriate control groups rather than hearing monolinguals alone.

6.3 Paper III

Writing Development in DHH Students: A Bimodal Bilingual Approach

Published in Journal of Deaf Studies and Deaf Education, December 14th, 2022

Author: Moa Gärdenfors

Most previous literacy studies on the DHH group have focused on their reading comprehension rather than their writing, and researchers have called for more studies on this group's writing and writing development (e.g., Mayer & Trezek, 2018). To address this research gap, the study aimed to describe the lexical and syntactic development of 24 DHH children using HT between 8 and 18 years of age. All participants were fluent in spoken Swedish at school and/or at home but had varying degrees of knowledge in STS. This study adopted a bilingual perspective to investigate whether sign language and other factors may influence their writing.

This study had a particular focus on the group's written product measures. For the lexical analyses, *lexical diversity, lexical density, adjective density, attribute density*, and *predicate density* were used. For the syntactic analyses, the *number of words-, T-units, and clauses, words per T-unit, words per clause*, and *subordinate clause index* were used. Most measures were analyzed manually, with the exception of lexical density and lexical diversity which were first re-coded and calculated by the software CLAN. The predictors were *age, gender, STS skills*, and *age of acquisition* (AoA).

Age was the predictor that explained most of the written measures, displaying a clear developmental pattern, in which the lexical and syntactical measures improved with age. In practice, this result means that the DHH children using HT write more longer and varied texts colored by more adjectives as they age. Even though the sample was small, there was a tendency for them to have a large developmental leap (similar to the one experienced by their hearing peers) after the age of fourteen (which is about a year later than their hearing peers).

The other predictors *gender* and *AoA* did not predict any measure. It is possible that AOA had no effect because there was no delayed AoA: many of the DHH children using HT had early access to language (of some kind) thanks to Sweden's systematic interventions for DHH children, providing them early hearing screenings, early and free CI operations, sign language

courses for parents, and schools with a bilingual approach. The final predictor *STS skills* did not significantly predict any measure, although there were two strong (almost significant) tendencies that showed that the most proficient signers used more adjectives and clauses than less proficient signers, which was discussed in terms of bilingual advantage. An explanation is that STS is rich and has features that do not exist in Swedish, such as depicting verbs, spatiality, and simultaneity. These features may have resulted in a higher desire in the most proficient signers to describe more in written Swedish by expressing more adjectives.

6.4 Paper IV

Written products and writing processes in Swedish deaf and hard-of-hearing children. An explorative study on the impact of linguistic background

Published in Fronters in Psychology May 8th, 2023
Authors: Moa Gärdenfors & Victoria Johansson

As mentioned in the review of Paper II, few studies had explored both the written products and the writing processes in the DHH group, so this paper built upon Paper II by further investigating the relationship between the writing product and writing process in this group. Unlike Paper II, which only included signing DHH children using HT and CODA children, this study took an exploratory approach and included hearing children without signing knowledge.

The study examined written narratives from 36 children, including 12 DHH children using HT, 10 CODA who used sign language and spoken Swedish, and 14 hearing children without signing knowledge aged 10 to 12.

The study incorporated 18 measures in three categories: written product, writing process including pauses, and revision. For the written product, the measures *number of words, word length, proportion of spelling errors, lexical diversity,* and *lexical density* were included. For the writing process, *writing time, writing flow (offline), writing flow (online), transition time, pause percentage,* and *P-bursts* were included. For revisions, *removed characters in %, inserted characters in %, bigger revisions, global revisions,* and *R-bursts* were included. A correlation analysis and a multiple regression analysis were used with four predictors: *age, gender, SignRepL2,* and *hearing*.

Age was identified as the strongest predictor, affecting writing fluency, text length, and lexicon measures. This results aligns with theories that suggested automating low-level processes like transcription and spelling frees up cognitive space for high-level processes, resulting in more advanced texts. The variable *hearing* predicted slower writing fluency, higher lexical density, and extensive revisions.

The DHH group using HT exhibited slower writing fluency, increased revisions (deletions and insertions), and higher lexical density compared to their hearing peers. These differences could be attributed to limitations in auditory input, which could contribute to uncertainty in lexical choices and spelling. The paper's main contribution was describing the writing behavior and potential challenges of the DHH group's writing.

7 Discussion

This chapter discusses the results of the thesis project in relation to the research questions listed in the introduction, and is divided into four subchapters based on the research questions: the written product (RQ1), the writing process (RQ2), the background factors (RQ3), and cross-linguistic influence (RQ4).

7.1 Research question 1: The written product

What are the characteristics of the written products of DHH children in terms of text length, spelling, syntactic complexity and lexicon?

