Research Reports

A Comparison of the Handwriting Abilities of Secondary Students with Visual Impairments and Those of Sighted Students

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Visual impairment affects approximately 1.8 million people in Australia (Resnikoff et al., 2004) and is defined as a visual acuity or equivalent field loss of less than 6/18 (20/60) by the *International Statistical Classification of Diseases and Related Health Problems* (World Health Organization, 2010). A variety of conditions can cause visual impairment, including cataracts, glaucoma, macular degeneration, diabetic retinopathy, trachoma (Bourne et al., 2013), retinitis pigmentosa, optic atrophy, albinism, and congenital nystagmus (Haymes, Johnston, & Heyes, 2002). Despite the large number of people with visual impairments in Australia, all Western Australian secondary students are required to complete their secondary exams using handwriting, unless they qualify for special provisions. Students with visual impairments do not necessarily qualify for special provisions on the basis of their visual impairment alone. It is hypothesized that students with visual impairments in Western Australia experience more difficulties with handwriting than their fully sighted peers, which can potentially limit their optimal performance.

Despite advances in technology and computer use within schools, a considerable portion of the school day in Australia is comprised of handwriting tasks (Graham et al., 2008; Marr, Cermak, Cohn, & Henderson, 2003; Ziviani & Watson-Will, 1998). For individuals with visual impairments, the use of handwriting can be challenging (Markowitz, 2006). Handwriting combines visual-motor abilities, motor skills, and coordination (Kaiser, Albaret, & Doudin, 2009). Factors that increase the likelihood of experiencing handwriting difficulties include decreased eye-hand coordination, visual ability, kinesthesia, sensory awareness, motor planning, and posture (Cornhill & Case-Smith, 1996; Karlsdottir & Steffansson, 2002). Many of these factors have the potential to be improved with the correct intervention. A permanent or progressive reduction in vision due to visual impairment, however, cannot be easily corrected.

The only existing literature on the effect of visual impairment on handwriting indicates that impairment of specific ocular structures or eye conditions can result in specific handwriting difficulties (Arter, McCall, & Bowyer, 1996). For example, for a person with a narrow visual field, the corresponding inability to see an entire word can make copying tasks arduous; and conditions that cause blurry vision may make it difficult to distinguish letter and word forms (Arter et al., 1996). A person with visual impairment, therefore, is more likely to experience difficulties such as lower legibility of handwriting and slower writing speed (Uysal & Aki, 2012); and difficulties with forming letters and maintaining even spacing, size, slant, and alignment of letters (Bonney, 1992; Yalo, Indoshi, & Agak, 2012).

Keyboarding as an alternative method of communication (Arter et al., 1996) does not assist students with visual impairments who use handwriting for the completion of school assignments. Assistive technology can play an important role in helping students with visual impairments with their education, but many students feel it does not replace the need for a method to produce handwritten assignments. For example, secondary school students with visual impairments state that although technology is useful, they enjoy having the ability to choose between technology and writing (D'Andrea, 2012). Furthermore, technology may stop working or be unavailable during servicing and can be expensive (D'Andrea, 2012). And one student with visual impairment stated that having the option of writing enabled her to be more equal to people around her, as it enabled her to write down phone numbers and quick messages without having to start up a computer (D'Andrea, 2012). Handwriting has also been shown to be superior in contributing to students' understanding of what they are writing to typing out the same content (Mueller & Oppenheimer, 2014). For these reasons, handwriting remains an important skill for students with visual impairments despite the availability of assistive technology.

Handwriting is a mode of self-expression and a subtle representation of a person's individuality that is particularly important for academic performance (Arter et al., 1996; Tseng & Chow, 2000). Difficulties with handwriting can negatively affect academic performance, and research has showed that more time is required to complete handwritten assignments (Connelly, Dockrell, & Barnett, 2005; Graham et al., 2008; Tseng & Cermak, 1993) and that poorly handwritten exams are marked lower than the same content presented in legible handwriting (Connelly, Campbell, MacLean, & Barnes, 2006; Hammerschmidt & Sudsawad, 2004; Sudsawad, Trombly, Henderson, & Tickle-Degnen, 2001). In addition, difficulties with handwriting can have a detrimental effect on self-esteem, personal relationships, and students' perceptions of themselves (Goyen & Duff, 2005; Graham & Weintraub, 1996).

