http://dx.doi.org/10.18666/LDMJ-2016-V21-I2-7751

Computerized Instruction in Translation Strategies for Students in Upper Elementary and Middle School Grades With Persisting Learning Disabilities in Written Language

Jasmin Niedo
Steve Tanimoto
Robert H. Thompson
Robert D. Abbott
Virginia W. Berninger

Students in grades 5 to 9 (ages 10 to 14; 6 girls, 27 boys) who had persisting specific learning disabilities in transcription (handwriting and spelling) completed three kinds of composition tasks requiring translation (thought to written language) on iPads using alternating transcription modes (stylus or keyboard) across every three lessons: personal narratives (6 lessons) and written summaries about read source material (integrated reading-writing) and heard source material (integrated listening-writing) (12 lessons). Before composing summaries, students clicked sequentially one at a time onto translation strategies, which they read and heard through earphones, and could click on again as needed during summary writing: (a) Level I composing of the very next sentence, and (b) Level II composing of a higher-level discourse structure. ANOVAs showed that Level I strategies were used significantly more often than Level II strategies; but the main effect for transcription mode was not significant. Written summaries of read source material had more errors in main ideas and factual details than heard source materials, but not more irrelevant statements. Applications of results are discussed for using computers for writing instruction, not just accommodations, for students with persisting transcription disabilities.

Keywords: *personal narratives, writing summaries, read versus heard source material, transcription disabilities, translation strategies for next sentence, translation strategies for text, integrated reading-writing, integrated listening-writing, self-regulated writing*

Writing disabilities have been left behind (Slavica, Colligan, Katusic, Colligan, Weaver, & Barbaresi, 2009) at a time when, at least in the United States, the main focus has been on reading and math (Every Student Succeeds Act, signed into federal law by President Obama, December 10, 2015). Relatively more research on specific learning disabilities has focused on reading disabilities than writing disabilities, but specific learning disabilities interfere not only with reading but also with writing (Arfé, Dockrell, & Berninger, 2015; Bahr & Silliman, 2015; Lin, Monroe, Troia, 2007; MacArthur, Graham, & Fitzgerald, 2006, 2015; Mather & Wendling, 2011; Swanson, Harris, & Graham, 2013; Troia, 2009).

Theoretical models of writing in the cognitive psychology tradition differentiate between transcription processes (handwriting and spelling) and translation processes for expressing cognitions in writing (Hayes & Berninger, 2010; Hayes, 2012; Richards, Berninger, & Fayol, 2012). Much of the research that does exist on writing in students with specific learning disabilities has tended to focus on their transcription difficulties, for example, handwriting in dysgraphia or spelling in dyslexia (Berninger, 2009). Relatively less research attention has focused on the difficulties these students may also have in translating their thoughts into written language, especially at the sentence syntax level (see Berninger, Mizokawa, & Bragg, 1991; Scott, 1988). The current study was designed, therefore, to study response to translation instruction for students with diagnosed persisting specific

learning disabilities involving transcription problems in handwriting and/or spelling.

Translation of thought into language is a complex process best understood from a multidisciplinary approach, drawing on the cognitive, linguistic, and psycholinguistic traditions in writing research (Niedo & Berninger, 2016). The relevance of each of these traditions to study of translation in writing is now discussed along with applications of computer science to teaching translation strategies and clinical assessment for treatment planning and accommodations.

Cognitive psychology. During transcription the writing scribe uses handwriting and spelling to record written language manually with various tools (e.g., markers, pencils, pens, finger press, mouse, stylus, or keyboard). During translation, the writer transforms thoughts into language. For an overview of the research on transcription and translation in developing writers, see Fayol, Alamargot, and Berninger (2012). On the one hand, online experiments have shown that transcription can affect the translation processes of developing writers during the elementary school grades (e.g., Alves & Limpo, 2015). On the other hand, teaching strategies to self-regulate the translation process, such as planning, translating, reviewing, and revising, can benefit struggling writers (e.g., MacArthur, Graham, & Fitzgerald, 2006, 2015; Santangelo, Harris, & Graham, 2008; Scott, 1994). Most research on explicit strategies for teaching translation has focused on the text-level for specific genres (Olinghouse & Wilson, 2013; Philippakos, MacArthur, & Coker, 2015) or combining two sentences into one (Myhill, 2009; Saddler & Graham, 2005; Troia, 2009).