Understanding the characteristics of written products is of great significance, particularly because writing skills are a critical component in the educational context and often serve as a fundamental assessment criterion for language development in general. It is through written products that students demonstrate their ability to compile information, convey thoughts and ideas, and utilize language effectively.

Together, the four articles demonstrate that the DHH group (especially these with HT) exhibited few differences within the group or between groups (compared to their hearing and CODA peers). The differences are the kind of spelling errors (Paper I), text length (Papers I and IV), and lexical density (Papers II and IV).

Regarding *text length*, the deaf group produced significantly shorter texts than the other groups (that is, DHH using HT or hearing peers) (Paper I). Similarly, the DHH group using HT produced shorter texts than their hearing peers (including hearing and CODA peers) (Paper IV).

Regarding *spelling*, there were no significant differences in the frequency of spelling errors between the groups, but the DHH group, especially the subgroup of deaf children, produced different kinds of spelling errors than the other groups (Paper I).

Regarding *syntactic complexity*, in terms of number of T-units and number of clauses, no significant differences could be found between the DHH group using HT and their hearing peers.

Regarding *lexicon,* the texts of the DHH group using HT had a *higher* lexical density (Paper II and IV), while no significant difference was observed

in terms of their texts' lexical diversity. It is worth noting that lexical density and lexical diversity were not investigated in the texts written by the deaf group.

Paper I stands out because it includes both DHH children using HT and their deaf peers. This study reveals some differences within the deaf group, characterized by shorter word lengths and different kinds of spelling errors than their DHH peers using HT or hearing peers. These patterns of shorter texts and unique pattern of spelling errors have been documented in previous studies of deaf and DHH children using HT (Bowers et al., 2016; Holcomb, 2023; Sarant, 2012; Singleton et al., 2004; Williams & Mayer, 2015). These trends are less pronounced among DHH signing children using HT who tend to have more conventional spelling errors. This observation suggests that, despite their hearing loss, the DHH children with HT rely on cues from spoken language. Given that a smaller vocabulary can be found among hearing bilinguals due to their shared input from two languages (Bialystok, 2009), these characteristics of the bilingual deaf group may have been further compounded by their unique challenge of having no input from spoken Swedish, with their sole exposure to Swedish coming from written texts.

Concerning the distinct spelling errors of the deaf group, one could speculate that the limitations of sound-based phonological coding in this group (Mayberry et al., 2011; Miller & Clark, 2011; Musselman, 2000; Petitto et al., 2016) prompts them to resort to alternative strategies. These strategies might include lipreading, fingerspelling, and using knowledge from sign language (Padden & Hanson, 2000), which are reflected in the kind and pattern of spelling errors, such as mixing up two very similar words, relying on the visual appearance of a sign into a word, or looking at how a word is formed on the lips (see also Gärdenfors, 2016). This phenomenon will also be discussed later in relation to RQ4 and in regard to possible transfer effects.

Regarding the written products of DHH children using HT and their hearing peers (including CODAs), only two significant differences could be observed: first, the DHH children using HT wrote shorter texts (Paper IV), and second, those texts had higher lexical density (Paper II). These findings are surprising considering previous research that has highlighted a wider range of differences within the DHH group, including writing difficulties leading to lower lexical variation, more spelling errors, and fewer syntactically correct sentences among others (e.g., Arfè, 2015; Asker-Árnason et al., 2012; Breland et al., 2022; Grenner et al. 2022; Mayer & Trezek, 2018, and several more). Concerning the shorter text length in the DHH group using HT, the same discussion about the combination of shared input and limited exposure to spoken language has been invoked (e.g. by Bialystok, 2009). It is clear though that DHH individuals who use HT benefit from their enhanced hearing, receiving more language input, which may explain why they have a larger vocabulary and, as a result, can write longer texts than their deaf peers. Higher lexical density will be discussed further under RQ4, as it overlaps with the question about CLI.

Overall, these findings suggest that the DHH participants using HT in this study displayed advanced writing skills, which is a unique result in international research on children with hearing loss. The advanced writing skills of this DHH group will be further discussed under RQ3, where background factors including AoA (which may be a plausible explanation) will be covered.

To summarize, the results of my research addressing RQ1 have shed light on the characteristics of written products produced by DHH children in Sweden, revealing few differences within the group and between groups (including different types of DHH). DHH individuals were proficient writers and had only a couple distinctive characteristics that distinguished them from their hearing peers.

7.2 Research question 2: The writing process

What are the characteristics of the writing processes of DHH children in terms of pauses, writing fluency, and revision behavior, and how can these be related to their written products?

Looking at the writing processes of DHH children is crucial for gaining insights into their cognitive and linguistic strategies when engaging with written language. Understanding their writing processes, including aspects such as pauses, writing fluency, and revision behavior, offers a window into the intricate mechanisms they employ to express themselves in text.