For students who are sighted, handwriting difficulties can be detected through the assessment of visual-motor integration abilities (Klein, Guiltner, Sollereder, & Cui, 2011). *Visual-motor integration ability* refers to the degree to which visual perception (processing of visual information) and fine-motor movements are coordinated (Gabbard, Conclaves, & Santos, 2001; Rodger, Brown, & Brown, 2005). To date, there is only one study that indicates that the assessment of visual-motor integration abilities is also positively correlated to handwriting ability in people with visual impairments (Uysal & Aki, 2012).

The primary objective of the study presented here is to determine if there is a statistically significant difference in the handwriting performance of people with visual impairments compared to that of sighted individuals. As a secondary objective, this study makes an effort to determine if there is evidence supporting the use of *The Beery-Buktenica Developmental Test of Visual-Motor Integration* (Beery & Beery, 2010). As an indicator of handwriting performance in individuals with visual impairments.

Methods

The current study followed a matched-pair design. Participants were separated into two groups: those with and without visual impairments. The groups were matched for age (within 6 months) and gender. Socioeconomic status was recorded, but matching for socioeconomic status was not practical because of sample restrictions. The confounding factors of motor skills, cognitive skills, self-esteem, and method of handwriting used and taught could not be practically matched between groups, but were considered when the results were analyzed.

Participants

For the participants with visual impairments, data on visual acuity, near vision, and conditions causing visual impairment were obtained with parental permission from records at VisAbility, the main support organization for people with visual impairments in Perth, Western Australia. For participants who are sighted, visual acuity and near vision were measured on the date of assessment using a standard eye chart test and a near vision assessment provided

Table 1
Demographics and descriptive statistics of participants.

Variable	Participants with vision impairment				Participants with sight			
	Males		Females		Males		Females	
Number	12		9		12		9	
Average age in years (mean)	14.63		15.10		14.56		15.29	
Hand dominance distribution*	L: 3	R: 7	L: 0	R: 9	L: 1	R: 11	L: 1	R: 8
Visual efficiency range scores	5–68%		8–68%		91–100%		96–100%	
Average visual efficiency scores (mean)	32.03%		33.15%		97.27%		98.89%	
Range near vision scores	4–32		3–16		4–6		4–10	
Average near vision scores (mean)	17.5		8.78		5		6	
Socioeconomic status (combined parental income)*								
< $60,000	1		0		2		0	
$60,000–$100,000	3		4		0		2	
> $100,000	2		2		9		6	
Type of vision impairment								
Congenital nystagmus or albinism	6		2					
Retinal dystrophies	3		3					
Optic nerve conditions	1		2					
Other	2		2					

* Missing data accounts for inconsistencies in numerical values.

by VisAbility. Visual acuity scores were then converted into visual efficiency scores for analysis (Snell-Sterling Visual-Efficiency Scale, n.d.). See Table 1 for information about the participants.

Research group (VI). Participants with visual impairments were recruited through convenience sampling methods from a previous study conducted by VisAbility in Perth, Western Australia (VisAbility, 2014). A sample size of 21 participants was estimated to be suitable for detecting changes in the outcome measures. Students with visual impairments were invited to participate in the study if they met the following criteria: diagnosis of visual impairment determined by an optometrist or ophthalmologist, aged between 12 and 18 years old, and use of handwriting as the main mode of completing school work. Students who were legally blind (visual acuity of worse than 6/60 [20/200]) were considered for this study, provided they used handwriting as their primary mode of completing schoolwork. Students were excluded if they had multiple disabilities, had vision greater than 6/18 (20/60) or equivalent field loss, were not involved in mainstream education, or were on a modified program.

Normative data group (control). Sighted participants were recruited using convenience and "snowball" sampling methods through private contacts. The sample size for the normative group was matched to the participants with visual impairments in the research group. Sighted participants were recruited in accordance with the following inclusion criteria: matched the age and gender of one included participant with visual impairment and had corrected or uncorrected vision greater than 6/18 (20/60) acuity or equivalent field. Students were excluded from the sighted group if they had visual impairments, diagnosed motor or intellectual disabilities, or were engaged in home-schooling or modified-schooling programs.

