The Application of Speech Recognition Technology for Remediating the Writing Difficulties of Students with Learning Disabilities

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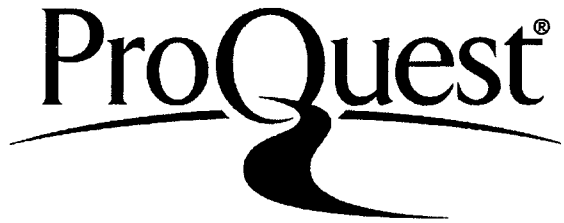

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Abstract

The Application of Speech Recognition Technology
for Remediating the Writing Difficulties of Students with Learning Disabilities

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This dissertation investigated the use of speech recognition technology as a means of remediating the writing problems of students with learning disabilities. The research question focused on whether young children with learning disabilities (LD) could produce narratives with higher fluency/quantity and/or better quality when using (a) a traditional paper-pencil mode (HW), (b) a dictation mode using normal speech-to-text technology of speech recognition software (SR), which students could see on the monitor what they had dictated, and could edit their dictated text if and as they chose, or (c) a simplified dictation mode using a digital voice recorder (DR), which students had no immediate visual text feedback or access to text editing. A single subject, alternating treatment design was employed. The study participants included four 9-year old students, who had been diagnosed with LD, were receiving special education services, and having writing objectives addressed in their Individualized Educational Plan. The results indicated that the two dictation modes (SR and DR) were notably superior to the handwriting mode in terms of the fluency and mechanical aspect of writing, but there was little to mild difference between the dictation modes and the handwriting mode in terms of the syntactic complexity and story structure level of the writing. The transcription demands of writing appeared to have significant influence on the writing performance of students with LD. All students performed better using the dictation-related technology, but different students on different technology. Considering the wide spectrum of differences among the struggling writers with LD, the dictation strategies implemented in this study may also serve as an assessment tool to match students with the proper type of technology support.

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Chapter I: Statement of the Problem

This chapter presents a brief overview about the importance of writing, the writing performance of youngsters in US, the writing problems of students with learning disabilities, the availability of research on writing interventions, and the potential of computer oriented intervention. Only brief references are provided in this chapter to support the major points. A more detailed literature review pertinent to each point is presented in Chapter 2. This chapter concludes with the specific problem addressed in this dissertation.

The Importance of Writing Proficiency

Writing proficiency is essential for success in school settings and in our lives outside school. In school, students who have poor writing proficiency are less likely to earn good grades, since writing is constantly used as an assessment tool in tracking progress in content subjects (Reynolds & Perin, 2009). Those students' low writing proficiency level could deprive them of the opportunity to demonstrate an ability to organize and present information, to evaluate the relevance of information, and ultimately to clarify, deepen and expand their prior knowledge, or support and extend their learning of new materials (Graham, 2006; Newell, 2006). Likewise, the learning progress of those students is more likely to suffer, and self-motivation in learning to be low.

Conversely, good writing skills can overcome negative effects of other risk factors in learning. Reeves (2004), for instance, reported that one common characteristic of the schools with high minority enrollment and high poverty levels where, despite the odds, with a high percentage of students (i.e. 90% or more) passed high-stakes assessments in content-area subjects was a strong emphasis on writing. The report was based on four years of test data (1995-1998) from more than 100,000 students in elementary through high school, representing various ethnic, socio-economic, and geographic groups. It offered evidence that the association between writing and performance in other academic disciplines was striking,

and that an emphasis on writing improvement had a significant impact on student test scores in other disciplines, including science.

Students' writing competence is also a significant direct predictor of individual performance on statewide reading assessments. Johnson, Jenkins, & Jewell (2005), for instance, examined whether writing would account for unique variance in reading scores when using performance-based reading assessments like those used at both the national and state level for high stakes assessment. In their study of 95 fourth graders, it was found that writing accounted for 12.7% unique variance in reading after controlling for the variables of decoding and listening comprehension. That is, writing ability emerged as an important source of individual differences in explaining overall reading ability.

As deficits in writing competence can significantly impact other areas of interest (reading, content area materials, etc.), it is no wonder why a good number of states use writing competence as a crucial factor in discerning grade retention, promotion, and graduation. For instance, 19 out of the 26 states in America, who responded to a state survey on high school exit exams, included essay writing in their writing or English language arts tests (Center on Education Policy, 2009). In addition, it is predicted that by 2012, 72% of high school students in America will be in schools that require exit exams, which involve assessments and application of writing skills in particular (Center on Education Policy, 2007). The impact of writing competence increases particularly in postsecondary school settings, where proficient writing is expected for admission into and completion of college degree programs. The chances of students with poor writing skills attending and graduating from college have been decreased, as higher educational institutes increasingly evaluate applicants' qualifications concerning their writing proficiency (Achieve, 2009; Peter D. Hart Research Associates, 2005).

Moreover, writing cannot merely play the role of an independently studied academic subject in school or educational settings. In the job market, writing is a "threshold skill" for employment and promotion in many, if not most jobs, especially in salaried or professional

positions (National Commission on Writing for America's Families, 2004, 2005). Writing, particularly using computers and computer-related technology, is also becoming more integrally related to a wider range of personal communication and relationships in our social and community life. For example, an ever-growing number of people nowadays use text messaging through cell phones, emails, etc. to communicate with friends and others.

In summary, writing is a virtually indispensable life skill that is closely linked to basic literacy, the movement of high stakes testing, entrance into and graduation from post-secondary schooling, procuring and retaining jobs, and computer usage in the recent decade.

The National Poverty in Writing Proficiency

Despite the importance of writing in and out of school settings, only between 24 and 33 percent of approximately 165,000 students in 8th, and 12th grades performed at or above the *proficient* level (Salahu-Din, Persky, & Miller, 2008). "Proficiency", in this case, is defined as a solid mastery level needed to perform challenging academic tasks. Although there were small gains in the results of the National Assessment of Educational Progress (NAEP) between 1998 and 2002, the proportion of our youngsters demonstrating proficiency in writing skills in 2007 still appeared insufficient. Figure 1 shows the detailed results of

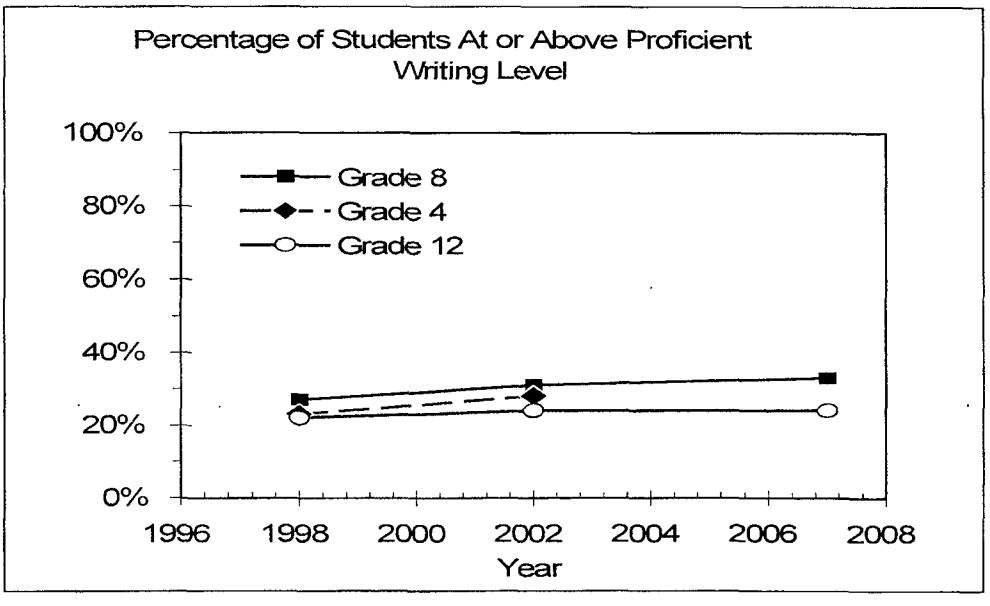


Figure 1. Percentage of Students at or above Proficiency Writing Level- NAEP Report

NAEP at Grades 4, 8, and 12: 1998, 2002 and 2007. The assessment was not administered at grade 4 in 2007 (Salahu-Din et al., 2008). Essentially, two out of every three youngsters in the US did not write well enough to meet expected grade-level demands.

This uninspiring national writing performance raises our attention to the phenomenon that writing has been a severely neglected literacy skill among the three "Rs" in the US (National Commission on Writing for America's Families, 2003). In the national efforts of educational reform, for instance, writing has traditionally received far less attention than reading from researchers and sponsors of funded research (Troia, 2009). While many would maintain that reading is a more important skill than writing, and should receive more attention, it still seems imperative for us to acquire more understanding about the poor writers and implement effective writing intervention for their writing difficulties.

Struggling Writers and Students with Learning Disabilities

A good proportion of our current knowledge about incompetent or poor writers comes from research studies of children with learning disabilities (LD). In Rogers & Graham's (2008) meta-analysis of single subject design writing intervention (Grades 1-12), for instance, 78% of the 76 studies investigated struggling writers, of which 75% were students with LD. Generally, students with LD differ not only in terms of the frequency of writing difficulties but in the nature and severity of difficulties as well. That is, students with LD often have written language deficits, and seldom produce texts of a quality comparable to that of their non-learning disabled counterparts (Graham & Harris, 1992; Graham, Schwartz, & MacArthur, 1993; McFadden & Gillam, 1996). Their written texts appear to have more errors in spelling and handwriting, and are generally less coherent, more disorganized, and more confusing to read. The average length of their texts also tends to be shorter than their typically developing peers (Graham et al., 1993; Newcomer & Barenbaum, 1991).

The investigation of the writing problems of students with LD is of particular importance not only because of the severity and complexity of their writing problems but

also the increasing prevalence of students classified with LD. In the 2007 NAEP writing assessment results, 95% of the students identified as having special needs were at or below the basic level for writing performance (Salahu-Din et al., 2008). Within the special education population, the percentage of students with specific learning disability (from age 6 to 21) in fall 2007 has reached 43.3%, which accounts for a higher proportion of all special education enrollments than any other classification under the Individuals with Disabilities Education Act (IDEA), and is almost double the 23% cited for the LD population when the child count began in 1976-1977 (Data Accountability Center, 2007).

Evidence-Based Writing Intervention for Students with LD

Evidence-based writing intervention for students with LD is based on findings validated through empirical studies, e.g., true experimental, quasi-experimental, and single-subject design intervention studies. These studies, which could involve quantitative and/or qualitative ones, provide evidence as to whether the intervention procedure has the desired impact, and appear to be a more data-driven source of information than simple appeals to "common practice," "accepted wisdom", or "authority."

Four evidence-based intervention categories can be *adapted* from the two most recent meta-analysis studies on writing interventions-- Graham & Perin's (2007) meta-analysis of writing treatment studies for adolescents with experimental and quasi-experimental design, and Rogers & Graham's (2008) meta-analysis of the single subject design writing interventions. The four intervention categories include: *explicit writing instruction* (e.g., strategy instruction); *scaffolding students' writing* (e.g., inquiry, with less strategy-direct approach); *process writing* (e.g., Writers' Workshop, originated from Calkins (1981; 1986) and Graves (1983), and with more emphasis on the natural process of writing, particularly within the context of authentic writing tasks); and the *use of alternative writing modes* (e.g., word processing software). Based on the two aforementioned meta-analysis studies, author of the present study generated Table 2, which listed the four intervention categories, their

subcategories, and definitions, as well as Table 3, which compared the two meta-analysis studies with two others on writing intervention.

Overall research findings showed that students with LD benefit from writing interventions that explicitly and systematically teach them the processes and strategies involved in writing (including planning, sentence construction, summarizing, and revising), such as the strategy instruction approach. They also benefit from a writing structure that encourages responsible, organized peer support (e.g., process writing approach), and that establishes clear, meaningful, and reachable goals (e.g., product goals). The application of word processor is likely to be advantageous to the students' writing performance when coupled with valid writing instructional programs as well as sufficient competency in using the tool. These interventions are generally rated as having moderate to strong impact, with effect size of 0.50 or percentage of non-overlapping data (PND) of 70% and above (Graham, Olinghouse, & Harris, 2009). It is noteworthy that computer-oriented intervention appears to be the least researched, despite the facts that its convenience/accessibility is advancing at a rapid pace, and that it offers certain cost-efficiency advantages and promotes student-independence.

The Application of Computer Technology & Dictation Writing

Computer technology for assisting struggling writers has been a comparatively recent innovation in writing research. In MacArthur's (2009b) comprehensive summary of research evidence associated with using technology for struggling writers, he indicated that a wide range of computer applications have been developed to support writing, and many of them are especially helpful for struggling writers. However, despite the fact that the number of research studies concerning this type of intervention has been growing, its overall proportion relative to studies of other forms of intervention remains relatively low.

The application of word processing appears to have received the most attention among all technology tools in the research field of writing instruction. Nevertheless,

exceptionally few empirical studies in the recent decade examined the effects of word processing application specifically on students with LD. Graham & Perin's (2007) meta-analysis on 123 writing treatment group-comparison studies (Grades 4–12), for example, located 18 studies for word processing, all of which had the control condition of composing by pencil and paper. However, only two of the 18 studies involved students with special learning needs, and both were conducted in the 1980s, and are considerably outdated considering the high rate of advancement in technology. Rogers & Graham (2008), a meta-analysis focused solely on single-subject design studies, located only five out of 88 evidence-based writing treatment studies that were pertinent to the application of computer. Those studies were also limited to the use of word processing software, which was used mainly as a means of facilitating the task of "transcription", with an exception of one study that used word processing with a reminder to take advantage of the editing features of the software. Four of the five studies involved struggling writers in Grades 1, 4, and 5, and only one study involved struggling writers with LD (i.e., Handley-More, Deitz, Billingsley, & Coggins, 2003). Overall, there is a shortage of research in computer mediated writing intervention, and that shortage is particularly severe concerning more recently developed technology, such as dictation or speech-to-text type of technology.

The prototype of speech-to-text or speech recognition technology in writing began with people dictating their compositions to a transcriber. For example, Winston Churchill (1874-1965), the only British Prime Minister to have received the Nobel Prize in Literature, composed nearly all his work by dictating to secretaries (Ashley, 1989). From the low-technology of human transcriber or tape recorder, to high- technology of computerized speech recognition, dictation involves not just different compositional tools than pencil and paper, but a different writing process.

Available literature about the application of dictation to writing has shown different findings regarding its effects on the writing performance and process of students with LD and their typically developing peers. For example, the critical written language production

components suggested by Scardamalia, Bereiter, & Goleman (1982) (also reported in Bereiter & Scardamalia (1987)), i.e., mechanical writing demands, short term memory, slow writing speed, production signaling, have different effects on the writing process and products of 4th and 6th graders with LD than their typically developing peers (Graham, 1990). Specifically, using "low-end technology" (e.g., tape recorder, human transcriber), Graham (1990) replicated Scardamalia, et al. (1982) on 4th and 6th graders with LD, and found that the interference of mechanical demands in writing and the slow speed of writing had more power to influence those students' writing performance than interventions using production signaling (i.e., external/verbal cuing to encourage more writing when students indicated they were finished with their composition). Those findings differed from Scardamalia, et al.'s (1982) study of typically developing (TD) children, where the factor of interference of writing mechanics had weak to null effect on the higher-level components of writing process. Both studies contribute to our knowledge about the influence of mechanical demands to the writing process of children with LD and their TD peers. However, neither study investigated the influence of supplementing the immediate visual feedback of the text dictated (speech-to-text) in the process of dictation writing.

With the innovation and advancement of speech recognition (SR) technology since the end of 20th century to the first decade of the 21st century as of today, computerized speech-to-text transcription has become substantially more accessible, more spontaneous, and more accurate than it had been before. SR-oriented studies such as Reece & Cumming (1996) and Quinlan (2004) found value in having visible text (i.e., immediate visual feedback of the composition dictated) for students with LD at the grade levels of middle school to high school.

It seems reasonable, therefore, that newly available SR technology be studied for its impact on the writing of students with LD, particularly at the *lower elementary grades*; and that such study addresses, in part, the usefulness of immediate visual feedback on what a

student has dictated during an SR session, as opposed to the sort of "non-feedback" experienced with simple dictation.

Research Study Questions

The research questions of the present study focused on whether struggling writers with LD at elementary grades 3-5 demonstrated different writing performance under the following conditions:

1. Hand-written compositions using paper and pencil;
2. Dictated compositions using SR-technology as currently intended (with immediate visual feedback on a monitor of what had been dictated, , which involved reading skills); and
3. Dictated compositions using SR-technology without immediate visual feedback of what had been dictated (i.e., with the "monitor off" while dictating to a digital voice recorder, which eliminated the necessity of reading skills);

The elements of writing performance being evaluated included:

1. Wring fluency—the total number of words and T-units produced, and rate of text production;
2. Writing quality—syntactic complexity (T-unit length, clause length, and number of clauses per T-unit), mechanics of writing (percentage of surface errors in the text), and story structure level.

Table 1 summarizes the major components of the research questions.

Table 1. Major Components of the Research Questions

TEXT INPUT: Writing Modes	**TEXT FEEDBACK: Process Constraints**
Handwriting- Pencil & Paper (HW)	- Visual text: Accessible at the participant's handwriting rate; - Revision: Permitted via paper and pencil mode. Brief and simple verbal direction was given at the onset of the writing session.
Dictation Mode 1- Speech Recognition Software- Dragon Naturally Speaking Version 11 (SR)	- Visual text: Accessible at the software's speech recognition rate; - Revision: Permitted via the SR software commands or keyboarding (depending on the student's preference). Brief and simple verbal direction was given at the onset of the writing session. The function of auto spelling check was activated, and auto grammar check, deactivated.
Dictation Mode 2- Digital Voice Recorder (DR), by concealing the monitor and/or text feedback access from the SR software	- Visual text: No visual representation of texts dictated (i.e., *only* texts as originally dictated were evaluated for the present study)[1]; - Revision: Permitted via dictation or voice commands. Participants were allowed to verbally express their intention to eliminate, change, or start over the text already dictated. Brief and simple verbal direction was given at the onset of the writing session.

1 Visual texts of DR/dictation writing mode2 could be accessible only after the students indicated complete with the required text production. Within the text production time limit of 12 minutes, they were allowed to dictate their desired revisions.

Table 2. Definition for the Four Categories of Evidence-Based Writing Intervention

Intervention Category	Definition
Explicit Writing Instruction of Skills, Processes, or Knowledge--	
Strategy Instruction	Emphasis of this approach involves explicit and systematic writing instruction on strategies for planning/drafting, revising, editing text (Graham, 2006), and/or constructing paragraphs (Rogers & Graham, 2008). Instruction is characterized by modeling of the strategy and guided practice to facilitate independent use of it. The instructional application ranges from processes to strategies designed for specific genres of writing, e.g. stories or persuasive essays (Graham & Perin, 2007; Rogers & Graham, 2008).
Grammar/Usage	This approach involves the explicit, high-focused, and well-sequenced/systematic instruction of grammar.
Sentence Construction	This approach involves teaching students to construct complex and sophisticated sentences through either sentence combining or a strategy for writing sentences.
Text/Genre Structure	This approach involves explicit and systematic instruction on knowledge about the structure of specific writing genre, such as stories or persuasive essays.
Summarization	This approach involves explicit and systematic instruction on strategies to summarize text and/or improving students' text summarization skills.
Scaffolding Students' Writing--	
Product & Productivity Goals	This approach involves setting explicit goals for the completed written product, including the quantity aspect of it.
Prewriting	This approach involves students using graphic organizers (e.g., story maps, schematic web or outlines) and/or engaging in activities designed to help them brainstorm, generate, or organize ideas prior to writing.
Procedural Facilitation	This involves providing facilitators such as questions, hints, prompts, or guidelines/text structure to help students coordinate one or more writing processes, such as planning or revising (Baker, Gersten, & Scanlon, 2002).
Process Writing Approach--	
	This approach involves extended writing opportunities; writing for real audiences; creating a supportive writing environment; encouraging high levels of student interactions around writing; engaging in cycles of planning, translating, and reviewing; stressing personal responsibility and ownership of writing projects (including self-reflection and evaluation (Pritchard & Honeycutt (2006).
Alternative Modes of Composing--	
Word Processing	This involves students using word processing computer programs to compose their composition. (Word processing--Students used word processing as their medium for writing.)

Table 3. Emphases of Four Recent Meta-Analysis Studies on Writing Intervention

Meta-Analysis Study	Grade Level	Types of Intervention Investigated	GC Studies Included? (ES)	SS Studies Included? (PND)	# of Studies Included & Total # of ES/PND	Result
Rogers & Graham (2008)	1-12	Interventions that included four or more studies (with conceptually similar outcome measure)	No	Yes (ATD, ABAB, CCD, MBD)	88 SS design studies located, 1 ES calculated for each TX tested in 4 or more studies	Using a similar outcome measure in ea identification of 9 writing evidence-ba: size, from high to low) —strategy instr teaching grammar and usage, goal setti instruction for editing, writing with a v specific writing outcomes, use of prew sentence construction skills, strategy ir
Graham & Perin (2007)	4-12	Interventions with four or more studies (effect sizes)	Yes	No	123 documents yielded 154 ES for writing quality	The average weighted ES for 11 interv (0.82), summarization (0.82), peer assi (0.75), setting product goals (0.70), wc combining (0.50), inquiry (0.32), prew writing approach (0.32), study of mod (– 0.32)
De La Paz (2007)	1-college	Strategy instruction (component effect comparison)	Yes	Yes	12 empirical studies with strategy instruction focus	- Self-regulatory components: modest strategies, positive generalization effec findings being evident for only half of - Motivation component: Inconclusive - Peers support: Noticeable generalizat appears advantageous, with clear bene
Graham (2006)	2-12	Strategy instruction	Yes	Yes (MBD only)	20 group comparison studies; 19 SS design studies	- Group Studies: ES = 1.15 (overall me (elements); 0.95 (length); 0.90 (revisio - SS: PND= 89% (overall mean); 89% (revisions)

Abbreviations: GC = Group Control; SS = Single Subject; ES = Effect Size; PND = Percentage of Non-overlapping Data

Chapter II: Literature Review

As discussed in Chapter 1, this dissertation will explore the use of speech recognition technology (SR) as a means of ameliorating the writing difficulties of young children with learning disabilities (LD). Despite the increasing importance of writing proficiency, the rising prevalence of children with LD, and the growing advancement of computer technology, little contemporary empirical research has been conducted in examining the impact of the use of SR technology mediated intervention on the writing process and performance of young children, particularly between the ages of eight to nine years old with this disorder. The present study will be conducted to provide data that are a first step in filling that gap in the literature.

The following review of the existing literature explores the relationships among the mechanical demands of writing, working memory, and the writing process of children with LD, and the purported benefits of using dictation-engineered intervention to improve the performance of children with LD in these writing and memory related areas and consequently their overall writing quality and quantity. Though this review focuses on studies involving children with LD, studies involving non-LD children with writing problems and their typically developing (TD) peers are included as they bear on the design and focus of this study.

This review is organized into four content areas: (1) writing problems of students with LD; (2) the transcription/mechanical aspect of the writing process among TD students, and how students with LD differ, particularly concerning the influence of the mechanical demands on their working memory and their development of writing proficiency; (3) dictation writing studies that investigated the interference of mechanical demands in writing and its relation with other essential factors of children's writing process, and extended from that, a theoretical model of the writing process and the rationale for its application to the present study; and (4) speech recognition (SR) technology mediated dictation writing, which

includes a basic description of the technology, the use of the technology as a writing mode/intervention for students with LD, the pros and cons of using the technology in writing, and a brief summary about why I believe the application of SR technology is appropriate for the present study as well as how the proposed study can contribute to the current science of writing research.

Writing Problems among Students with LD

The writing problems of students with LD are usually manifested in one or more of the three areas: handwriting, spelling, or composition (Hallahan, Lloyd, Kauffman, Weiss, & Martinez, 2005). Specifically, the handwriting of LD students often appear very slow and illegible, and their spelling, problematic with little correspondence between sounds and letters. Their composition, when compared to their TD peers, appears to have lower quality in word usage, sentence complexity, and paragraph organization, as well as a lower quantity of ideas and important compositional components (Graham & Harris, 2002; Montague & Graves, 1992). Although even the best and most fluent writers can have less-than perfect handwriting, misspelled words, and a shortage of compositional ideas, the kinds of problems that students with LD exhibit tend to be especially complex and severe.

The complexity of the writing problems of students with LD is illustrated by MacArthur's (2000) study. In his review on the use of computer technologies for the writing problems of students with mild educational disabilities, MacArthur (2000) indicated that more research had focused on students with LD, who had writing problems concerning all aspects of the writing process. He categorized the writing problems of the struggling writers with LD as falling into four general areas, which classification has often been used to characterize major areas of writing difficulty:

- **Understanding the General Writing Process.** Students with LD show a poor understanding about the characteristics of good writing and about the writing process in general. That is, they are less sensitive to the differences of genres or the traits of

good writing, and appear to place more emphasis on the mechanical processes than the content of the writing.

- **Planning/Organizational Skills.** Students with LD often employ only minimum planning and poor organization in the writing process. They are prone to omit the prewriting stage and plunge headlong into the final draft or struggle with the brainstorming of ideas for writing.
- **Transcription.** Students with LD often appear to have significant difficulties in basic transcription processes such as spelling, handwriting, capitalization, and punctuation.
- **Revisions.** If a revision is made, it is mainly confined to error corrections and insignificant word changes which reiterate the pre-revised meaning. Students with LD tend to define revising as finding the mechanical (spelling, punctuation, capitalization) errors rather than errors in style or composition.

These categories are helpful in clarifying the complexity of the writing problems. However, these categories, per se, offer no specific information regarding the relative importance, severity, or prevalence of the various aspects of writing difficulties for this group of students. For research that has strong emphasis on the effectiveness of intervention, these categories neither specify the critical elements that may have played a more significant role in intervening or inducing the series of writing problems, nor do they reveal the possible confounding correlations among the various factors in the writing process. The following discussion will address those aspects while reviewing the relevant literature.

The Mechanical Demands in Writing

Based on the four categories of writing problems listed previously, it is fair to infer that the writing difficulties experienced by students with LD appear to arise from problems with both basic, lower level of writing skills (i.e., spelling, grammar, capitalization, punctuation, and handwriting), and higher level skills (i.e., planning, organizing ideas, expressing them in coherent sentences, and making substantive revisions) (Graham, Harris, MacArthur, & Schwartz, 1998; MacArthur & Cavalier, 2004). See Figure 2.

Mechanical difficulties, mainly those related to the basic processes of transcription (e.g., handwriting and spelling) are likely to interfere with the higher order processes of composition, and could contribute to the fact that many students with LD produce less written work and work of lower quality than their TD peers. This phenomenon of mechanical interference in the writing process and performance of students with LD also has been observed among TD children, particularly among the younger ones. To reach a deeper understanding about the characteristics of writing development among students with LD, therefore, it will be useful to identify and compare the paths of development among their TD peers. The discussion in this section will focus on findings about the development as well as the influence of mechanical writing skills in TD children, and in comparison, how individuals with LD differ. Additionally, to appreciate the importance of mechanical difficulties, the discussion will involve how those difficulties can reflect and/or impact cognitive processes, particularly the utilization of working memory.

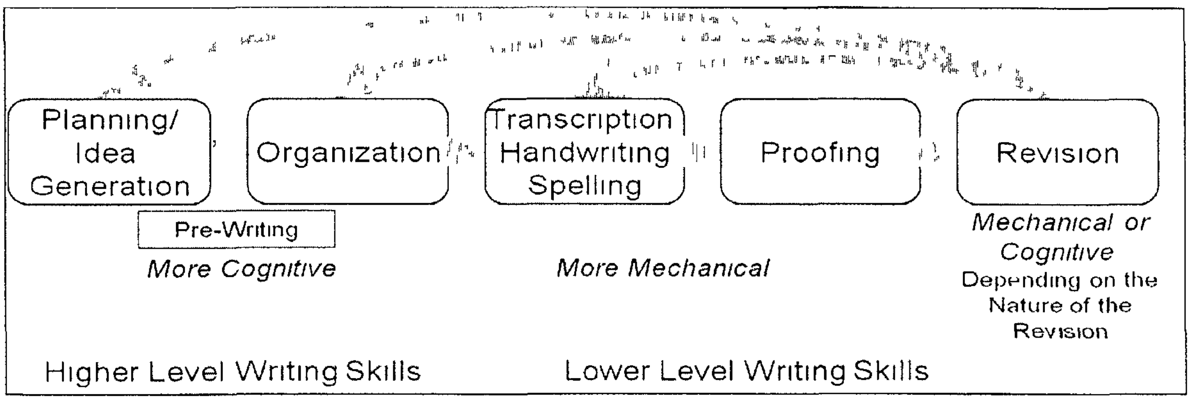


Figure 2. A Global [illegible] Depiction of Writing Proce

Mechanical Demands of Writing and Typically Developing Children

The mechanical demands in writing appear to correlate strongly with the overall writing performance of TD students in the elementary grade level, but those correlations often lessen as the students proceed to the intermediate or higher grades (Berninger & Swanson, 1994; Graham, Berninger, Abbott, Abbott, & Whitaker, 1997). Since the strength and significance of those correlations often lessen as TD students grow older (and improve in

mechanics without special intervention) and/or as students with LD receive effective interventions concerning writing mechanics, there is some suggestion that the relationship between writing mechanics and writing outcomes might be causal. Nonetheless, these causal relationships have only been directly demonstrated in only a few studies thus far. The present study hopes to bear upon that issue. The existing literature, as noted below, is equivocal. In addition, discussions about the handwriting aspect of the mechanical demands in the present review will focus on handwriting fluency/speed rather than legibility/quality, since the findings about handwriting quality are less consistent (Graham & Harris, 2000) and are more likely to be confounded with other factors such as personal preferences in the esthetic aspect of scripts.

Graham, Berninger, Abbott, Abbott, & Whitaker (1997) applied multiple-group structural equation modeling to analyze the structural relationships between latent factors underlying handwriting, spelling, and compositional quantity or quality. The participants included 300 primary-grade students (Grades 1-3) and 300 intermediate-grade students (Grades 4-6). All but one primary-grade participant received special education services, and no information was provided concerning the type of special education services that the particular participant received. The findings of the study indicated that handwriting fluency and spelling explained a considerable proportion of the variance in compositional quantity (41%–66%) and compositional quality (25%–42%). Specifically, the path from a factor based on independent measures of handwriting to a factor based on compositional fluency/quantity or compositional quality was significant across the grade levels. It suggested that individual differences in handwriting skills, with the particular emphasis of handwriting fluency (i.e., the amount of text copied correctly per min) in this study, predicted reasonably well how much and how well children wrote. The path from spelling, on the other hand, was significant only to the compositional fluency and only at the primary grades. It indicated that the spelling performance of primary-grade students, but not of intermediate-grade students, predicted how much but not how well they wrote under timed conditions. Additionally, the contribution of spelling was considered "indirect" due to its correlation with handwriting

fluency. The different weights of contribution of the two transcription skills to the students' writing performance also imply that handwriting may pose a different kind of resource demand than a more text-focused or composition-driven skill like spelling (Graham, Harris, & Fink, 2000; Jones & Christensen, 1999). Young writers, for example, might be able to bypass spelling demands by paying less attention to correct spelling through the use of invented spelling, but less able to avoid the demands of handwriting unless supplemented with an alternative writing mode such as keyboarding or dictation tools (Graham, Harris, & Chorzempa, 2002).