Linguistics. One of the contributions of linguistics has been to document that both oral and written language can be described, processed, and produced at multiple levels or units—subword, word, syntax/sentence, and discourse/text (e.g., Abbott, Berninger, & Fayol, 2010). Each level is related to the next higher level but not in a simple one-to-one way. For example, sentences are composed of words, but ordering of words creates clauses with syntax structure; more than vocabulary knowledge of word meaning is involved. Linguistic coding is an established method for characterizing language productions at different levels of language, which when applied to composing written language at the word, sentence, and text levels documented intraindividual differences within students as well as interindividual differences across students (Whitaker, Berninger, Johnston, & Swanson, 1994). In the current study, linguistic coding was applied to both sentence-level and discourse-level composing, because a prior computer writing study showed that fourth grade writers with writing disabilities often struggled as much or more in constructing the very next sentence as in creating the overall text (Berninger et al., 1991).

Psycholinguistics. Translation requires cross-domain communication between cognition (Hayes, 2012; Niedo, Berninger, & Abbott, 2014) and language (Chomsky, 2009; Scott, 1988, 1989, 1994) at different levels of language (Fayol et al., 2012). How cognition and language are interrelated during translation varies across the levels of language—the next sentence (Level I translation) or the text level of the evolving discourse structure of all the accumulated text so far (Level II translation) (Niedo & Berninger, 2016). Both Level I and Level II cognitive-linguistic relationships are relevant to whether the translated product is coherent at the cognitive psychological level and cohesive at the linguistic level (Halliday & Hasan, 1976). In addition, translation of cognitions into language may depend on more than one language system: language by ear (listening comprehension), language by mouth (oral expression), language by eye (reading), and language by hand (writing) (Fayol et al., 2012). For example, writers may write notes (language by hand) while listening to teachers' oral language instruction (language by ear), benefit from thinking aloud before writing thoughts (language by mouth), and reading what they write in order to review and revise their compositions (language by eye) (Alamargot, Chesnet, Dansac, & Ros, 2006).

Computer science. Both human teachers (Graham, McKeown, Kiuhara, & Harris, 2012) and computer teachers (Berninger, Nagy, Tanimoto, Thompson, & Abbott, 2015; Crossley & McNamara, 2016) can provide effective writing instruction. Although relatively less research on computerized instruction has focused on writing than reading instruction (for reviews see Wijekumar, Meyer, Lei, 2013; Wijekumar et al., 2014), the field of research on computerized writing instruction is growing (e.g., see Crossley & McNamara, 2016; Tanimoto et al., 2015).

Clinical psychology and school psychology. Research often employs data analyses approaches based on groups. However, when the findings are applied to real-world settings for clinical and educational purposes, individual differences need to be considered. Students exhibit individual differences both within themselves across learning activities and among themselves; research findings based on groups may not apply to all individuals in a classroom (Berninger & Abbott, 2000) for either designing instruction or accommodations. Thus, in the current study, not only group analyses but also intraindividual differences within a student and interindividual differences across students were examined.

The goal of the current study, which is part of a programmatic line of research on computerized writing instruction, was, therefore, to adopt a multidisciplinary

approach as explained next to study how students with researcher diagnosed transcription disabilities in grades 5 to 9 respond to computerized writing instruction in translation strategies—both for the very next sentence and the evolving discourse. Of special interest was whether computer-taught translation strategies at the sentence level and text level would be learned and applied differently as a function of the writing task—personal narrative or writing summaries of expository texts that are read or heard—or the mode of transcription interface with the computer—stylus or keyboard.