Data collection and measures

During all assessment sessions, participants with visual impairments were permitted the use of their preexisting assistive equipment, such as slant boards, modified lined paper, and optical devices such as dome magnifiers. Assessment sessions were conducted over a 4-week period and organized at locations that allowed privacy and during times that were convenient for participants. The lengths of sessions varied between 30 and 60 minutes and were conducted by the primary investigator or therapists from VisAbility. Data collection was conducted through the following modes: Detailed Assessment of Speed of Handwriting (DASH) and Beery VMI.

DASH. Participants completed all subtests of the DASH assessment (Barnett, Henderson, Scheib, & Schulz, 2007) in their natural handwriting, resulting in a mix of manuscript and cursive writing. Four subtests measured handwriting under different conditions: copying a set sentence for 2 minutes in their neatest and then their fastest handwriting, writing the alphabet repeatedly for 1 minute in their typical handwriting mode, and completing 10 minutes of uninterrupted handwriting on a topic of their choosing in their daily handwriting style. Each subtest was scored for performance recorded as the number of legible words completed per minute (wpm). The combined number of legible words completed per minute was then standardized to provide an overall score for handwriting performance. In addition, the fifth subtest handwriting sample provided a percentage score for legibility. DASH has been standardized for subjects aged 9 to 17 years and takes approximately 30 minutes to complete (Barnett et al., 2007). Reliability testing of the DASH revealed high levels of inter-rater agreement (reliability coefficients ranging from 0.853 to 0.999 across the subtests). These coefficients were established based on a population of American students without disabilities, ranging in age from 9 to 17 years, and no students with visual impairments were included within this group.

Beery VMI. Beery VMI is a standardized assessment used extensively in pediatric practice to assess the visual-motor integration abilities of children aged 2 to 18 years in which participants to copy shapes of progressing difficulty (Beery & Beery, 2010). Shapes begin with simple figures such as circles and rectangles and progress to layered figures in which shapes overlap. Reliability and validity testing of Beery VMI has been conducted by the authors of the assessment and by external parties based on an Australian population (Brown & Hockey, 2013). Overall, the high scores for interscorer reliability (0.93–0.97) and tests for content, concurrent, constructive, predicative, and control for bias support its effectiveness in measuring visual-motor integration abilities. However, tests for the reliability and validity of this instrument have not been conducted with people with visual impairments. The test's estimated completion time is 5 to 15 minutes. On the standard assessment form, participants copied shapes using the writing utensil they used during their daily school activities. The size of the shapes to be copied was not changed for the participants with vision impairments as it was deemed by professionals in the field of visual impairment to be a suitable size for participants to view.

Observations

During all assessment sessions, the administrator was required to record observations on a provided template. These observations included descriptive data and recorded factors such as hand position, special equipment used, occurrence of pain, and posture, as well as general observations regarding performance.

Parent questionnaire

The written questionnaire for parents was provided to parents at the start of the study prior to the children participating in handwriting assessment sessions and asked for information on the percentage of homework completed using handwriting, whether students were receiving or had received handwriting interventions, current allowances permitted by schools, socioeconomic status in regards to income and parents' highest education level, and general comments regarding the children's handwriting. This information was used to account for confounding variables and considered in the analysis of the results.

Procedure and data management

Ethical approval was obtained from the Edith Cowan University Human Research Ethics Committee. Consent and assent were obtained from each participant prior to participation, and a student was free to withdraw from the study at any stage. All data were stored securely and confidentially and participants were provided with a summary of results reported at the completion of the study.

Data analysis

Data were analyzed and coded in PASW-22 SPSS (IBM, 2013) for statistical analysis. The study aims were met through descriptive statistics, with measures of central tendency used to determine the distribution of the data. These tests for normality resulted in nonparametric tests used for statistical analysis. Raw assessment scores were converted to standard scores for analysis. All tests for statistical significance were conducted using the Mann-Whitney *U*-test, and all correlational tests were conducted using Spearman's Rho coefficient. Statistical significance was set at $p = .05$. The clinical meaning of differences among variables was also considered.