With typically developing students, age is apparently the most common correlational mediator among spelling, handwriting, and writing outcomes. In a cross-sectional research involving nearly 900 children from Grades 1 through 9, Berninger and Swanson (1994) found that the spelling and handwriting abilities among the majority of the participants had strong correlations with their writing quality in the elementary grade level, but the correlations lessened as students proceeded to the intermediate or higher grades. That is, proficiency with mechanics is highly related to demonstrated overall writing ability even for normally achieving elementary school students, but that relationship appears to diminish with age. Variance in mechanical skills narrowed across subjects with age and, therefore, correlations diminished.

For spelling, Graham et al. (1997) found that younger primary-grade students misspelled almost four times more words in their writing than the older students, and their text quantity was more highly correlated with their spelling skill as well.

For handwriting, Graham and Harris' (2000) review of studies on the role of handwriting in children's writing development supported the notion that handwriting is a critical element in the developmental process, and showed that handwriting fluency generally improved with schooling/intervention and age. Specifically, children made an average fluency increment of 10 letters or more per minute with each subsequent grade level (from another handwriting review study of Graham & Weintraub, 1996). As individuals proceed to

high school, approximately around Grade 9, handwriting frequencies stabilized at a fluency similar to adults (Graham, Berninger, Weintraub, & Schafer, 1998). This developmental course of handwriting skill was also noted in Hamstra-Bletz & Blote's (1990) longitudinal study involving 127 Dutch children beginning in general education Grade 2. After tracking the children's handwriting development up to Grade 6, a strong relationship between grade and handwriting speed/fluency was reported (i.e., adjusted R^2s of .72, .69, and .66 for Grades 2-6, 2-5, and 2-4, respectively). In contrast, the legibility of handwriting appeared to deteriorate around and after Grade 4. A few reasons were suspected. First, formal handwriting instruction was generally discontinued at Grade 4, and training received by that point could have been inadequate to facilitate maintenance in handwriting legibility. Second, students' perceptions about handwriting could be shifting from it being an end in itself to a means in accomplishing text production, making handwriting speed, per se, of greater importance than handwriting quality. Finally, as the pupil grows older, personalization of handwriting style might become more personally valued, even if at the expense of legibility.

A practical approach for studying the relationship between the demands of transcription process in writing and writer's cognitive/chronological development is to observe individuals' oral expression during the writing process (a "write-out-loud method") and then analyze differences. In an earlier unpublished study (reported in Bereiter & Scardamalia, 1987), Bereiter and his colleagues observed syllable and/or word mouthing behavior, which was identified as one sign of the transcription process with primary students as they wrote. It was found when asked to mouth/voice their thinking while writing, the majority of second and third graders mouthed individual letters and words as they wrote, whereas half of the fourth graders were more likely to mouth strings of words. Moreover, a positive correlation was found between the compositional quality and the language mouthing frequency among the fourth graders. The observed change in syllable mouthing behavior was believed to be an indication of a correlation between the transcription process and age factor.

Bereiter & Scardamalia (1987) further posited the opinion that as younger children invested significant amount of attention in the transcription process, it left little to no room for planning or for the higher-level skills in writing to take place. Along with the evidence of correlation, it was thus believed that children rarely showed signs of simultaneous execution of transcribing and planning processes until they reached fourth grade. Interestingly, this borderline corresponds to a general statistic that students with LD are often identified by the time they reach late third or early fourth grade (Bender, 2004).

What makes such observational study valuable is not only its findings on the relationship between the demands of transcription process and children's cognitive/chronological development, but also its implications concerning the complexity of intersecting phenomena in the writing process. Namely, the psychology of writing cannot be explained by one connection between text transcription speed and text quality. When a writer puts the pen in action, there are a variety of unseen and unconscious mental activities taking place. I will address the complexity of those issues later in this review. For the moment, however, it is sufficient to note that the mechanical writing demands do appear to be strongly related to the writing performance of typically developing children, but the magnitude of that relationship grows weaker as children grow older and/or receive more education.

Mechanical Demands of Writing and Students with LD: Re Working Memory

Concerning students with LD, age appears to be less well correlated with reductions in the mechanical interference of the writing process. Research findings have shown that spelling and writing quality of students with LD may correlate at all ages, and that misspelled words and deficiencies in mechanical and syntactic elements are more likely to be found in their compositions than their TD peers at any age (Higgins & Raskind, 1995; Quinlan, 2004; Raskind & Higgins, 1999). Such a special trajectory in the development of spelling skills among students with LD might be a result of atypical development in handwriting skill. Or, both spelling and handwriting problems might be a function of some third variable. Handwriting, which tends to be a temporary constraint to the writing development of

typically developing young writers, appears to remain a constraint to the writing performance of students with LD across all grades (Englert et al., 1988; Temple, 1988) and even into adulthood (Connelly, Campbell, MacLean, & Barnes, 2006).

Interestingly, generating or brainstorming ideas about what to write appears to be less difficult for students with LD than transferring these ideas into written language (Hooper et al., 1994; Poplin, Gray, Larsen, Alison, & Mehring, 1980). It has been speculated that devoting attention to the basic skills of getting text onto paper taxes the writers' working memory capacity, and in turn impedes the higher order skills such as constructing sentences, organizing, and evaluating (Berninger, 1999; Graham & Harris, 2000; McCutchen, 1995). Namely, if all of the processes of writing share a limited cognitive capacity, the interference of transcription or mechanics-related processes may represent a considerable cognitive load with developing writers, and negatively impact planning, revising, and other higher-order writing processes. Difficulties with handwriting, for instance, can interfere with the execution of compositional processes as children have to switch attention constantly from composing to the mechanics of how to form a particular letter. That mental switching process between the content and mechanical demands could very likely make writers forget the ideas or plans that were already constituted, but had to be suspended due to an overload in working memory.

The connection between the mechanical demands of writing and working memory appears to support the notion of multifaceted developmental characteristics among individuals with LD. First, LD students often demonstrate deficits in short-term memory below the 25th percentile, but score much higher (often in the "normal" range) in assessments of long-term memory (Harwell & Jackson, 2008). This indicates that most students with LD will be likely to retain information when the information is mastered or acquired. Unfortunately, while average children take approximately 22 exposures to information before it is retained in their long term memory, children with LD may take many more exposures, or special techniques/strategies may be required to achieve a similar level of mastery. In addition, once the information is in long term memory, periodic reinforcement through use is

required to maintain it or to make it accessible in working memory. Children with LD also appear to need the periodic reinforcement in higher frequency and with more emphasis on the generalization aspect of the information than their TD peers.

Second, researchers have found that individuals (even adults) with LD require a longer time to retrieve known information, e.g., 10 fifth to sixth graders with a specific reading disability/ LD spent about 300 milliseconds longer to retrieve a known word than the average of 500 milliseconds demonstrated by 10 of their TD peers (Manis, 1985). Retrieval refers to the mental operations we experience while extracting the desired piece of information from memory. The retrieval dysfunction of individuals with LD can be manifested in various ways, including a slower rate of vocabulary retrieval, a longer time requirement with a lower accuracy achievement for general card sorting tasks (Copeland & Reiner, 1984), and a much lengthier processing speed than TD children. Wolf & Bowers (1999) proposed the application of the concept of developmental dyslexia to describe these problems — children with more systemic processing-speed deficits have underlying visual and auditory processing problems, which can result in a double-deficit of naming-speed and phonological processing. Undeniably, the slow memory retrieval problems encompass multiple layers of factors, which can further confound the persistent problem that students with LD have had in the mechanical demands of writing. The processing problems (short term memory, retrieval, etc.) altogether might "gang up" on students with LD and make transcription fluency a much more critical variable in determining writing outcomes.

Within the context of working memory, Bourdin and Fayol (1993; 1994) investigated the reasons why written language production could be and often appeared to be more difficult than oral language production. Their theoretic basis was that working memory had limited capacity. In addition, every writing component imposed a cognitive load, and could take away the available resource shared among the writing components. They also stratified the process of writing production into low-level/graphic transcription activities and high-level/planning and translating activities. To evaluate whether low-level activities consume

more cognitive resources (i.e. working memory) with children than with adults, they applied a serial recall paradigm in which both adults and children were asked to recall a series of words and generate sentences, either orally or in writing. It was found that children were better at recalling information and generating sentences orally than in writing, whereas adults were similarly proficient with either mode of language output. The difference was taken to be an indication that the transcription process of getting language onto paper imposed a much greater cognitive load on developing writers than it did with more experienced, adult writers.

Nevertheless, Bourdin and Fayol (1994) argued that such study would not be sufficient to evidence that graphic constraints were responsible for the poorer written performance of children. They conducted another study with adult participants by requesting them to write in cursive uppercase letters[2] during the serial recall. The purpose was to impose graphic constraints on the highly fluent transcription processes among adults, which McCutchen (2000) suggested would represent a deprivation of access to long term working memory and impose a greater dependence on the limits of short term working memory. The result was a drop of performance in the capital cursive letter condition. Interestingly, the drop was found identical as the drop observed in children's written work performance. The authors thus supported the notion that letter writing and word retention drew on the same resource pool when the transcription process was not "fluent".

Those findings about graphic constraints, which specifically referred to the planning and controlling of graphic execution, appear to serve as valuable extensions to a number of influential data-based models of handwriting performance developed earlier (e.g., Margolin, 1984; van Galen, 1993). These models generally shared the perspective that the act of handwriting entails retrieving and retaining the letter in working memory, activating the pertinent motor protocol, and setting constraints for the protocol in determining the letter size and production speed. The argument centers on the notion that handwriting is not merely a

[2] There is another body of literature that have the study participants write with their least preferred hand although it has not been well organized on the issue of working memory.

physical motion. Unconscious, invisible mental and/or neurological activities take place along with the motion, such as orthographic and phonological processing, which may draw on the limited capacity of working memory. Although the cognitive cost of handwriting appears small with average educated adults who have attained a certain level of automaticity, it is unlikely for the skill to become so automated that it is completely cognitively costless (Bourdin & Fayol, 1994; McCutchen, 2006).

In summary, until transcription processes, such as handwriting, reach a reasonable level of automaticity, they can continue drain a writer's mental resources and limit other writing processes. By age 10 (Grade 4) or after, typically achieving students often can attain sufficient handwriting fluency to release more working memory for higher-level processes (McCutchen, 2006). Students with LD, on the other hand, appear to continue to struggle with transcription demands, and often produce written texts that are considerably shorter and with lower quality than oral texts (Graham, 1990). These phenomena generally appear comparable to the findings in younger, average developing children. Moreover, as the processes of spelling and handwriting are often executed simultaneously, the degree of interference during handwritten transcription will likely be intensified and complicated.

Dictation Writing and a Theoretical Model of Writing Process

The critical role that mechanical demands play in the writing development of students with LD implies that removal of the difficulties in this aspect of writing may grant students the freedom to compose, review, and edit their writing, and thus produce texts that are longer and higher in overall quality (Graham, 1990; MacArthur & Graham, 1987). Dictation writing, as a method for minimizing mechanical transcription demands, might therefore have a facilitating impact on the higher-level skills of the writing process. To address that possibility, Bourdin and Fayol (1993; 1994) conducted serial recall experiments where children performed significantly better in oral mode than in written mode of language production — concerns for the lower-level requirements of writing, such as penmanship or typing, spelling, and punctuation appeared to be attenuated. That would hold true, of course, only if speech is

sufficiently acquired and automatized (minimizing the otherwise various production requirements that good speech necessitates). The studies outlined below address those issues.

Dictation Studies and Essential Factors of Children's Writing Process

"The most obvious place to look for an effect of production factors on written composition is at the interface between the metal process of language generation and the physical process of transcription", indicated Bereiter & Scardamalia (1987, p.102), one of the pioneering writing studies involved dictation. Explicitly, the ingrained interference of writing mechanics, particularly in students with LD, may be properly addressed via dictation studies since dictation enables researchers to physically isolate the variance of mechanical demands in writing by comparing the oral text production with the written. Such studies are discussed below. The studies of Scardamalia & Bereiter (1979) and Scardamalia, et al. (1982) (as reported in Bereiter & Scardamalia (1987)) will be discussed in detail for at two major reasons. First, most dictation studies of writing cite one or both of those studies, but fail to provide detailed discussions of their methods and conclusions. Being aware of the study outcome is as critical as being analytical regarding the dictation writing tools/settings and research methods applied. Second, both of these studies represented a critical part of the pioneering work to understand children's writing processes, and allow us to attempt a delineation of how the writing processes of students with LD differ from those of their TD peers. Further, based on this detailed discussion, I will explicate my rationale for the adoption of Hayes' (1996) writing framework, a revised model from Hayes & Flower's (1980) cognitive process model of writing, aka expert model of writing.

Dictation Writing Related Components: Mechanical Demands, Short-Term Memory, Accessibility and Immediacy of Dictated Texts

Early dictation studies often centered on an attempt to understand the writing development in children, and how their writing processes differed from those employed by adults. Scardamalia & Bereiter (1979) speculated that factors of mechanical interference and short-term memory loss due to slow writing speed/rate might be considerably more important

in writing with children than with adults. To examine the effects of those production factors, children in Grades 4-6 were involved in three experimental conditions: handwriting (HW), normal dictation to a tape recorder (ND), and slow dictation to a human scribe who paced transcription according to each child's previously determined writing rate (SDHS). The comparison of HW with SDHS was to isolate the effect of mechanical interference (i.e. the requirements of handwriting and/or the mechanical impacted factor, spelling) as opposed to the potentially confounding factor of speed of transcription, per se. The comparison of SDHS and ND was to isolate the effect of compositional speed when the potentially confounding factor of mechanical interferences was controlled.

Each subject produced three compositions, each on a different opinion essay topic. With three essay topics, the assignment of writing topics to the three experimental conditions was counterbalanced so that each pairing of topic-condition occurred with equal frequency. Order of treatment condition was also counterbalanced, with the single limitation that the handwriting condition was conducted before the slow dictation condition. This was necessary because the rate of composing during the writing conditions was used to determine the rate at which the examiner recorded during slow dictation.

The results showed significant differences among the conditions in terms of writing quantity but not quality. Specifically, when subjects could determine how long they engaged in the compositional exercise, they produced 86% more words in SDHS condition than in HW, and 163% more in ND condition than in HW. The quality differences were nevertheless small. The SDHS condition resulted in the highest quality, ND produced the next-best quality, and HW, the lowest quality products. The authors suggested that mechanical demands and rate had additive effects on the quantity of written production, but that a more rapid rate of production provided *no support* for enhanced quality, and the mechanical demands had a weak to null effect on higher-level concerns with the writing process.

Scardamalia & Bereiter's (1979) interpretations of their study findings may appear convincing. However, I would add that the effect of speed/production rate on the writing

performance, particularly writing quantity, was found less direct or less significant than that of mechanical demands in their study, since the factor of production rate oftentimes *explains* a considerable variance in the effect size of the factor of mechanical demands (e.g., Graham et al., 1997). Other factors could also have confounded the control of the factors of writing speed and mechanics. "Habit", for instance, may have weakened the effect as it may take a considerable period of time for students to develop the more advanced writing skills that would improve writing quality. That is, the students have been hampered a long time by mechanical demands and might, therefore, not "spontaneously" engage in more advanced planning/organization/editing skills when those demands are attenuated. After more practice in writing without the mechanical demands, those higher level cognitive skills might emerge. The speculation here is that students might have simply lacked experience with dictation writing and, therefore, needed more time to explore those possibilities before benefiting from a hands-free writing mode. To test such a possibility I will track the students individually over a considerable period so that any improvements in writing quality are not simply a function of "maturation."

Additionally, the visual availability of text-- seeing what has been dictated, typed or composed, could offer prompts in terms of what to compose next, provide mental/memory connections for a better writing fluency, and result in higher writing performance. Early studies of dictation, whether to a tape recorder or a human scribe, generally withheld visual text from the writer or did not allow the writer to see immediately what had been dictated. In Scardamalia & Bereiter's (1979) study, texts dictated to a tape recorder were not available to the subjects until they were typed days after the compositional session. In contrast, texts transcribed by human scribe in the slow dictation condition were available to the subjects in their individualized and adjusted pace, but the subjects were *not* given instruction/permission to read or pay attention to the transcription. Had the subject's reading of the text transcription been encouraged explicitly, Scardamalia & Bereiter's (1979) study results concerning the effects of writing rate via the comparison of natural dictation/tape recorder (ND) and human scribe (SDHS) conditions might have been different, and enriched via further comparison of

the effects of transcription speed and accuracy to the writing process. In addition, to ascertain a valid comparison between ND and SDHS condition (concerning the effect of writing speed), the experiment should have been conducted under the premise that social impetus from human scribe had as little effect as possible. That is, the differences of writing performance between the two conditions might not be directly caused by the variance of dictating to a machine vs. to a person. Perhaps studies conducted now, with more choices of technology/tools available for use, might help us gain a more holistic and accurate picture of the contributions of mechanical interference and writing speed to writing performance while contrasting the differences between the human-oriented writing modes and technology-oriented ones. Particularly with modern technology, it would be possible to evaluate the value of dictation, per se, with and without immediate visual feedback on a monitor.

The more ground breaking finding was perhaps in Scardamalia, et al.'s (1982) study (as reported in Bereiter & Scardamalia (1987)), in which the three conditions from their 1979 study were re-evaluated, and also with children in Grades 4 and 6. The major difference introduced with the new study was an extra experimental factor added across all the conditions — children were given three standardized, contentless "production signals" to encourage more writings when they indicated they were finished with their composition. For example, *That's fine, This is hard to do, but now can you say (write) even more?* Or, *Do you think you could say (write) 10 more sentences about this?* The purpose of this extra condition was to examine whether the *lack* of the sort of external cuing, which is often provided in conversation but not in writing, disrupted writing production. This cuing/signal approach assimilates a procedural facilitation (Scardamalia & Bereiter, 1986), in which external support like cue cards being utilized to facilitate students' execution of one or more cognitive writing processes. (*Procedural Facilitation* is a writing instruction strategy that involves providing facilitators such as questions, hints, prompts, or guidelines/text structure to help students coordinate one or more writing processes, such as planning or revising (Baker et al., 2002).) A few other differences in their experimental protocol included: (1) Children in every condition were given a general direction to "write as much as you can" (for the purpose of

encouraging more production output than their 1979 study); (2) Every child had only one writing session per day (instead of three different, randomized modes of writing sessions per day in their 1979 study); and (3) Human scribes sat beside the children in the dictation conditions so as to avoid eye contact, nods, or expressions that might give subtle social input to the composing process or inadvertently initiate conversational elements into the experimental conditions.

The results showed the overall writing performance differed significantly with children's grade level. Sixth graders wrote better and longer compositions than the fourth graders. Prior to production signaling, the writing quantity and quality in all three conditions were similar to the previous study. That is, children produced the most words in ND, the least in HW, and intermediate number of words in SDHS. The writing quality differed in the same order across writing modes, but those differences were statistically insignificant. After adding the production signal, the quality rating for HW improved, but dropped for both the ND & SDHS conditions; the total number of words for HW & ND was doubled, which means that effects observed in the earlier study concerning ND were retained, but the differences between HW & SDHS largely disappeared.

An extra coherence analysis was conducted to determine which subcomponents might have lead to the increase of writing quality in HW condition and the decrease in dictation conditions after production signaling. This component analysis in text quality was believed to be the first time it was conducted in the field. Specifically, coherence analysis analyzed the content and structure of all the extended compositions via two variables: (a) the length of longest coherent string of functional elements, as measured by the number of text units the string contained; (b) the location of the end of the first coherent string- whether before, precisely at, or beyond the onset of production signaling (Bereiter & Scardamalia, 1987, p.122). A coherent ordering of units followed either one of the two patterns: (a) premise followed by reasons with elaborations following the initial statement to which they were related; or (b) premise followed by reasons with elaboration in parallel with the initial

statements to which they were related. Any digression from these patterns (e.g., the introduction of a nonfunctional unit) was considered a break in the coherent string.

The analysis showed that production signaling apparently led children in the HW condition to extend coherent strings whereas the initial coherent string had oftentimes stopped in the dictation conditions. Bereiter & Scardamalia (1987) (based on the findings of Scardamalia, et al. (1982)) suggested that providing cuing to bridge the discourse disruption in children's text production process was far more critical than assumed, to the extent that its influence exceeded the power of the other two factors, i.e., mechanical demands and text production rate. Production rate was believed to cause only a slight amount of difference to short-term memory loss, which in turn was denied an important production factor. The factor of mechanical demands appeared to affect mainly children's ability to keep up a more fluent text production, and was *no longer* regarded as interfering with higher-level processes. On the contrary, the demands of writing mechanics were believed to facilitate the evaluating, revising, or reconstructive sort of activities relevant to the higher-levels of written production. Bereiter & Scardamalia (1987) reasoned the facilitating role of writing mechanics based on the observation that children in the dictation conditions, when compared to the same children in the handwriting condition, evidently showed more difficulty transitioning from their whole/content-oriented writing approach (i.e., overall oral text production) to the detail-oriented activities such as adding and revising the content. That is, the authors reversed the probable negative energy of the interference of mechanical demands such as the seemingly process-interfering question, "Where was I", into a positive force of inducing the needs for text reconstructive activities so as to improving the text quality.

As reasonably applicable as these implications may seem to normally developing children, particularly those in grade four and older, I suggest they would be *unfitting* to younger elementary children and especially so for individuals with LD. First, based on the perspective of limited working memory and cognitive capacity as I have discussed earlier, mechanical demands should interfere with the higher-level compositional processes

significantly more for younger developing writers than older typically developing writers, and that interference appears chronic for most struggling writers with LD. For instance, if a fifth grader has to subconsciously post the question of "where was I" five times to get through a writing activity of 10 minutes, the frequency or duration of such memory retrieval question will most likely be increasing for a second grader or a developing, struggling writer. That is, the impact of having to regurgitate that memory retrieval activity intensively can lead to severe depletion of energy, attention, cognitive, or even affect level in any individual, which in turn could decrease the likelihood of maintaining or improving writing performance.

Second, availability of the written text is a critical component to consider. As I have argued earlier, visual text could elevate performance across the three writing conditions experimented in Scardamalia & Bereiter's (1979) study, and that elevating effect may be more pronouncing concerning the experimental condition of production signaling in their 1982's study. Nevertheless, Bereiter & Scardamalia's (1987) review on both studies (Scardamalia & Bereiter, 1979; Scardamalia et al., 1982) refuted this consideration as they asserted that children were generally more capable in creating ideas derived from memory than available text. For example, they reported that children in the HW condition were rarely or never found to consult their actual text for a high-level compositional plan when asked to write more at the onset of production signaling. In addition, the authors reasoned that mental representation of the text was what mattered in composition from a psychological standpoint; graphic representation of the text, on the other hand, could occupy unnecessary attention from children and thus deprive them of the memory necessary for the content and structure. Although there is a certain degree of legitimacy in these explanations, I hold a different perspective-- text representation can be a memory aid in recalling information through writing tasks and particularly so in the process of revision.

I suggest that Bereiter & Scardamalia (1987) neglected to observe a few crucial elements about the function of visual text in their discussion. First, the availability of text could serve a very different purpose to children when they dictated their writing than

handwrote. Handwriting is literally a process of transferring the text from one's mind through their hands to paper. Such process involves (at least) visual and kinesthetic memory reinforcement, which may enhance children's competency in retrieving the text they already composed even "without looking". In contrast, when children dictate to a tape recorder or human scribe, their metal memory about what was already said could very well be weak, not only because of the lack of the handwriting related reinforcement as mentioned, but also because most auditory information is likely to get lost from short-term memory within a few seconds (Harwell & Jackson, 2008). Specifically, the mental and physical representation of text can often be intertwined and reciprocal in the process of writing. A mental text representation, which Bereiter & Scardamalia (1987) believed to have greater importance than the graphic type for young writers, is somewhat fleeting in its nature since the working process of human minds are prone to evaluate, add, or delete ideas from time to time, whether conscientiously or unconscientiously. Such a nature of mental text representation suggests the relative significance of having a concrete, immediate physical representation in writing output, such as ink on paper or any visually accessible format. Furthermore, with a generally higher writing quantity in dictation conditions than handwriting, children would evidently have to invest more mental power to attain a sufficiently holistic picture of the already-dictated text, particularly for the reconstructive activities targeted in production signaling.

One critical suspicion to the perspective stated above, however, is that the visual text feedbacks can have counter effects to the children's writing performance if they have reading problems, as students with LD generally do. That is also what I propose to investigate in the present study-- I hypothesize that the benefits of visual text feedbacks in dictation writing will outweigh the children's problems in reading, and the children will show better writing performance in conditions with visual text feedbacks than without. As a result, I argue that the lack of production signals, i.e., external cuing, may have less power to children's writing performance than Bereiter & Scardamalia (1987) suggested. Additionally, the factor of interference of mechanical demands in writing, in contrast, remains a critical production

factor for developing and struggling writers as it may deflate their minimal working memory capacity and significantly influence their ability in executing the higher-level skills in writing.

Overall, some of the major findings in the two studies, Scardamalia & Bereiter (1979) and Scardamalia, et al. (1982), appear dissimilar to dictation studies conducted in the more recent decade, particularly those involving students with LD (which will be discussed in the following section). The dissimilar findings generally evidence the belief that struggling writers with LD differ from the typical developing writers not only in the vast number of difficulties they have in writing but also the nature of those difficulties, i.e. the writing development and writing processes. That is, supposing the data of the two studies were correct, more research remains indispensable to gather additional data, particularly via different experimental methods/tools, to better our understanding about the processes and psychology of writing among developing and struggling writers.

Cognitive Process Model of Writing

Three major cognitive writing processes (the mental operations in writing) were described in Hayes & Flower's (1980) model, i.e. *planning* what and how to write, *translating* plans into written text, and *reviewing* to improve the text. The essence of the model is a "monitor" or metacognitive authority (as described by Glaser & Brunstein, 2007) in that the execution of these cognitive processes is under a writer's direct control, and that the processes/subprocesses can operate in a mutually exclusive or inclusive manner until the written product meets the writer's intent. For instance, planning might interrupt translation if writers came across another idea in the midst of their initial drafting; likewise, translation might integrate with reviewing as writers could make any change in the midst of text generation.

In Hayes's (1996) model, the three cognitive writing processes were retained, and also reconceptualized considerably from the Hayes & Flower's (1980) model. Incorporating new empirical findings in the field of writing research during the timeframe of 25 years, the 1996 revised model reflects a broader context of writing, which encompasses factors within

individual writers (i.e., cognitive writing processes, working memory, long term memory, motivation/affect) as well as factors external to individual writers (i.e., the social environment, the physical environment). Overall, working memory is proposed to be a central component in Hayes's model, meaning working memory is a resource that is available to and presumably used by all of the writing processes. The flowchart Figure 3 depicts the gist of Hayes's (1996) framework in conceptualizing cognition and affect in writing. Bereiter and Scardamalia's (1987) model, although influential in the studies of children's writing process (applicable to adult writers as well), does not include most of the comprehensive strategies listed in Hayes & Flower's (1980) expert writing model.

Bereiter and Scardamalia's (1987) model identified two sects of writing processes, i.e., "knowledge-telling" and "knowledge-transferring", which were distinguished according to the capacities and knowledge of the writer. In an essence, "Knowledge-telling" entails that writing is a memory probing/activation process. Specifically, when cues such as the assignment topic and/or genre are given, students' memory is activated to inspect the relevant/related knowledge that constitutes the content of the composition. "Knowledge-transferring", in contrast, takes the ideas retrieved from memory, transforms them by resolving potential conflicts between ideas, and results in generation of new ideas, extensive content, and a deeper understanding of the pertinent subject.

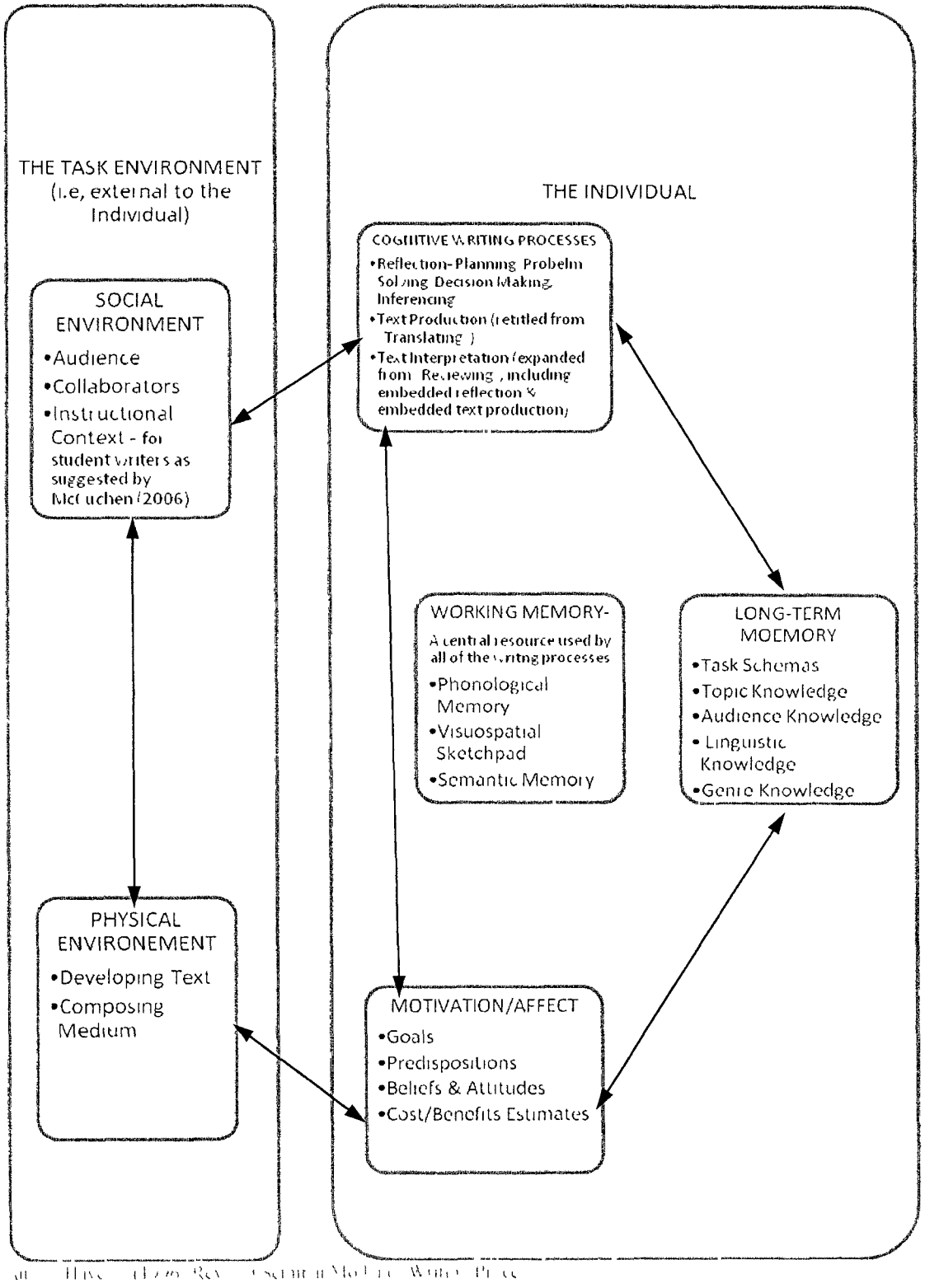


Figure 1. Hayes' (1996) Revised Model of Writing Process

Perhaps, the portion of "knowledge-telling" has a higher relevance to struggling or developing writers than "knowledge-transferring". McCutchen (2000) categorized "knowledge telling" as "a potentially *adaptive* response to the heavy processing demands that writing can impose on novice writers" (p.116, italics added), which shows its undertone of adaptation to cognitive processing demands. On the other hand, "knowledge-telling" can have the implication that children are inclined to take a passive role in writing as they are often situated in a writing environment where it is ordinary to write only for *one audience* such as their teacher, and have limited choices of topics if not just one. Further, the construct of "knowledge-telling" may also suggest that the act of writing in children is generally a *recycling* process of what they already knew. Namely, the essence or major components of the writing products stays the same, yet with only a different presentation/outlook. For instance, writers might be prone to state the same old thing in different words or paraphrases. One possible solution to such a potential criticism regarding the concept of "knowledge-telling" is offering children a more supportive writing environment with more choices of authentic writing activities so as to induce and exercise their potential in developing sophisticated writing skills.