Cognitive. Much research on teaching writing has investigated various genres of writing ranging from impersonal and personal narratives (e.g., Boscolo, Gelati, & Galvan, 2012) to informational, persuasive, and compare and contrast expository to poetry (e.g., Kambelis, 1999; Moore & MacArthur, 2012; Moss, & Loh, 2010; Olinghouse & Wilson, 2013; Philippakos et al., 2015). Yet, succeeding in school also requires writing to learn (Klein, 2000): (a) reading source material and using summaries to develop reading comprehension skills or reading source materials, taking notes, and writing reports; (b) listening to teachers talk and following directions for written assignments; and (c) listening to teachers talk, taking notes, and using the notes to study for tests or perform homework assignments. Thus, writing tasks were used outside the genres of traditional impersonal narrative story about others and expository writing independent of reading or listening to source material relevant to content areas of the curriculum: the personal narrative (about the self who guides the writing process) and integrated-reading and integrated-writing about source material.

Linguistic and psycholinguistic. In the current study, the strategies taught by the computer teacher for integrated reading-writing and integrated listening-writing were grounded in levels of language, a concept from linguistics, in that they involved syntax (Level I) or text (Level II). Level I and Level II also involved cognitive-linguistic translation strategies, a concept from psycholinguistics, in that Level I required cognitive-syntax translation within sentences and Level II required cognitive-text translation across sentences. Both Level I and Level II strategies were observed in the narrative and expository writing of typically developing writers in a longitudinal sample (Niedo & Berninger, 2016). Of interest was whether the students with specific learning disabilities in transcription (handwriting and spelling) would learn and use the same Level I and Level II cognitive-linguistic translation strategies observed in typically developing writers in grades 1 to 7. These translation strategies were taught sequentially one at a time before writing summaries of read or heard source material and children were given access to them again while they wrote their summaries.

Computer science. Although many have questioned the value of handwriting in the computer era, it is the case that keyboards are not the only interface with a computer for various writing tasks. Indeed, styluses and electric pens, which require letter formation and production similar to handwriting, are increasingly available to use with laptops. Computerized instruction was also of interest because increasingly the annual tests, yoked to standards for writing achievement (Olinghouse, & Colwell, 2013; Troia & Olinghouse, 2013), are administered by computer.

Also, although computers are often used for accommodations for students with specific learning disabilities in transcription for writing tasks, they can also be used to teach writing—not only transcription (Tanimoto et al., 2015) but also translation strategies using multiple input and output modes (Thompson et al., 2016). Computers can also be used as well to monitor response to writing instruction during a lesson. Papadopoulos, Parrilla, and Kirby (2014) in their Festshrift for Das explained how Das and colleagues introduced this approach of analyzing patterns of response to instruction for clues to the processes used by individual students during learning.

Clinical psychological and school psychology. Not only group findings but also profiles for individual students were examined so that response to instruction could be described for individual students as well as the group. Although many psychologists organize their assessment results in descriptive profiles across multiple measures, a profile approach to examining individual differences may be less familiar to some researchers.

Specific Research Questions and Tested Hypotheses

The first research question was whether students with specific learning disabilities in transcription would use the taught cognitive-linguistic translation strategies in their written summaries based on read or heard source material. These translation strategies were taught using the special properties of the computer platform that allowed students to click on a button and read each visually displayed strategy on the screen as they listened to it stated orally through earphones. Thus the learning activities engaged language by ear, language by eye, and language by hand. This computerized instruction for Level I (next sentence) and Level II (evolving multi-sentence text) strategies was taught before students engaged in integrated reading-writing and integrated listening-writing with content material of the curriculum. However, students could review these strategies as needed during the translation process by clicking on a menu at the bottom of the screen

where what they wrote was displayed as they composed summaries. The first hypothesis tested was that students would use the taught Level I and Level II strategies in their integrated-reading and integrated-listening for expository texts about the history of math and world geography and culture. However, any additional translational strategies observed would be noted.

The second research question was whether the same Level I and Level II translation strategies would be observed in the personal narrative writing samples as in the integrated reading-writing and integrated listening-writing samples, even though these strategies were not explicitly taught before writing the personal narratives. The second hypothesis tested was that Level I and Level II strategies would be used in personal narratives because the typically developing writers showed use of Level I and Level II strategies in their narratives as well as expository writing.

The third research question was whether students would respond the same to the translation strategy instruction at Level I (sentence level) as they did at Level II (discourse/text level). The third tested hypothesis was that because of their transcription disabilities these students would use relatively more Level I than Level II translation strategies. The rationale was that challenges in producing letters and spelling would require considerable mental effort and reduce their working memory capacity for dealing with text level construction, which requires holding multiple syntactic structures in mind over time.