Results

DASH

Handwriting performance. The score from DASH was used to record handwriting performance in reference to the number of legible words written per minute. A Mann-Whitney *U*-test indicated that the handwriting performance of participants with visual impairments was statistically significantly lower than that of the sighted participants ($U = 393.50$, $p \leq .00$, mean $VI = 29.74$, mean $C = 13.26$). Handwriting performance was not significantly different between genders, both among people with visual impairments ($U = 68.50$, $p = .3$, mean males $VI = 12.61$, mean females $VI = 9.79$) and people who are sighted ($U = 43.50$, $p = .46$, mean males $C = 9.83$, mean females $C = 11.88$).

Handwriting legibility. The free-writing subtest of the DASH assessment also provided a score for legibility as a percentage. *Legibility* was determined by dividing the number of legibly written words by the total number of words written. Analysis of all the groups revealed no significant difference between the legibility of the writing of high school students with visual impairments and those who are sighted ($U = 253.00$, $p = .63$, mean $VI = 23.05$, mean $C = 19.95$), and no difference between males and females among participants with visual impairments ($U = 71.50$, $p = .22$, mean males $VI = 12.94$, mean females $VI = 9.54$) or participants who are sighted ($U = 75.00$, $p = .15$, mean males $C = 13.33$, mean females $C = 9.25$).

Visual-Motor Integration ability (Beery VMI scores)

Results from the Beery VMI indicated that the participants with visual impairments had statistically significantly lower visual-motor integration abilities than the sighted participants ($U = 426.00$, $p \leq .00$, mean $VI = 31.29$, mean $C = 11.71$). Comparing individuals from the same group indicated no statistically significant difference between males and females in regard to visual-motor integration abilities for both participants with visual impairments ($U = 60.00$, $p = .70$, mean males $VI = 11.67$, mean females $VI = 10.50$) and those with no visual impairments ($U =$

55.00, $p = 1.00$, mean males $C = 11.11$, mean females $C = 10.92$).

Correlational analysis

No significant correlation was found between the Beery VMI and the DASH scores in either participants with ($p = .14$, $r = 0.34$) and without visual impairments ($p = 0.35$, $r = 0.21$). A bivariate Spearman's Rho correlation coefficient test revealed no statistically significant correlation between the participants with visual impairments' near vision ability and performance on the DASH ($p = -.22$, $r = 0.40$) or the Beery VMI ($p = -.11$, $r = 0.68$). For participants with visual impairments, visual efficiency had a weak correlation to performance on the DASH ($p = .17$, $r = 0.31$) and a moderate correlation to performance on the Beery VMI ($p = .10$, $r = 0.09$). For the sighted participants, visual efficiency was positively correlated to handwriting performance (DASH) ($p = .00$, $r = 0.75$) but not to visual-motor integration ability (Beery VMI) ($p = 70$, $r = 0.09$).

Observations and participant reporting

Observations recorded common patterns in the outcome measures completed by participants with visual impairments that were not present in the participants who are sighted. There was a higher number of participants with visual impairments (43%) compared to participants who are sighted (4%) whose drawings in the Beery VMI were of a noticeably larger size. In the handwriting samples, participants with visual impairments were more often unable to write within the constraints of the lines provided (19% of participants with visual impairments, compared to 4% of sighted participants). In addition, six participants with visual impairments were noted to have large writing—that is, writing that is greater than 1/3 of the space between the lines—and four participants had small writing—where the body of the letter was less than 1/3 of the space between the lines. In one case, a participant with visual impairment produced words that were indistinguishable due to the wide spaces between letters.

Patterns were recorded to determine whether the type of visual impairment produced specific effects on handwriting. The group of participants with congenital nystagmus or albinism had the lowest average score (71.5) in the DASH assessment, whereas the group with retinal dystrophies had the lowest average Beery VMI scores (72.67). Differences in legibility were negligible between the groups of participants with visual impairments. Participants with retinal dystrophies had the highest occurrence of insufficient spacing between letters, resulting in writing being very close together. Although other participants displayed insufficient spacing, 62.5% were represented in the group with retinal dystrophies. For a majority of participants within this group, there was also a higher occurrence of large gaps on the right side of the paper, in which no writing was present. A notable gap was considered larger than 15 mm (0.59 inches). Only participants with retinal dystrophies produced gaps ranging from 18 mm to 50 mm (0.70 to 1.97 inches). This neglect on the side of the paper was also present in one of the corresponding Beery VMI assessments in which drawings were consistently positioned to the left of the page.

