**Factors Contributing to Braille Learning and Reading Performance as Individuals Age**

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# Introduction

As the prevalence of age-related vision loss continues to increase, rehabilitation specialists encounter a growing number of working-age and older adults who experience reading related difficulties [1, 2]. In the United States alone, the prevalence of age-related vision loss is expected to double by 2050, placing increasing burdens on healthcare and rehabilitation systems [3]. Previous research on braille learning in the past has focused primarily on the needs of blind children who acquire braille as a literacy medium [4]. Far less is known about the unique experience of braille learning in adulthood following acquired vision loss, or about the impact of aging and other factors on this process.

The primary goal of this multiphase research is to add to the limited body of knowledge about braille learning and usage among working-age and older adults. Collectively, these studies explore the influence of age-related physiological and cognitive factors on braille reading performance, as well as the enablers and obstacles encountered by working-age and older adults who pursue braille rehabilitation training. The findings shed much-needed light on the experience of learning and using braille in adulthood and will contribute to the development of evidence-based practices that better meet the unique needs of a rapidly aging population.

## Overview

 This work consists of four separate phases (shown in Table 1 below) which investigate the learning and usage of braille among working-age and older adults from distinct but complimentary perspectives. This report will highlight results from the first two phases. Results from Phase 3 will be elaborated upon during the presentation. Collectively, these results clarify aspects of braille usage among adults and seniors and carry important clinical implications that will be discussed.

**Table 1: Research phases and overall objectives**

| **Phase** |  | **Methodology** |  | **Objective** |
| --- | --- | --- | --- | --- |
| 1 |  | Scoping Review |  | To identify the tactile, motor and cognitive factors which have been shown to correlate with braille reading performance, and the instruments used to measure these factors in prior research. |
| 2 |  | Qualitative Interviews (interpretive phenomenological analysis) |  | To explore the experience of the adult braille learning process and the enablers and obstacles encountered by working-age and older adults who pursue braille training. |
| 3 |  | Correlations / multiple regression |  | To determine predictors of braille reading performance among working-age and older adults, as well as the influence of age on these factors. |
| 4 |  | Experimental training intervention |  | To explore the influence of reading medium (paper vs. electronic braille) on braille training outcomes among working-age and older adult braille learners |

## Background and Context

Two types of adult braille clients may be encountered within the vision loss rehabilitation context. The first group consists of those with congenital visual impairments who were introduced to braille early in life, though may seek rehabilitation services for changing needs throughout adulthood. The second group (a growing majority) consists of adults who experience age-related vision loss and who may benefit from braille instruction for the maintenance of daily living activities [5]. Within this context, working-age and older adults are already literate as print readers prior to acquiring vision loss. For these clients, braille instruction does not focus on the acquisition of literacy skills, but instead on the development of tactile perception and other capacities needed for efficient braille reading.

Few studies have explored the experiences of older adults who pursue braille training. For the most part, these previous investigations have focused on the implications of learning a new skill later in life. For example, several studies explore the degree of learning plasticity that can be expected in adulthood. It is well established that children who learn braille early in life recruit the visual cortex during braille reading and that this cortical magnification is more likely when braille is learned in childhood [6, 7]. Some studies have suggested that this cortical reorganization may be experienced by adult learners of braille if they are exposed to consistent practice [8]. A series of other studies have explored the impact of aging on the tactile, motor and cognitive capacities that are expected to be essential for braille reading, leading to mostly contradictory findings [9-12]. Normal aging is also associated with subtle yet steady declines in working memory [13]. This has been shown to negatively impact reading comprehension among sighted print readers [14], but the potential impact of these declines have not been explored in relation to braille [6, 15, 16].

While not centred on braille, a wide body of research has also investigated the unique process of learning in adulthood. These studies have emphasized that andragogy (adult learning) is distinct from pedagogy (childhood learning) and that this carries implications that should be considered during training. Among the components of adult learning, proponents accentuate the role of previous life experiences as important reference points, and the need for adults to understand the practical application of what they are learning in order to sustain motivation and engagement. The theories of andragogy as they apply to braille reading, as well as other factors already known to influence outcomes of adult braille learners, will be elaborated on in the presentation [17, 18].

Previous braille research has, to a large degree, focused on the learning of braille in childhood, leaving a significant void in our knowledge of the influences of braille learning success among adults and seniors with acquired vision los. Research on braille and aging will help to inform evidence-based practice that better meets the needs of working-age and older adults who pursue braille training. Below, we summarize a high-level overview of results. As these are now being considered for publication, we are unable to include full findings for consideration here. Instead, these will be discussed within the presentation itself.

# Phase 1: Scoping Review

To canvass the existing literature regarding the relationship between tactile, motor, and cognitive function and braille reading performance, we performed a scoping review [19, 20] as a means of mapping the existing evidence addressing these two core questions:

1. What is known about the relationship between tactile perception, motor dexterity, cognitive ability and braille reading performance?
2. What measurement instruments have been used to assess these tactile, motor and cognitive factors in prior braille research?

## Procedure

 We collected 1,320 articles whose title or abstract contained the word “braille” based on a search of four academic databases (PsycINFO, Cochrane Database of Systematic Reviews, ERIC, and PubMed/MEDLINE). The abstracts of those 1,320 articles were reviewed by the first author and a research assistant to determine their relevance and suitability, and 397 were ultimately selected for a full-text review (with 96% agreement between the reviewers, *kappa* = .91 [.88, .94], p < .001). An article was deemed worthy of further examination if it reported primary research exploring a potential correlation between one or more measured tactile, motor or cognitive factors and braille reading performance (speed, accuracy, or comprehension). Only peer-reviewed, English language articles were included, but no limitations were otherwise imposed regarding date of publication, geographic location, study type, or sample characteristics. The full text of the 397 identified articles were retrieved and assessed more fully against the inclusion criteria by the first author and research assistant, yielding a total of 26 relevant included studies [10, 11, 21-44] (with 94.6% agreement between the reviewers, *kappa* = .82 [.77, .87], p < .001).