For students with LD, on the other hand, a workable solution might have to emphasize both "adaptive" and "individualized" elements, since these students often have dysfunctional adaptive ability to the external writing environment or in their cognitive writing processes. Proper strategies or tools must be implemented or instructed directly to bridge the gap so as to help strengthen the memory activation process in knowledge sharing. As a result, I believe that a comprehensive model that entails both the internal and external components of the writing process encountered by a writer, i.e., Hayes's (1996) model, can best assist me in observing the various writing issues with struggling writers from a more holistic viewpoint. Particularly with the atypical writing development often found among individuals with LD, it would be most reasonable to adopt a writing process model whose power lies in its flexibility (maneuverability) with simple principles and with good extension

of complexity to entail the cognitive processes of writing among different individuals (Graham, 2006).

Speech Recognition Technology Mediated Dictation Writing

Technically, speech recognition (SR) uses the software equivalent of a neural net to "learn" to recognize the user's voice. As the user speaks, the recognition software remembers the way the user says each word. This customization allows voice recognition, even though everyone speaks with varying accents and forms of inflection. To achieve maximum speech dictation rate, users must be disciplined in the consistency of their pronunciation. In addition to learning how individual user pronounces words, SR also uses grammatical context and frequency of word usage to predict words that the individual may wish to use for input. These powerful statistical tools allow the software to reduce the number of words kept in its immediate memory before the user even speaks the next word (Forsyth, 2009).

A Brief History of Speech Recognition Technology: Discrete vs. Continuous

Older versions of SR software required each word to be separated by distinct, *space-discrete speech*, i.e. a pause between each word of at least 200 milliseconds, which allowed the machine to determine where each word began and ended. The discrete type of SR could recognize at most 75 words per minute (Al-Aynati & Chorneyko, 2003), including digitized text and system commands. In contrast, *continuous speech,* a newer type of SR software, allows a user to dictate text at more normal speaking speeds without artificial pauses. Recent SR applications, e.g., Dragon NaturallySpeaking 10.0, can recognize speech at up to 160 words per minute for well trained users. That rate is similar to the pace with which average people converse[3], and appears significantly faster than an average typing rate of 45 words per minute.

[3] General data suggest that the "burst rates" of conversation or speech among people often significantly exceed the recognition rate of 160 words/per min (the current rate with Dragon NaturallySpeaking 10 0) while "overall average" rates often don't, because of multiple "pauses" in speech

Interestingly, several research studies, at the transition of SR technology, found that the majority of users (especially those with LD) preferred the earlier discrete systems to the later continuous speech (Roberts & Stodden, 2004), and that the discrete speech type produced greater remediation effects for the writing and reading deficits of students with LD (Higgins & Raskind, 2000). Despite its agedness, the discrete SR system was found to serve the special needs of at least some groups better than its continuous descendant (specifically in earlier versions of the software). Some researchers indicated that the discrete SR system generally matched better with the phonological processing deficits found among students with LD (Roberts & Stodden, 2004; Higgins & Raskind, 2000). Perhaps, due to its less complicated error correction procedure than that of continuous SR system, the discrete SR was recommended by some experts with clinical experiences for students with severe writing problems (MacArthur, 2000). That is, similar to beginning readers or children with limited exposure to print, students with difficulties in phonological processes are often incompetent in segmenting words from streams of speech. A discrete speech system that presents the orthographic form of each individual word on the monitor thus makes a more explicit learning approach to word recognition for the students than the continuous speech system that shows the entire utterance without pauses between words. If a research proposal is to investigate SR as a reading intervention, the application of discrete SR software can very likely be causing different intervention effects than that of the continuous type.

Nevertheless, regardless of its historical value and potential benefits, the discrete SR system is rarely used and can hardly be accessed in the current era. In addition, it would be difficult to employ that older technology with modern computers, due to changes in operating systems and processors. These concerns about the accessibility and usability of the discrete SR system denote that the application of a continuous SR possesses a higher generalizability for the research purpose of the present study even if a discrete SR might still be of interest in future studies.

Writing Application of Speech Recognition Technology for Students with LD

A general finding in studies that involved the application of SR technology indicated that students with LD or poor writers dictated compositions that were both substantially longer and qualitatively superior to compositions written via handwriting or word processing, with mostly individuals at middle school level (Graham, 1990; MacArthur & Graham, 1987; Quinlan, 2004; Reece & Cumming, 1996) and at the postsecondary/college level (Higgins & Raskind, 1995). This finding was consistent with one earlier non-SR dictation study with younger TD elementary children (King & Rentel, 1981), who over a study period of 2 years showed better quality and higher quantity in their dictated texts than handwritten texts. These results appeared dissimilar with those for general dictation (SR & non-SR) studies involving *older TD students* in upper elementary grades and above, in which dictated texts were found longer but not qualitatively better than handwritten texts (Bereiter & Scardamalia, 1987; Reece & Cumming, 1996), or no significant difference was found in writing quantity or quality by different writing modes (MacArthur & Cavalier, 2004; Quinlan, 2004).

Although, arguably, a dictation-writing approach for struggling writers also appears to induce more significant quantity improvement than quality in writing, variability in study results must be considered. For instance, MacArthur & Cavalier (2004) in their application of dictation and SR as test accommodations for high school students with LD found a moderate difference in text quality, but contrary to the general expectation, a little to no difference in text length between SR and handwriting mode. By and large, there is a consistently smaller disparity between the two text rating results, i.e., quantity & quality, regarding to the writing improvement observed in the dictation mode among struggling writers or students with LD while comparing to that of TD groups.

The effect difference between student types again suggests a rather severe and more lasting interference power of mechanical demands for struggling writers with LD than their TD peers. In his SR-mediated study with fluent and less fluent writers (not everyone formally identified with LD) at middle school level, Quinlan (2004) rather boldly asserted that SR

technology can support writing *only* when the underlying writing difficulties are present. Further, the improvement of writing fluency/quantity is very likely tied to the improvement of writing quality as it was found also in Quinlan's (2004) study that narrative length related positively to the holistic quality of SR dictated texts. It may be speculated that bypassing writing mechanics via dictation gives leeway to the minimal capacity of working memory for the higher-level components in writing process. The improvement of writing fluency, which has generally been found significant, could lead to a longitudinal effect on overall writing performance (Graham et al., 2002).

Evaluation of the Pros & Cons of SR Application in Writing

Generally speaking, although there have been far more apparent advantages related to SR, disadvantages have also been reported. In terms of its situational practicability, the application of SR may interfere with other students (or employees in a work setting) since the user of the software must speaking into the microphone. In terms of its usability, SR is also less practical for students who have difficulties pronouncing words or delays in speaking. The portability/accessibility issue has become less a concern with the technology advancement in recent decade, e.g., SR program can oftentimes be installed in a book-size computer notebook for easy access.

As with any technology, the activation and/or operation of an SR system hinges on human efforts. From the experiences of common users of SR, the system has been found evidently easier to use for people who have certain capabilities (EPEC, 2001-2002). One of the foremost cognitive traits is being able to read and spell at a second grade level or better. Ironically, despite its claim of relieving users from spelling difficulties, spelling ability is important in SR because when the system does not correctly recognize a word, the user must make the correction by spelling the word letter-by-letter. Further, intact oral language skill and speech consistency are the minimum requirements to activate the machine's functionality. It is less likely for people with speech and/or language disorders, such as aphasia or apraxia to find this system a useful communication tool. Having the ability to pronounce the same

word in the same way each time (i.e., speech consistency) is generally a more crucial criterion than speech clarity because voice recognition systems learn a particular user's pronunciation patterns. That is, individuals with unusual speech, such as people with cerebral palsy, may also find the system a useful communication tool as long as their speech is consistent.

Nevertheless, even with users who meet the criteria mentioned above, and with the dramatic improvement of SR technology in recent years, voice decoding accuracy can still be limited, even after training the system reasonably well to understand the user's voice (MacArthur, 2000, 2009a). Overall all, the accuracy of the software is an issue. Software reviews typically report accuracy for adults of 95 percent or better (e.g.,Metz, 2006).

According to a report by Alwang (1998), the best system at that time, continuous SR, could only accurately recognize 91% of words dictated by adults after initial training. Accuracy increased to more than 95% only after extended use. For the later development of SR technology, Dragon NaturallySpeaking 10.0 claimed to have an accuracy rate of 99% and above, but general user reports with adults showed an accuracy rate around 98% or below, or success with about four out of five words (e.g., Wenzel, 2008). These data suggest that the speech recognition accuracy for individuals with nonstandard pronunciation or language problems might be problematic, and the limitations of SR might place additional cognitive burdens on the users (e.g. users must intentionally dictate word-by-word in a discrete speech system or avoid extraneous vocalizations in a continuous speech system).

MacArthur and Cavalier (2004), for instance, investigated the feasibility and validly of applying simulated SR (with human scribe) and mechanical SR as test accommodations for high school students with LD. Specifically, two groups of students, one with LD and the other without, composed text in three writing modes: handwriting, dictating to a human scribe, and dictating to an SR program. The study focused on the quality of composition, and found that the variation of writing modes appeared to have an effect on students with LD, but not on students without LD. Students with LD produced texts that were significantly better

when dictating to a human scribe, as opposed to SR, which texts in turn were superior to the handwritten. These findings seem to match with the findings of other dictation studies with students with LD (Graham, 1990; MacArthur & Graham, 1987; Reece & Cummings, 1996).

In an SR study like this, dictating to a human was presumed to mimic what a "perfect" SR program might accomplish. The implications from the findings of earlier research support the idea that dictation does alleviate mechanical difficulties in writing for students with LD, in spite the fact that the currently available SR technology still carries a layer of functional complexity not found in ordinary dictation. It seems reasonable to assert that the more closely SR simulates the proficiency of human scribe, the more significant the effects one can expect to find in the writing improvement of students with LD. Whether the presumably improved SR technology of today more closely approximates that standard than the SR technology of half or a decade ago remains to be seen.

Summary

In summary, students with LD often face difficulties with written language, which might considerably correlate with or possibly be caused by their persistent problems with the mechanical demands in writing. Speech recognition might allow students with LD to use their oral language abilities, which oftentimes precede and exceed competency in their written performance (an implication drawn from the findings of Bereiter & Scardamalia's (1987) study as well as King & Rentel's (1981) two-year longitudinal study that investigated the cognitive development of speech and writing competency with 72 TD primary-school children). Equally important, speech recognition technology makes dictation writing possible with a highly synchronous speech-to-text function, and without the direct support of another person such as the involvement of a human scribe as discussed previously. The technology of speech recognition offers a pathway of automatic transcription where most students with LD may avoid problems with writing mechanics, e.g., handwriting and spelling, ease cognitive loads, release working memory capacity, and enhance their writing performance. Figure 4 shows how the application of speech recognition technology intervenes in the writing

processes of struggling writers with LD. Similar benefits may be applicable to typically developing students, particularly at the lower elementary level. Nevertheless, the effect of benefits may dwindle and the nature of the benefits could vary as the students proceed to upper elementary level and above.

The present study will investigate how younger children with LD write differently when using a speech recognition system, a simulated tape recorder, and with their hands. Older students with LD, at the grades of middle school and up, have shown positive improvement in their writing performance when using speech recognition system to write. Can this same dictation system be an effective writing intervention to children at the lower elementary grades? Considering the said rationale and potential of such intervention as well as the relatively lack of research studies about it, the present study will be a meaningful and mandatory addition to the field.

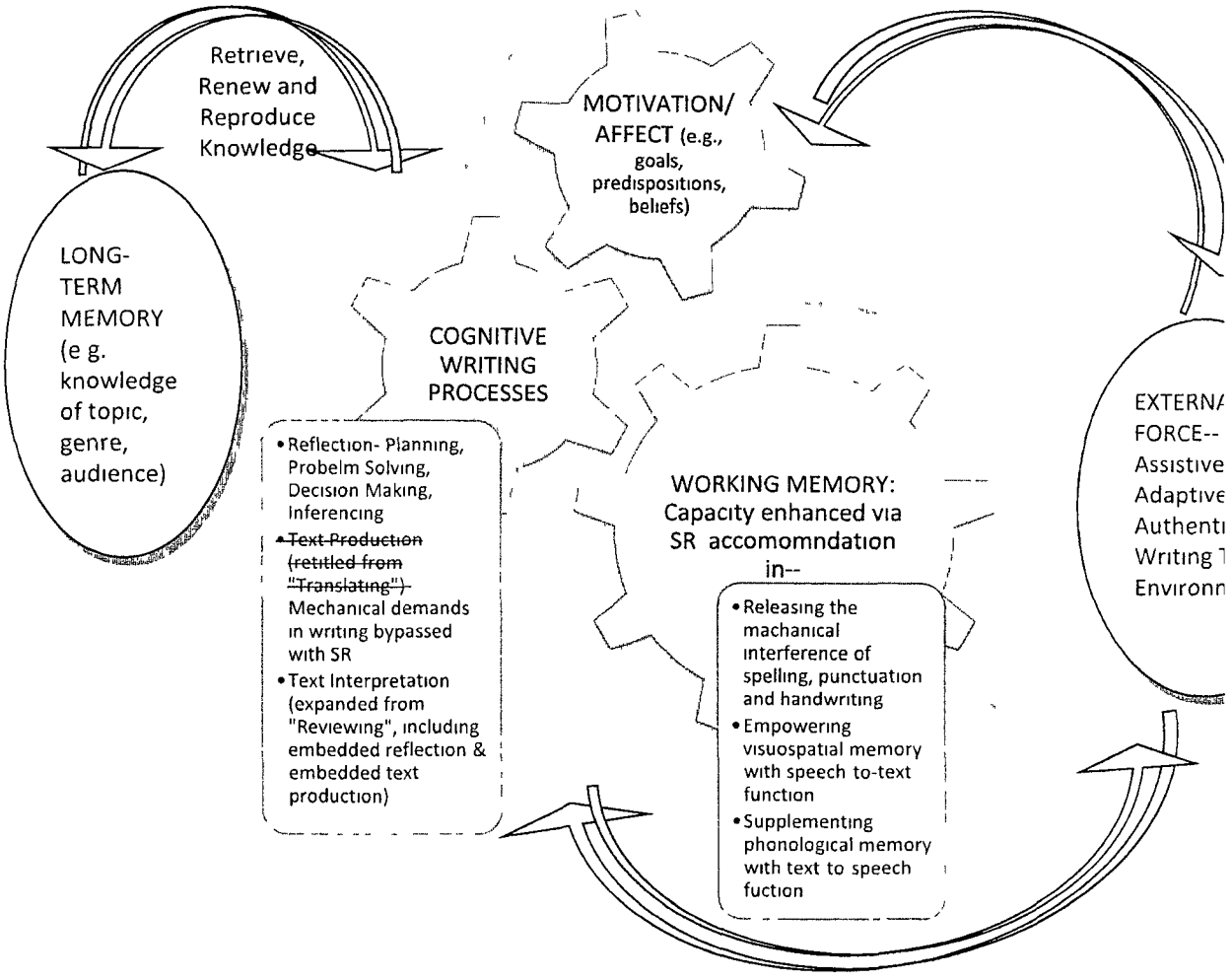


Figure 1 An SR-Intervened Writing Process for Students with Learning Disabilities

Chapter III: Methods

This study employed a single subject, alternating treatments design (ATD) to compare the impact of writing production modes on the writing performance of four elementary grade students with learning disabilities (LD). Baseline evaluations of text produced with handwriting were followed with preliminary user training in speech recognition technology, then an alternating treatments intervention to compare the students' text produced via handwriting (HW), speech recognition technology (SR), and digital voice recorder (DR) (which was bundled with the speech recognition software for auto-transcription but *without* immediate access to the text transcribed on the monitor).

Participants

This section includes the criteria for including and excluding potential participants, the process of recruiting and enrolling participants, and the descriptions of individual participants.

Participant Inclusion and Exclusion Criteria

This study included four nine-year-old children at elementary grade 4, diagnosed with learning disabilities and with problems in writing. The selection criteria were:

1. $3^{rd} - 5^{th}$ elementary grade students (between 9-11 years old), boys or girls, any ethnicity;
2. Diagnosed with LD and recognized as such by the school district;
3. Had a verbal or full-scale IQ score between 85 and 126 on an individual intelligence test;
4. Native English speakers;
5. Had a discrepancy between oral and written language production, i.e., scored within the normal range on standardized oral expression tests while at least one standard deviation below the mean on standardized writing tests;

6. Had no special education qualification for Speech and Language Disorders noted in their school records (IEP).
7. Had little or no experience in the use of SR technology, as reported by the participants, the participants' teachers, and the participants' family.

The author worked with district staff to develop a protocol for accessing school records (see Appendix 1). All information above was found in the participants' existing school district records, and was confirmed with the participants' teachers. No additional assessments were administered in conjunction with this project.

Participant Recruitment and Enrollment

Participants for this study were recruited from Johnson Elementary and Westview Elementary Schools (pseudonyms) in Seattle Public Schools District, WA. The school's resource room program provided services to 3rd-5th elementary grade students with LD, and the resource room teachers indicated the need of improving the students' writing performance. The designated schools were therefore a "sample of convenience". The school principals, classroom and resource room teachers were informed of the study, provided with *Participant Inclusion and Exclusion Criteria* as listed above, and given flyers that briefly described the study (see Appendix 1 and Appendix 2).

Teachers agreeing to participate consulted their student lists, and identified those students who met the inclusion criteria. The author reconfirmed each child's eligibility for the study by reviewing the inclusion/exclusion criteria with the classroom or resource room teacher. The parents/guardians were then informed of their child's eligibility and given the opportunity to reconfirm their willingness to enroll their child in the study. Five students were enrolled in the study under the consent of their parents/guardians.

Participant Descriptions

A total of five students in grade 4 were recruited for the study. One student dropped out of the study after the first study session due to the study's time conflict with her class

schedule. The remaining four students, Hanna, Mary, Tom, and John (pseudonyms) participated throughout the entire study. All four students were 9 years old, and all fit the participant criteria listed above. The main differences among the four participants include: (1) Gender—two girls and two boys; (2) Ethnicity—Tom was the only African American and the rest were Caucasians; (3) Severity of emotional and behavioral problems—Tom had instances with physical aggression and emotional disturbance, and John had severe attention and disruptive behavior problems, which were controlled with medication. The two girls did not show significant behavioral problems and no instances were reported by their teachers or parents; (4) Writing competence—At the time of the study, all four students had writing objectives addressed in their IEP, and all had problems in punctuation, capitalization, and spelling. Hanna was reported to rarely have avoidance behaviors for writing tasks, Mary, sometimes, and Tom and John, oftentimes. Mary was receiving many sessions of literacy tutoring outside school. Tom had severe spelling difficulties that interfered with the readability of his writing work. His manuscript often was interspersed with upper and lower case indiscriminately, but by the time Tom began participating in the study, his handwriting had improved. John had relatively low writing quantity that was oftentimes less than 50 words. Table 4 lists these pertinent information on each study participants.

Table 4. Other Pertinent Information of the Study Participants

	Hanna	**Mary**	**Tom**	**John**
Gender	Girl	Girl	Boy	Boy
School	Johnson	Johnson	Westfield	Westfield
Ethnicity	Caucasian	Caucasian	African American	Caucasian
Emotional and/or Behavioral Problems	No significant instances reported	No significant instances reported	Reported instances of physical aggression and emotional disturbance.	Reported instances of attention and disruptive behavior problems, which were controlled with medication
Avoidance Incidences for Writing Tasks	Rarely observed	Sometimes observed	Often observed	Often observed
Other	Had a grandfather who wrote a book via dictation software.	Received multiple hours of literacy tutoring outside school.	Had severe spelling difficulties that interfered with the readability of his writing work; produced manuscripts that often interspersed with upper and lower case indiscriminately.	Had relatively low writing quantity that was oftentimes less than 50 words; showed more interest in writing short jokes or composing music.

Setting & Materials

All sessions across phases were conducted with each study participant individually at the participant's school, in a quiet room designated for all the writing conditions, i.e., paper-pencil/handwriting (HW), speech recognition technology (SR), and digital voice recorder (DR). All sessions were conducted *one-on-one* to avoid distractions to participants and to their peers. Having one-on-one SR training session, in particular, allowed the instructor/the author to devote attention to the individual needs and responses of each participant, and helped promote the learning effectiveness of those students with learning disabilities.

The physical setups of the SR and DR condition were similar in that the study participants dictated their writing to a computer equipped with speech recognition software in both conditions. The two setups were different in that the computer monitor was covered in the DR condition in addition to an activated digital voice recorder. That is, the major difference in the setup between the two conditions was the availability of speech-to-text screen, which provided visual output of the text transcribed and was *not* immediately available in the DR condition. In addition, a "cheat sheet" with a list of SR dictation commands was placed right next to the monitor for the participants' use during SR training and SR intervention sessions (see Appendix 3). The provision of the cheat sheet followed logic similar to the use of a dictionary for conventional writing assessments, in that it offered a tool to facilitate technical aspects of the writing process, rather than replacing the cognitive actions, per se.

Equipment & Software

The platform for the SR condition was a Toshiba Charcoal Satellite A665 laptop PC (with 4GB of DDR3 SDRAM system memory and an Intel Core i5-480M processor, running at 2.66 GHz on a Windows 7 operation system), equipped with DOLBY® Advanced Audio™, built-in harman/kardon® speakers, and an Andrea NC-185VM USB headset microphone. Installed on the PC was Nuance Dragon NaturallySpeaking Premium 11.0 (2011), an SR program designed for continuous-speech dictation.

The Dragon system was chosen among others in the market because of its empirically demonstrated, higher usability, particularly with its advanced speech recognition rate. Dragon V.11 claimed to have the recognition rate/accuracy of 99%+, which was 15% greater out of the box compared to Dragon V.10 (Nuance Communications, 2002-2011). Also, the minimum reading time required to train Dragon V.11 for use with a digital voice recorder was reduced from 15 to 4 minutes. Note that the quality of microphone could significantly influence the recognition accuracy of an SR program and consequently the participant's competence in dictation writing. Andrea NC-185VM is a high quality noise-canceling headset compatible with the Dragon software. Thus, the SR system consisted of the highest quality and most advanced components generally available at the time of data collection.

For the DR condition, Sony Digital Voice Recorder ICD-UX70 was used under the same physical setup as the SR condition but with the computer monitor covered from the students. This setup allowed the author to investigate the effects of immediate visual text feedbacks in the dictation writing process by directly comparing the DR condition to the SR's. Also, the author could conveniently attain rough transcriptions of the voice files without having to manually transcribe them all later. That is, the author applied the automatic transcription feature in the SR software to save the time and energy cost required for the data collection process.

Research Design

A single-subject, alternating treatment design (Kazdin, 2011) was applied to investigate the relationship of writing modes and writing performance for young children with learning disabilities (LD). The design included the following phases:

1. A **baseline phase,** in which students wrote by hand;
2. A **Training Phase**, in which students were trained to employ the speech recognition technology; and
3. An **alternating treatment phase**. Three conditions were alternated randomly: handwriting (HW), dictation writing with speech recognition (SR) software, and

normal dictation writing using a digital voice recorder (DR) with the monitor concealed during the use of SR technology.

Each of these phases is described in more detail in the *Procedures* section.

Outcome Measures: Writing Prompts and Assessment Targets

Narrative writing tasks were used for the writing sessions because young children are likely to have more experiences and higher competence in composing stories, rather than other genres (Bereiter & Scardamalia, 1987; McCutchen, 1987). The writing prompts and assessment procedures were mostly taken from a criterion referenced assessment and treatment program known as *The Expression Connection* (Klecan-Aker & Brueggeman, 1991). This treatment writing program culminated a number of research projects, which were all designed to ascertain useful methods for the elicitation, transcription, and analysis of children's narratives. Quinlan (2004) adopted the same program in investigating the effects of speech recognition technology on children's writing process and performance.

The writing prompt in the present study consisted of pictures and a short verbal protocol introducing the narrative writing task with picture-relevant sample/stimulus stories. See Appendix 5 for examples. Pictures served the primary prompts because a good percentage of students with LD also had relatively poor reading skills which might contraindicate the use of written story prompts.

Students' narratives were analyzed for their level of fluency and quality. The analysis measures, which were similar to those in Quinlan's (2004) study, signified the essential elements of story writing among youngsters: *total text produced* or text length, *text production rate* (wpm), and *total number of T-units* suggested overall writing fluency; *percentage of surface errors* represented an aspect of mechanics in writing; *T-unit length, clause length,* and *clauses per T-unit* reflected the syntactic complexity of text; *story structure level* denoted the general writing quality or language organization especially the story grammar components (Klecan-Aker & Gill, 2005; Quinlan, 2004). These measures

were to examine whether there was improvement in the students' writing performance across different writing conditions during intervention and in comparison to the baseline. Below provides a detailed description of each measure:

1. **Writing fluency** was measured by the total text (words) produced, text production rate, and total number of T-units.
    a. *Total text produced* or number of words was tabulated automatically, using the word-count feature of a word processor.
    b. *Text production rate* was the total number of words divided by the total text production time, which was recorded in seconds, and then multiplied by 60 to make the production rate unit as number of words produced per minute.
    c. *Total number of T-units* was counted manually with a simple or complex sentence equaled one T-unit, and a compound sentence equaled two or more T-units, each of which consisted of independent equal clauses (Hedberg & Westby, 1993).
2. **Writing quality** included syntactic complexity as measured by T-unit length, clause length, and number of clauses per T-unit, mechanics of writing as measured by percentage of surface errors in the text, and story structure level.
    a. *T-unit length* was the total number of words divided by the total number of T-units. It is often used to measure the complexity of a sentence, and generally a reliable and objective way for teachers to understand students' written language growth (White, Scott, & Grant, 2002).
    b. *Clause length* was the total number of words divided by the total number of clauses. Some studies found clause length to be a better way to examine beginner's level of writing fluency than T-unit length because the T-unit was more appropriate for learners who had already achieved a certain level of language proficiency (Wolfe-Quintero, Inagaki, & Kim, 1998); in contrast, some studies found clause length positively correlated with quality for essays but not for narratives (Beers & Nagy, 2009). As both clause length and T-unit

length can be good indicators of a student's grade level and that calculating one is *not* necessarily better than the other, both were measured.

c. *Number of clauses per T-unit* or T-unit complexity ratio was the total number of clauses divided by the total number of T-units.

Specifically, all the narrative compositions or stories were divided into T-units, and followed with calculations of number of words per T-unit, number of words per clause, and number of clauses per T-unit. The *Expressive Connection* (Klecan-Aker & Brueggeman, 1991) provided guidelines for obtaining those measures. Also, each T-unit was assigned a story grammar component as listed in the measure of *story structure level*. This component defined the role of the T-unit in the story, and collectively with other components facilitated an analysis of the story structure.

d. *Surface errors* was defined as any word that was either (a) semantically or grammatically inconsistent or (b) orthographically incorrect (Quinlan, 2004). These errors basically included misspelled words in the handwritten texts, recognition errors in the SR texts, and grammatical errors such as verb errors in the DR texts. The analysis of surface errors assessed the students' ability to produce readable text via the three writing tools. The involvement of a second rater and the interrater reliability are described in the *Reliability* section.

e. *Story structure* was defined by seven narrative developmental levels, which were based on the number of story grammar components students included in their texts. Note that the narrative developmental level was based on a modified *Expression Connection* version (Klecan-Aker & Colson, 2009), which had two more developmental levels (levels 6 and 7) added to its 1991 version (applied in Gilmore, Klecan-Aker, & Owen, 1999). The story grammar components included:

    i. setting statement — who/when the story is about and when and where the story takes place;

ii. initiating event — the problem or the main point setting the stage for the story;
iii. internal responses — the reaction of the main character to the initiating event (thinking and feeling statements);
iv. action — an attempt to solve the problem;
v. consequence — the result of the action;
vi. dialogue — asking or telling statements (they don't need to be direct quotations); and
vii. ending — the tells the final resolution of the story.

See Table 5 for the descriptions and examples of the story grammar components (adapted from Gilmore et al., 1999; Klecan-Aker & Colson, 2009).

Basically, the type of story grammar components found in the story determines the story's developmental level. Both levels 1 and 2 stories involve no real use of story grammar components; however, unlike level 1 stories where students simply talk/write randomly, level 2 stories involve students labeling or describing items in the picture. Level 3 stories contain the three core story components, i.e., initiating event, action and consequence. Levels 4, 5, 6 and 7 stories have additional story grammar components, one for each level. These additional story components are not specified because choices of the added components can vary among different students, and research has not revealed any specific pattern. Level 0 stories do not correspond to any other categories. See Table 6 for the detailed descriptions of the seven narrative developmental levels (adapted from Gilmore et al., 1999).

In addition to the quantitative type of measures described above, the author took notes of the students' behaviors with respect to the availability of written text during the composing process in intervention. Taking field notes is a qualitative, not quantitative research technique that researchers often use in cognitive interviews, usability studies, etc. It can provide descriptive, supplemental narrative to enrich the main research question, and perhaps further inform other related research questions. As for the present study, the related

research question of interest was how the availability of visual text influenced the writing performance of young children with LD, with particular emphasis on their revision behaviors.

Table 5. Story Grammar Components, Descriptions, and Examples

Story Grammar Components	Descriptions	Examples
Setting statement	Introduces the main character and tells where and when the story will take place	"One day, Alice was walking in the woods."
Initiating event	A statement of the problem	"A spaceship landed and two aliens came out."
Internal responses	Thinking or feeling statements, may be sensory or cognitive	"The girl saw the aliens." "She thought she should run." "The aliens were sad."
Action	An attempt to solve the problem	"Alice gave the aliens some candy."
Consequences	The result of an action; the outcome	"They became friends."
Dialogue	Asking or telling statements (with or without direct quotations)	"' Come with us to our planet', the aliens asked." "Alice told them she couldn't miss school."
Ending	A resolution for the problem; can also be a summary statement	"Alice will visit the aliens during summer time." "The aliens went back to their home."

Table 6. Descriptions of the Seven Narrative/Story Developmental Levels

Story Levels	Descriptions
Level 0	Any story that does not fit in any of the other categories.
Level 1	No real use of story grammar components. Students label or describe events, actions, or objects, but there is no central theme.
Level 2	No real use of story grammar components. Students label or describe events, actions, or objects, and follow a central theme or one topic.
Level 3	These stories contain the three story grammar components of initiating event, action, and consequence. Students begin to use syntactical subordination.
Level 4	These stories contain the three story grammar components in level 3, plus one more. The fourth component may vary from student to student.
Level 5	The stories contain the three story grammar components in level 3, plus one more and an ending. The endings of level 5 stories are strong and indicate a resolution for the initial problem.
Level 6	These stories contain six story grammar components, five of which consist of setting statement, initiating event, action, consequence, and an ending. The sixth component may vary from student to student, and may be either an internal response or a dialogue statement.
Level 7	These stories contain seven story grammar components, consist of setting statement, initiating event, action, consequence, ending, internal response, and dialogue/reporting.