Discussion

The results from this study support the hypothesis that participants with visual impairments have lower handwriting performance than participants who are sighted. The handwriting assessment in this study measured performance using the number of legible words completed per minute; results therefore show that the representative sample of students with visual impairments in Western Australia complete fewer legible words per minute.

In addition to overall lower handwriting performance, participants with visual impairments had higher occurrences of large-scale drawings and writing, a larger diversity in the size of writing, an inability to write within the constraints of the lines, and irregularity maintaining spacing between letters and words. These conclusions are consistent in research and support the findings made in Uysal and Aki's 2012 study that compared Turkish students with visual impairments to their sighted peers. The observations made in this study support similar observations made in previous studies (Yalo et al., 2012). However, a statistical study that supports these observations as common in people with visual impairments has yet to be conducted.

We found that handwriting legibility among participants with visual impairments was not significantly different from sighted participants. These results are in contrast to the only other study conducted comparing handwriting between people with visual impairments and those who are sighted (Uysal & Aki, 2012). Differences in the handwriting assessments used may account for the differences, however, since only two studies investigated the legibility of handwriting produced by people with visual impairments compared to that of people who are sighted, conclusive statements will not be made.

Studies on participants who are sighted support the theory that females have more legible handwriting than males (Berninger, Nielson, Abbott, Wijsman, & Raskind, 2008). Despite the results of this current study indicating no statistically significant difference in the legibility of handwriting between females and males in either group of participants, there was still a recorded difference (males with visual impairments 93.29%, males who are sighted 94.16%, females with visual impairments 95.40%, females who are sighted 96.77%). Further research is required to determine whether or not this difference was the result of chance or is representative of the population of people with visual impairments.

The secondary objective of this study was to investigate whether the assessment of visual-motor integration abilities can be indicative of handwriting performance, a concept supported in people who are sighted (Duiser, van der Kamp, Ledebt & Savelsbergh, 2014; Klein et al., 2011). This study has indicated that people with visual impairments had lower visual-motor integration abilities than people who are sighted, a result supported in Uysal & Aki's 2012 study on Turkish students with visual impairments. Despite this result, no correlation was found between performance on the Beery VMI and DASH. Therefore, lower visual-motor integration abilities do not necessarily result in a corresponding difficulty in handwriting performance, which is a contrasting finding to the study in which visual-motor integration abilities were positively correlated to handwriting ability in people with visual impairments (Uysal & Aki, 2012). The difference in handwriting assessments and the population from which the participants were recruited may account for the differences.

Specific visual characteristics such as near vision and visual efficiency did not show any correlation to handwriting. Near vision was recorded in font size, and visual efficiency was recorded as a percentage of efficient vision. The small sample size limits the conclusiveness of results, and therefore further investigation should be undertaken in order to determine a convincing outcome regarding the effect of visual characteristics such as near vision and visual efficiency on handwriting.

Unique occurrences in the handwriting of participants with retinal dystrophies were observed. These included producing letters close together and a lack of use of space on the right side of the page. Since this group of participants includes those with retinitis pigmentosa, which can result in visual field loss, these observations are consistent with expectations. However, since these observations were not statistically supported and come from a small range of participants, they can be considered areas for development in future research.

Limitations

A potential limitation of this study is the generalizability of results to the wider population of people with visual impairments because of the small sample size and the fact that all participants with visual impairments were recruited through VisAbility. Despite these limitations, the support of other studies investigating the handwriting difficulties experienced by people with visual impairments lends strength to the results. Outcomes in this study may be affected by the increase in the use of technology within society and schools, reflecting a decrease in handwriting use and abilities.

Conclusions

The expectation of secondary students with visual impairments in Australia to complete their secondary exams under the same conditions as their sighted peers does not represent an equal opportunity. Results indicate that Western Australian students with visual impairments may complete fewer words per minute and write at slower speeds than their peers who are sighted when using handwriting.