The writing processes of the DHH group were examined in three papers (Paper I, II, and IV). However, the writing process results are more comprehensive among DHH children with HT justifying why the discussion will primarily focus on this group rather than the deaf group.

The writing process results demonstrated that, overall, the DHH group using HT had few distinctive traits compared to their hearing peers. The observed differences included a significantly slower offline writing fluency (number of characters in the final text divided by the writing time), a significantly slower median transition time (time in seconds between two consecutive keystrokes within a word), and revised their texts significantly more, including removing and inserting characters (as reported in Paper IV). Other notable tendencies observed were the DHH group (including both deaf and DHH using HT) higher average number of spelling attempts during their writing sessions (as reported in Paper I)

Hayes and Flower (1980) proposed that there are three fundamental writing processes (planning, translating and reviewing), each of which will be discussed below.

Planning, reflected in pauses during writing, provides insights into the cognitive processes involved in organizing and structuring a written text (Chanquoy, 2001; Matsuhashi, 1981; Spelman-Miller, 2006; Wengelin, 2006). In this thesis, the pause distribution in the DHH children using HT did not significantly differ from the other children, with all participants

incorporating similar amount of pausing during writing. As previously detailed in the method section (5.5), regardless of their diverse backgrounds, all children comprehended the writing prompt and developed uniform structural outlines for their narratives, encompassing essential elements like main protagonists, narrative settings, critical events, and closing remarks. The DHH children using HT encountered no significant difficulties in comprehending and planning their content based on the cartoon, which is consistent with findings by Alamargot et al. (2007), which showed that deaf children had no problems with planning writing.

One possible explanation for this intact planning ability is its close connection to visuospatial capacity, which is the capability processing and storing visual and spatial information (Kellogg, 1996) without relying on auditory cues. Although my research did not extensively delve into the depth of the planning process, it is reasonable to assume that the planning conducted by children in this study primarily focused on a local level, as children in this age group have not yet developed advanced strategies for addressing the high-level processes (such as planning, reading, and global revision) that characterize adult writing. This idea aligns with expectations for this age group (Bereiter & Scardamalia, 1987; McCutchen, 1994; Sasaki et al., 2018). Local planning can also be compared to the knowledge-telling strategy proposed by Bereiter and Scardamalia (1987), which posits that young writers do not have space to invest effort in global planning and revision, and therefore they cannot perform tasks like taking the audience in consideration; rather, young writers have "think it, say it" behavior. One previous study (Wengelin, 2002) has however suggested that deaf adults continue to exhibit non-planning behavior and use a linear, straightforward writing process. Further research on older DHH individuals using HT is therefore needed to explore how their planning abilities evolve during adolescence and adulthood.

The second and third processes proposed by Hayes and Flower are *translation* and *reviewing*. Because these two processes are somewhat intertwined, they will be discussed simultaneously below.

The DHH children using HT had slower offline writing fluency, particularly in terms of transition time, and a higher frequency of revisions and spelling attempts. When I analyzed their spelling behavior, it became evident that they had an intense focus on local writing, involving multiple spelling attempts and significant revisions, mostly in close connection to the inscription point (that is, at the local level). This behavior primarily involved removing a few letters at a time. This writing behavior may explain why their text length was significantly shorter compared to that of their hearing peers, as they allocated more time to word and grammar selection and attempting to spell correctly, at the expense of overall text length.

Overall, these writing process measures reveal that the DHH group using HT have different translation processes, and they seem to invest more cognitive effort in their writing, aiming to enhance the overall quality of their texts, including proper grammar, word choices, spelling, and structure.

The DHH group using HT's writing process is consistent with hearing students writing in two languages (Lindgren et al. 2008) as well as in deaf writers (Alamargot, 2007). Lindgren and colleagues (2008) examined writing in hearing Swedish L1 and English L2 in 15- to 16-year-old students and found increased disfluency and revision behavior in L2 writing due to slower lexical retrieval and the writers' needs to make conscious choices regarding word usage and grammar. A study by Alamargot (2007) compared French deaf middle school students with their hearing peers and observed that the deaf group put more effort into their writing. One possible explanation for this phenomenon could be linked to phonological difficulties and challenges in accurate spelling, both of which can be associated with a limited vocabulary or a slower lexical retrieval—characteristics that can be observed in bilinguals (Bialystok, 2008, 2009)

The different fluency behavior in DHH using HT's writing mirroring intensive local revisions, coupled with numerous spelling attempts, may help explain why there were no significant differences in lexical diversity and spelling errors when this group was compared to their hearing peers.