## Results

 Of the 26 studies, 11 focused on the effect of tactile acuity on braille reading performance. Among the 14 tactile measurements used in these studies, 2 primary categories emerged: those which measure passive acuity (when a stimulus is applied to the stationary finger) and active acuity (or haptic touch which involves movement, as with braille reading). Thirteen studies considered different motor functions and their relationship to braille reading. Here, the most significant attention was devoted to the role of hand movement patterns during braille reading. With the exception of hand movements which appear to influence braille reading speed, most of the other measurements used yielded inconsistent results. Among the 5 studies which considered cognitive measures, 10 separate measurement instruments were employed. These cognitive measures fell into 3 broad categories: intelligence or IQ tests, lexical or phonological tests, and tests which measure short-term working memory. Among these, short-term working memory appears to correlate with braille reading accuracy and comprehension, but the remaining studies led to inconsistent findings.

 Though the specific measurements and their results will be expanded upon during the presentation, what becomes immediately evident is that prior research on tactile, motor and cognitive abilities and braille reading performance among adults and seniors is highly inconsistent. For the most part, where measurements are used, they have not been replicated and have resulted in inconsistent and contradictory findings. It would be unwise to base any decisions about adult learners on the results emanating from any of these tests. Above all else, the scoping of prior literature accentuates the need to replicate previous studies to review their reliability when used with older braille readers. It is also important to note that less than 12 of these studies included participants above the age of 60, and none specifically explored the influence of age as a variable on braille reading outcomes.

# Phase 2: Qualitative Study

 It is recognized that the learning process is influenced by a variety of factors that move above and beyond physiological and cognitive considerations alone. For this reason, the goal of this phase was to explore the experience of learning braille in adulthood, as well as the facilitators and barriers that are encountered during the adult braille learning journey. An Interpretive Phenomenological Analysis approach was used, which allowed us to derive meaning from the stories shared by participants who have experienced braille learning in adulthood following vision loss [45]. In total, 14 participants from Canada completed in-depth semi-structured interviews on their braille learning experiences and the factors which played a role. Participants were between the ages of 40 and 72 and learned braille between the ages of 33 and 67.

## Results

 Participants described that the learning of braille in adulthood is influenced by a variety of personal, social and institutional factors. Among the personal factors, participants expressed that the motivation to learn braille is often instigated by a need to maintain meaningful adult roles. Prior identity also emerged as an important factor, where those who viewed themselves as readers prior to vision loss felt that braille allowed them to reconnect with a lost sense of self. Participants also highlighted the role of their psychosocial responses to blindness and braille, and the influence of previous learning experiences (whether negative or positive) as important considerations. At the social level, participants described the influence of family and friends, and the negative impact of misconceptions about braille or blindness held by those in their immediate circles. The response from the general public was described at length by almost all participants. Here, participants illustrated the ways in which their responses towards the attention they garner from others when using braille in public is often dependent upon their views towards blindness as an identity category. Most importantly, it was felt that experienced braille users functioned as positive sources of support, but that these networks are often not available to adult learners. Among the institutional factors, participants touched on the lack of available resources and devices for adult braille learners and the benefit of learning alongside other adults. Results also highlight a perceived reluctance among some rehabilitation specialists to provide braille training due to ageist stereotypes and the beliefs about the abilities of older adults. These full results and their implications will be expanded upon in the presentation.

# Phase 3: Correlation Study

 The third phase of this research, which is ongoing, measures a variety of tactile, motor and cognitive functions in a sample of experienced adult and senior braille readers across the age spectrum, and their potential relationship to braille reading performance (speed, accuracy and comprehension). The specific measures selected for this phase are based upon the scoping review conducted in Phase 1, in order to replicate prior research and to consider the additional implication of age on these factors. The three research questions we are exploring in this phase of the research are:

1. Are tactile, motor and cognitive functions influenced by chronological age or the age of braille acquisition?
2. What physiological and cognitive factors best predict braille reading performance across the adult and senior age spectrum? What is the role of age, age of braille acquisition and frequency of braille usage on braille reading measures?
3. Does reading format (paper vs. display) influence braille reading performance, and is this impact moderated by the key variables outlined in this study?

To explore these relationships, 45 participants (all experienced braille-reading Canadians from Quebec, Ontario, and British Columbia) underwent an extensive assessment protocol that collected demographic details (including braille history), tactile perception (using four different tactile acuity assessments), and data on motor and cognitive functioning. Data collection for this phase concluded in February 2020 and analysis is currently underway. Preliminarily (as these results are subject to further refinement), analyses reveal that those who are older as well as those who learn braille later in life achieve higher (worse) active and passive tactile acuity measures. Analyses currently also suggest that age, age of braille acquisition and frequency of braille usage are most predictive of braille reading performance. Most notably, frequency of braille usage appears to play a role, regardless of when braille is learned. A paired-sample t-test also reveals that there is no significant difference in braille reading performance when reading on paper vs. an electronic display. However, future analyses are required to determine whether the effect of format on reading performance is moderated by any demographic, tactile, motor, or cognitive measures, including age and age when braille was learned.

While it does not appear that among the experienced readers in this study there was any significant difference in reading performance on paper versus on a braille display, in Phase 4 of this research we will be exploring whether any greater difference arises among naïve adult and senior braille learners who are just beginning braille instruction. The results of these phases will be discussed in greater detail during the presentation, along with the clinical implications for working-age and older adults who pursue braille rehabilitation training.

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