In order to create equality for people with visual impairments, an assessment of handwriting ability is required to determine the degree to which visual impairment affects their ability to produce handwriting equal to their sighted peers. Evidence shows that a specific visual impairment diagnosis does not directly result in a type of handwriting difficulty. Despite the high occurrence of decreased space between letters and potential neglect on the right-hand side of the page observed in participants with retinal dystrophies, many difficulties in handwriting were observed in participants with visual impairments. These difficulties included larger writing, irregular spacing, and poor sentence alignment for all participants with visual impairments regardless of diagnosis. A consistent outcome was that participants with visual impairments completed fewer words per minute than their sighted peers.

Implications for clinical practice

The implications of this study and its results can be used to inform parents, teachers, and therapists of students with visual impairments. For parents and teachers of students with diagnosed visual impairments, the observations and results of this study can be used to determine if the student is experiencing difficulties and may require intervention, such as an increased time allowance when completing handwriting tasks.

Therapists are frequently the professionals who make recommendations and liaise with academic staff members regarding allowances to facilitate the best performance for students with visual impairments. The results of this study will strengthen observations made during handwriting assessments and help support the need for recommendations made by educators or therapists. For many therapists, a referral for handwriting includes an assessment of visual-motor integration abilities. However, results from this study indicate that assessment of visual-motor integration abilities is not effective as handwriting assessments for people with visual impairments. The assessment of visual-motor integration abilities can still be used, however, in conjunction with a formal handwriting assessment and considered in light of the above finding. The generalizability of this finding is limited to the population represented in this study (secondary students with visual impairments from Western Australia), but still requires further investigation to determine whether it is a definitive conclusion. Furthermore, the handwriting of people with visual impairments is an area in need of further investigation. Future studies are needed to determine whether the eye structure affected increases the occurrence of specific types of difficulties with handwriting.

Despite the availability of assistive technology for students with visual impairments, the learning of handwriting enables freedom of choice and decreases reliability on expensive technology that may not always be accessible.

References

Arter, C., McCall, S., & Bowyer, T. (1996). Handwriting and children with visual impairments. *British Journal of Special Education, 23*(1), 25–28.

Barnett, A., Henderson, S. E., Scheib, B., & Schulz, J. (2007). *Detailed Assessment of Speed of Handwriting (DASH)*. London: Pearson Assessment.

Beery, K. E., & Beery, N. A. (2010). *The Beery-Buktenica Developmental Test of Visual-Motor Integration* (6th Ed.). San Antonio, TX: Pearson Education.

Berninger, V. W., Nielson, K. H., Abbott, R. D., Wijsman, E., & Raskind, W. (2008). Gender differences in severity of writing and reading disabilities. *Journal of School Psychology, 46*(2), 151–172.

Bonney, M. A. (1992). Understanding and assessing handwriting difficulty: Perspectives from the literature. *The American Occupational Therapy Journal, 39*(3). 715.

Bourne, R. R. A., Stevens, G. A., White, R. A., Smith, J. L., Flaxman, S. R, Price, H., . . . Naidoo, K. (2013). Causes of vision loss worldwide, 1990-2010: A systematic analysis. *The Lancet Global Health, 1*(6), 339–349.

Brown, T., & Hockey, S. C. (2013). The validity and reliability of Developmental Test of Visual Perception-2nd edition (DTVP-2). *Physical & Occupational Therapy n Pediatrics, 33*(4), 426–439. doi: 10.3109/01942638.2012.757573

Connelly, V., Campbell, S., MacLean, M., & Barnes, J. (2006). Contribution of lower order skills to the written composition of college students with and without dyslexia. *Developmental Neuropsychology, 29*(1), 175–196.

Connelly, V., Dockrell, J. E., & Barnett, J. (2005). The slow handwriting of undergraduate students constrains overall performance in exam essays. *Educational Psychology, 25*(1), 99–107.

Cornhill, H., & Case-Smith, J. (1996). Factors that relate to good and poor handwriting. *American Journal of Occupational Therapy, 50*(9), 732–739.