This finding, demonstrating comparable lexical variation within the DHH using HT group, aligns with a study by Lindgren et al. (2008). The study showed that L2 writers could enhance the quality of their texts despite experiencing higher cognitive loads, characterized by disfluency and increased revision activity, by dedicating more writing time to this task. Nevertheless, intensively focusing on the low-level-processes such as spelling, grammar, and word choice will burden working memory and will limit the capacity for more advanced writing activities in the long run.

We will now turn to the ability of DHH children using HT to carry out global revisions such as erasing entire words or larger portions of text. Here we could see no significant differences among the DHH using HT as well as hearing groups. This observation may be attributed to the age range of the participants, all of whom were middle-schoolers between 10 and 12 years old. Global revision behavior, involving substantial content changes, often becomes more prevalent among older writers (Chanquoy, 2001, 2009; Chenoweth & Hayes, 2001). Investigating revision patterns in older DHH children may offer a more comprehensive understanding of the evolution of their revision strategies, making it an area for future research.

Drawing on the theoretical frameworks presented by Hayes and Berninger (2014) and Chenoweth and Hayes (2001), it is evident that writers with specific characteristics, such as young age, second language proficiency, bilinguality, or being DHH, often experience different writing fluencies. This fluency manifests as increased revisions and slower transition times. I will now attempt to describe a complete scenario describing the writing process of DHH children using HT between the age 10–12 according to the theoretical framework by Hayes and Berninger (2014).

DHH individuals using HT encounter few challenges when it comes to generating and planning ideas (proposing) due to their intact visuospatial

capacities (Alamargot et al., 2007; Kellogg, 1996). Their ideas are then transformed into language strings, whether in Swedish or STS, using the translator. However, when they attempt to convert these strings into written text through the transcriber, they face slower lexical retrieval, limited phonological awareness, and spelling challenges (Miller & Clark, 2011; Musselman, 2000; Petitto et al., 2016). In other words, their vocabulary and spelling may not be sufficient for the task, leading them to experiencing typical features associated with young, inexperienced writers, second language learners or bilinguals. As a result, the cognitive processing of the transcriber slows down, and the working memory becomes burdened, potentially resulting in conveying limited or incorrect information. Consequently, the writer produces spelling errors, inappropriate word choices, or grammar mistakes.

To address these challenges, the DHH writers must engage in evaluating and refining their written texts using the evaluator, stepping in to compensate for inaccuracies through numerous revisions that ultimately improve the texts. While these children may have a wealth of ideas, they struggle to transform them into coherent written expressions, which can create a bottleneck in the writing process (Alves and Limpo, 2015). In the long run, constantly relying on low-level processes becomes unsustainable, unless the writer in question possesses enough resources that they can address this challenge through intensive correction attempts. As discussed previously, this behavior draws on cognitive resources, leaving insufficient mental effort for the necessary recursive engagement with high-level processes like planning, (re)reading, and revising, as proposed by the writing composition model of Hayes and Flower (1980). These high-level processes are crucial prerequisites for producing longer and more mature pieces of writing (Chanquoy, 2001; Just & Carpenter, 1992; McCutchen, 1996).

To summarize, the results of my research addressing RQ2 have shown that DHH children using HT exhibited planning behavior similar to that of their hearing peers. However, their translation process was characterized by slower writing fluency, marked by increased revisions and spelling attempts. Notably, DHH children using HT's extensive local revisions and spelling efforts compensated for their challenges, resulting in comparable lexical diversity and spelling proficiency comparable to their hearing peers. This understanding is crucial for addressing the unique needs of DHH children and supporting their development as writers.

7.3 Research question 3: Background factors

What background factors influence the writing DHH children, and do those factors differ from those that influence their hearing writers?

The research question aims to identify and address the unique challenges to the linguistic development of DHH students, and how these students are affected by their different backgrounds. All the papers included background

factors which comprised *age, gender, age of acquisition, hearing degree* and *sign language proficiency.*

The findings revealed that *age* was the most influential predictor that explained most differences in observations, followed by *gender* and *hearing*, which also contributed significantly to explaining various writing outcomes. *AoA* did not prove to be a predictor for any observations. Finally, *Sign language proficiency* predicted specific outcomes including adjective density and number of clauses.