The fourth research question addressed whether application of taught translation strategies might vary with mode of writing production—by stylus or by keyboard—for the group as a whole and for individual students with specific learning disabilities in transcription. Of interest was whether there might be group or individual differences as to which mode best supported the students with transcription disabilities in their written composing. Findings of intraindividual or interindividual differences in transcription mode (stylus or keyboard) would have application to recommending the most appropriate interface between computer and user for both accommodations and writing instruction for individual students with specific learning disabilities in transcription. The fourth tested hypothesis was that, although there would not be a significant main effect for mode based on group analyses, replicating a finding of Berninger et al. (2014), intraindividual differences would be observed across the lessons. This prediction is based on clinical observations of the struggles students with specific learning disabilities in transcription have, regardless of mode, with automatizing their letter and word production processes (Berninger, 2009).

Method

Participants

Thirty three students in grades 5 to 9 (27 males, 6 females) were first given comprehension diagnostic assessment using procedures described in Berninger et al. (2015) and met evidence-based criteria for specific learning disabilities in transcription. That is, they had impaired handwriting on two or more normed measures and history of persisting difficulties with handwriting despite prior intervention; and/or impaired spelling on two or more normed measures and history of persisting difficulties with spelling despite prior intervention. As a group, their mean pretest scores fell in the below average range or low average range on three handwriting measures, in the low average range on three spelling measures, and nearly two standard deviations below the population mean on a fourth spelling measure. Some, but not all had co-occurring reading problems. Otherwise, they were typically developing children and youth.

They also participated in this study of computerized writing instruction. Their ages and grades ranged from 10 years in grade 5 to 14 years in grade 9 when they began the intervention; mode for grade (n = 21) was grade 6. They attended schools in which elementary school ended in either grade 6 or 5 and middle school began in either grade 7 or 6 and ended in grade 9 or 8. Parent-reported ethnicities of the children included Asian-American (2.9%), Pacific Islander (2.9%), White (79.4%) and mixed ancestry–White-Middle Eastern (2.9%), White-African American (2.9%), White-Asian (2.9%), and White-Hispanic (5.9%). Their mothers' level of education ranged from 2.9% high school degree to 44.1% a college degree to 52.9% more than a college degree. Parents granted informed consent and children gave assent to participate using procedures approved by the Institutional Review Board (IRB) at the university where the research was conducted. The research was carried out in compliance with the ethical guidelines of the American Psychological Association for human participation in research.

Computerized Writing Lessons

Modes of transcription. Participants were randomly assigned to order—whether they first wrote with a stylus or with a keyboard. They wrote by one mode for three lessons in a row and then switched to the other mode for three lessons in a row for three cycles (first set of six lessons, second set of six lessons, and third set of six lessons). Participating students were familiar with each tool for mode when it was introduced, having used each before. However, none had previously received explicit instruction

in integrating these letter production tools with their written composing. Some, but not all, participants shared that the stylus did not feel comfortable in their hand because it was too smooth. All used hunting and pecking to operate the keyboard (looking at keys to find them rather than at the screen as in touch typing and using one hand rather than both hands as in touch typing).

Translation strategy instruction and tasks. The translation strategies were not taught during the first six lessons in which the writing task was a personal narrative. The translation strategies were taught during the next 12 lessons prior to the integrated reading-writing and integrated listening-writing activities for which the task was writing a summary of the read or heard source material. Students were instructed to click on a box to find a set of ordered strategies, and then click sequentially on each link in the menu one at a time and read each strategy displayed on the screen while they listened through ear phones to the computer teacher read the strategy orally. At the end of the overview of each strategy they were asked to use these strategies in writing their summaries and shown how, during composing, they could tap a link at the bottom of the screen to replay any of the strategies. That is, they could access the menu of strategies and review as needed at any time during the summary writing process. Each screen page—a blank notepad—included a link back to the strategies. Research assistants noted that participants would often pause during composing summaries and click on the list to access the list of translation strategies.