D'Andrea, F. M. (2012). Preferences and practices among students who read braille and use assistive technology. *Journal of Visual Impairment & Blindness, 106*(10), 585–596

Duiser, I. H. F., ven der Kamp, J., Ledebt, A., & Savelsburgh, G. J. P. (2014). Relationship between the quality of children's handwriting and the Beery-Buktenica Developmental Test of Visuomotor Integration after one year of writing tuition. *Australian Occupational Therapy Journal, 61*(2), 76–82. doi: 10.1111/1440-1630.12064

Gabbard, C., Conclaves, V. M. G., & Santos, D. C. C. (2001). Visual-motor integration problems in low birth weight infants. *Journal of Clinical Psychology in Medical Settings, 8*(3), 199–204.

Goyen, T., & Duff, S. (2005). Discriminant validity of the Developmental Test of Visual-Motor Integration in relation to children with handwriting dysfunction. *Australian Journal of Occupational Therapy, 52*(2), 109–115. doi: 10.1111/j.1440-1630.2005.00488.x

Graham, S., Harris, K. R., Mason, L., Fink-Chorzempa, B., Moran, S., & Saddler, B. (2008). How do primary grade teachers teach handwriting? A national survey. *Reading and Writing, 21*(1), 49–69.

Graham, S., & Weintraub, N. (1996). A review of handwriting research: Progress and prospects from 1980–1994. *Educational Psychology Review [H.W. Wilson – EDUC], 8*(1), 787. doi:10.1007/BF01761831

Hammerschmidt, L. S., & Sudsawad, P. (2004). Teachers' survey on problems with handwriting: Referral, evaluation and outcomes. *American Journal of Occupational Therapy, 58*(2), 185–192.

Haymes, S. A., Johnston, A. W., & Heyes, A. D. (2002). Relationship between vision impairment and ability to perform activities of daily living. *Ophthalmic & Physiological Optics: The Journal of the British College of Ophthalmic Opticians (Optometrists), 22*(2), 79–91.

IBM. (2013). *IBM SPSS Statistics* [Computer Software]. Retrieved from http://www-01.ibm.com/software/au/analytics/spss/products/statistics

Kaiser, M. L., Albaret, J. M., & Doudin, P. A. (2009). Relationship between visual-motor integration, eye-hand coordination, and quality of handwriting. *Journal of Occupational Therapy, Schools, & Early Intervention, 2(*2), 87–95.

Karlsdottir, R., & Steffansson, T. (2002). Problems in developing functional handwriting. *Perceptual and Motor Skills, 94*(2), 623–662.

Klein, S., Guiltner, V., Sollereder, P., & Cui, Y. (2011). Relationships between fine-motor, visual-motor, and visual perception scores and handwriting legibility and speed. *Physical & Occupational Therapy in Pediatrics, 31*(1), 103–114.

Markowitz, M. (2006). Occupational therapy intervention in low vision rehabilitation. *Canadian Journal of Ophthalmology, 41*(3), 340–347.

Marr, D., Cermak, S., Cohn, E. S., & Henderson, A. (2003). Fine motor activities in head start and kindergarten classrooms. *The American Journal of Occupational Therapy, 57*(5), 550–557.

Mueller, P. A., & Oppenheimer, D. M. (2014). The pen is mightier than the keyboard: Advantages of longhand over laptop note taking. *Psychological Science, 25*(6), 1159–1168. doi:10.1177/0956797614524581

Resnikoff, S., Pascolini, D., Etya'ale, D., Kocur, I., Pararajasegaram, R., Pokharel, G. P., & Mariotti, S. P. (2004). Global data on visual impairment in the year 2002. *Bulletin of the World Health Organization, 82*(11), 844–851.

Rodger, S., Brown, G. T., & Brown, A. (2005). Profile of paediatric occupational therapy practice in Australia. *Australian Occupational Therapy Journal, 52*(4), 311–325.

Snell-Sterling Visual Efficiency Scale. (n.d.). *Millodot: Dictionary of Optometry and Visual Science* (7th Ed.). (2009). Retrieved from http://medical-dictionary.thefreedictionary.com/Snell-Sterling+visual+efficiency+scale

Sudsawad, P., Trombly, A. C., Henderson, A., & Tickle-Degnen, L. (2001). The relationship between the evaluation tool of children's handwriting and teachers' perceptions of handwriting legibility. *American Journal of Occupational Therapy, 55*(5), 518–523.