The results highlight that *age* predicts a diverse set of measures, spanning both written products and writing processes. As the DHH children using HT age, their writing processes become more automatized, resulting in longer and more advanced, vocabulary-rich texts with fewer spelling errors. Put simply, in the DHH group using HT, both written products and writing processes improve with age, exposure, and training. The results corroborates the general observation that development in DHH children using HT is similar to that of hearing children from 8 to 18 years old. Other previous research has suggested that it is difficult to identify a clear developmental trend in hearing students aged 10–12, as these middle school students apparently develop multiple processes and skills simultaneously. Previous research has shown that there is noticeable improvement in various writing practices after the age of 12 (Berman & Verhoeven, 2002; Johansson, 2009; Löhndorf, 2021). A similar trend was observed among the DHH group using HT, albeit occurring a year later. This time difference may be attributed to factors related to phonological challenges (Mayberry et al. 2011), slower lexical retrieval, shared language input, and the cognitive demands of mastering two languages (e.g., Bialystok, 2008; 2009). These factors could mean the DHH individuals using HT require additional time and support for fully automating their low-level processes and enhancing their writing skills (e.g., David, 2008).

The second variable, *gender*, has received limited attention in DHH writing research. However, this thesis has shown that girls in the DHH group using HT tend to produce longer texts, longer words, and exhibit higher lexical diversity than boys (Paper IV). This finding is consistent with previous research on both L1 and L2 writing (e.g., Kanaris, 1999; Reynolds et al., 2015; Saeed et al., 2011, and many others). Understanding gender differences in writing in the DHH population could conceivably shed some light on the factors that affect writing. Further research on this topic is needed to get a comprehensive understanding to address gender disparities in DHH writing development.

The third variable, *AoA*, was not a significant predictor for any of the outcomes (Paper III). This finding is particularly remarkable when viewed from the international standpoint. In this section, I will further delve into the discussion that was initially introduced in connection with RQ1, specifically addressing the few differences in the written products of the DHH group using HT and their hearing peers, and using AoA as a potential explanatory factor. It is possible that the strong writing abilities of my particular DHH participants using HT can be attributed to various background factors that differentiate

them from many other DHH children worldwide. It has often been reported that DHH students face severe literacy delays due to factors like delayed AoA through non-signing parents, language deprivation, late cochlear implant surgeries, limited access to bilingual schools, and more (Traxler, 2000; Hall, 2017), and those conditions are possibly not experienced by the Swedish DHH population.

Sweden offers interventions including hearing screenings, access to cochlear implant operations, and hearing aids, sign language courses, bilingual schools at an early age compared to other countries (SOU, 2016:46; Schönström & Hauser, 2021). Collectively, these measures significantly reduce the risk of delayed AoA for DHH children. They serve as a safety net for DHH children, preventing them from falling behind and facing adversity, while promoting the development of their overall language skills.

This finding aligns with the Critical Period Hypothesis theoretical framework proposed by Lenneberg (1967), which posits the existence of a biological window for language acquisition in children generally. To maximize language development in DHH children, it is crucial for them to be exposed to language within this critical window, underscoring the importance of early interventions (see also Boudreault & Mayberry, 2006; Cormer et al., 2012; Mayberry, 1993).

The fourth variable, *hearing degree*, emerged as a significant predictor for several outcomes, including writing length, writing time, and performance on the sign language test (Paper I), the frequency of character removal and lexical density (Papers II and IV), and offline writing fluency and transition time (Papers II and IV). It also seems that a hearing child dedicate more time to their writing, resulting a faster writing flow with shorter transition times. These children also engaged in fewer revisions and produced longer texts with lower lexical density than their peers with less hearing.

When it comes to STS test outcomes (Paper I), the deaf group achieved the highest points, which can be attributed to several key factors, with one particularly significant element being the fact that all of these deaf children had deaf parents. In addition, the exclusive reliance of these children on sign language as the primary mode of communication sets them apart from their peers with hearing abilities or those using HT, who divide their language use between sign language and spoken Swedish. Deaf children can allocate a larger share of their language development to their sign language skills, thus enhancing their proficiency in this visual-gestural language.

Some previous studies have also emphasized the significance of degree of hearing in literacy development (e.g., Colletti et al., 2012; Dettman et al., 2016; Karltorp et al., 2019; SOU, 2016:46). For example, a child with full hearing easily receives the necessary linguistic input to comprehend function words, such as prepositions; morphology and syntax, and so forth. Consequently, they do not need to devote as as much time to conscious effort when writing, because the input of Swedish (through spoken language) has always been easily accessible. Together these factors offer additional insights into

why the cognitive starting point advantages hearing children over DHH children, who have not automated these linguistic aspects to the same degree due to their hearing loss. The disparity observed in writing can be attributed to the extra cognitive burden experienced by DHH children due to elevated linguistic demands – that is, all the processing of inputs that then needs to be translated into written words – which, it has been suggested, affects their writing abilities (e.g., Arfé, 2015; Bell et al., 2022; Mayer & Trezek, 2018; Williams & Mayer, 2015). Taken together, it may mean that DHH children using HT may have different starting points than their bilingual hearing CODA peers who grow up with full access to two languages (Swedish and STS).