Procedures

General Session Procedures

All participants were assigned the same writing prompt/ topic (pictures with verbal instructions) during any given session/condition, and with one new writing prompt assigned for each successive session. An average of 20 different writing prompts[4], with similar style, black-and-white format and age appropriate, were selected and adapted from the *Expression Connection* (1991) program and the web. Each writing prompt was used only once and randomly assigned to any one writing session of the study. Five of the 20 writing prompts were randomly selected for the baseline phase, and were given in a fixed order to each participant. The rest of the writing prompts were randomly assigned to the intervention phase, and were given in blocks of three writing conditions, which order was varied across the participants. Basically, the order of the three conditions had six *non-repeating* possibilities for individual participant: (1) SR→HW→DR; (2) SR→DR→HW; (3) DR→SR→HW; (4) DR→HW→SR; (5) HW→DR→SR; (6) HW→SR→DR. Hanna, for instance, had her intervention sessions in this sequence above, Mary, in the sequence of (2)(1)(3)(4)(6)(5), Tom, (2)(3)(1)(5)(4)(6), and John, (1)(3)(2)(6)(5)(4). This is a random selection without replacement in blocks of 3 sessions. This process was developed to eliminate repetitive patterns with long strings of sessions under any given condition, and assure overall equal exposure to each condition during the course of the study.

Across phases, all participants produced writing for at least 5 different prompts during baseline, 15 different prompts during intervention — five different sets/orders of three writing conditions, or more until a clear writing performance trend in the individual participant was observed. Each session for the baseline and intervention phases took approximately 15 minutes, with 3 minutes of verbal instruction for the writing prompts,

[4] To make up an incomplete intervention session, Mary had one extra intervention session with one new writing prompt, which summed up a total of 21 writing prompts for Mary. That is, Mary had one more writing prompt than the 20 for the other three students.

followed by at most 12 minutes of student composition time. Only one session was held per day per student, for a maximum of five times per week, over a period of no less than five weeks and no longer than seven weeks. Mary finished the study a week after other students due to the study's time conflict with her class schedule.

For the 3 minutes of verbal instruction in each study session, the author/researcher started by giving a writing task introduction (adapted from Quinlan, 2004):

> *I am going to tell you a story. Listen carefully so you will know what a story is. After I finish my story, it will be your turn to write/tell (depending on the writing mode used) me yours.*

The author showed the picture to the participant along with the accompanying sample story. After the sample story was demonstrated, the author gave the following instruction:

> *That was an interesting story, wasn't it? In fact, before people start writing stories, they usually use a story map, like this one. A story map helps people to remember ideas and keywords. (Give a couple examples.) You can use the story map before you start writing your story on the line paper. Now, look at the picture on your worksheet and write/tell your own story. If you're not sure how to spell a word, just make your best guess. You will have a maximum of 12 minutes. If you need more paper, let me know and I'll give you some. Begin.*

The author gave the student a 2-minute warning after 10 minutes had elapsed.

Introduction for the writing tasks in SR and DR condition followed a similar protocol as stated above, except that the participants were directed to dictate their story to a headset and a computer for the SR condition, and a digital voice recorder for the DR condition. Also, the participants were given a blank paper and story map to jot down their ideas or keywords during their dictation writing process. See Appendix 5 for the story map.

During SR training sessions, the author provided directions, guidance, and feedback to the study participants as appropriate. During the test/text production sessions, nevertheless, the author no longer provided any assistance or feedback on the writing tasks or the basic use

of the SR system. The author provided assistance concerning equipment problems or failures only when necessary.

All sessions (including those in the training phase) for any given student were completed with the author individually. During each baseline and intervention session, the examiner/the author recorded the total amount of text production time in minutes and seconds. This information was applied in calculating text production rate and also served as a cross-reference to the analysis of writing quality. Notes concerning the students' pre-writing/planning and revision behaviors were taken by the author for later analysis. Observations were conducted to monitor the use of writing materials, e.g., ensuring that students didn't use anything other than the prescribed equipment, and that they stayed on task. When students were clearly off-task or showed little or no attempt to work on the assigned tasks during any of the sessions, the author would remind them to keep working. Otherwise, with the exception of the initial prompts, instructions and directions (as detailed above), the author did not provide any guidance or assistance to the students. Eye contact with the participants was avoided while they were composing. This was to control the possibility of providing subtle social input during the process of composing.

Phase One: Baseline

During baseline sessions, the students produced handwritten stories about the same narrative topics that were assigned in the same order to every student. In baseline, the students were given their topic, as described above, and also to write for 12 minutes. A prompt to finish up was provided after 10 minutes of writing.

Training

Each student received 3-4 sessions of training in dictation writing with an SR program, Nuance Dragon NaturallySpeaking Premium 11.0 (2011), as a preparation for the intervention phase. Each training session was about15-25 min, during which the students learned to operate the SR program, and to attain the recognition accuracy rate of 90% or above. A training protocol was specially designed for the present study, based on Dick and

Carey's (1990) instructional design model, *The Systematic Design of Instruction*. The protocol included the length of the training time, specific training objectives and tasks, instructional strategies to achieve the training objectives, and assessment techniques for the training objectives achieved. See Appendix 4 for a detailed description of training procedures and materials.

Specifically, two measures were used to evaluate the accuracy of speech recognition, i.e., word-list and sentence probes. The probes were identical for every student and included: (1) Word-list probes— a list of 44 words was taken from an informal reading inventory in the grade level of three through five; (2) Sentence probes—17 sentences were taken from a collection of brief narrative passages at a second-grade reading level and all together were about 120 words. Note that word-list and sentence probes are both essential since SR system has a built-in syntax recognition function for sentences, which could significantly increase or decrease the recognition accuracy comparing to that of word-list. Also, to compose writing using an SR system requires the skills of mentally familiarizing and verbally applying the writing and revising commands. The word-list and sentence probes were to help students train the SR system toward a tolerable accuracy rate, which served a general index of their fluency and familiarity with the system.

Procedures for the recognition accuracy assessment included:

1. Prior to dictating the probes, students practiced reading the sentences and word lists and received help with reading if necessary.
2. Students were not permitted to correct any speech recognition errors during the dictation assessment. The author positioned the computer screen in an inaccessible fashion from the students, and told the students that the author would be monitoring the computer's work for them at this time.
3. Each dictated document was saved as a computer file, and scored for the percentages of words that had been accurately recognized by the SR system for the sentence and word-list probes.

The data of dictation frequency/speed was not collected at this point since students were allowed to take as much time as they needed to pronounce each word and sentence as clearly and consistently as they could.

All students passed the SR accuracy assessment at a rate of 91-95% for word-list probes and 92-98% for sentence probes. Note that the assessment results of the recognition accuracy in the present study served the purpose of subject screening as well as a cross-reference in analyzing the research results.

No particular training was necessary for the HW and DR conditions, except practices of the simple dictation procedure prior to the first writing session of DR condition. See the detailed description in *Phase Two: Intervention.*

Phase Two: Intervention

The students were asked to produce narrative texts about their pre-assigned topics by using one of the three production modes (HW, SR, and DR). To control the sequential confounding variable, random assignment without replacement, as discussed in the section of *General Session Procedures*, was applied, meaning each text production mode took place only *once* during each block of three intervention sessions and the order of the production modes within each block varied among the students.

Instruction for the writing tasks was given and pertinent data collection procedures followed. In the handwriting condition, study participants were told to write as much as they could on the assigned topic. If there was any word in the participants' composition that the author could not read, they would be asked to read at the end of the writing session.

SR Dictation Condition

In the SR dictation condition, participants were told to speak as much as they could, but by the means of a headset and a speech-to-text software, which they received training earlier. A cheat sheet with the basic SR software operation commands was provided and

available to the participants throughout the session. See Appendix 3. An example of the verbal instruction or directions is as the following:

> *You have learned the special computer program to write without hands earlier. Yes. You can command the program like a boss or pilot to do all the handwriting/keyboarding, spelling, grammar checking, etc. for you! Today, you will get to command that special program to write a story, and no, you do not need your hands or pencils to write it. I am going to give you a story topic, and you are to say as much as you can about it through the headset/microphone. The computer screen will show what you have said immediately for you. If you are not satisfied with what you see on the monitor, you can make changes by using the special commands you learned earlier. And just like before, I want you to tell as long a story as you can.*

DR Dictation Condition

In the DR condition, the author set up the SR system with the computer screen concealed from the study participants, which simulated a normal dictation condition as engineered by tape recorder. Participants were given directions similar to those provided for the SR condition except that participants were asked to speak their composition into a digital voice recorder, and told that a secret scribe would later check on their Dragon transcribed composition. An example of the verbal instruction or directions is as the following:

> *Have you listened to stories on tapes or CDs? Yes? Those were made by people who recorded their writing or stories through a tape or voice recorder. Today we're going to do something cool like that. I'm going to give you a story topic to talk about, and you are to say as much as you can about it. I want you to tell as long a story as you can, just like before. Only this time, you don't have to write it as you normally do or look at the computer screen as when you used Dragon. You just say what you think to this voice recording microphone/headset. A secret typewriter will listen to your voice and make sure that Dragon typed your story exactly the way your voice dictated.*

Interrater Agreement, Procedural Reliability and Social Validity

Prior to the beginning of data collection for the present study, a graduate student in College of Education was trained as the second rater for the purpose of collecting interrater agreement. The author and the second rater together reviewed the scoring rubrics for T-units, clauses, surface errors, and story structure level (see also Appendix 6 and Appendix 7), and applied the rubrics on a couple writing samples from *The Expression Connection* (Klecan-

Aker & Brueggeman, 1991). Five more sample narrative writings of struggling writers or children at 3rd grade or younger were later independently graded for practices, and the average level of interrater agreement was above 80% on all parameters, including the total number of T-units, clauses, and surface errors, and story structure level.

For the evaluation of story structure level in particular, the author and the second rater read each composition, and took into account the story grammar components in forming a single judgment about the overall quality of the composition, and that no one component should receive undue weight. Compositions were scored on a 1–7 point scale, with seven representing the highest quality of writing, and one, the lowest quality. Surface errors were ignored when evaluating the story structure. The second rater was unfamiliar with the purpose and design of the study, and independently assigned story structure levels to the participants' compositions.

During the data evaluation procedures, all identifying information on the writing products was removed prior to scoring. That is, all compositions collected regardless of the study phases or conditions were formatted identically in terms of margins, spacing, and font, then assigned a unique identification code to ensure participant anonymity. The handwritten compositions in particular, were typed verbatim, preserving errors of spelling and punctuation. The author performed all the outcome analyses, integrating the analyses from a second rater. Everyone involved in scoring was masked to the experimental conditions.

Agreement was checked for 2-3 randomly selected stories by each student in each condition (with one baseline story included in the HW condition), which added up a total of 27 stories, i.e., about one-third of the grand total of 80 stories. Half way through the intervention phase, the second rater evaluated the 1st batch of seven compositions, and then the 2nd and 3rd batch in every other week. If reliability ever dropped below 80%, retraining and discussions with the second rater (with changes noted in the rating protocols), and reassessment of interrater reliability would continue until reliabilities reached a level at or

above 80%. Since permanent products were available for all compositions, these procedures could be implemented at any time during or after the study, per se.

A frequency ratio ([smaller total ÷ larger total] x 100) was used to determine percent agreement between raters for each randomly selected story. Average interrater agreements for the student stories written during the baseline (BL) and intervention (I) phases were as follows: T-units (BL = 100%, I = 97%); clauses (BL = 98%, I = 97%); and surface errors (BL = 96%, I = 90%). For the level of story structure, interrater agreement was 85% as calculated by [agreement total ÷ disagreement total] x 100. This percent agreement involved both BL and I phases since the four samples in BL alone were not sufficient in evaluating interrater agreement for the type of scales of story structure. See Table 7 for the abbreviated version of the calculation records and Appendix 8 for the detailed version.

To insure the use of standard procedures within and across conditions, procedural reliability checklists (Billingsley, White, & Munson, 1980) that delineated equipment set-up, the amount and type of prompts, and when the prompts, directions or instructions could be provided were developed for each condition. The author checked off the items on the checklists for setting, equipment and materials prior to each session, and those for prompts and instructions after each session. The reliability level was close to 99%, which was determined by dividing the number of steps followed correctly by the total number of steps on the checklist. The few items that were missed included an *immediate* provision of a story map to the student after verbal instruction for the writing task was given, one constant timer (made up by a watch or clock available in the room), and a consistent reminder when two minutes were left for the writing tasks.

Social validity is concerned with the consumers of the present study, including teachers, parents and students. The consumers were given a questionnaire twice, once at the before the study and once after, and comprised three components as following: (1) Importance, e.g., Do you think it's important that your children learn and improve on their writing? (2) Program workability, e.g., Do you think the program would work? Specifically,

was the equipment easy enough to operate? Was the program effective? (3) Program accessibility, e.g., Do you think you will have the opportunity to use the program? Is it ethical and nice? Any price/expense concerns? Overall, the data collection procedures were reasonably reliable and valid. The feedbacks from the students, parents, and teachers were generally positive and consistent.

Table 7. Interrater Agreement by the Writing Measures across Subjects

	T-Unit		Clauses		Synt Er (s)		Cap Er (c)		Surf Er=(s)+(c)		SS Level	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd		
BL Total	44	44	54	55	76	72	35	35	111	107		
Smaller Total	44		54		72		35		107		Agree	2
Larger Total	44		55		76		35		111		Disagr	2
BL Ave FR	**100%**		**98%**		**95%**		**100%**		**96%**			
I Total (Hanna)	74	73	117	107	49	45	4	3	53	48		
Smaller Total	73		107		45		3		48		Agree	5
Larger Total	74		117		49		4		53		Disagr	1
FR Ave (Hanna)	**99%**		**91%**		**92%**		**75%**		**91%**			
I Total (Mary)	124	117	183	179	91	83	35	34	126	117		
Smaller Total	117		179		83		34		117		Agree	5
Larger Total	124		183		91		35		126		Disagr	1
FR Ave (Mary)	**94%**		**98%**		**91%**		**97%**		**93%**			
I Total (Tom)	72	69	86	87	57	50	14	12	71	62		
Smaller Total	69		86		50		12		62		Agree	5
Larger Total	72		87		57		14		71		Disagr	0
FR Ave (Tom)	**96%**		**99%**		**88%**		**86%**		**87%**			
I Total (John)	107	105	143	140	41	38	17	17	58	55		
Smaller Total	105		140		38		17		55		Agree	6
Larger Total	107		143		41		17		58		Disagr	0
FR Ave (John)	**98%**		**98%**		**93%**		**100%**		**95%**		**AA Ratio**	**23/27**
I Ave FR (Subtotal)	**97%**		**97%**		**91%**		**89%**		**91%**		**BL & I Ave FR = 85%**	

Abbreviations: BL = Baseline; I= Intervention; BL Ave FR = Baseline Average Frequency Ratio; I Ave FR = Intervention Average Frequency Ratio; AA Ratio = Accumulated Agreement Ratio (Total # of agreement/ Total # of narratives); 1st = 1st rater (the researcher); 2nd = 2nd rater; Synt Er = Syntactic Errors; Cap Er = Capitalization Errors; Surf Er = Surface Errors; SS Level = Story Structure Level; Agree = Scoring agreement between the researcher and 2nd rater; Disagr = Scoring disagreement between the researcher and 2nd rater.

Data Analysis and Evaluation Procedures

Data from this study were comprised of handwritten and dictated compositions from all the writing sessions (which were all typed, with punctuation and spelling errors corrected, and student names masked) and field notes with narrative responses and observations gathered from participants in all the writing sessions. Participant writing data were the primary sources, with voice files and field notes serving to corroborate, clarify or enrich narrative findings, particularly concerning the participants' revision behavior.

Using the writing quantity word count and the Klecan-Aker & Colson's (2009) seven-point writing quality rating scale (as discussed in *Outcome Measures* section), the author charted the changes of individual participant's writing performance. Surface errors, T-unit length, clause length and number of clause per T-unit were also calculated to enrich the data analysis for writing quality. Additionally, data for revision behaviors were derived from field notes. The author made notes of the students' attempts to change the previously composed or dictated text, and classify those changes/revisions to by the categories of content or surface oriented. To evaluate whether performances in one condition appeared to consistently exceed those in another condition, all data were graphed and inspected visually for differences in levels and trends between conditions (Kazdin, 2011). Data were also compared to determine whether there was separation between the datum points for the three conditions (Barlow, Hersen, & Nock, 2006).

Chapter IV: Results

This study set out to determine whether elementary students labeled as students with Learning Disabilities demonstrated different writing performance under three different writing modes—handwriting (HW), dictation-writing using a speech recognition software (SR) and, dictation-writing using digital voice recorder (DR). Specifically, I was interested in investigating the differences of writing fluency or productivity of writing as measured by *total text (words) produced*, *text production rate* (number of words per minute), and *total number of T-units*, and writing quality concerning syntactic complexity as measured by *T-unit length, clause length* and *number of clauses per T-unit*, mechanics of writing (text readability) by *percentage of surface errors*, and story structure by *story structure level.*

All students started baseline phase during the last week of April, 2011. Baseline consisted of an average of five handwriting sessions for every student. After completing the baseline, the students received individual training on an SR software program, Dragon NaturallySpeaking 11.0 Premium, all had 3-4 training sessions, and all achieved the speech recognition accuracy rate of 90% and above for both sentence and word probes. The intervention phase started at the 2nd week of May, 2011 and ended within four weeks, which altogether accounted for an average of 15 intervention sessions per student, i.e., 5 sessions per intervention condition. The datum for Mary's 3rd HW intervention session was discarded due to the inadequate text production time caused by her unexpected early dismissal, and consequently a 6th HW intervention session was conducted.

Figure 5 through Figure 20 present the results obtained for each student on each parameter. For data analysis, all data were graphed and inspected visually for notable differences in levels and trends between conditions (Kazdin, 2011). Data were compared to determine whether there was separation between the datum points for the three conditions.

Analysis of Writing Fluency

Three of the measures, *total text produced, rate of text production* and *total number of T-units*, measured the students' fluency of writing in the baseline phase as well as the three different writing conditions (HW, SR, DR) in the intervention phase.

Total Text Produced

Figure 5 shows the total text produced, and Figure 13, the means or averages for the total text produced by each student in all text production modes across phases. All four students had a stable baseline with little trend and relatively consistent performance. Hanna and Mary appeared to have a more obvious decreasing trend than Tom and John, and they also started their sessions and were on average producing relatively higher quantity of text than Tom and John and within themselves in the baseline. Generally, the students produced more text in the intervention phase than the baseline. The minor exceptions were Hanna and Tom, who appeared to have a higher mean (118 and 64 words respectively) in their handwriting (HW) condition at baseline than the same condition in intervention (85 and 55 words respectively).

During the intervention phase, all students consistently produced more text in SR condition than HW condition, all (except Hanna) consistently produced more in DR than HW, Mary and John, consistently more in DR than the other two conditions, and Tom, consistently more in SR than the other two conditions—All of these observations above had no overlap between their respective datum points. As for the means of total text produced, Hanna and Tom had their highest mean in SR condition whereas Mary and John, DR condition. For Mary, the mean total of 376 words in DR condition was over two times more than the163 words in SR condition, and three times more than the 110 words in HW condition; for John, the DR mean (408 words) was almost four times more than the SR's (113 words), and 10 times more than the HW's (44 words). For Hanna and Tom, however, the differences between the means of their SR and DR conditions appeared smaller than

Mary and John's. That is, Hanna had a mean of 145 words in SR condition, and Tom, 314 words, which were respectively about 20 and 100 more words than their DR's.

Note that Tom had a substantial increase on text quantity in his 2nd SR session and a substantial decreasing trend from his 3rd SR session and on (despite a relatively small increase in his 4th SR session). The sharp increase in Tom's 2nd SR session might be a result of the introduction of the DR mode in the two sessions previously, which prompted him to dictate his text without pauses and without checking or correcting the text transcribed on the screen. Also, there was a mild increasing trend in HW condition at the intervention phase across all four students. This observation shows that the two dictation-oriented writing approaches might have some intervening effects on the improvement of students' handwritten text quantity

Overall, all four students produced more text through the dictation writing modes (either SR or DR) than handwriting mode. Although different students had better performance with different technologies, all four students consistently produced more text when aided by appropriate technology.

Rate of Text Production

Figure 6 shows the rate of text production, and Figure 14, the means or averages for the rate of text production or the number of words produced per minute (wpm) by each student in all text production modes across phases. All four students had a stable baseline with little trend and relatively consistent performance. Hanna appeared to have a more obvious decreasing trend compared to other students. Both Hanna and Mary started their sessions and were on average producing text at a relatively higher rate than the other two students and within themselves in the baseline. The students generally produced text at a higher rate in the intervention phase than the baseline. The one exception was John, who appeared to have a slight higher mean rate in the HW baseline phase (5.6 wpm) than his HW intervention phase (4.5 wpm).

During the intervention phase, all students consistently had a higher text production rate in DR condition than HW condition, all (except Tom) consistently had a higher rate in DR condition than the other two conditions, and both Tom and John consistently had a higher rate in SR than HW—All of these observations above had no overlap between their respective datum points. As for the means of text production rate, all students (except Mary) had a higher mean in SR condition than HW condition, and all students (except Tom), their highest mean in DR condition. For Hanna, the mean rate of 23.8 wpm in DR condition was slightly higher than the14.3 wpm in SR condition, and over two times higher than the 9.8 wpm in HW condition; for Mary, her DR mean rate (65.0 wpm) was four times higher than her SR's (16.6 wpm), and close to four times higher than her HW's (17.4 wpm); for John, his DR mean rate (67.7 wpm) was over five times higher than his SR's (13.7 wpm), and 13 times higher than his HW's (4.5 wpm). On the other hand, Tom on average produced text at a higher rate in SR condition than the other two conditions. That is, his SR mean rate (34.0 wpm) was slightly faster than his DR's (31.6 wpm), and four times higher than his HW's (8.3 wpm). The difference of the mean text production rate between SR and HW conditions during the intervention phase was greater for Tom than other students, and the difference between SR and DR conditions also was greater for Mary and John than Hanna and Tom.

Note that all students (except Hanna) showed a decreasing trend in their DR text production rate, which was contrary to the trend in their HW's in baseline, and this decreasing trend was especially evident for Tom and John. Also, all students showed a mild increasing trend in their HW text production rate during the intervention phase.

Overall, all four students produced text at a higher rate through the dictation writing modes (either SR or DR) than handwriting mode, and three of the four students had their DR text production rate consistently higher than their SR's. The text production modes appeared to effect the rate of text production for all four students.

Total Number of T-Units

Figure 7 shows the total number of T-units, and Figure 15, the means or averages for the total number of T-units in the text produced by each student in all text production modes across phases. All four students had a stable baseline with little trend and relatively consistent performance. Hanna and Mary appeared to have a more obvious decreasing trend than Tom and John, and they also started their sessions and were on average producing text with relatively more T-units than Tom and John and within themselves in the baseline. Generally, the students produced text with more T-units in the intervention phase than the baseline. Exceptions were that all students (except John) had a slightly higher T-unit mean for their baseline HW condition than their intervention's, and Hanna, a mean of 2 T-units more for her baseline HW than DR condition.

During the intervention phase, all students (except Hanna) consistently produced text with more T-units in SR condition than HW condition, and Mary and John, consistently more in DR than the other two conditions—All of these observations above had no overlap between their respective datum points. As for the means of total number of T-units, all students had their higher mean in either SR or DR condition than HW condition. Specifically, Hanna and Tom had their highest mean in SR condition whereas Mary and John, DR condition. For Mary, the mean total of 37.6 T-units in DR condition was over two times more than the16.6 T-units in SR condition, and three times more than the 11.0 T-units in HW condition; for John, his DR mean (42.2 T-units) was almost three times more than his SR's (14.8 T-units), and eight times more than his HW's (5.4 units). For Hanna and Tom, however, the differences between the means of their SR and DR conditions appeared smaller than Mary and John's. That is, Hanna had an SR mean of 13.8 units, and Tom, 33.0 T-units, which were respectively about 2 and 9 more T-units than their DR's.

Note that Tom had a substantial increase on the number of T-units in his 2nd SR session, and also a substantial decreasing trend from his 3rd SR session and on (despite a relatively small increase in his 4th SR session). Additionally, for children in 3rd grade or

higher, stories should be 8 T-units or more (Klecan-Aker & Brueggeman, 1991). In view of the means, all students (except John) were above the risk level of 8 T-units across phases. Specifically, Hanna only had one HW intervention session (5 T-units) below the risk level, Mary, only one baseline session (6 T-units) below the risk level and the rest all above, Tom, one DR (7 T-units) and some HW sessions (6-7 T-units in both baseline and intervention phase) below the risk level, and John, most HW sessions (3-6 T-units in both baseline and intervention phase) below the risk level.

The results of this measure generally reflect those for the *total text produced* in Figure 5 and Figure 13, but with milder trend and level differences within individuals and across conditions. One main difference of the results in this measure from the measure of *total text produced* was in the overlaps between the datum points of the three conditions during intervention. Overall, all four students produced text with more T-units via the diction writing modes (either SR or DR) than handwriting mode.

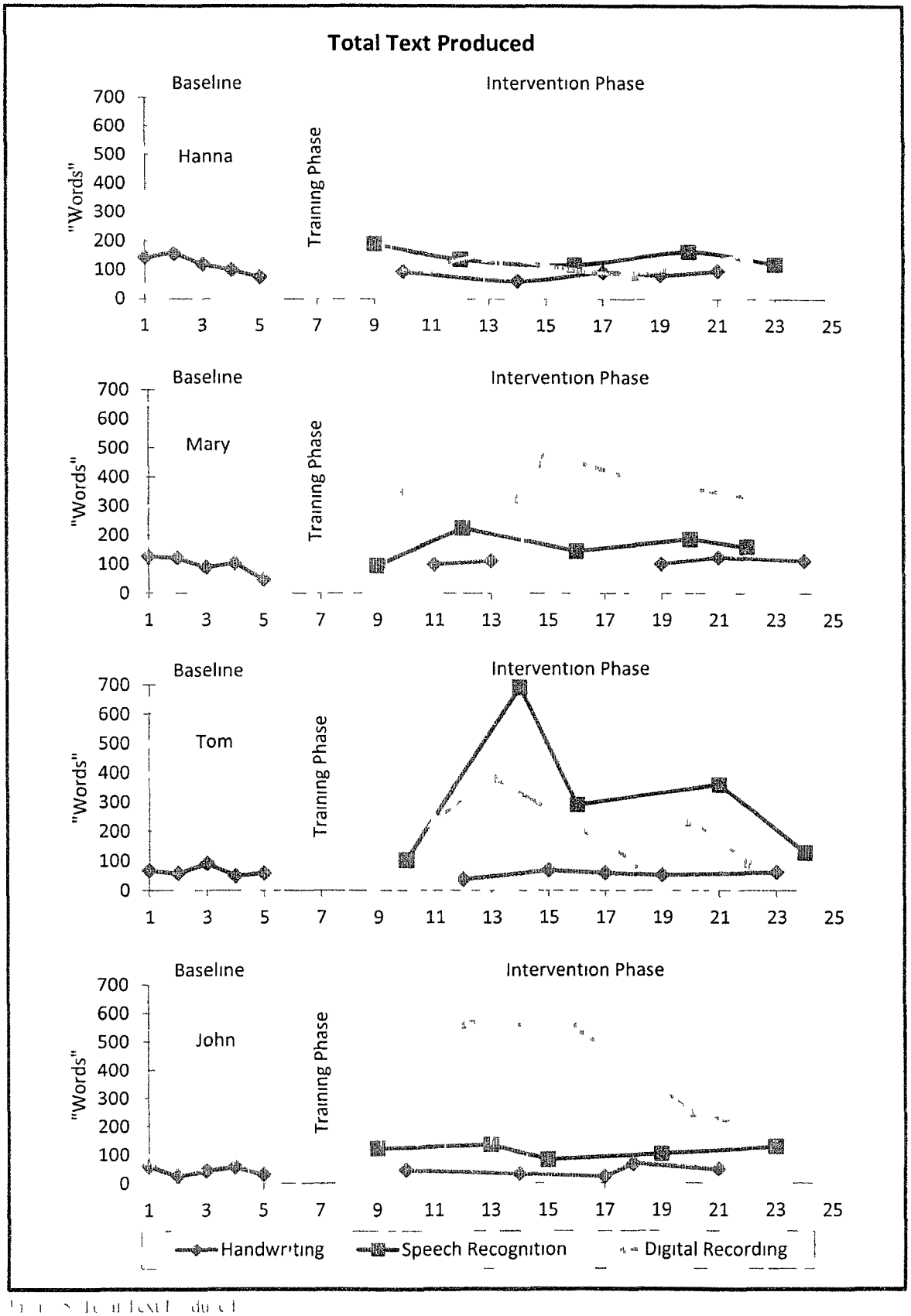
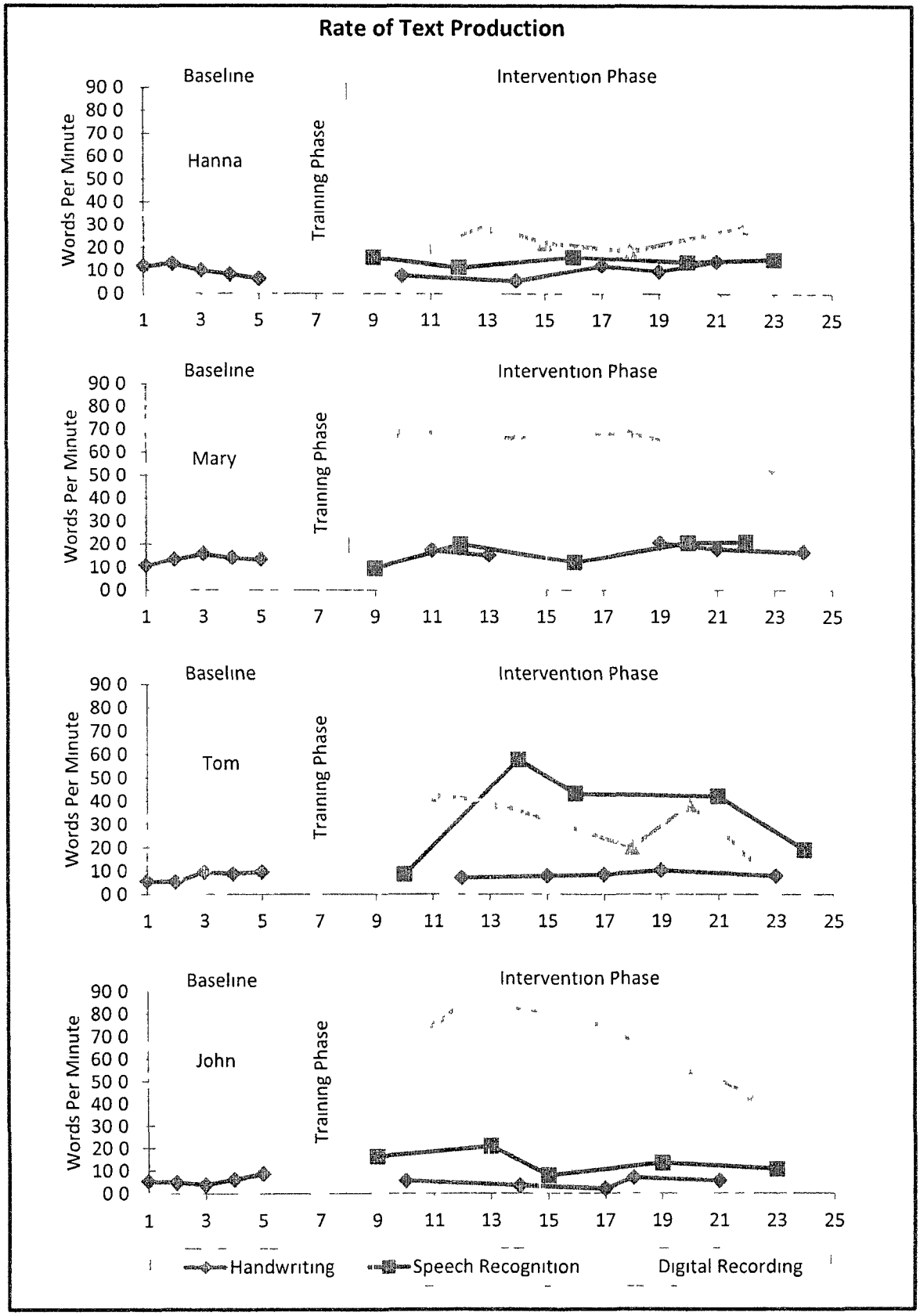