Tseng, M. H., & Cermak, S. A. (1993). The influence of ergonomic factors and perceptual-motor abilities on handwriting performance. *The American Journal of Occupational Therapy, 47*(10), 919–926.

Tseng, M. H., & Chow, S. M. K. (2000). Perceptual-motor function of school-age children with slow handwriting speed. *American Journal of Occupational Therapy, 54*(1), 84–88.

Uysal, S. A., & Aki, E. (2012). Relationship between writing skills and visual-motor control in low-vision students. *Perceptual and Motor Skills, 115*(1), 111–119.

VisAbility. (2014). *Home page.* Retrieved from http://www.visability.com.au

World Health Organization. (2010). *International statistical classification of diseases and related health problems, 10th revision.* Geneva: WHO. Retrieved from http://www.who.int/bulletin/volumes/90/10/12-104034/en

Yalo, J. A., Indoshi, F. C., & Agak, J. O. (2012). Challenges and strategies of working with learners with low vision: Implications for teacher training. *Educational Research and Reviews, 7*(10), 238–243.

Ziviani, J., & Watson-Will, A. (1998). Writing speed and legibility of 7-14 year old school students using modern cursive script. *Australian Occupational Therapy Journal, 45*(2), 59–64.

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Efficacy of ScripTalk Automated Prescription Label Reader and Veterans with Visual Impairments

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Visual decline is one of the most prominent features of age-related disability among older adults. In 2012, more than 20.6 million American adults reported vision loss (Blackwell, Lucas, & Clarke, 2012), and worldwide, according to the World Health Organization (2014), more than 285 million people are estimated to have visual impairment.

Individuals with visual impairments are affected by significant psychosocial stressors, functional limitations, and increased mortality (Kempen, Ballemans, Ranchor, van Rens, & Zijlstra, 2012). Studies have shown that older individuals with visual impairments have diminished ability to perform activities of daily living (Knudtson, Klein, Klein, Cruickshanks, & Lee, 2005), and demonstrate poor health and increased disability (Crews, Chou, Zhang, Zack, & Saaddine, 2014). Furthermore, individuals with vision loss are often socially isolated (Alma et al., 2011), and have increased levels of psychological distress, anxiety, and depression (Kempen et al., 2012; Rovner, Zisselman, & Shmuely-Dulitzki, 1996). Although studies have shown a relationship between vision loss and depression, Rovner et al. (2014) demonstrated that the combination of mental health treatments and low vision interventions halved the incidence of depressive disorders relative to standard low vision interventions alone in individuals with macular degeneration. Furthermore, there is a correlation between visual impairment and increased mortality (Jacobs, Hammerman-Rozenberg, Maaravi, Cohen, & Stessman, 2005; Christ, Lee, Lam, Zheng, & Arheart, 2008; McCarty, Nanjan, & Taylor, 2001; Cacciatore et al., 2004). Compared to individuals with hearing deficits, individuals with vision loss have higher morbidity and are more likely to suffer from diabetes mellitus, heart disease, and hypertension (Crews & Campbell, 2004; Crews, Jones, & Kim, 2006). Notably, an association has been identified between visual impairment and an increased risk of hospitalization, which is likely secondary to the reduced functional ability associated with visual impairment and other comorbidity (Evans, Smeeth, & Fletcher, 2008). It is noteworthy that reading prescription labels and self-administering the correct drug and dosage at correct intervals requires a level of vision that most individuals with visual disabilities are incapable of, even with appropriate optical or auxiliary aids.

Studies have suggested that medication mismanagement may be related to vision loss (American Foundation for the Blind, 2008; Murray, Darnell, Weinberger, & Martz, 1986; Smith & Bailey, 2014). The American Foundation for the Blind in 2008 reported that individuals with visual impairments lack access to critical medication use instructions. Common negative consequences of visual impairment include not taking medications at proper dosages or mistakenly taking expired or incorrect medications (American Foundation for the Blind, 2008; Smith & Bailey, 2014). As shown previously, difficulty with medication adherence can cause detrimental health consequences (McCann et al., 2012; Gellad, Grenard, & Marcum, 2011; Hughes, 2004). Prior studies have noted that individuals with visual impairments are more than twice as likely to need help managing their

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