The fifth variable, *sign language*, predicted adjective density and number of clauses (Paper II), which can be interpreted as meaning that the more skilled DHH signers using HT produced more adjective-dense texts, including more clauses than their non-signing DHH peers with HT. However, it should be noted that sign language was a less strong predictor in my studies than other studies. Previous studies have reported that DHH signing children using HT performed on par with, or better than, their non-signing peers (Amraei et al., 2017; Davidson et al., 2014; Goodwin & Lillo-Martin, 2019; Hassanzadeh, 2012; Pontecorvo et al., 2023). The results of my studies may have been affected by the diversity of backgrounds that my DHH children using HT had in STS, with a majority having fluent signing skills, while others being less proficient in STS, which might have skewed the results. So other variables may have taken over, and reduced the sign language effects. To gain deeper insights into sign language's true influence, it would be necessary to include more non-signing DHH children using HT in future studies. (It is somewhat ironic that, in my research, I had trouble finding *non*-signing DHH children, since other researchers have found it harder to include signing DHH children (Szarkowski, 2018) in research projects.)

Nevertheless, the discovery of comparable performance levels in the signing and non-signing DHH groups using HT, with signing DHH children using HT even surpassing their non-signing counterparts in certain writing measures, stands out as one of the research project's most important findings. This finding strongly suggests that sign language proficiency, when used in conjunction with spoken language, does not hinder the development of written language in these children. This finding is consistent with recent research indicating that acquiring and using sign language alongside spoken language does not have a negative affect on the writing development of DHH children using HT.

In fact, previous studies have shown that bimodal bilingual children often perform at similar or even higher levels than their non-signing peers (Caselli et al. 2021; Hassanzadeh, 2012; Pontecorvo et al., 2023). Proficiency in a sign language can fill the gaps in spoken or written languages that heavily depend on auditory skills, offering a comprehensive and enriched understanding of communication, especially when one language (sign language) supports

another (Swedish) that profoundly relies on auditory cues which the DHH group using HT may not fully perceive.

Now, I take the opportunity here to shift the discussion away from the previous topic and instead consider the language access perspective (see also Hall & Dills 2017; Kermit, 2010; Szarkowski, 2018). In addition to being bilingual in sign and spoken languages, the DHH bimodal bilingual children possess the advantage of using sign language, which they fully understand, to navigate situations where they might struggle to comprehend spoken language. On the contrary, non-signing DHH children may find themselves confined to spoken language, which they may not always perceive in every context. In conclusion, the benefits of being bimodal bilingual as a DHH individual extend beyond the traditional concept of a typical (hearing) bilingual, encompassing a wide range of linguistic and psychological advantages.

To summarize, the results of my research addressing RQ4 indicate that age is the most influential predictor, followed by gender and hearing degree, all of which influence a range of outcomes. AoA did not predict any outcome. Sign language proficiency predicted the use of adjectives and the number of clauses, underscoring that proficiency in sign language along with spoken language does not hinder written language development.

7.4 Research question 4: Cross-Linguistic Influence (CLI)

Can patterns be observed in terms of transfer of linguistic knowledge from Swedish Sign Language (STS) into the writing of DHH children?

Considering the significance of the participants' sign language skills as a unique variable in this thesis, this section aims to end the discussion by highlighting and discussing possible observations of some sign language features in the writing of DHH individuals (Paper I), including adjectives (Paper III) and lexical density (Paper II and IV) in DHH children using HT.

As scholars in CLI research have emphasized, transfer is a highly individualistic, multidirectional, and complex process, which makes it challenging to identify when a transfer occurs. Additionally, bilingual individuals tend to seek similarities rather than differences between two languages that they know, which means that, when two languages are similar, any pattern of one language that is re-used in the other language might be extra hard to detect merely because it is similar (Odlin, 2013; Ringbom, 2007; Jarvis, & Pavlenko, 2008).

However, certain potential transfers were identified, one of which pertains to lexical density. This connection may not be directly associated with CLI, but rather originates from a characteristic within the group. In other words, their hearing loss induces a particular transmission in their writing. Notably, the DHH group using HT demonstrated higher lexical density than their

hearing peers, regardless of linguistic background (as evidenced in Papers II and IV). It was suggested that the higher observed lexical density in the DHH group using HT might primarily result from their limited auditory input in spoken language. Spoken language, being less dense in nature, is expected to be more easily translatable into writing for hearing children (Brännström et al., 2022; Johansson, 2009). This could be attributed to the reduced use of function words in the DHH group using HT, which may include potential omissions. Children within the DHH group using HT may not always perceive these smaller function words in spoken language, which are the words contributing to a decrease in lexical density. Missing out on transferring the function words into written texts may also explain their significantly fewer number of words compared to their hearing peers. If the total word count is diminished due to a reduced use of function words, the consequence will be that the proportion of content words becomes comparatively larger, resulting in higher lexical density.