Figure 5. Total text produced


Rate of Text Production
Baseline
Intervention Phase
Training Phase
Words Per Minute
Hanna
Mary
Tom
John
90 0
80 0
70 0
60 0
50 0
40 0
30 0
20 0
10 0
0 0
1 3 5 7 9 11 13 15 17 19 21 23 25
Handwriting
Speech Recognition
Digital Recording

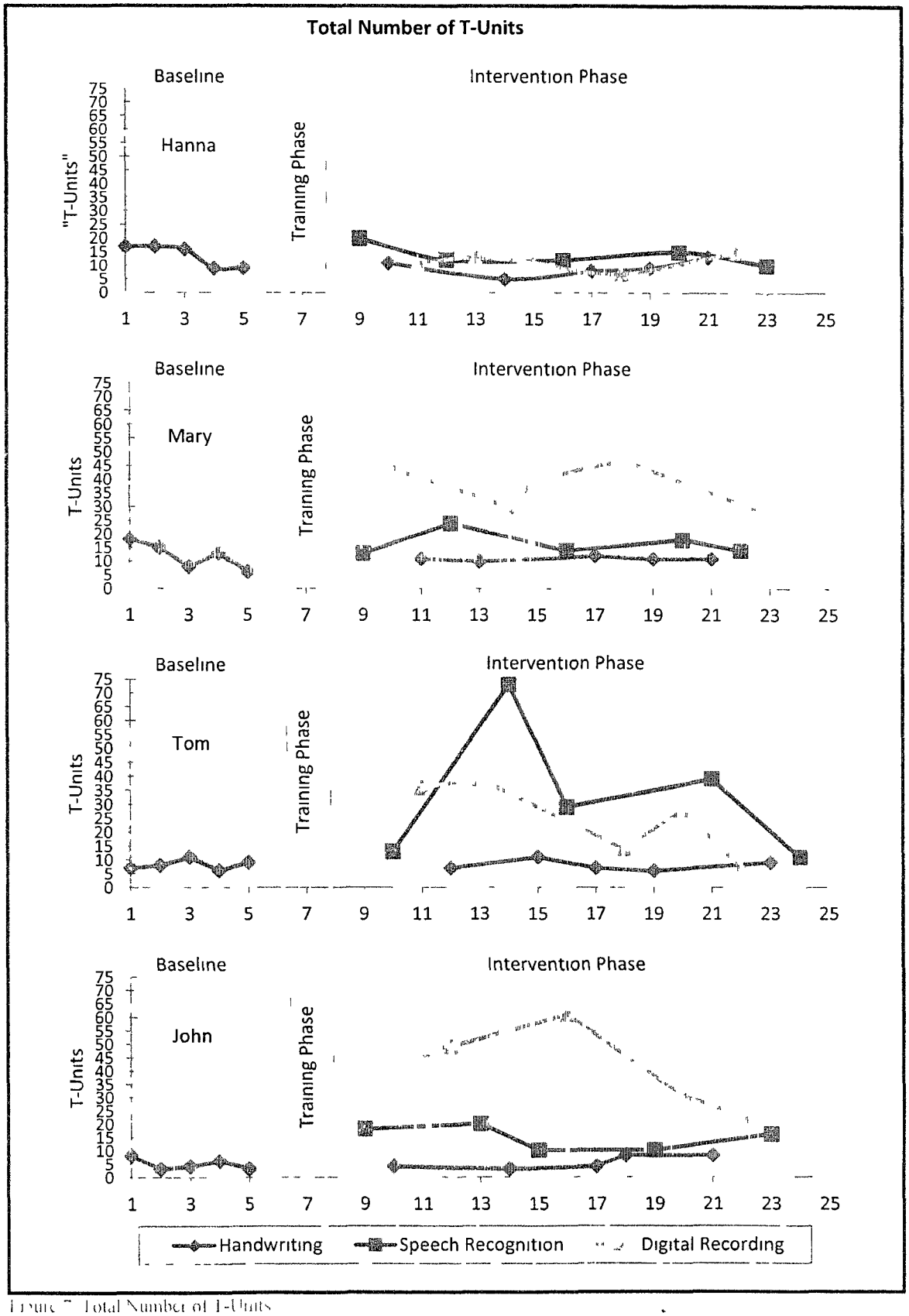


Figure 7. Total Number of T-Units

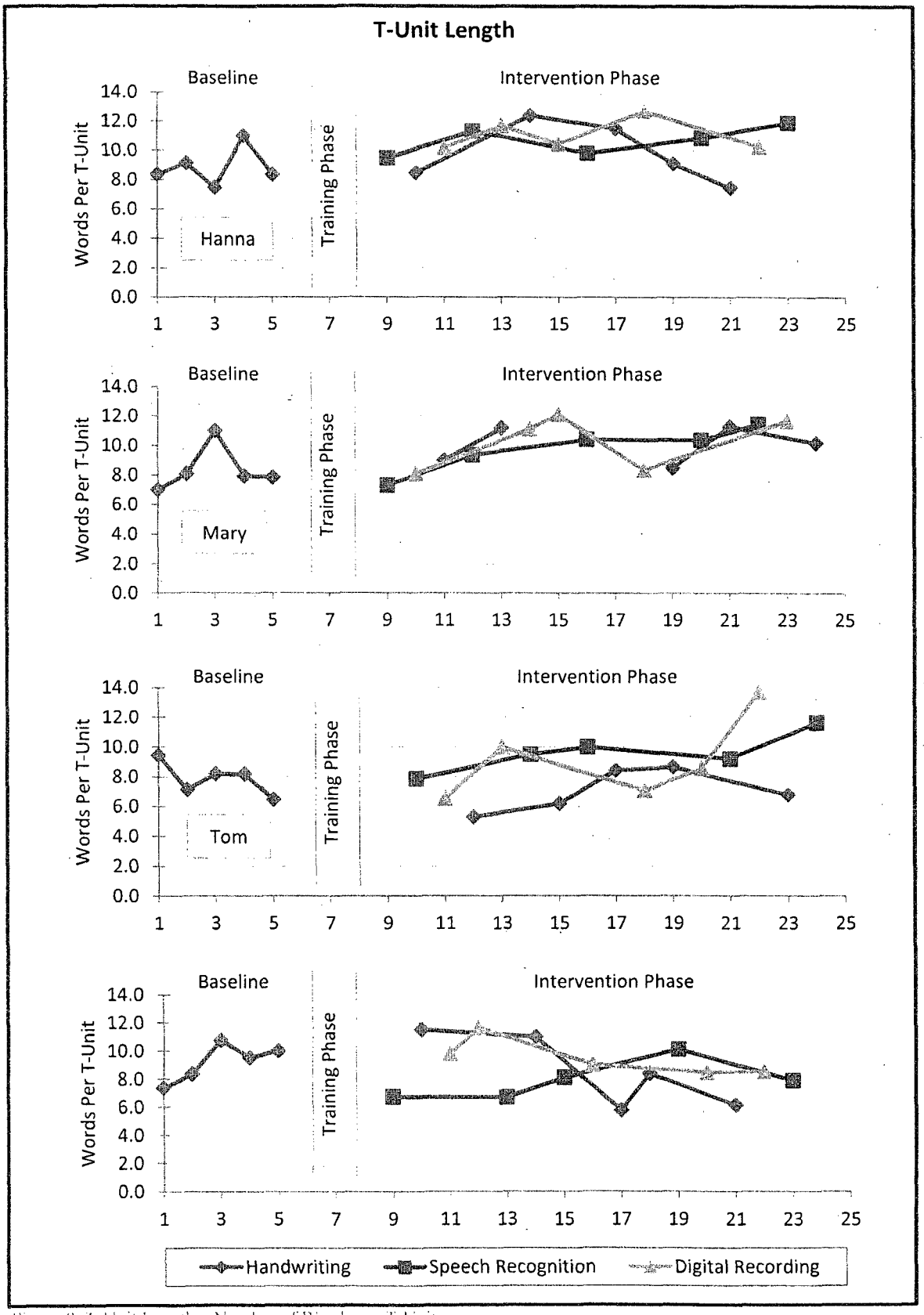


Figure 8. T-Unit Length - Number of Words per T-Unit

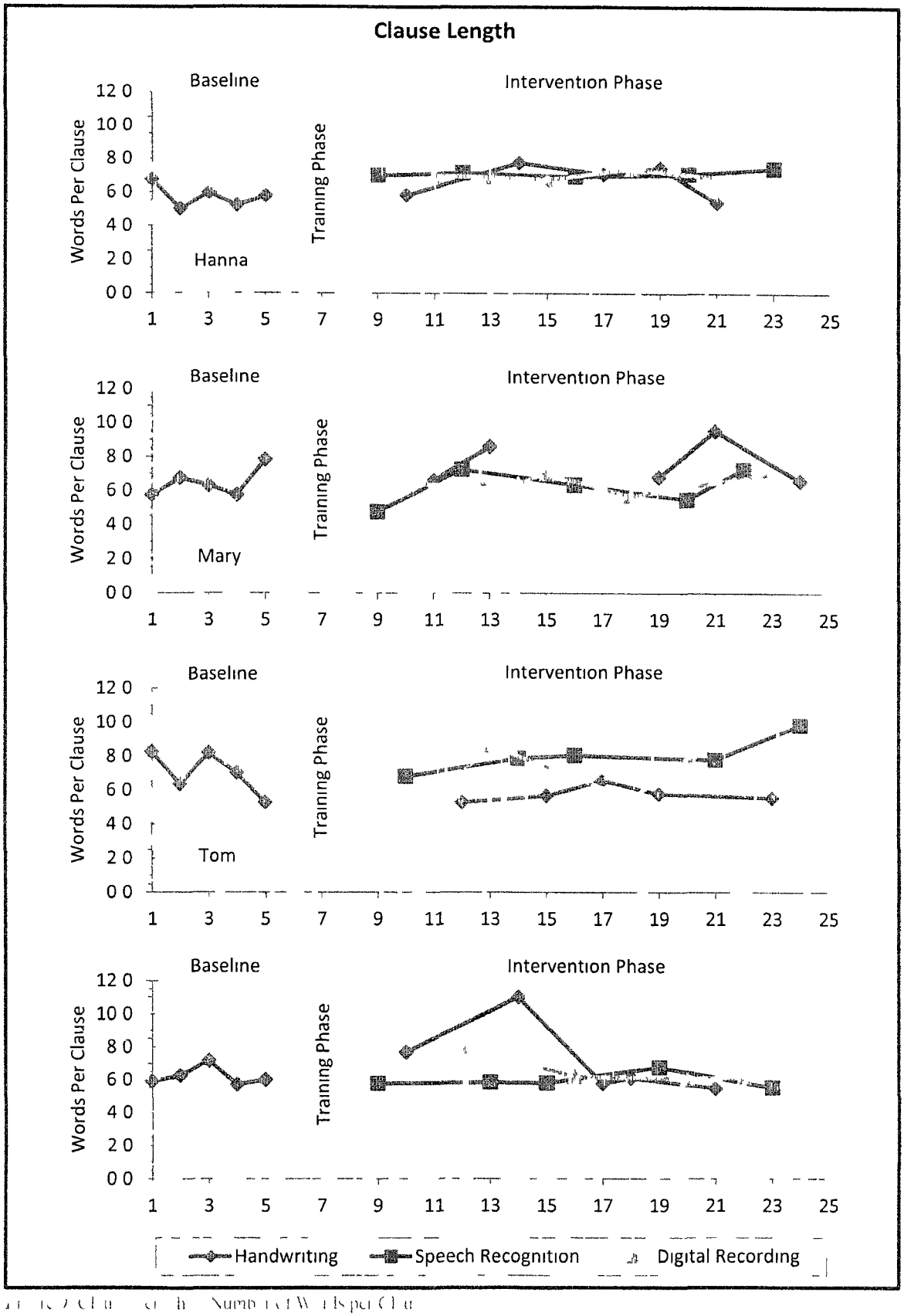


Figure 2 Clause Length: Number of Words per Clause

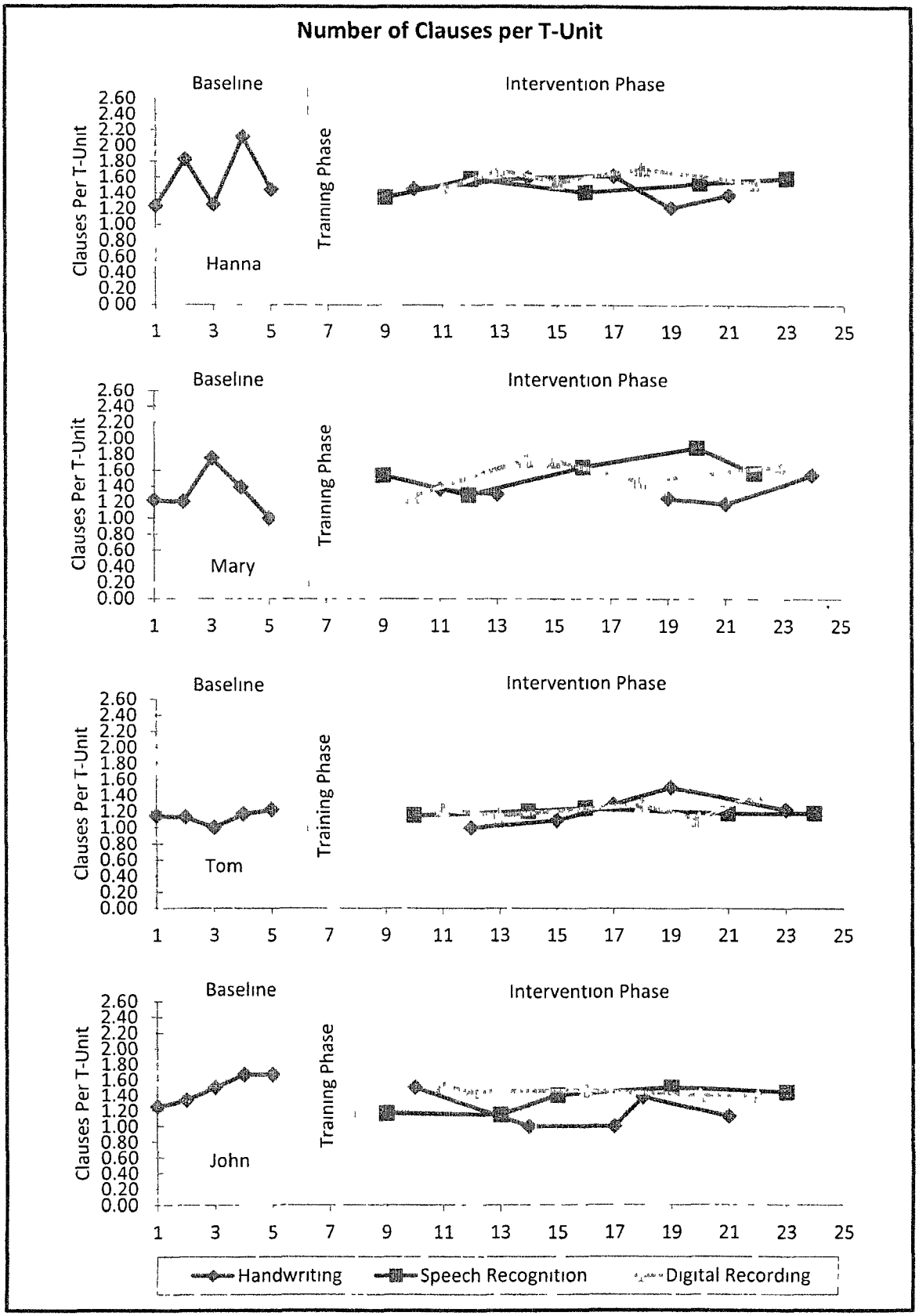


Figure 10. Number of Clauses per T-Unit

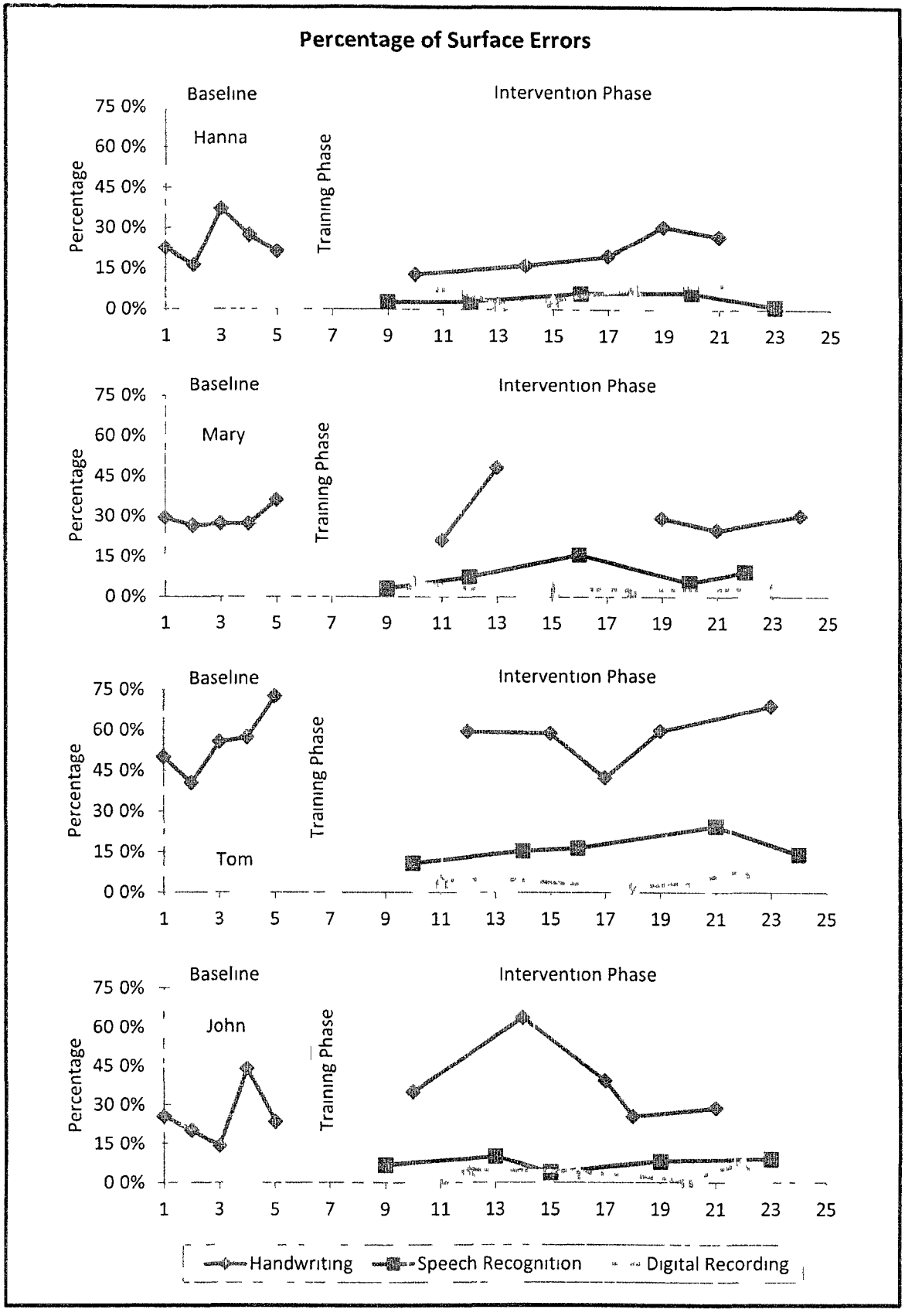


Figure 11 Percentage of Surface Errors

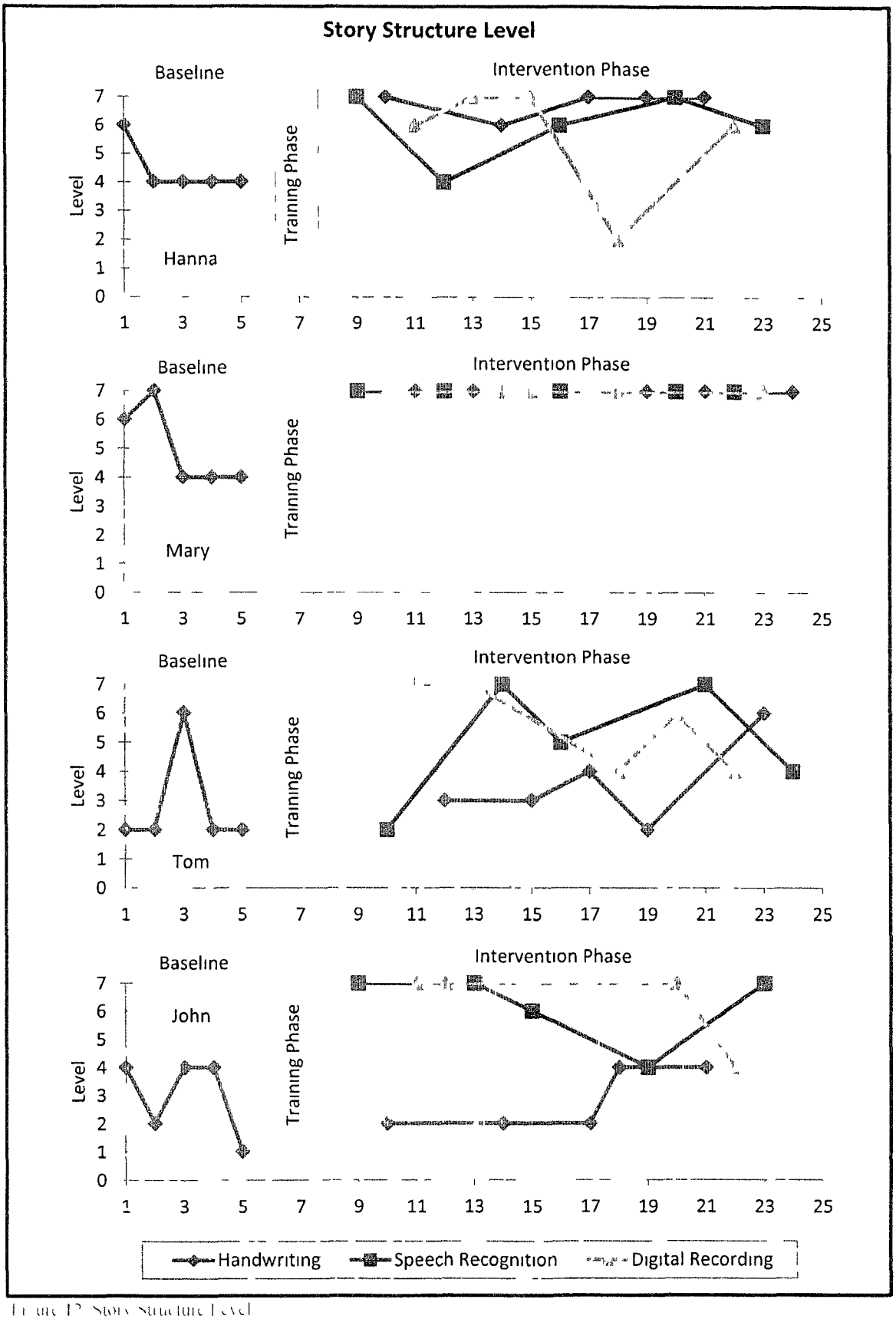


Figure 15 Story Structure Level

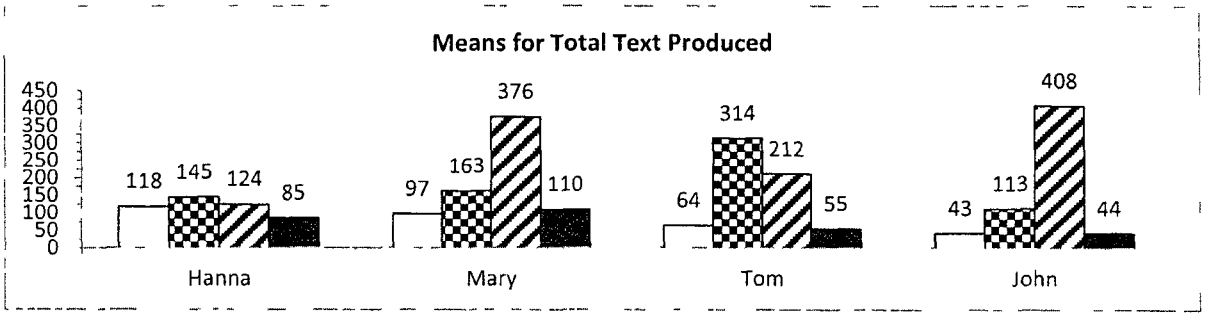


Figure 13 Means for Total Text Produced by Subjects in All Conditions

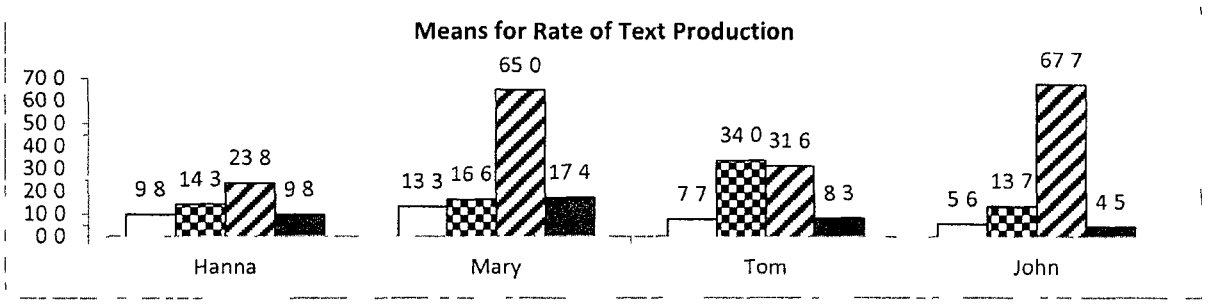


Figure 14 Means for Rate of Text Production by Subject in All Conditions

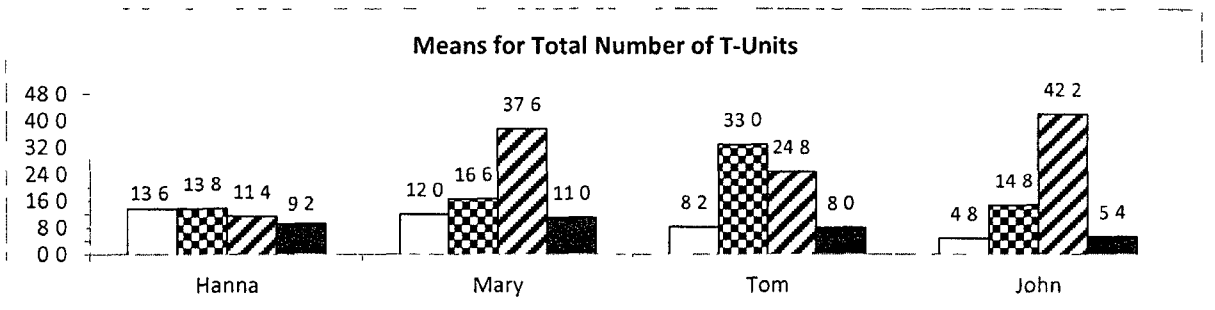


Figure 15 Means for Total Number of T-Units by Subjects in All Conditions

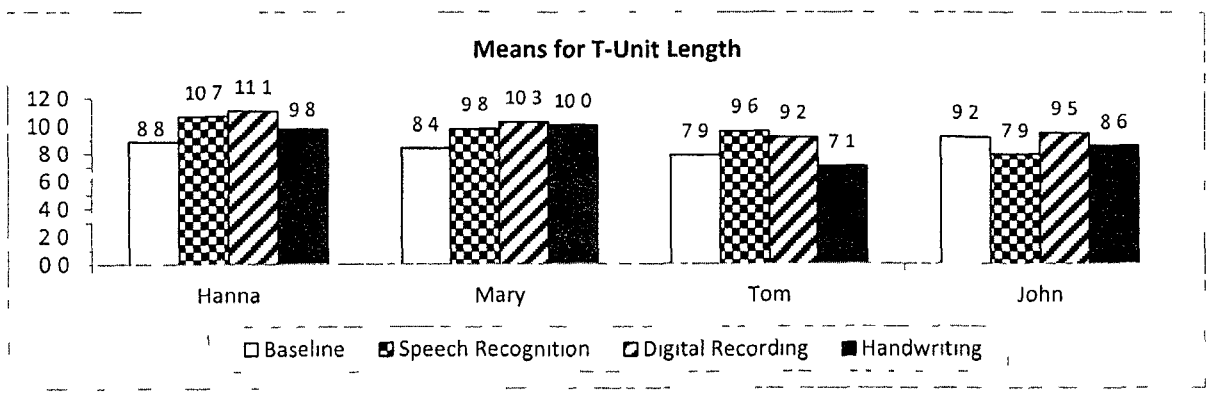


Figure 16 Means for T-Unit Length by Subjects in All Conditions

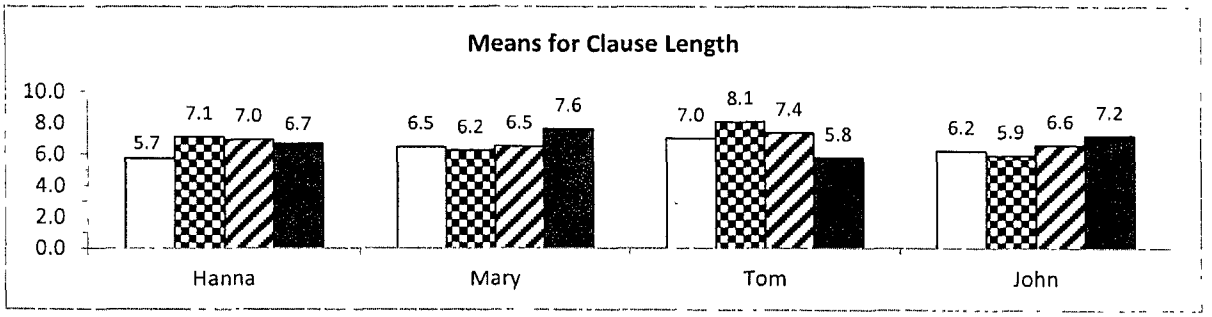


Figure 17 Means for Clause Length by Subjects in All Conditions

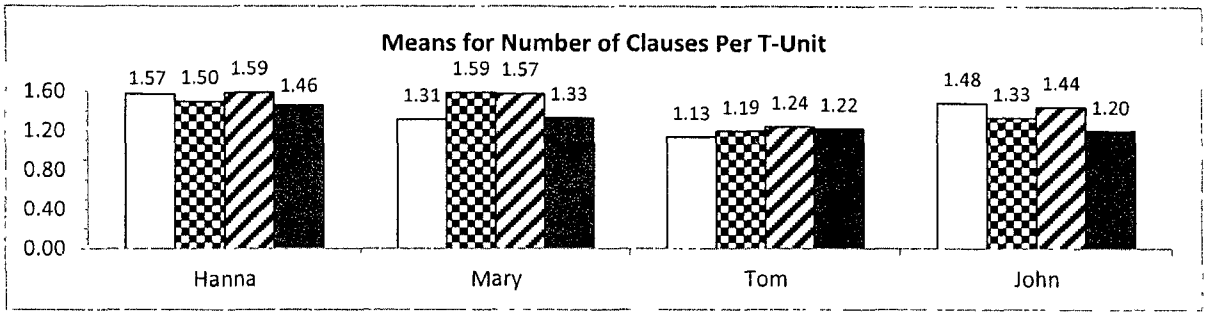


Figure 18 Means for Number of Clauses per T-Unit by Subjects in All Conditions

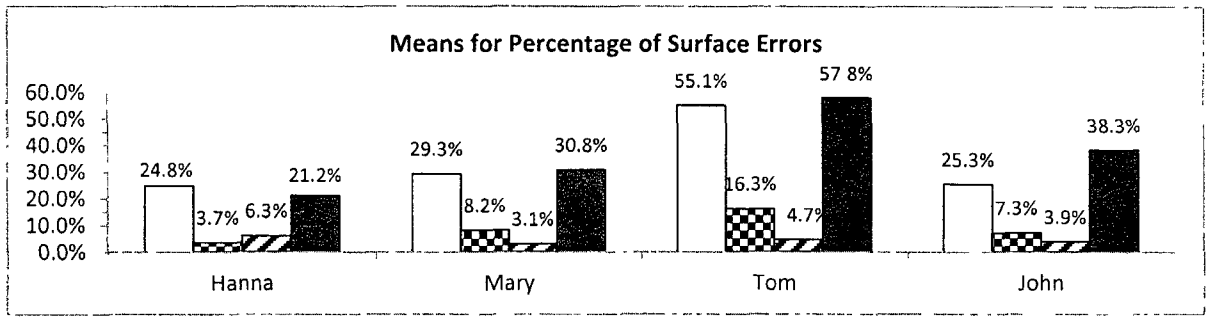


Figure 19 Means for Percentage of Surface Errors by Subjects in All Conditions

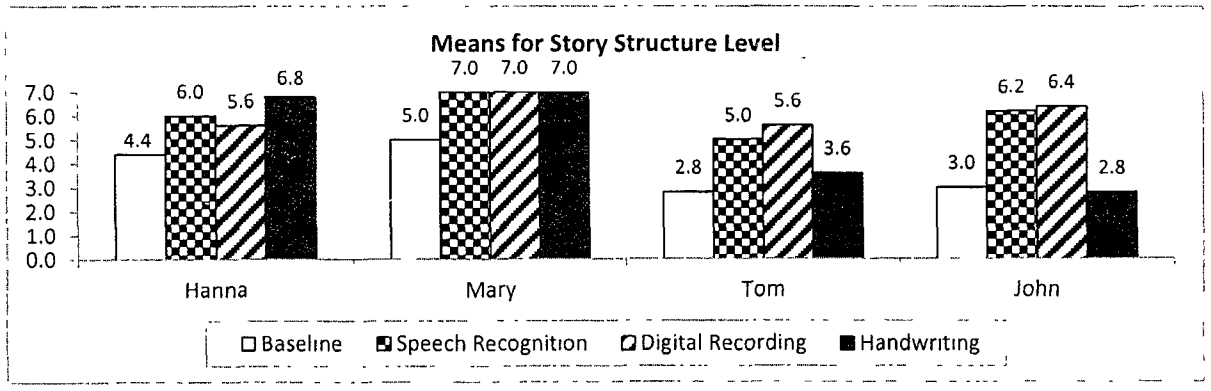


Figure 20 Means for Story Structure Level by Subjects in All Conditions

Analysis of Writing Quality

Four of the measures, *T-unit length, clause length, number of clauses per T-unit, percentage of surface errors,* and *story structure level*, measured the students' overall quality of writing in the baseline phase as well as the three different conditions (HW, SR, DR) in the intervention phase.