Personal narratives. For the personal narratives, students self-generated their texts rather than writing about source material. They could write for up to 10 minutes because the programmatic research on writing over the years found that most children could only sustain composing on their own for this length of time without a break. Topics for each of the first six lessons included the following: Lesson 1: "My Autobiography during the School Years," Lesson 2: "My Autobiography before the School Years," Lesson 3: "My Autobiography after the School Years," Lesson 4: "My Family in My Home and Outside My Home," Lesson 5: "My Country and My World," and Lesson 6: "My Interests In and Out of School." They were given these instructions: "A writing strategy for story writing is to think with your inside voice. What you think, you "say" silently with your inside voice and you can turn into sounds, spelling, and base words with and without fixes. That is you can turn your thoughts into written language!"

Note-taking and summary writing for expository texts. In each of the next 12 lessons, students completed both a reading-writing and a listening-writing task. Both the read source material and heard source material were equated for number of words (on average about 200 words per lesson) and content subject of the curriculum (Lessons 7 to 12 math concepts and history—the history of math in human civilization; and Lessons 13 to 18 world geography and cultures—social studies with multicultural themes). First, students read source material and took notes (5 minutes) and wrote a summary (15 minutes) and then they listened to source material and took notes (5 minutes) and wrote a summary (15 minutes) with access to notes but not source material. More time was given for summary writing than for personal narratives so that the students could look back at their notes and access links with translation strategies. Although students were given a total of 15 minutes to compose before the computer lesson ended the session, students typically took less time to complete their summaries, consistent with prior findings of ten-minute sustained independent writing bouts. In keeping with the goal of building writing stamina, students were encouraged, by computer teacher prompts and human teacher reminders, to keep writing until time ran out, but often they did not.

Topics for source material and written summaries included the following with the source material for reading always first (left column) and source material for listening (right column) always second:

Counting First	Number Line Up
Language of Math	Math by Hand
Invention of Zero and Place Value	Invention of Computation Algorithms
World History Math	Spreading Word about Math
Native American Math	Lessons from Mathematicians
Writing and Reading Math	What Is Math?
The Pacific Islands	Oceania Culture
Japan: An Island with Islands	Japanese Islands: World Leader
Mariana Islands	Guam
Republic of Philippines	Hawaii
United Mexican	Mexico's Diversity
Africa	African Diversity

The computer teacher instructed students to include the main idea and supporting details in the summaries, but no strategies were taught for doing so in this study. At the beginning of each reading-writing or listening-writing activity across the lessons, students were reminded again that at any time while they were composing they could click a menu at the bottom of the screen to get access to the strategies for writing the next sentence to assist them in figuring out what to write next. A server linked to the ID for each student writer saved all the written compositions for future analyses. One-word ending statements such as Done, The End, or Finished were not coded, because

they served only as indicators students had ended their summary.

Coding Scheme

Linguistic coding was employed to identify the Level I and Level II translation strategies in the personal narratives and written summaries. Written compositions stored in the computer server were printed out for this linguistic coding. Two coders with prior experience in using the coding scheme in a prior study each independently coded 30 summaries in the current study. Interrater reliability of 87% agreement across coded categories within each Level of Translation was achieved. Then the first author coded the remaining summaries, but consulted with the last author when questions arose; they discussed the item until mutual agreement was reached.

The final coding scheme contained the following translation categories taught in the computerized lessons; examples are provided for each to illustrate the nature of linguistic coding for those not familiar with this methodology and because they provide strategies teachers can use in non-computerized instruction as well. Almost all examples are from the current study, but occasionally from other studies that also taught translation strategies to students with specific learning disabilities. Note that spelling errors and failure to capitalize are uncorrected and illustrate these students' transcription difficulties. Roman numerals indicate Level I or Level II translation strategy. Capital letters indicate categories of translation strategy with Level I or Level II. Arabic numerals indicate sub-categories within a given category that were observed in the children's writing.

I. Thinking about Writing the Next Sentence

A. Add Information

IA1. State fact or facts for which there is general agreement.
Japans histroy dates back to prehistric times, and was known as the land of the rising sun.

IA2. State an opinion (belief)
Japan is a country with lots of important and interesting information!