In Paper II, it was suggested that the influence of STS might be less significant in this context. This argument was supported by the fact that there was no significant difference in sign language knowledge between the DHH group using HT and the CODA group. Nevertheless, the writings of the DHH group using HT had higher lexical density, and the correlation analysis indicated a relationship between hearing and lexical density, but not with STS.

But to put this in context, CODA with full hearing are able to perceive all the function words in spoken Swedish without needing to rely on other strategies such as leaning on STS. Therefore, the potential transfer from STS may be more influential for the DHH group with HT, who have limited auditory input and may need to rely on their knowledge of STS to compensate for possible challenges in spoken language comprehension. While the limitations in auditory input might result in a pattern from STS being used in writing, it would be counterproductive to reject potential transfer from STS as a strategy (which is described as a language that is rich regarding content words), which would explain the higher lexical density in the writing of this group. In fact, it is reasonable to consider that the DHH group with HT may draw upon their knowledge of STS when faced with challenges in spoken language.

Expanding on the topic of the richness and density of sign languages, another noteworthy transfer that may occur from STS is the use of adjectives in written narratives. In Paper III, it was observed that the most proficient signers had a tendency to incorporate more adjectives in their writing than their DHH peers using HT with limited or no knowledge of sign language, even when they had similar degrees of hearing. This finding suggests that the increased use of adjectives in writing may be a potential transfer from STS, which is a descriptive language. Similar observations were reported by Holcomb (2023) in a study on American Sign Language (ASL) and written English among deaf children. There, the results were discussed in terms of a kind of meta-linguistic transfer from ASL, which supports the idea of cross-linguistic influence between sign language and written language production.

In my studies, there were indications that transfers from STS were more distinct among the deaf children, one example of which pertains to their spelling. Based on the evidence that the deaf group excels in STS (Paper I), as shown by their superior performance on the STS language test in comparison to all of their signing peers. Their ability to effectively communicate and ask relevant questions during testing sessions strongly indicates their significantly enhanced language proficiency in STS compared to written Swedish. It is clear that the deaf individuals put considerable effort into their writing in order to make themselves understood, and it seems that they do that through a variety of creative strategies, including transferring their STS knowledge into written Swedish which will be discussed below.

Paper I noted that some deaf children struggled with how to spell certain words (they made several spelling attempts), and they seemed to occasionally incorporate the handshape of a sign into their spelling. For instance, they might write "rätt" ['right', as in 'correct'] instead of "rädd" ['scared'] because the sign for "RÄDD" in STS is performed with a handshape resembling the letter T. This suggests a possible transfer from STS handshapes to written spelling.

Another example of transfer was found in the use of possessive pronouns. In instances where Swedish possessive pronouns had multiple homonyms, deaf children sometimes used a semantically incorrect Swedish word. For example, they might write "din" ['your'] instead of "sin" ['his/her/its'], as the signs for these possessive pronouns are identical in STS. These findings align with the research conducted by Holcomb (2023), which demonstrated that deaf children in the early stages of their literacy development tend to directly transfer examples from ASL into written English, which can be attributed to their limited vocabulary in English. Previous studies have indicated that the occurrence of such transfers tends to lessen with increasing proficiency in the target language (Czubek, 2021; Hoffmeister, 2000; Holcomb, 2023; Wolbers et al., 2014, among others).

These examples highlight the potential influence of sign language on the written language production of DHH children. The incorporation of sign language elements into writing and the transfer of meanings between Swedish sign language and written Swedish support the notion that sign language can play a role in shaping the writing process of deaf individuals.

To summarize, the results of my research addressing RQ4 highlight the significant influence of sign language skills on the written language products of DHH children. Proficient signers use more adjectives in their writing, indicating a potential transfer from (the descriptive) STS. Lexical density was higher in DHH children using HT than their hearing peers, which can be due to a combination of auditive limitations, and transfer from STS. The deaf group showed signs of incorporating sign language handshapes into their spelling, leading to occasional spelling errors.

7.5 Future research

In this final section, I will suggest some potential avenues for future research. There are numerous uncharted territories in the realm of DHH writing, and much more awaits exploration.

This study was based on a range of writing models, with the bilingual aspect primarily grounded in CLI and proficiency in sign language. Looking ahead, it would be of considerable interest to delve even more deeply into the various effects of bilingualism on writing. An idea is to delve deeper into the writing process and its relationship to a final written product, using a more extensive sample of DHH children. Ideally, such research would include larger groups of both monolingual and bimodal bilingual DHH children and adolescents. Such a study would help shed light on the true extent of sign language's influence on writing.