T-Unit Length

T-unit length (wpt) is the total number of words divided by the total number of T-units (Klecan-Aker & Brueggeman, 1991). Figure 8 shows the length of T-units, and Figure 16, the means or averages for the length of T-units in the text produced by each student in all text production modes across phases.

All four students had a stable baseline with little trend and relatively consistent performance. Tom's baseline appeared to have a more obvious decreasing trend, and John's, more increasing trend than other students. The students generally produced text with longer T-units in their intervention phase than their baseline. One exception was John, who had more than half of his intervention sessions below his mean T-unit length in baseline (9.2 wpt).

During the intervention phase, only Tom demonstrated clear improvements in his T-unit length under SR condition with no overlap between those datum points and his HW condition during intervention. None of the other students had a consistently longer T-unit in any one condition than another, meaning every condition had some degree of overlap with another in their respective datum points. The students generally showed no obvious level difference in their T-unit length among the three conditions; in contrast, they showed a more obvious increasing trend in their SR condition than other conditions (except Tom, whose DR increasing trend appeared slightly more obvious than his SR's). As for the means of T-unit length during intervention, all students (except Tom) had their longest T-unit mean in DR

condition, and Tom, in SR condition; all students (except John) had their lowest mean in HW condition, and John, in SR condition.

Overall, the students made mild improvement from their baseline T-unit length during the intervention phase as they wrote slightly longer T-units during intervention sessions than baseline (except John). The students also had their longest T-units in either one of their dictation conditions. The variation of text production modes appeared to have little to mild effect on the T-unit length in the text for the students.

Clause Length

Clause length (wpc) is the total number of words divided by the total number of clauses. Figure 9 shows the length of clauses, and Figure 17, the means or averages for the length of clauses in the text produced by each student in all text production modes across phases.

All four students had a stable baseline with little trend and relatively consistent performance. Tom's baseline appeared to have a more obvious decreasing trend than other students. The students generally showed no consistent improvement or regression from their baseline to their intervention phase. One exception was Hanna, who had the majority of her intervention sessions above her mean clause length in baseline (5.7 wpc).

During the intervention phase, only Tom demonstrated clear improvements in his clause length under SR condition with no overlap between those datum points and his HW condition during intervention. None of the other students had a consistently longer clause in any one condition than another, meaning every condition had some degree of overlap with another in their respective datum points. The students generally showed no obvious level difference, which was mostly in the range of 5-7 wpc, and had little trend difference in their clause length among the three conditions. The few exceptions, such as the length of 11 wpc at John's 2nd HW intervention session, were oftentimes resulted from a relatively smaller total number of words along with a relatively smaller total number of clauses. Also, a

decreasing trend in John's HW condition was relatively more obvious than other students' during intervention. As for the means of clause length during intervention, Hanna and Tom had their longest clause mean in SR condition and lowest in HW whereas Mary and John, the opposite, meaning their highest in HR condition and lowest in SR.

The results of this measure generally reflect those for the *T-unit length* in Figure 8 and Figure 16. A couple main differences in the results between the two measures were that the *clause length*'s had milder trend differences within individuals and across conditions than the *T-unit length*'s, and that less students improved from their baseline to intervention for the *clause length* than *T-unit length*. Overall, the variation of text production modes appeared to have little effect on the clause length in the text for the students.

Number of Clauses per T-Unit

Figure 10 shows the number of clauses per T-unit (cpt), and Figure 18, the means or averages for the number of clauses per T-unit in the text produced by each student in all text production modes across phases.

All four students had a stable baseline with little trend and relatively consistent performance. The students generally showed no obvious difference in trend and level among the three conditions and between the baseline and intervention phase. The one exception was John, who had a consistently higher number of cpt in DR condition with no overlap between those datum points and the HW condition during intervention.

One general guideline for T-unit analysis is that clauses per T-unit should be no less than 1.3 (Klecan-Aker & Brueggeman, 1991). In view of the means, Hanna and Mary were above the risk level of 1.3 cpt in all conditions across phases, and John, too, except the HW condition in intervention; in contrast, Tom was below the risk level in all conditions across phases. The magnitude of the means among the conditions mostly varied from one student to another. The only pattern was that all students had their lowest mean of cpt in their handwritten text (either at baseline or intervention phase), and none of them had their lowest

in their dictated text. Specifically, Mary and Tom had their lowest mean when they handwrote their text at baseline whereas Hanna and John had theirs when using the same text production mode at intervention. Further, Hanna had all of her SR and DR sessions above the risk level, Mary, almost all of her SR and DR sessions, and John, all of his DR sessions whereas Tom had almost all sessions (for both baseline and intervention) below the risk level.

Overall, all students (except Tom) had the majority of their number of cpt above the risk level. Also, the students were less likely to produce text at a lower number of cpt in the dictation writing modes than the handwriting mode. The variation of text production modes appeared to have little effect on the number of clauses per T-unit in the text for all students.

Percentage of Surface Errors

The percentage of surface errors was generated by dividing the number of surface errors by text length. Figure 11 shows the percentage of surface errors, and Figure 19, the means or averages for the percentage of surface errors in the text produced by each student in all text production modes across phases.

All four students had a stable baseline with little trend and relatively consistent performance, and Tom appeared to have a more obvious increasing trend than other students. During the intervention phase, all students had a consistently higher percentage of surface errors in HW condition than the other two conditions, and the percentage was consistently higher in SR than DR condition only for Tom. All of these observations above had no overlap between their respective datum points. The students generally had a higher percentage of surface errors in HW condition (at both baseline and intervention) than the dictation conditions, and the percentage in SR's was generally higher than DR's.

As for the means of surface error percentage, all students had their highest mean in HW condition, and lowest in either SR or DR condition. For Hanna, her mean in HW intervention condition was about six times more than her SR's and over three times more

than her DR's; for the other three students, all their means in HW intervention condition were about three to five times more than their SR's and around 10 to 11 times more than their DR's. That is, only Hanna had her lowest mean in SR condition whereas other students had theirs in DR. Hanna also had the lowest mean in every condition (except in DR) among all the students whereas Tom, the highest. That means Hanna generally showed the least difficulties in the mechanical aspect of writing among all the students and Tom, the most. Further, only Hanna had a lower mean in the intervention HW condition than the baseline whereas others did not. This indicated that most students did not improve on the mechanical aspects of their handwritten narratives during intervention.

Overall, all four students produced text with a lower percentage of surface errors via the dictation writing modes than handwriting mode, and the difference was particularly notable between DR and HW mode. The variation of text production modes appeared to affect the mechanical aspect of writing or the percentage of surface errors in the text for all students. The results of this measure also significantly illustrate the unique traits of each text production mode.

Story Structure Level

Figure 12 shows the story structure level, and Figure 20, the means or averages for the story structure level of the text produced by each student in all text production modes across phases.

All four students had a stable baseline with little to no trend and relatively consistent performance. Tom's baseline showed no trend whereas the other students' appeared to have a mild decreasing trend. Hanna and Mary started their sessions and were on average producing text at a higher story structure level than Tom and John and within themselves in the baseline. The students generally produced text at a higher story structure level in the intervention phase than the baseline. One exception was John, who appeared to have a slightly higher mean level in his baseline phase than his HW condition in intervention.

During the intervention phase, none of the students had a consistently higher story structure level in any one writing condition than another—Every condition had some degree of overlap with another in their respective datum points. Mary's intervention phase was a complete overlap with no trend as her story structure scored at level 7 in all intervention writing sessions; John's, in contrast, had the least degree of overlap among the conditions as the story structure level of his DR and SR condition were both consistently higher than his HW's with only one respective datum point at the same level in between. As for the means of story structure level during intervention, Tom and John had their higher mean level in dictation writing conditions (both DR over SR) than HW condition; Hanna, on the other hand, had a higher mean level in HW than dictation conditions, and Mary, no differences among the three intervention conditions.

Overall, the students improved from their baseline story structure level during the intervention phase. All students had their average story structure above level 5 in both dictation conditions whereas their average level in HW condition varied, ranging from a level lower than 3 to top 7. The variation of text production modes appeared to have little to mild effect on the story structure level for the students.

Summary

The results of the measures for writing fluency, i.e., *total text produced*, *rate of text production* and *total number of T-units*, showed that the students generally produced more text, had a higher text production rate and higher number of T-units via the diction writing modes than handwriting mode. During the intervention phase, all students consistently produced more text and consistently had more T-units (except Hanna) in SR than HW condition; all students consistently produced more text (except Hanna) and consistently had a higher text production rate in DR than HW condition; Mary and John consistently performed better in all three measures in DR condition than the other two conditions whereas Tom, consistently better in SR than the other two conditions—All these observations above had no overlap between their respective datum points. Among the results of the three measures, DR

condition appeared to have the strongest consistency in getting a higher text production rate for all students.

Additionally, the results of the measures for writing fluency showed that all four students had a relatively stable trend during baseline phase. Hanna and Mary began their baseline sessions and were on average having relatively higher quantity of text and T-units as well as higher production rate than the other two students and within themselves. During the intervention phase, all students (except Hanna) showed a decreasing trend in all three measures for the DR condition. That is, when the students regressed on their total text and total T-units produced in the DR condition, their rate of text production in the same condition also regressed. Also, all students showed an increasing trend in both *total text produced* and *text production rate* for their HW condition during intervention. That is, when the students improved on the quantity of their HW text during intervention, their HW rate tended to improve as well. One explanation for this result is that the dictation intervention might have helped improve the students' handwriting quantity and rate since the students were more confident in composing text with the technology application and the effect carried over to their handwriting performance.

For writing quality, the measures included syntactic complexity (*T-unit length*/ wpt, *clause length*/ wpc, and *number of clauses per T-unit*/ cpt), writing mechanics *(percentage of surface errors*), and writing structure (*story structure level*). The results showed that the variation of text production modes had little to mild effect for the students in the measures of syntactic complexity and story structure level. Only the results for the mechanics of writing showed the effect, which significantly illustrated the major differences among the three text production modes for the students. During the intervention phase, all students consistently produced text with higher percentage of surface errors in their HW than their dictation conditions; in contrast, none of the students but Tom consistently produced text with longer T-units and/or clauses in any one condition, and Tom's was only consistently longer in his SR condition than his HW; none of the students but John had a consistently higher level of

story structure in any one condition, and John's was consistently higher (with one datum point doubled for each) in his DR and SR condition than his HW—All the above observations with one writing condition being consistently different than another had no overlap between their respective datum points.

Like all the measures for writing fluency, the students had a stable baseline with little trend or relatively consistent performance in all the measures for writing quality. Also, the results of *percentage of surface errors* reflected those of writing fluency. Other than these two observations, no significant similarity was found between the results for writing quality and writing fluency, particularly in terms of level change or degree of overlap among the datum points during intervention. Hanna and Mary, who generally started their baseline sessions with higher performance in all measures for writing fluency and the measure of story structure level, did *not* necessarily have a higher baseline in the measure for syntactic complexity than the other two students. During the intervention, however, Hanna and Mary had higher averages on their T-unit length (all above 8 wpt) and their number of clauses per T-unit (all above 1.3 cpt) than the other two students.

In summary, the variation of text production modes appeared to have a notable effect on the fluency and mechanics aspect of writing for all four students, and have a little to mild effect on the syntactic complexity and story structure level of writing.

Chapter V: Discussion

This study investigated the impact of two dictation writing modes on the writing performance of four elementary 4th graders with LD. The main question addressed by the study was whether these struggling young writers with LD could produce text with higher quantity/fluency and/or better quality under a dictation mode using normal speech-to-text technology of SR software, or dictation mode using a digital voice recorder along with modified, monitor-off/text-free SR software than under the traditional paper-pencil mode. The results showed that both SR and digital voice recorder modes generated text that was superior to the handwriting mode for these children with LD. Their dictated narratives were rated notably superior in terms of length, production rate, number of T-units, and percentage of surface errors. This reduced output due to handwriting is not limited to the 9-year-old, young elementary children with LD in the present study. Older students with LD or poor writers at middle school level (Graham, 1990; MacArthur & Graham, 1987; Quinlan, 2004; Reece & Cumming, 1996) and at the postsecondary/college level (Higgins & Raskind, 1995) have also been found to produce handwritten texts that were both quantitatively and qualitatively inferior to their dictated texts.

Dictation writing modes may not greatly affect the composing of skilled writers and/or older typical developing children (MacArthur & Cavalier, 2004; Quinlan, 2004), but it clearly mattered for younger, struggling writers with LD such as those in the present study. Similar to what Quinlan (2004) found in his SR study for the 11-14 year-old, less fluent writers, the SR narratives composed by the 9 year-olds with LD in the present study had notably more words, T-units, higher production rate, and fewer surface errors than their handwritten narratives. SR apparently alleviated the mechanical demands in writing, specifically the transcription-related interference, and perhaps has freed working memory resources for higher fluency in text production. These notable effects in the SR condition were found even at a higher level in the DR condition. Having children normally dictate their writing to a digital voice recorder eliminated children of the requirement of operating the SR

program, and resulted in a greater effect in enhancing the children's writing fluency, particularly for the text production rate. However, similar to SR condition, this notably higher rate of text production *did not* produce a notably better syntactic complexity and/or story structure level.

Although both dictation conditions showed small effects in improving the overall syntactic complexity and structure level of narratives in the present study, a strong relationship between writing mode and writing mechanics suggested that increased fluency in the dictation modes may eventually contribute to better story quality and story development. This suggestion seems reasonable based on the results that all students in the present study had their longest T-unit in either one of their dictation conditions, and they were less likely to produce a lower number of clauses per T-unit in their diction conditions than their HW condition. Also, the average level of story structure in their dictation conditions was more consistently above level 5, with a less degree of discrepancy than their HW condition. Compared to dictation writing, a major inefficiency of handwriting is the constraint of translating narrative ideas into text, which could result in shorter and less developed stories (Quinlan, 2004). When this transcription bottleneck of handwriting is reduced in the dictation conditions, it may allow the working memory to focus on the higher-level components in the writing process. The students, as a result, are most likely to improve their text-generation fluency and efficiency, which could lead to more narrative ideas and better developed stories. That is, the improvement of writing fluency, which has generally been found significant, could lead to a longitudinal effect on overall writing performance (Graham et al., 2002).

Although the dictation writing fluency may have contributed to the writing quality, the positive effect of the SR dictation mode, in particular, may have been undermined by critical factors such as the student's familiarity with the SR program, the reading requirement, and error correction of the SR text transcribed. These were also factors that generally differentiated SR from DR dictation mode. Comparing the results of the two dictation modes, we found that the more SR error corrections that the students had to make, the less text

quantity was produced and there was no substantial difference observed in quality of the dictated text. This relationship suggests that the extra requirement of SR program during the writing process apparently distracted the students' writing fluency but not their writing quality. Hence, when children become more experienced users of the SR program, they may be less distracted by the recognition errors, the program's recognition accuracy will be higher, and more improvement in their writing quality could be expected.

Additionally, SR is a more practical and beneficial alternative to handwriting than DR for the young struggling writers with LD. While substantially reducing the number of surface errors like the DR mode, SR promoted the writers' independence by eliminating their reliance on a human scribe in the DR mode, and further provided more readable, immediately accessible and revisable narratives. About surface errors in particular, the results showed that spelling was evidently a problem for those young writers with LD as the spelling errors in their handwritten text on average ranged between 20% to over 50%. Spelling requires orthographic and phonological skills (Graham et al., 2002; Margolin, 1984), and the graphemic formation of words increases the difficulty of handwritten transcription (Quinlan, 2004). The speech-to-text feature of SR eases the mechanical demands in writing such as spelling, but the orthographic challenge of identifying and correcting recognition errors remains. In the present study, all four children, similar to both the fluent and less fluent writers in Quinlan's (2004) study, frequently encountered and corrected recognition errors. The correction frequency, as observed during the data collection process, was on average at least once for every two sentences. Tom was an exception among all four students since he decided to ignore most recognition errors starting from his 2nd SR session, which contributed to a higher number of syntactic errors than other students. The frequency of recognition error correction generally suggests the novelty level of this SR technology to the children.

While it takes time and practices for the children to become adroit SR users, the process of improving recognition accuracy can be constructive in improving the students' spelling and reading proficiency. For example, starting from the 2nd SR intervention session,

John would whisper read the SR transcribed text to check recognition errors whenever he finished dictating one sentence or two. Then, he would quickly find the errors, voice command the program to select that word, and replaced it with a proper word suggested in the drop-down list. These independent reading and error correction behaviors were not observed prior to the intervention or even during the SR training when John would either avoid reading and ignore the errors or seek the author's answer to the right word from the word list. This bonus beneficial effect of SR writing to the students' reading improvement was also found true in Raskind & Higgins's (1999) study, where its SR group showed significantly more improvement than the control group in word recognition, spelling and reading. Evidently, the students with LD benefited not only by trading frequent handwritten spelling errors with less frequent SR errors (Quinlan, 2004) but also the highly probable remedial effects of the SR error correction function to their spelling and reading proficiency.

Fluency in SR error correction takes time and practices, but ironically, we cannot deny the relative role of these experience-related factors when considering the substantial performance discrepancy between SR and handwriting. For the time factor, those children came to the study with around 3 or 4 years of formal experience in handwriting, yet a mere 2 hours (in 3 or 4 sessions) of SR instruction and practices provided them with a more fluent and accurate mode of text production, despite the new mechanical demands of recognition error corrections. Also, the children's handwriting fluency prior to the intervention did not appear to be a major factor in determining the positive effects of SR program. For example, Hanna, the student who appeared most comfortable with handwriting tasks among all the four study participants, appeared to make the least notable gains in her dictation narratives, particularly in terms of the writing fluency. In contrast, Tom and John, who on average produced handwritten narratives at a less quantity and with a lower story structure level than the other two students across phases, also on average produced text with notably higher quantity and quality or showed notably better writing performance in their dictation writing conditions. This confirmed with findings in previous studies (e.g., MacArthur & Cavalier,

2004; Quinlan, 2004) where fluent writers appeared to benefit less from the dictation style of writing than the dysfluent writers.

Overall, the dictation intervention benefited all four students in the present study. The narratives below exemplify the fluency and quality effects of both SR and DR dictation modes, in comparison to the handwriting mode.

Handwritten narrative: one day a thing was walking over a brig and he saw for ether things. one was bigger than him he was scard and then they killed him and they went mwahaha. but that is to bad becaus he was cut. they killed him for no reasun. the end!!!

SR narrative: One day a boy was walking through the park and he saw two birds. He said, "those are two big birds." And he kept on walking. And then he said, "wow, it would be cool to have those birds" and then he heard somebody talking to him and he walked back and the birds were talking to him. And they said, "what you doing kid" "nothing," "okay." And then the kid kept walking. He said to himself, "wow," and then he went home and need to connect anyone dared how were those birds so big. Then he went to sleep and in his dream. The birds were there and he got scared. He was so scared he said this "I have to go pee" the end.

DR narrative: Once there was a little guy named Toad. He, it was his birthday. He gave a gift to himself. He was like "oh I am so spoiled!" That what he did is he gave a present to himself, and over the years, he kept giving presents to himself like see that crown on his head and like see, like the walker in his hand and see the cape and he'll bec he got all those things because he was so rich, and every but every year, people had to give him presents for all his birthdays and he didn't have just one he had millions! Ok, maybe not millions but he had lots. One day he was playing in a swingset and then he realized it was his 15th birthday. Woah. And then what he wanted to do was climb up a hill and go buy himself a bike, so he ordered it, and he ordered it because he wanted it to be a surprise for when it'll come for himself. So then when it got here he was like this is the size of a bike? What the? And then he opened it and it was a Little Miss Muffet Doll. Wee! So what he did was he took it outside with his BB gun and he shot it up and blew it to smithereens. Then he went out and bought that bike he wanted. Hee hee hee! And then the next day, he was kind of sad, we don't know why, but he then he told me that he that he fell into a swamp . He was so gooey and when he got home his mom yelled at him and he had to go up into his room. Noooo! So then he was really sad. And then he bought himself another Barbie doll. This one wasn't for shooting with his BB gun. This one was for...I don't know.

but he'll tell us later. Hee hee! So when he went to the park he was swinging on the swings, and then a little girl came up. She was the sweetest girl he had ever seen, but then he started yelling at her for no reason. She was what like wah! And then she cried home to her mommy. She was like this mommy, mommy this bad, dad toad was yelling at me. He made me cry. That wasn't very nice was it? No it wasn't little Aggie. No. And then they went down to him and they punched him in the mouth and red and green and every color in the whole world splattered everywhere except from the people who ran into him, and then it started raining. It was actually God trying. He was mad and then quite sad at that guy. Dun dun dun wee! Bye!

All three narratives were composed by John, via handwriting, SR, and DR. These narratives generally approximated norms of the performance discrepancy among the three writing modes for the four students in terms of length, story structure, and surface errors. At first glance, a prominent difference among the three narratives was the length. In addition to being shorter, the handwritten narrative had many more misspelled words. Similar to children's invented spelling, these misspellings may be decoded with relative ease, but they do detract from the readability of the text. Another noticeable difference among these narratives was the extent of story grammar components which defined the level of story structure. The stories produced via SR and DR were not only longer but also included more background and details. For example, in the SR narrative, the size of the two "big birds" caught the boy's attention initially, and then the boy later exclaimed "wow" when the birds started to talk to him. Expression of the internal states of the character animated the storyline and enriched the complexity level of the narrative. In contrast, the handwritten narrative was less developed and consisted less details about the events and/or the characters. Judging from the narrative of both DR and SR, there is no doubt that John had the ability to compose better structured and more developed stories. Apparently, the handwriting inefficiency can be so severe for the students with LD that it constrains the transcription fluency and idea generation. With a more fluent mode of writing expression, such as SR or DR, these students are most likely to have better writing performance.

Limitations of the Study

This study has a number of rather conspicuous limitations. One limitation of the present study is that the type of participants was restricted. In order to exclude other variables, the teacher-researcher only included students without prior experiences in the speech recognition software, native English speakers to implement the present study. However, since the sample is restricted to a certain set of characteristics, the results cannot be broadly generalized. (From another perspective, this limitation is also a value of clinical oriented study as the present study since in reality students with LD who also demonstrated severe writing difficulties are often the exceptional few from the norm.) Another limitation is that there was not enough time for the students to practice using the dictation software. SR dictation writing with the Dragon software at less than two times a week during the three weeks of intervention was not a long enough period of time to recognize full development in writing fluency and particularly writing quality. Also, this study did not include extensive training in the use of speech recognition. The students received approximately 2 hours of individual instruction on training the software to recognize their speech and using it to compose stories. Guidelines for assistive technology specify that the technology should be used regularly for academic work in school and at home. If students had been using speech recognition on a regular basis, their recognition accuracy and/or writing performance might have been better.

Due to the type of research questions in the present study, the research method of alternating treatment design (ATD) was a proper choice. However, ATD is generally not meant to be a longitudinal type of research method so another type of research method, such as multiple baseline or ABAB design, is suggested to investigate whether the long-term effect of the dictation writing practices would have on the students' improvement in writing quality. Besides, the writing syntax measurements of clause length and T-unit length may not be sensitive to measure the intervention effects for younger writers with LD. It would be better to make use of some other assisted measurement. This is also discussed in the *The*

Expression Connection program (Klecan-Aker & Brueggeman, 1991)—"T-unit or clause length is *NOT* addressed separately in this program, independent of story organization. As children tell more coherent and well organized narratives, the length of T-units should fall within an appropriate age range."

Pedagogical Implications

This study offers practitioners, such as speech language pathologist, resource room and classroom teachers, etc., some ways or strategies of implementing dictation writing. As shown in the results of this study, all students performed better using the dictation-related technology, but different students on different technology. We may speculate that those dictation implementation strategies could be used as an assessment tool to match students with the proper type of technology support. Considering the wide spectrum of differences among the struggling writers with LD, the teachers should take the following suggestions into consideration when implementing dictation writing.

It is recommended that teachers let students practice dictation writing, specifically dictation with SR technology as early as 2nd grade. The students prior to 2nd grade often have little requirement to write English compositions. Students start writing English compositions after 2nd grade. However, many researchers have claimed it is important for youngers (especially those with LD) to experiment written language as early as possible (e.g., King & Rentel, 1981). This study proves the potentials and positive effects of dictation writing on the overall writing fluency, writing mechanics, and story structure level of young writers with LD. Therefore, dictation writing, particularly the use of SR technology is appropriate for young writers with LD. Besides, due to the composition test requirement starting from their third grade annual testing, i.e., Measurements of Student Progress (MSP), it is recommended that teachers not wait until the struggling writers are in their fourth grade of elementary school to implement dictation writing. Second-grade elementary kids can also start to dictate their compositions using Dragon speech recognition technology (or as soon as they start developing their reading competency).

Second, offering the writing prompts for students is a way to lessen students' struggle with what to write about in their story. In the present study, students used the picture prompts and stimulus stories as their story starters. Offering the writing prompts helps lessen the students' struggle with what to write about. Since story writing is narrative-oriented and learner-centered, students can decide what to write about and writing prompts serve as a reference. However, teachers and practitioners should be careful and culturally sensitive when choosing the themes of the writing prompts, which are not merely age appropriate but also sensitive to students' interests. For instance, writing prompts with themes related to students' daily lives are more relevant to them, and with stronger prior knowledge, students can generate more ideas about the themes. Besides, teachers should be flexible about the themes. If a special event has recently happened in students' lives, teachers are not advised to stick to the previously designed writing prompts. Changing the topic of the writing prompts to that of the current event is a good way to stimulate students' motivation for writing in addition to make writing meaningful for students.

Another suggestion is to incorporate reading in the dictation writing practices (e.g., MacArthur & Cavalier, 2004; Quinlan, 2004). In the present study, the author incorporated the students' reading books into the SR training process to help enhance the level of SR recognition accuracy. As those were previously-read reading books or textbooks, using them helped reinforce students their learned vocabulary and the knowledge of sentence structures, in addition to giving them the opportunities to practice and generalize what they had learned from the formal classroom setting.

Teachers are advised to make good use of the stimulus stories. Note that the stimulus stories related to the picture prompts should be short and brief to serve the purpose of stimulating the students' imagination and interest for story writing. Long stimulus stories can drain the students' energy and attention, and leave little room for the students' personal creation. In this study, it was found that some students imitated what the teacher-researcher wrote after they heard the stimulus stories. Therefore, it is recommended that teachers and

practitioners use the stimulus stories to reinforce something new or unfamiliar to the students. Thus, students can also learn from listening to teachers' stimulus stories.

In addition, teachers should try to lead students to view the difficulties they meet positively. In SR technology training process, students may encounter some difficulties in applying the correct commands or dictate their writings via machine. Sometimes, the difficulties may be due to their personal limitations. It is very important for teachers to lead students to view these limitations in a positive way or maybe offer students some suggestions and help them to overcome the problems. For example, John showed frustration in correcting the SR recognition errors during the SR training process. Since he had earlier expressed interests in becoming a plane pilot, the author suggested to him that operating the Dragon SR program was like being a plane pilot who must be clear and precise about his orders and commands. When he made those recognition corrections, it was preparing himself to become a better and safer pilot. With that concept in mind, John then started to use the SR commands, including those for recognition errors, with more positive attitudes in addition to enhanced efficiency and effectiveness.

Finally, modeling, offering guidelines and introducing the purpose of dictation writing to the students can help them have a clearer idea about dictation writing. In this study, two of the students (Hanna and Tom) appeared confused about the differences between the SR and DR condition at the beginning intervention sessions. Therefore, the teacher can model dictation commands and its process in response to the confusion about the dictation conditions. This is more effective to the students than mere verbal instructions or a list of commands on paper.

Suggestions for Future Research

In view of the limitations of the study stated earlier, some suggestions for future studies and research are given as follows. First, future studies should involve more subjects for data collection to enhance the generalizability of the study. Future studies on dictation

writing should include elementary students without LD and also from earlier grades, i.e., 3rd graders and younger, as the subjects to expand the generalizability pool of the study and the applicability of SR technology for younger writers.

Second, since writing is not a skill that can be improved within a short period of time, it is recommended that the time for students to practice dictation writing be increased. Future studies should be conducted for longer periods of time, e.g., longitudinal studies using a different research method, in order to have more data about the improvement of the writing fluency and writing quality, particularly in terms of clause length and T-unit length. This could also show the maintenance effect of the intervention. Also, the research method can be switched to other single subject designs, such as ABAB, multiple baseline designs, etc.

Third, although clause length and T-unit length have been used widely in writing research, they may not be appropriate measurements for the writing fluency improvement of struggling writers with LD, especially when using a quick, time-efficient research design as alternating treatment design. Also, future study would benefit from further investigation on the writing process differences between SR and HW via the use of eye movement track, pencil movement recorder, videotaping, etc.

Finally, there is a need for future studies to include not only the quantitative type but also qualitative type of data in the studies. For instance, during the three weeks of intervention process, school teachers reported the students' improvement in their confidence and performance in writing. All four students took their statewide testing, MSP, in May. Tom and John, in particular, showed no refusal behaviors and also made improvement in their writing test from their past norm of a short paragraph with few words to 3 full paragraphs. It is recommended that future studies include qualitative measures such as field notes, interview questionnaire, etc. so as to reach a better understanding about their perception and preference for those text production modes.

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Appendices: List of Supporting Documents

Appendix 1: Study Participant Recruitment Letter for Teachers

Dear Teachers:

THANK YOU for your support in this writing intervention study offered via the support of University of Washington, Seattle! To make sure this study best benefits the students, I will need your help and collaboration in the list of tasks below.

- **Check the list of criteria below with the potential participant's profile:**
  (1) 3rd - 5th elementary grade students (9-11 years old), boys or girls, any ethnicity;
  (2) Have been diagnosed with LD and recognized as such by the school district;
  (3) Have a verbal or full-scale IQ score between 85 and 126 on an individual intelligence test;
  (4) Native English speakers;
  (5) Have a discrepancy between oral and written language production, i.e., scored within the normal range on standardized oral expression tests while at least one standard deviation below the mean on standardized writing tests;
  (6) Have no special education qualification for Speech and Language Disorders noted in their school records (IEP).
  (7) Have little or no experience in the use of speech recognition (SR) technology, as reported by the students, the students' family, and the students' teachers.

If no record is on file to support criterion 5, I will administer the WIAT-II to attain the information. Permission to administer the assessment will be requested in the consent form to the parents. I will have a flyer, a letter, and a consent form for you to send home with the students. If the parents have questions about the study, you can ask them to call or email me.

- **Purpose & Procedure of this Study: What I will do for the students—**

The purpose of this study is to investigate the effects of SR technology application upon the writing products and writing process of students with LD. I will be providing the students writing prompts and brief instruction, based on which they will handwrite or dictate write stories. Each writing session takes approximately 15 minutes. Only one session will be held per day, for a maximum of five times per week, over a period of no less than four weeks and no longer than six weeks. All sessions (including the SR training) will be completed with me.

Prior to their story dictation, the students will receive training, learning how to dictate their writing using the SR program. Through the training, the students will be expected to attain the recognition accuracy rate of 90% or above, within a maximum of 6 hours of training in two weeks. This is a *final* step for the participant screening process. That is, if the students do not attain the set accuracy level with the SR software in the set time, they will *not* proceed to the intervention phase.

- **What the school can provide—**
  - A quiet room where the students and I can work one-on-one
  - Scheduling with the teacher to make sure that the instructions that the students will lose from the pullout, 15-30 minutes each day in the time frame of four to six weeks, *serve* the purpose of increasing their writing skills, as proposed by the present study.

THANK YOU AGAIN FOR YOUR SUPPORT!!
Ms. Cinthia Lee (PI) & Dr. Eugene Edgar (Faculty Advisor)

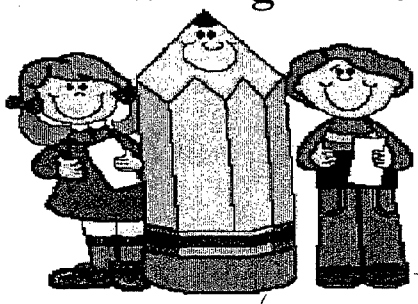
Appendix 2: Study Flyer: A Brief Introduction of the Study

WRITING WORKSHOP

A Great Opportunity to Improve Writing Performance

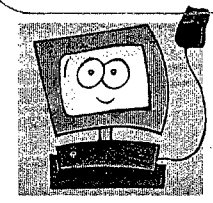
Computer Integrated Writing Workshop !

In 12 Writing Sessions



Provide writing instructions and writing prompts to enhance story writing skills

Provide speech-to-write software and training to enrich writing experiences or enhance performance



Interested in participating or questions, please contact Cinthia Lee via phone or email.

Phone: (206) xxx-xxxx
Email: xxxxx@uw.edu

This project is a University of Washington research study, advised by Dr. Eugene Edgar.

Appendix 3: Summary Sheet of SR Commands

☺ "Cheat Sheet": Common Voice Commands- Dragon 10 (

When dictate, always remember to...

- Speak *clearly* but naturally.
- Stay silent if uncertain.
- Aim for *full* phrases.

Navigate

SAY...	TO...
New Line	Press the Enter key once
New Paragraph	Press the Enter key twice
Space Bar	Press the space bar
Tab	Press the Tab key
Go to top/bottom	Move to insertion point to the beginning/end of the document.
Insert before/ Insert after <XYZ>	Move the insertion point before or after certain text to insert text there.

Punctuation

Period or Full stop	.
Comma	,
Question Mark	?
Colon	:
Semicolon	;
Hyphen	-
Open Quote; Close Quote	" "

Edit & Format

SAY...	
Select <XYZ>; **Select**<X>**Thru**<Y>	Select a replace
Cap <XYZ>; **Cap next** <XYZ>	Start th E.g., "C
Underline That	Apply u
Scratch That, Undo That	Delete
Delete/Cut/Copy/Correct That or <XYZ>	Delete, selecte
Paste That	Paste c

My Memo

Appendix 4: Lesson Plans for Speech Recognition Software Training

Beginning User Training for Dragon NaturallySpeaking 11: Emphasis on Speech Recognition Accuracy

~ General Guidelines of the Training ~

General Training Purpose: To provide dictation-based writing exercises for students with learning disabilities (LD) and writing difficulties (at elementary grades 3 to 5 or ages 9 to 11) to acquire the skills of operating a speech recognition (SR) program, Nuance Dragon NaturallySpeaking 11.

Training Goal: Upon completion of the dictation writing exercises, the targeted students will be able to—

1. Operate the SR program at a recognition accuracy level of 90% or above. That is, the exercises are designed for the students to train the SR software to recognize their speech to an acceptable accuracy level, and thereafter get them started as potential users of the dictation based writing program.
2. Use the basic dictation commands, such as select and correct texts.

General Training Location: *Consistency matters!* For best results, create the user/voice profiles in one consistent/"normal" environment, with ***the same*** background noise and equipment as when the dictations usually take place.

General Computer Setup: Prior to each training session, PI will make sure to—

1. *Turn off the grammar checker* in the Word Program.
2. Run the microphone test.

~ Lesson 1 ~

Time: 15-25 minutes/per session. This lesson may take up two sessions (depending on the student's ability in following directions and reading fluency.)

Materials: Two laptops & two headsets (the 2nd set for backup); printouts of the reading passages (provided from Dragon software); poster board with sentence prompts (*Three Things about Me*); timer; pencil; paper; notecards with the lesson scripts/flow.

Procedures: PI will—

1. Set up the equipment for the preliminary user/voice profile creation process—
    a. Launch Dragon > *Profile Creation (*Or, choose *New User Profile* in the DragonBar's Profile menu.)
    b. Answer the questions on the subsequent screens, including the profile/user name, e.g. ICL-March2011, age (*13 or under*, very important for *young voices* like this group of students), language, identifying the region (words the user says) and the accent (how user pronounces words).
    c. Indicate the microphone type/ ***Dictation Source*** and verify the sound system used.
    d. Check *Open the new dictation source now* (for the possibility of incorporating the digital recorder later).
    e. *Pause* at this screen. Check Microphone: ***Dragon will adjust your volume***. (Cover the monitor at this time.)
2. Ice Breaker (3-minute time limit)—
    a. Greet student (The personal intro would have been done at *Baseline* prior to the training.)
    b. Say, *"Do you know you can write without hands?" "How about commanding a computer to do all the handwriting/typing, spelling, grammar checking, etc. for you?" "Now I am going to show you that special writing trick."*
    c. Play a 1-mintue user video clip.
3. Inform students of the training objectives—
    a. Say, *"So, what makes this special trick work? Very much like training your pets to follow your commands so they can be your buddy everywhere you go,*

here you will train the computer to know your voice so you can have it do thousands of writing assignments for you."

4. Guide student to position/adjust the microphone.
    a. Say, *"Let's make sure your microphone is plugged in and positioned correctly." "Also, the microphone listens to you the best when it's left alone as the way we set it up now." "You may fold your hands in front of you or put your hand on the side like a boss or commander from now on. Use only your voice."*
    b. Plug the microphone all the way in and position it correctly. Adjust the size of the headset so that it feels stable and comfortable. The microphone's listening side must **face the corner** of the student's mouth (not the front) about **an inch away.** It **must not** touch the student's hair or catch **breathing sounds**. Bend the "boom" if needed. Aim for consistency in the microphone position!
5. Turn on the monitor.
6. Say, *"The computer needs to listen to you read some text aloud, with your clear and natural voice for about 10 seconds. The text is as appeared in the gray box. Once the computer likes your voice, you will hear a beep sound and you can stop reading. I can whisper read the text with you if you prefer."*
7. Click ***Start Volume Check***.
8. Say, *"You may start reading the text."*

READ→ *While you are reading this, the computer will adjust your microphone volume settings and then beep to signal that the process is complete. Speak to the microphone as if you were talking to a friend in person. It should only take about ten seconds to complete this step. If you do not hear the beep, start reading the text again from the beginning until you do.*

9. Click *Next* to ***Start Quality Check*** screen.
10. Say, *"The computer will now test the quality of the sound system and microphone." "You may begin reading the text in the box aloud, clearly and naturally. Again, once the computer likes your voice, you will hear a beep sound and you can stop reading. I can whisper read the text with you if you prefer."*
11. Click *Start Quality Check*
12. Say, *"You may start reading the text."*

READ→ *For Dragon to recognize your voice accurately, it needs to check the quality of your audio system and your microphone. Speak into the microphone as clearly and naturally as you did in the previous step. While reading this, Dragon is listening to you and examining the quality of your audio. Once Dragon has enough information, you will hear a beep to signal that the process is complete. This should take about fifteen seconds. If you do not heard the beep, start reading again from the beginning until you do.*

13. Click *Next* when audio quality check signals PASSED or ACCEPTABLE.
14. Say, *"By reading aloud for about 4 minutes, you can* ***train the computer to your special/personal way for speaking.*** *"* Choose for *Show text with prompting* (Dragon will display text and follow along with a prompt. This is the first step for the *General Training.*)
15. Click *Next* to **Read Training Text** screen.
16. Say *"After I click* ***Go****, you can read the following sentence aloud. The words will turn* ***gray*** *once the computer has heard them, but there is no need to wait for this to happen: just speak at your normal pace, clearly and* ***naturally.*** *If the computer needs to hear you re-read something, a yellow arrow will show you where to start."* (PI will click on the **Redo button to move the yellow arrow back, if** the student is found misread something.**)**

READ→ *Welcome to general training. Training is about to begin.*

17. ***Select Text****: Stories Written by Children (Reading for Children)* or *Talking to your computer (Easier Reading: Instructional).* Click *OK.*
18. Say, *"Let's echo read the following paragraph together."*
    a. Note: Student will also be given *the* ***option of rehearsing*** *the story from a handout* with PI before reading it from the computer with the microphone. Other story choices as listed later in this document won't be provided *unless* the student has not reached the 90% accuracy level with the software. To access those alternative stories/readings in the software, click DragonBar's Audio menu or from the Accuracy Center.
    b. Note: Dragon version 11 may end the reading passage anytime when the reading/recording of the user satisfied the voice recognition standard of the program. However, depending on the student's *training progress* and/or

reading fluency, the designated reading passage in the following could take two sessions to complete.

READ→ *You are about to read some short stories out loud. The computer will listen while you read, so that it can learn what your voice sounds like.*

19. Click *Next*

READ→ *Students at Provo High School wrote these stories for you to read. Michael Rutter and Karl Barksdale edited them. We hope you enjoy the stories!*

Suzi, The Singing Swine by J.E. Rockwood

Once upon a time there was a pig. But this wasn't any ordinary pig. This pig could talk! Oh, it sounds crazy, but it's true! She could say all the words you and I can, and even some we can't. Farmer Bill used to come out every day and talk with that pig. It was quite a sight to see. Farmer Bill sat on a tree stump with the pig right by him. They talked as though it was the most natural thing in the world for a farmer and his pig to speak with one another.

It had never occurred to Bill that most pigs can't talk. It was quite a shock when it dawned on him. He was talking to his wife, Lucille, during dinner. Bill mentioned something his pig had said. Lucille looked up from her plate and stared at Bill. "Pigs can't talk! They're stupid," she said as she took another bite. Bill thoughtfully chewed his carrots. Obviously not all pigs were too stupid to talk. His pig could talk!

Then he thought that if his pig could talk just like people can, maybe she could do other things people can do, too. Maybe she could cough, hum, or maybe she could sing! What an idea! The thought kept churning over in Bill's mind as he finished his supper. He calmly walked out to the pasture and knelt by Suzi, the pig.

"I have a question," he said. "Can you sing?" The pig smiled as well as a pig can smile and said, "Of course I can sing!" She started singing the most amazing song, Beethoven's "Ode to Joy." It was the best song Bill had ever heard! "That's amazing!" he said. "Can you sing anything else?" Suzi pranced around Farmer Bill singing Mozart.

"I've never heard anyone sing like you before!" Bill patted the pig's head and smiled warmly before walking back to the house. Once inside, Bill picked up the phone and called an old friend of his from school. This friend happened to run Carnegie Hall. It was the very

same Carnegie Hall that all the great musical people have performed in! They had a pleasant conversation before Bill went to bed.

A week later, a huge crowd gathered at Carnegie Hall. Nobody knew what was going on. They heard that some special performer was out to sing, someone fantastic. But not a single person knew who it was! The mystery only added to the excitement. The crowd became quiet as the orchestra warmed up. They were still as the lights dimmed. There was a long silence as the crowd leaned forward in their chairs and listened to the announcer.

"Carnegie Hall is proud to present...Suzi!"

Farmer Bill walked onto the stage in a suit. Following him on a leash came his amazing pig. She wore a bright pink dress with tiny white polka dots and trimmed in lace. Around her head was a white bow. The crowd sat in surprised silence. They didn't know if they were supposed to cheer or laugh!

Bill removed the leash as Suzi sat herself down in front of the orchestra. Bill walked off the stage, leaving Suzi alone. Suzi cleared her throat, and somehow, the crowd got even quieter. From the orchestra came the sounds of the opening of the song, "Ave Maria."

Suzi began to sing. The crowd sat with their jaws wide open. It took a full thirty seconds after Suzi's voice faded from the hall for a single person to begin clapping. Then came another, and another, until the entire crowd cheered, begging for more! "Sing! We love you, sing some more!" Suzi sang until her voice was hoarse and cracking.

And so it was that Suzi, The Singing Swine, became a household name. People will talk about her for generations. Scientists will always wonder what could have produced an opera singing pig, and music lovers everywhere will never forget those first few notes of "Ave Maria".

20. Click *OK* on the popup screen: "Congratulations! You have finished training. When you click OK, the computer will spend *a few minutes* adapting your user profile. If you would like to improve your recognition accuracy, you can train the computer more later."
21. While the computer is saving the user's profile, say, *"Now that we are waiting for the computer to remember your voice, think about three things ABOUT YOU that you*

would like to tell me and the computer." "Let's take off the headset for a couple minutes while you are thinking and talking to me."

22. Show the student a poster with three fill-in blank sentences. For example, *"My name is _____. My favorite person is _____. My favorite animal is _____. My favorite weather is _____. On a sunny day, I like to _____. On a rainy day...."* Say, *"These sentences will help you think faster. And in a few minutes when the computer is ready, you will get to try the special trick!"*
23. Program shows voice file saved. PI takes over the computer to answer a few system setup questions until the screen says "Congratulations, your profile is ready for use!" This takes less than 30 second to finish.
    a. Note: For Accuracy Tuning (which has been set up by PI prior to the training session), click the *Change Schedule* button, Dragon presents the dialog box *Select Time and Frequency*. Schedule Dragon's tasks for around **6:30am** *daily* when the computer will be *on (not asleep, not hibernating)* and Dragon program is *not* active (including an inactive *QuickStart* mode).
    b. Language Model Optimization is typically much faster than Acoustic Optimization.
24. Click *Finish.* Skip *Open the Dragon Tutorial* for next session to get started.
25. **Open Word document**. Click microphone icon on the top left corner to start dictation. Fill in student's response in the blank on the poster. Say, *"Now the computer is ready. You can tell the computer the three things about yourself and try the special writing trick."* (If the program doesn't recognize the student's dictation accurately, say, "*The computer is telling us that it needs to hear* ***more*** *of your voice and we can do that next time."*)
26. Say, *"Good job for today. Next time when we meet, we will get to the Tutorial of this special writing program, and that will make the computer a better writer for you."*
27. PI saves all files and/or updates the individual student's profile.

~ Lesson 2 ~

Time: 15-25 minutes/per session. This lesson may take up two sessions (depending on the student's ability in following directions.)

Materials: Two laptops; two headsets; *"oops All About Me"* printout (for the practice of voice commands); voice command cheat sheet; timer; pencil; paper.

Procedures: PI will—

1. Launch Dragon. Open the student's user profile. Open *Tutorial* from *Help* on the menus.
2. Say, *"Welcome back. Remember in our last lesson, you helped the computer to hear and memorize your voice? Today, we will go through a fun tutorial. It will show you the tricks that will help the computer to be a better writer for you. It's like training your puppy to be the best puppy, your best buddy in the world. You will have to help your puppy learn your key words so he/she will do exactly what you ask him/her to do."*
3. Give the student a copy of the *"oops All About Me"*, which content will be presented in a format that require the dictation commands selected in the lesson. Open also the *"oops All About Me"* document in the computer. Supplement some of the commands with video clips provided in the tutorial. Prompt the student to perform the following tasks—
    a. Launch Dragon (for a new user). Turn on the microphone before dictating. Do this by clicking on the microphone button on the top left corner of the DragonBar. Practice *"Wake Up"*, *"Go to Sleep"*. (To lessen cognitive loads or distractions, save these two commands for later until the student is getting used to the dictation concept.)
    b. Start a new paragraph by saying *New Paragraph.*
    c. Start a new line by saying *New Line.* (Save this for later until the student gets used to the use of *New Paragraph.*)
    d. Go to the start of the paragraph by saying *GoToTop.*
    e. Go to the end of the paragraph by saying *GoToBottom.*
    f. Put a space by saying '*Space Bar*'. (Save this for later until the student is getting used to the dictation concept.)

   g. Correct a recognition error by saying '*Select*' and then the '*Word*' without a pause between them i.e. '*SelectWord.*' (If the target word is in the Quick Correct list say '*Choose*' and then the number besides it. If the word does not appear on the list, students can choose to spell it by saying '*Spell That*'.)
   h. Delete a word- Select the word by saying '*SelectWord*' and then get rid of the word by saying '*Scratch That*'.
   i. Add a word to the document- Say '*Insert Before*' or '*Insert After*' the word to be added. Then just dictate the word to add.
4. Turn off microphone. Have student take off the headset.
5. Say, *"Now that you have all those key words/commands under your belt, it's time to see how the computer listens when you give the special key words." "Better yet, you get to have a cheat sheet to remind you of those key words!"* Hand student the voice command cheat sheet.
6. Say, *"Remember last time you read the story about a singing swine? Now here's a small fun part of that story. It's already typed for you in the computer, but the person who typed it made some funny mistakes. So as a reading story detective, let's read and look carefully for the mistakes. When we catch a mistake, let's see how can use the special key words to command the computer to fix the mistake for us."*
7. Say, *"Also, remember to* ***pause briefly*** *before and after you say any of the special key words or voice commands."*
8. Make sure to turn the microphone *off* when reading and *on* when making the correction.
9. PI will check off the commands used on a pre-made checklist and give necessary support.
10. When finished, say, *"Good job for today. Next time when we meet, you will get to tell the computer a fun story, see how well it listens to you and writes it down for you."*
11. PI saves all files and/or updates the individual student's profile.

~ Lesson 3 ~

Time: 15-25 minutes/per session.

Materials: Two laptops; two headsets; short story printout (for dictation practice and review of voice commands)-- "*How Long Does It Take*" & "*Dogs at Work*" (for JS), *"I Know" "Bunny"* (for Westfield); printout with lists of word and sentence probes; voice command cheat sheet; timer; pencil; paper.

Procedures: PI will—

1. Launch Dragon. Open the individual student's profile and a new Word document.
2. Say, "*In the last few sessions, you were able to help the computer to know your voice and follow your commands. In our session today, we are going to give the computer a test. You have read this story (story name) before with your classroom teacher. Today, you will get to tell the computer this story, and* ***test*** *how well it listens to you and writes it down for you."* Give student the story printout. *"If you'd like, I can echo read the short story with you."*
3. Say, *"After you finish each sentence, you can check whether the computer wrote down what you just said. If not, guess what? You can pull out your special key words (cheat sheet) and tell the computer to make it right."* PI will mark the recognition mistake on a separate handout and calculate the % of accuracy later. This is **preliminary recognition accuracy test**.
4. When finished, say, *"That was a fun exercise. You did well. And now, I have a list of* ***'celebrating' words and sentences*** *that you can read to the computer. They will show me whether we are ready to celebrate your learning of the special writing trick, meaning whether you are ready to tell YOUR OWN stories to the computer in the future."*
5. Turn the computer screen away from the student. Show student one sentence/word flash card at a time. Say, *"I will read the word/sentence first, and then you can re-read the word/sentence to the computer aloud, clearly and naturally just like before. To finish this exercise fast, we will keep reading even if the computer writes down the wrong word. You may make the corrections later if you wish."*
6. Word-list and sentence probes will be used to evaluate the accuracy of speech recognition. The probes are *identical* for every student:

   a. Word-list probes- The word lists are taken from an informal reading inventory in the grade level of three through five. Each probe includes 35 words.
   b. Sentence probes- The sentences are taken from a collection of brief narrative passages at a second-grade reading level (the general reading competency level required for the use of Dragon program). Each probe includes about 70 words.
7. PI will mark on a separate sheet the words that were transcribed incorrectly and calculate the accuracy % later.
8. If the 90% of accuracy rate isn't attained at the end of this lesson, the student will receive a couple more training sessions, supplemented with more dictation practices of short stories, word and sentence probes.

~ Tips ~

- Choose *Standard* for accent and perform *Acoustic Optimization* after using the product for several hours. Acoustic Optimization updates user profile with accumulated acoustic data from any corrections and additional training each user may have done. Running Acoustic Optimization will **increase overall accuracy**. In the process of increasing the accuracy, Acoustic Optimization may select a different accent for the user.
- To use another type of audio input device when a Dragon profile is already created, *add a source* to the profile instead of creating a separate *profile*. Open the DragonBar's Profile menu and choose "**Add audio source to current User Profile.**")
    - IMPORTATNT! Having multiple sources *within a profile* enables the same V*ocabulary* to be used **and refined** each time Dragon is used, regardless of the audio input device used. (Note: Personalizing the Vocabulary ***early and often*** is one of the keys to getting Dragon's full benefits.)
- Dragon works with **one voice at a time**, so interviews or meetings cannot be transcribed directly.
- **Natural Language Commands and Speed vs. Accuracy:**
    - After the user profile is created, the program may show a special message if it determined that the computer's characteristics wouldn't allow optimal performance. This message indicates that Dragon has adjusted the *defaults* for two of its options—
        - The ***Speed versus Accuracy*** **slider was moved toward speed**, and
        - The ***Natural Language Commands*** **for Microsoft Word, Excel, PowerPoint, and Corel WordPerfect were disabled**. (Note: Not all editions and languages of Dragon support these commands.)
- Reverse these changes through *Dragon's Options* dialog, depending on the user's particular needs. For example, enable or disable the Natural Language Commands for any of these four applications individually, and/or experiment with various settings of the *Speed-Accuracy slider*. *Help* menu provides more details, and its ***Performance Assistant*** offers many suggestions for optimizing Dragon's transcription speed on the computer.

~ Other Choices of the Children's Stories in Dragon 11 ~

The Howl of the Wolf by Linsey Duncan

Everyone knows what a wolf howl sounds like. It is deep, beautiful and eerie all at the same time. But why does a wolf howl? Some people think that wolves howl at the moon, but they don't. The howl is a way that wolves talk to each other. Wolves feel no need to talk to the moon.

Wolves can say many things through a howl. If a wolf is by himself, he can howl to tell his pack where he is. He might also howl if a bird or something startles him, but he is not scared enough to run away. If he sees or smells a wolf of another pack or a human, he will howl to tell his friends that an intruder is coming. Howls are also used when a pack is hunting, or even after a really fun playtime.

Wolves like to sing together, even when they are not hunting. But they don't like to sing the same note. Instead, they sing in chords, like a choir. Not only does this sound like a wolf choir, it can fool people into thinking that there are more wolves than there really are. After a long howling song, the pack will be quiet for a while, maybe to listen for other wolves. Wolf howls can be heard ten miles away in good weather. The can last up to eleven seconds each, or be as short as half a second.

Wolves will respond to howls, even those made by humans, or tapes made of wolf howls. The most likely wolf to answer a howl is the leader, or head, wolf. Like the coach of a sports team, the head wolf speaks for his pack and directs them with howls, barks or growls. But some wolves do not howl much at all. Wolves in southern Asia howl very rarely. We don't know why they don't howl often. Some think it is because these wolves were hunted a lot by people. These wolves learned to be quiet so they can hide easier.

Even when he is lying down, a wolf can howl. Wolves like to howl so much that they will run to sing with their pack. They will sing alone too, maybe to tell the world they are lonely. In any case, no matter what the howl is for, or how many wolves are lifting their voices, the howl is a beautiful and thrilling thing to hear.

Owls by Renee Underwood

Have you ever walked out on a summer night and seen a big bird flying by? Chances are that bird was an owl. They are birds, but they are quite different from the little songbirds you see flying around during the day. These are fascinating animals that live in a world of night.

There are many types of owls. They can be as different from one another as people are. Owls vary in size. The Great Gray owl is about as big as a fat cat. The Elf owl, however, is about the size of a small guinea pig. Owls are very different from each other because they have adapted to where they live.

The Snowy owl is white. This bird lives in Northern Canada where it is often snowy and always cold. They Snowy owl can hide in the snow, making it easier for it to sneak up on the small rodents it eats. The Spotted owl is brown and white spotted. Have you ever seen sunlight fall through the leaves of trees? It makes spots on the tree trunks. Since these owls live in the forests of Oregon and Washington, their spots help them hide from the rodents and fish found in the forest.

Another owl that is uniquely colored is the Burrowing owl. It is dark brown. It does not live in tees like most owls do. This interesting night bird digs holes in the dirt in open fields and lives there. This owl eats the rodents and small critters that make their homes on the prairie.

There are many different kinds of owls. Most have yellow eyes, sharp talons, and meat tearing beaks. Owls are nocturnal, meaning they hunt and are awake at night, and sleep during the day. Owls, like most other birds, fly to other places in the winter. This is called migration. They sometimes fly very long distances just so that they can be warm all year round. Along the migration, they communicate with other owls by their calls.

Most people can recognize owl calls right off. If you have ever heard a low call that sounds like HOO HU HU HOO HOO, then you have heard the call of the Great Horned owl. Some owls use high pitched squeals or clicks, while others use humming or chirping.

Owls all have exciting weapons to help them hunt better. As you know, most owls hunt at night, so seeing a tiny mouse from a high tree branch I quite hard. But owls can do it by using sounds. They send sound down to the forest floor, and measure how far away a

critter is by how quickly the sound bounces back. This is how an owl can silently swoop down and pluck a rat from the ground with no effort at all.

Owls are amazing creatures. We have much to learn about them still. Scientists are only scratching the surface in what they know about owls. But sadly, some species are disappearing from the earth. People who cut down trees destroy owl homes. Careless people who litter and pollute the earth are killing the homes and food for these birds. It is up to us to save the owls. We must work hard to protect owls for years to come.

Molly's Dream by Linsey Duncan

Molly pet her dog quietly as she looked into the fire. She was bored, but warm and comfortable. She didn't want to get up from the couch. It was soft and fluffy like a pillow right out of the dryer. She kept sinking down into it, and it got more warm and comfortable with each passing moment Eyelids drooping, her hand kept stroking the rough dog fur until she finally fell asleep.

"I'm hungry," her dog said in her dream, looking at her with large brown eyes. "I'm hungry. You forgot to feed me again." "I'm sorry, Tessie." Molly searched for the big bag of dog food, but she was in the middle of a green field. If the bag was there, the grass hid it. "I'm sorry, Tessie. I don't have any food right now."

"But I'm hungry! Do you have any beef steak in your pockets?" Tessie grinned, her tongue hanging out. "No, I don't have any beef steak, funny dog All I have is a couple of peanuts left over from my snack." "That's okay. Can I have them?" Tessie's tail wagged excitedly and she trotted right up to Molly, still grinning.

Molly dug the peanuts out of her pocket, cracked them, and gave them to Tessie. Tessie had to tilt her head to get the peanuts under her back teeth. She crunched loudly, and then the peanuts were gone. The tail wagged again and Tessie winked up at Molly.

"I'm still hungry, but thanks anyway I liked the peanuts." "I'm glad you liked them." Molly reached down and scratched behind Tessie's ear. The dog panted happily and her leg started twitching Soon her leg was twitching so hard that Molly had to stop. She laughed and gave Tessie a little pat on the head. Then she looked around the field.

It was a very quiet field with waves of grass and some scattered white flowers. A black and bright blue butterfly fluttered a few feet away. It landed, slowly opening and closing its colorful wings. Molly watched it silently, wanting to touch it, but she was afraid it would fly away if she came too close.

Then a beautiful song caught her attention. She turned toward the sound and saw a fallen log with a craggy branch sticking up out of it. On the branch was a small bird with a yellow throat. Its mouth was wide open. It didn't mind that she was listening. Tessie nudged her leg and Molly sat down to pet her. She wanted to keep watching the bird. Then Tessie

started licking her hand and Molly had a hard time concentrating on the bird. The whole field started to flicker out.

"Stop it, Tessie," Molly murmured. Her voice sounded funny. One more lick and the whole field disappeared. Instead molly was back on the couch, the fire slowly dying. The dog was licking her hand as hard as she could, wanting Molly to wake up and pet her.

"I'm awake," Molly said, a little louder this time. Then, remembering her dream, she sat up groggily. "Are you hungry, Tessie?" Tessie opened her mouth in a grin and wagged her tail, backing up a couple steps. "Okay then... I'll get you something." She got up and walked downstairs to get the dog food, Tessie trailing eagerly behind.

They're Really Not There by Charlotte McKinlay

We all grew up on fairy tale stories about beautiful princesses, handsome princes, and magical fairies. But the dragons, goblins and witches were always more exciting. Of course we've always known that these things are just make believe (at least there was always an adult around to tell us that they were), but there was a time when people really believed in magic and witches. In fact, people were so convinced that there were witches in their town that they put people on trial for witchcraft and hanged them.

In 1692, in Salem, Massachusetts, when people had just started coming to America from England, there was a witch scare. It was started by the little girls of the town. There really want' much for children to do in those days, so the girls would get together at the reverend's house in the kitchen to tell stories and talk. The reverend's name was Samuel Parris. He had a black slave woman names Tituba. Tituba was from the Barbados islands, and she knew fascinating stories about witches from home.

The girls would listen to Tituba talk about her home, even though they knew that they weren't supposed to be listening to stories like that. They knew if their parents found out, they would be badly punished Soon the stories got scary enough that the girls started doing strange things. They had nightmares, and they would twitch and have fainting fits. Their parents wanted to know what was going on.