Important insights were gained about the writing process, specifically planning and revision behaviors. Since this study revealed that DHH children using HT who were 10–12 years old demonstrate a "here-and-now" planning behavior, including intensive local revision behavior, it would be valuable to follow up on this finding by collecting data from older DHH children and adolescents. This follow-up research could investigate whether and when these individuals transition to using global planning and revisions, a characteristic feature of more mature writing. Understanding the timeline of this transition, along with the automatization of their high-level processes, could provide insights into the developmental trajectory of the writing skills of DHH children.

Clearly it would also be important to investigate how the findings of this thesis could be used in the development of pedagogical strategies that specifically support the writing skills of DHH children. Understanding the distinct challenges faced by this group and their writing processes could help create targeted educational interventions aimed at enhancing their writing proficiency. This research has the potential to lead to more effective support systems and improved educational outcomes for the DHH community.

8 Conclusion

In conclusion, this thesis has provided insights into the characteristics of the written products and writing processes among deaf and hard-of-hearing children. It has examined the influence of various background factors, including age, gender, age of acquisition, hearing degree and sign language proficiency, on their writing abilities. Through a comprehensive investigation, the research findings have unveiled both similarities and differences within and between various groups of DHH children including DHH children using HT and deaf children, shedding crucial light on essential aspects of their writing, including the understanding that sign language learned alongside spoken language does not hinder writing development.

Research Question 1 analyzed essential aspects of written products, including text length, spelling, syntactic complexity, and lexicon. My studies pertaining to this questions found that, in general, DHH children using HT exhibited few differences within their group and when compared to writers with different hearing and linguistic backgrounds, which is unique from an international perspective. The differences included spelling errors, text length, and lexical density. Deaf children, in particular, generated shorter texts and made distinct spelling errors, which can be attributed to their restricted exposure to spoken language, prompting them to employ alternative visual strategies for spelling. In contrast, DHH using HT made more conventional spelling errors, indicating their reliance on cues derived from spoken language.

Research Question 2 delved into the writing processes of DHH children, providing insights into their strategies. My studies pertaining to this question explored various aspects of writing, including pauses, fluency, and revision behavior, and the findings shed light on several key observations. Firstly, it was evident that DHH children using HT had typical planning abilities for their age group, owing to their intact visuospatial capacity, which played a significant role in the planning process. Additionally, they demonstrated a conventional knowledge-telling strategy, characterized by a “think it-say it” approach, commonly seen in young writers. However, the DHH children using HT had slower translation processes, including increased number of revisions and spelling attempts. This additional cognitive load may have placed a burden on their working memory. Remarkably, despite the challenges posed by

this diminished writing fluency, their determination to address these issues led to lexical diversity and spelling proficiency levels comparable to those of their hearing peers.

Research Question 3 investigated the influence of various background factors on the writing of DHH children, including age, gender, AoA, hearing, and sign language proficiency. My research revealed that *age* was the most influential predictor, affecting both written products and writing processes. DHH children using HT's writing skills improved with age and training, which is the same pattern observed in hearing children. *Gender* also played a role, with girls tending to produce longer texts and higher lexical diversity. Surprisingly, *AoA* was not a significant predictor, potentially due to early interventions and language accessibility available in Sweden. *Hearing degree* was another significant predictor that affected various outcomes. A child with full hearing easily grasps linguistic elements like smaller words such as prepositions and grammar etc. As a result, a hearing child requires less time and effort for writing, thanks to their ready access to spoken Swedish. When it comes to writing, hearing children have a cognitive advantage over DHH children using HT, who have not automated these linguistic aspects as extensively due to their hearing loss. Signing and non-signing DHH children using HT performed similarly on writing tasks, although the signing children produced more adjectives and clauses in their written texts. The results suggest, as in line with previous research, that *sign language proficiency* acquired along with spoken language does not hinder the development of written language in these children. DHH children using HT proficient in both sign and spoken languages can benefit from using sign language when they encounter challenges in comprehending spoken language, while their non-signing DHH peers using HT cannot. Consequently, the positive effects of bilingualism, particularly bimodal bilingualism, is expected to be more pronounced among DHH children than their bilingual peers with full hearing.

Research Question 4 explored the potential patterns of linguistic knowledge transfer from STS into the writing of DHH children. My research here revealed potential transfers, particularly in spelling errors, adjectives, and lexical density. These transfers suggest that STS influenced the writing of the DHH group, with deaf children displaying more distinct transfers than their DHH peers using HT. These observations suggest that both the limitations in auditory input and potential transfers from STS play a role in the writing of the DHH group. Further research is needed to better understand the complex interactions between different background factors and their combined impact on the written products and the writing processes of DHH children.

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