The girls couldn't tell their parents they had been listening to stories about witches. They would be publicly whipped for it. To keep herself from being whipped, Elizabeth Parris, the reverend's daughter, was the first to accuse someone as a witch. She said that Tituba was bewitching her and making her do strange things.

Soon after, two other women were accused by other girls. Sarah Good, Sarah Osborne and Tituba were arrested and questioned for bewitching the girls. The townspeople told them that they could either confess to being witches or be hanged. Tituba was frightened and confessed to being a witch. She also said that Sarah Good and Sarah Osborne were witches too. The girls went wild. They saw an opportunity to get rid of their enemies. The whole town was at their command. All they had to do was point a finger at any person who made them mad, and that person would be whisked off to jail.

Ann Putnam was one of the "afflicted" girls. Her family had been in a fight with the Nurse family for years over a piece of land that both families claimed. Ann accused Rebecca

Nurse of witchcraft to get back at their family. Rebecca refused to say that she was a witch. She was hung, along with Susannah Martin, Elizabeth Howe, Sarah Good and Sarah Wildes. Dorcus Good, Sarah Good's daughter, as also accused of witchcraft and sent to jail even though she was only four years old.

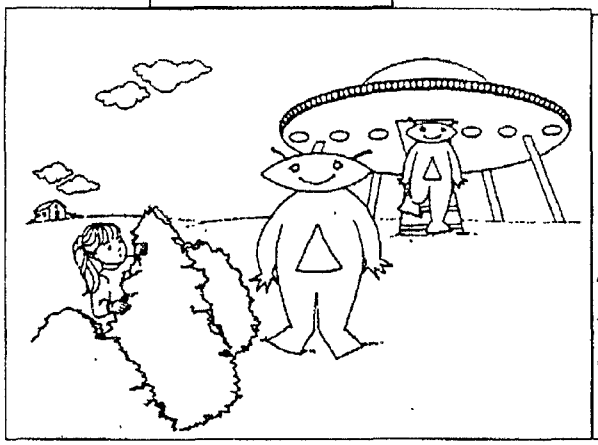
Seventeen women and two men were hanged on Gallows Hill in Salem. One man was pressed to death, and thirteen people died in jail for witchcraft. Finally, the Mayor's wife was accused, and that made the town realize that they had gone too far. Forty-nine people accused of witchcraft were given apologies and released from jail. Nothing was done to punish the girls who had made a whole town go crazy enough to kill more than twenty people. Some of the girls apologized to the town. Others never admitted to lying.

Appendix 5: Writing Prompts: Instructions and Samples

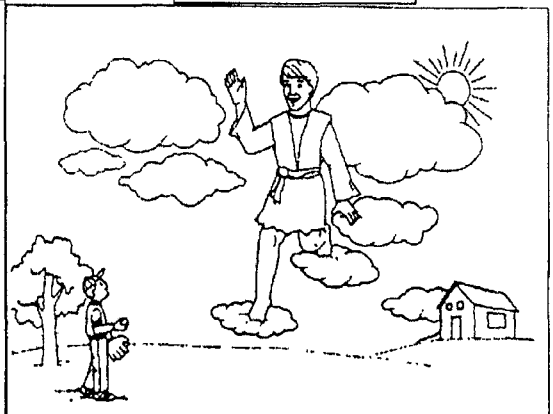
Narrative Writing Prompts

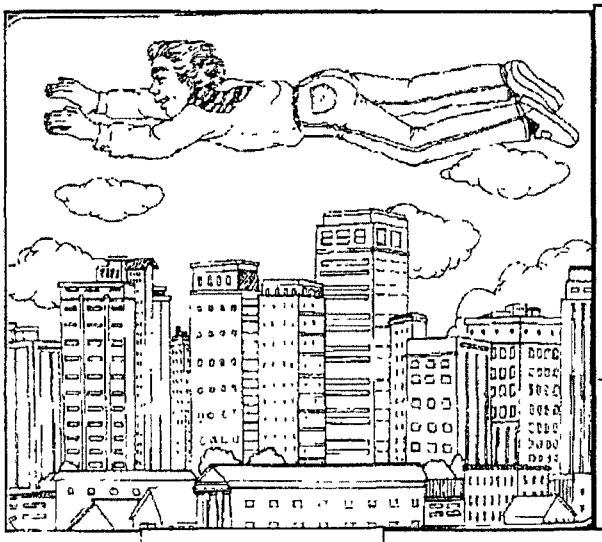
Composition Instructions: "*I am going to tell you a story. Listen carefully so you will know what a story is. Then, I'll ask you to write a story on your own.* " (Show the picture and read the story.) "*Now you can write a story about the picture on your worksheet. Be sure to write about the picture at the top of your paper. If you're not sure how to spell a word, just make your best guess. You will have 10 minutes. If you need more paper, raise your hand and I will bring you some. Begin.*" (Give the student a 2-minute warning after 8 minutes have elapsed.)[5]

Story Prompt 1

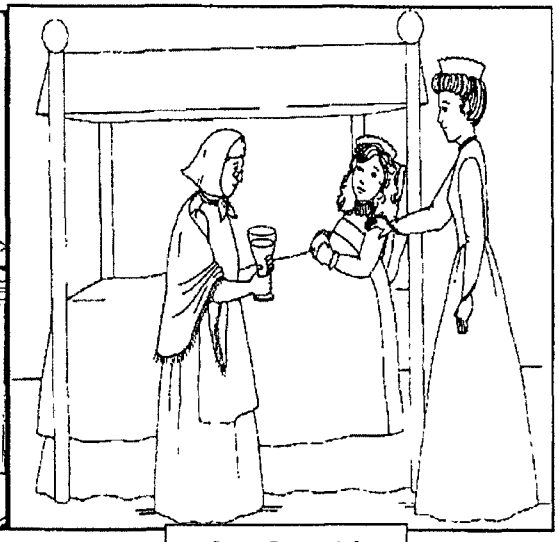


Story Prompt 2





Story Prompt 3



Story Prompt 4

[5] Note: The materials in this document are derived from *The Expression Connection: A Structural Approach to Teaching Storytelling to school Age Children* by Klecan-Aker, J. S. & Brueggeman (1991).

Stimulus Stories

Story 1

One day a young girl looked up in the sky and saw what seemed to be a spaceship. As she watched, the spaceship landed very close to her house. She was both frightened and excited. She ran over to the spaceship but hid in some bushes that were close by. Strange creatures started walking out of the spaceship. The girl tried to run away, but one of the creatures grabbed her arm. She screamed, and the creature let her go. Then the creature began to talk. He said, "Please don't be afraid. I just want to see what you are like." The little girl was still afraid so she ran all the way home. For many days she thought about the strange things that she had seen.

Story 2

Once upon a time there was a giant who lived in the sky. He had no friends. He was very sad so he decided to come down from the sky and look for a friend. He climbed down from the clouds and saw a little boy playing ball. The little boy was frightened when he saw the giant, but soon they began to talk. The giant liked the little boy. They became friends, and the giant came to visit him every day. The giant was never lonely again.

Story 3

One day I had a dream, I dreamed of me chased by millions of cockroaches. I ran and ran, but I simply couldn't find a place to hide. They were crawling everywhere on the wall, in my bedroom, living room, kitchen, closets, and even everywhere out on the streets. I called my sisters for help but the only they could do was screaming with me. I called my parents, but they were on vacation in a far land. "This is the most terrible, disgusting thing ever happen in my life", I said. My legs then were so tired after so many hours of running and my voice went out after so many hours of screaming. Before those cockroaches crawled to my body, I made a big superman wish, and with a huge leap, I was flying happily and freely in the sky. Oh, wasn't I laughing with great relief when I woke up, but I also found my legs badly trapped by my layers of bed sheets. This taught me a lesson that I should make my bed every day.

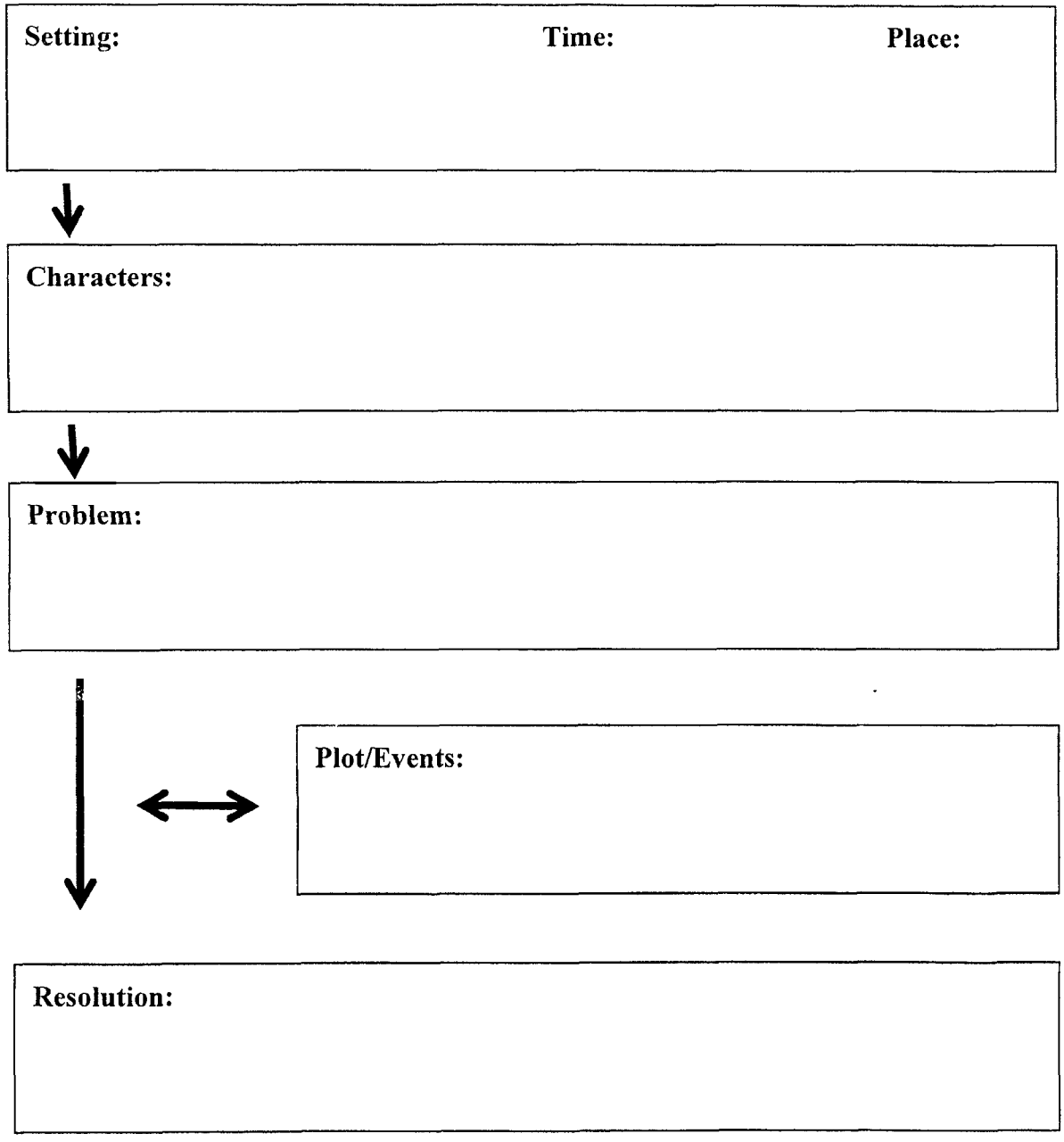
Story 4

Once upon a time a princess lived in a castle. The princess could not walk. She was very sad. Once day an old woman came to the castle. She told the princess that if she wished very hard and drank some special potion, she would be able to use her legs. The princess became very excited and started wishing and wishing and wishing. She also drank the special potion that the old woman had given her, but her legs still did not move. The princess went to bed that night. She was very sad, but she kept on wishing. She wanted to walk very badly. When she woke up in the morning her mother, the queen, came to help the princess get out of the bed. The princess' legs started to move. She and the queen were very excited. The princess was glad that she had kept on wishing.

Story Map

Pre-writing planning graphic organizer instruction: "*Exciting Stories include using the 5 Ws to Tell Your Story. At the beginning of your story, tell Who- Names of Characters? Where- Place of Story? And When- Time of Story? In the middle of your story, tell Action, such as First and/or Second Event about What happens and How does it happen? At the end of your story, tell how your story ends.*"

Write your notes or keywords in each section.



Appendix 6: Data Collection Form

Spontaneous Story Scoring Form

Student Code_____ Session Code _____ Date _____

Writing Fluency

_____ = _____ / _____ Total # Words/ Total Writing Time (min. seconds)

Surface Errors

_____#Spelling
_____# Capitalization
_____#Syntactic Errors (i.e., subject-verb agreement, pronouns, sentence fragments, misplaced/ dangling modifiers)
_____# TOTAL

T-Unit Analysis

_____ T-Units	_____ Words/T-Unit
_____ Words	_____ Words/Clause
_____ Clauses	_____ Clauses/T-Unit

Present (√)	Number	Story Grammar Components*
☐	_____	Setting Statement
☐	_____	Initiating Event*
☐	_____	Internal Response or Plan
☐	_____	Attempt/Action*
☐	_____	Consequences*
☐	_____	Dialogue
☐	_____	Ending

Developmental Level

_____ Level 1	_____ Level 2
_____ Level 3 (starred components)	_____ Level 4 (Starred Components + one)

_____ Level 5 (starred components + ending + one)
_____ Level 6 (starred components + ending + setting statement + one)
_____ Level 7 (starred components + the rest four = All)

Number of Episode Systems

0	1	2	3	4 or more

Note: The measurement *Number of Episode Systems* is not mandatory for the purpose the present research, but it will be collected as a side reference for the data analysis of other major measurement items.

Appendix 7: Data Measurement Guidelines

~ Measurement ~

The following measurement will be used to evaluate the elements of writing performance: *(*Second rater will check item #3.)*

1. **Writing Quantity/Length**—the total number of words produced. This variable will be tabulated automatically, using the word-count feature of a word processor.
2. **Writing Fluency**—the number of words generated per minute on task;
3. **Writing Quality**—surface errors, T-unit length, and story structure of the composition.
    a. **Surface errors** include any word that is:
        i. Semantically or grammatically inconsistent, e.g., errors in subject-verb agreement, verb tense, or singular/plural usage;
        ii. Orthographically incorrect, e.g., errors in spelling, punctuation or capitalization. (See the details in the following section.)
    b. **T-units length:** A simple sentence equals one T-unit, and a compound sentence equals two or more T-units, each of which consists of independent equal clauses.
    c. **Story structure** includes *seven* narrative developmental levels[6], which are based on the number of story grammar components students included in their texts. The story components include *setting statement, initiating event, internal responses, action, consequence, dialogue*, and *ending*. The definition and examples of each developmental level are provided as in Table 5 and Table 6.

[6] PI and a second rater will be reading each composition attentively, and will take into account the story grammar components in forming a single judgment about the overall quality of the composition, and that no one component should receive undue weight. Compositions are scored on a 1–7 point scale, with seven representing the highest quality of writing and one representing the lowest quality.

~ Surface Errors[7] ~

_____#Spelling

Tip: Use spell-checker, but remember it won't help with homonyms, words that sound alike but have different spellings and meanings. Below is a list of words that can cause trouble.

- **their** (possessive form of *they*)
- **there** (*in that place*)
- **they're** (contraction of *they are*)
- **accept** (a verb, meaning *to receive* or *to admit to a group*)
- **except** (usually a preposition, meaning *but* or *only*)
- **who's** (contraction of *who is* or *who has*)
- **whose** (possessive form of who)
- **its** (possessive form of *it*)
- **it's** (contraction of *it is* or *it has*)
- **your** (possessive form of *you*)
- **you're** (contraction of *you are*)
- **affect** (usually a verb, meaning *to influence*)
- **effect** (usually a noun, meaning result)
- **than** (used in comparison)
- **then** (refers to a time in the past)
- **were** (form of the verb *to be*)
- **we're** (contraction of *we are*)
- **where** (related to location or place)

[7] Information in this document (except the *Capitalization* section) is derived from an online source--http://www.indiana.edu/~wts/pamphlets/proofing_grammar.shtml#punctuation, provided by the Writing Tutorial Services at Indiana University, and adapted for the purpose of my dissertation study.

_____# Capitalization[8]

Capitalization Rules	Examples
Capitalize the first word of a quoted sentence.	- *He said, "Treat her as you would your own daughter."* - *"Look out!" she screamed. "You almost ran into my child."*
Capitalize a proper noun.	- *Golden Gate Bridge*
Capitalize a person's title when it precedes the name. DO NOT capitalize when the title is acting as a description following the name.	- *Chairperson Petrov, Ms. Petrov, the chairperson of the company, will address us at noon.*
Capitalize the person's title when it follows the name on the address or signature line.	- *Sincerely, Ms. Haines, Chairperson.*
Capitalize the titles of high-ranking government officials when used before their names. DO NOT capitalize the civil title if it is used instead of the name.	- *The president will address Congress.* - *Governor Fortinbrass, Lieutenant Governor Poppins, Attorney General Dalloway, and Senators James and Twain will attend.*
Capitalize any title when used as a direct address.	- *Will you take my temperature, Doctor?*
Capitalize points of the compass ONLY when they refer to specific regions.	- *We have had three relatives visit from the South.* - *We live in the southeast section of town.* (*Southeast* is just an adjective here describing section, so it should not be capitalized.)
Always capitalize the first and last words of titles of publications regardless of their parts of speech. Capitalize other words within titles, including the short verb forms *Is*, *Are*, and *Be*. DO NOT capitalize little words within titles such as *a, an, the, but, as, if, and, or, nor*, or prepositions, regardless of their length.	- *Day of the Jackal* - *What Color Is Your Parachute?* - *A Tale of Two Cities*
Capitalize *federal* or *state* when used as part of an official agency name or in government documents where these terms represent **an official name**. If they are being used as general terms, use lowercase letters.	- *State Board of Equalization collects sales taxes.* - *Her business must comply with all county, state, and federal laws.*
Capitalize words such as *department*, *bureau*, and *office* if the text is prepared as:	- *The Bureau of Land Management (Bureau) has some jurisdiction over Indian lands. The Bureau is finding its administrative role to be challenging.*
DO NOT capitalize names of seasons.	- *I love autumn colors and spring flowers.*

[8] Information of the *Capitalization* section is derived from an online source--http://www.grammarbook.com/punctuation/capital.asp, provided by 2010 GrammarBook.com©, and adapted for the purpose of my dissertation study.

Capitalization Rules	Examples
Capitalize the first word of a salutation and the first word of a complimentary close.	- *My dear Mr. Sanchez:* - *Very truly yours,*
Capitalize words derived from proper nouns.	- *I must take English and math.* (*English* is capitalized because it comes from the proper noun *England,* but *math* does not come from *Mathland.*)
Capitalize the names of specific course titles.	- *I must take History and Algebra 2.*
After a sentence ending with a colon, DO NOT capitalize the first word if it begins a list.	- *These are my favorite foods: chocolate cake, spaghetti, and artichokes.*
DO NOT capitalize when only one sentence follows a sentence ending with a colon.	- *I love Jane Smiley's writing: her book, A Thousand Acres, was beautiful.*
Capitalize when two or more sentences follow a sentence ending with a colon.	- *I love Jane Smiley's writing: Her book, A Thousand Acres, was beautiful. Also, Moo was clever.*

_____# Subject-Verb Agreement

- A singular subject has a singular verb, and a plural subject a plural verb.
    - Wrong: A central **part** of my life goals **have been** to go to law school.
      Right: A central **part** of my life goals **has been** to go to law school.
- Caution: when the subject is made up of two or more parts joined by *and* or *or*; when the subject is a word like *committee* or *jury*, which can take either a singular or a plural verb depending on whether it is treated as a unit or as a group of individuals; or when the subject is a word like *mathematics* or *measles*, which looks plural but is singular in meaning.
    - Wrong: My **brother** and his **friend** *commutes* every day from Louisville.
      Right: My **brother** and his **friend** *commute* every day from Louisville.
    - Wrong: The **committee** *was taking* all the responsibility themselves.
      Right: The **committee** *were taking* all the responsibility themselves.
      (Note that the use of the word *themselves* shows that *committee* is being treated as a group of individuals, not as a unit.)
    - Wrong: **Measles** *have become* less common in the United States.
      Right: **Measles** *has become* less common in the United States.

_____# Pronouns

- A pronoun (like *I*, *it*, *you*, *him*, *her*, *this*, *themselves*, *someone*, *who*, *which*) is used to replace its antecedent, so the antecedent does not have to be repeated. Check each **pronoun** to make sure that it agrees with its **antecedent** in gender and number.
- Remember that indefinite pronouns like *each*, *either*, *neither*, and *one* are singular. When they are used as antecedents, they take singular pronouns and singular verbs.
    - Wrong: Every **one** of the puppies thrived in **their** new home.
      Right: Every **one** of the puppies thrived in **its** new home.
    - Wrong: **Each** of the items in these designs **coordinate** with the others.
      Right: **Each** of the items in these designs **coordinates** with the others.
- Antecedents made up of two or more parts joined by *or* or *nor* take pronouns that agree with the nearest antecedent.
    - Wrong: **Neither Jane nor Susan** felt that **they** had been treated fairly.
      Right: **Neither Jane nor Susan** felt that **she** had been treated fairly.
- Collective-noun antecedents (audience, team) can be singular or plural depending on whether they refer to a single unit or a group of individuals.
    - Wrong: The **team** frequently changed **its** positions to get varied experience.
      Right: The **team** frequently changed **their** positions to get varied experience.
- A relative pronoun, like *who*, *which*, or *that*, takes a verb that agrees with the pronoun's antecedent.
    - Wrong: He is one of the **employees** who **works** overtime regularly.
      Right: He is one of the **employees** who **work** overtime regularly.
- A vague pronoun reference: If a **pronoun** could refer to more than one **antecedent**, and/or if the antecedent is implied but not explicitly stated, these will be counted as errors.
    - Wrong: Before Mary assaulted Mrs. Turpin, **she** was a judgmental woman.
      Right: Before Mary assaulted Mrs. Turpin, **the latter** was a judgmental woman. (In the first sentence, *she* could refer to either Mary or Mrs. Turpin.)
    - Wrong: They believe that an egg is as important as a human being, but **it** can't be proved.
      Right: They believe that an egg is as important as a human being, but **such an assertion** can't be proved. (In the 1st sentence, the antecedent of *it* is unclear.)

_____**#Sentence Fragments**

- Sentence fragment: an incomplete sentence punctuated as a sentence. (The fragment must join the main clause to be a complete sentence.)
    - Wrong: She is a good friend. A person whom I trust and admire.
      Right: She is a good friend, **a** person whom I trust and admire.
    - Wrong: In the workshop, we learned the value of discipline. Also how to take good notes.
      Right: In the workshop, we learned the value of discipline. We **also learned** how to take good notes.
    - Wrong: The old aluminum boat sitting on its trailer.
      Right: The old aluminum boat **was sitting** on its trailer.

Tip: To proofread for sentence fragments, check all sentences for a subject, a verb, and at least one clause that **does not** begin with a subordinating word like *as*, *although*, *if*, *when*, *that*, *since*, or *who*.

_____**#Misplaced/Dangling Modifiers**

- Misplaced or dangling modifiers are words, phrases, or clauses **not clearly connected** to the word they modify. (Move a misplaced modifier closer to the word it describes, or revise a sentence to give a dangling modifier a word to modify.)
    - Wrong: **They** could see the eagles swooping and diving **with binoculars**.
      Right: **With binoculars, they** could see the eagles swooping and diving.
    - Wrong: A rabbit's teeth are never used for defense even **when cornered.**
      Right: **Even when cornered, a rabbit** never uses its teeth for defense.
    - Wrong: **As a young boy**, his grandmother told stories of her years as a country schoolteacher.
      Right: **As a young boy, he** heard his grandmother tell stories of her years as a country schoolteacher. (*You may find this type of misplaced modifier more common among the writing products in my study.)

Tip: To proofread for misplaced or dangling modifiers, circle all modifiers and draw a line to the word they describe. Be sure they can't mistakenly modify some other word.

_____**# TOTAL SURFACE ERRORS**

Appendix 8: Interrater Agreement Calculation Records

Interrater Agreement on the Writing Measures across Students for Baseline Phase

	T-Unit		Clauses		Synt Er (s)		Cap Er (c)		Surf Er=(s)+(c)		SS Level	
Baseline	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
H.5.5	17	16	21	21	28	28	4	3	32	31	6	6
M.5.4	15	15	18	18	20	18	12	13	32	31	7	7
T.5.1	9	9	11	11	23	21	19	19	32	40	2	4
J.5.4	3	4	4	5	5	5	0	0	5	5	2	4
Total	44	44	54	55	76	72	35	35	111	107		
Smaller Total	44		54		72		35		107		Agree	2
Larger Total	44		55		76		35		111		Disagr	2
BL Ave FR	**100%**		**98%**		**95%**		**100%**		**96%**			

Abbreviations: H = Hanna; M = Mary; T = Tom; J = John; BL = Baseline; I= Intervention; BL Ave FR = Baseline Average Frequency Ratio; I Ave FR = Intervention Average Frequency Ratio; AA Ratio = Accumulated Agreement Ratio (Total # of agreement/ Total # of narratives); 1st = 1st rater (the researcher); 2nd = 2nd rater; Synt Er = Syntactic Errors; Cap Er = Capitalization Errors; Surf Er = Surface Errors; SS Level = Story Structure Level; Agree = Scoring agreement between the researcher and 2nd rater; Disagr = Scoring disagreement between the researcher and 2nd rater.

Note: The number and/or letters followed by the initial of each student's name served an identification code for the narrative evaluated. For instance, H.BL1 stands for Hanna's narrative from her 1st baseline writing session, and T.5SR (in the following table for intervention phase) stands for Tom's narrative from his 5th speech recognition session.

Interrater Agreement on the Writing Measures across Students for Intervention Phase

	T-Unit		Clauses		Synt Er (s)		Cap Er (c)		Surf Er=(s)+(c)		SS Level	
Intervention	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**
H.3HW	8	8	13	13	15	15	3	2	18	17	7	7
H.2SR	12	13	19	16	4	3	0	0	4	3	4	7
H.4SR	15	13	23	23	9	8	1	1	10	9	7	7
H.2DR	13	12	22	20	3	3	n/a	n/a	3	3	7	7
H.3DR	11	14	17	15	4	3	n/a	n/a	4	3	7	7
H.5DR	15	13	23	20	14	13	n/a	n/a	14	13	6	6
Total	74	73	117	107	49	45	4	3	53	48		
Smaller Total	73		107		45		3		48		Agree	5
Larger Total	74		117		49		4		53		Disagr	1
FR (for H)	**99%**		**91%**		**92%**		**75%**		**91%**			
M.2HW	10	10	13	14	32	30	22	21	54	51	7	6
M.4HW	12	11	15	15	17	17	13	13	30	30	7	7
M.1SR	13	13	20	21	3	2	0	0	3	2	7	7
M.4SR	18	17	34	34	10	7	0	0	10	7	7	7
M.1DR	44	40	56	53	19	17	n/a	n/a	19	17	7	7
M.5DR	27	26	45	42	10	10	n/a	n/a	10	10	7	7
Total	124	117	183	179	91	83	35	34	126	117		
Smaller Total	117		179		83		34		117		Agree	5
Larger Total	124		183		91		35		126		Disagr	1
FR (for M)	**94%**		**98%**		**91%**		**97%**		**93%**			
T.4HW	6	6	9	8	21	23	10	8	31	31	2	2
T.1SR	13	12	15	14	8	6	3	3	11	9	2	2
T.5SR	11	10	13	17	17	15	1	1	18	16	4	4
T.3DR	14	14	18	18	2	0	n/a	n/a	2	0	4	4
T.4DR	28	27	31	30	9	6	n/a	n/a	9	6	6	6
Total	72	69	86	87	57	50	14	12	71	62		
Smaller Total	69		86		50		12		62		Agree	5
Larger Total	72		87		57		14		71		Disagr	0
FR (for T)	**96%**		**99%**		**88%**		**86%**		**87%**			
J.5HW	8	7	9	9	9	8	5	5	14	13	4	4
J.2SR	20	21	23	23	8	5	5	5	13	10	7	7
J.3SR	10	10	14	12	2	1	1	1	3	2	6	6
J.5SR	16	15	23	23	5	5	6	6	11	11	7	7
J.4DR	30	30	42	42	2	4	n/a	n/a	2	4	7	7
J.5DR	23	22	32	31	15	15	n/a	n/a	15	15	4	4
Total	107	105	143	140	41	38	17	17	58	55		
Smaller Total	105		140		38		17		55		Agree	6
Larger Total	107		143		41		17		58		Disagr	0
FR (for J)	**98%**		**98%**		**93%**		**100%**		**95%**		**AA Ratio**	**23/27**
I Ave FR	**97%**		**97%**		**91%**		**89%**		**91%**		**BL & I Ave FR = 85%**	

Abbreviations: See the description provided in the baseline table above.

~ Vita ~

I-Xing Cinthia Lee

PROFESSIONAL PREPARATION

University of Washington, Seattle, WA
Doctor of Philosophy, December 2011
Major: Special Education- High Incidence, Literacy & Technology Track

Eastern Michigan University, Ypsilanti, MI
Master of Art, April 2000
Major: Learning Disabilities
Bachelor of Science, April 1998
Major: Special Education- Mentally Impaired; Minor: Planned Program

CERTIFICATION

Michigan State Elementary Provisional *Teacher Certificate*, K-5
Special Education Teaching Endorsements in *Mental Impairment*, K-8, April 1998 and *Learning Disabilities*, K-12, June 2000

ACADEMIC ASSISTANTSHIP EXPERIENCE

Teaching Assistant, Dept. of Special Education, University of Washington, Eugene Edgar, Ph.D., Spring 2010
- Create video clips that introduce different categories of special needs
- Give feedbacks on student assignments, and course evaluation and improvement

Graduate Assistant, Dept. of Special Education, Eastern Michigan University, Nancy Halmhuber, Ph.D. & Lynne Rocklage, Ph.D., Fall1998-Winter2000
- Assist in Special Technology Lab for software installation and tech problem solving
- Design and update the homepage of Special Education Department
- Create webpages for conference and online courses
- Teach the education & cultural perspective of Asian family and the special needs
- Prepare Power Point slides and lectures &/or departmental projects

TEACHING EXPERIENCE

Special Education Middle/High School Teacher, Anchorage School District, AK, 2007-2008
- Manage teacher collaboration for group instruction in a language art class
- Coordinate teacher's meeting and curriculum planning
- Design & implement IEPs & individualized behavioral functional plan

TechStart Instructor, Technology Access Foundation, Seattle, Washington, Spring 2007
- Teach & Design lessons that integrate technology with literacy and math learning

English Substitute Teacher, Tainan Elementary Schools, Taiwan R.O.C., 2002-2003
- Teach English phonics, conversation, and beginning reading skills
- Make lesson adaptations according to the class' learning dynamics

Special Education Elementary Teacher, Dearborn Public Schools, Michigan, 2000- 2001
- Plan, teach & assess lessons pertaining to IEP in all academic areas
- Host IEP and Multi-discipline Evaluation Team meetings
- Participate in School Reading Improvement Committee
- Collaborate with teachers and staffs to facilitate the least restrictive environment

HONORS RECEIVED

Martha & Elizabeth Stone Scholarship, University of Washington, 2006-2008
Ting's Scholarship, Eastern Michigan University, Fall1998- Winter2000
Provost's Medal for Excellence in Graduate Assistance Nominee, Eastern Michigan University, Winter2000