IA3. Describe: paint a picture with words
it is surrounded by water

IA4. Describe a state of mind or feelings
I don't get it that is weird

IA5. Describe a function or use of an object
Zero represents No Number in that place where a Number would be

IA6. Describe observable behavior
Europeans took people from their homes they live in for thousands fo years

IA7. Tell the next step or procedure
Number lines: How you would make a number line is to draw a line
and draw more lines going up and draw a number. and thn you write a number in between the number lines and then find the anser.

IA8. Tell next event
first the Spanish came & a priest Hildag led a movement in 1810 for Mexico to have there independance. He was killed, but Mexico got there independance.

IA9. Define what something is
Reefs are low lying stretches of sand coral, close or under the water.

IA10. Define what something is not
Japan is not an island near asia...group of islands

IA11. Illustrate: give one or more examples or counter-examples
some islands are diffret from others
like some islads are alone and some have lots of islands together called
arcapalego like australia.

IA12. State a wish
I wish culture more friendly years ago instead of fights and wars

IA13. State a goal/plan
My gole for Japan, China, and Asia is that the people can have as many children as they want

IA14. Tell a plan for reaching the goal
So I am going to right math for 15 mins then produced 9 pages 9 pages of numbers and equations

IA15. Make a prediction
I predict tomarow will be uneventful

IA16. State conditions If… then... (then may be implied not stated)
if we did not have zero there wouldent be a number line…

IA17. Pretend or imagine what could be but does not necessarily exist
island reminds me about kraty kid and spongebob square pance

IB. Provide an explanation
It used to have a nother name "the islnd of thieves" given to it by th esoanirds[Spaniards]
after a missunder standing in 1521 after a the chamorrs not understading the consept of
private portly[property] took a boat from the spardurdes[Spaniards].

IC. Modify Text

IC1. Qualify a prior statement—place limit(s) on it
[Babies]are able to differentiate between numbers such as one and two and count them to their abilities. But they still haven't mastered it.

IC2. Evaluate content or organization of what you are writing
The Philipines have a right to be proud of their islands, the oldest man ever alive existed there 67000 years ago. (That doesn't seem right…)

IC3. Repeat part of prior text with substitution
Mexico has a very good history of it's ownership… Mexico has a great history of how it came to be today.

IC4. Paraphrase prior text
The journey math begins with counting all the way *to very computationally- driven math problems,*

D. Create Dialogue

ID1. Among Characters: Tell next comment in conversation (dialogue).
Like this simple question and answer 4 + 2 – 4 + 5 =7 …or in algebra 2 + x = 5 what is it in this 6 x 5

ID2. Pose question for reader audience
did you know that there are 20,000 to 30,000 islands in the pacific ocain

ID3. Make editorial comment for the reader audience
…Japans population and Japan contane 1/10 of wrolds pop. That's one crowded iland.

ID4. Issue direct or indirect command for reader audience
I mwan have you ever thought about how lucky you were to have this beautiful world unstead of just wanting more? Think and Discuss!

II Coding Connecting Sentences Together (See examples in III).

A. Within Same Level (produced in next sentence to tie it to a prior sentence)

IIA1. Tie the other sentences together with a connecting word and/ or sentence.

IIA2. Make a comment that interrupts the idea in progress and then continues with that idea unless at end because time runs out.

B. Across Levels (sentence that ties multiple prior or subsequent sentences together at discourse level)

IIB1. State a topic sentence for the sentences that follow.

IIB2. Summarize main ideas or points so far.

IIB3. Draw conclusion.

IIB4. State outcome of a sequence.

IIB5. Compare: how same and/or how different.

IIB6. Make an ending statement for text

III. Example of Coding at Levels I and II

Math is a journey. IA1 (quoted from prompt); IIB1
Starting with counting on a number line to real-world shapes. IA11; IIA1
Also reading clocks, that include finding minutes to hours. IA11; IIA1
Also it goes to patterns with usally more than two digets. IA11; IIA1
Also doing computatienal math problems. IA11; IIA1
The journey math begins with counting all the way to very computationally-driven math problems IC4; IIB2
it's a long, fun and endless journey that anyone can do. IA2; IIA1, IIB6

IV. Additional Coding for the Reading-Summaries and Writing-Summaries Designed after Reading the Summaries to Code the Translation Strategies

Was a main idea stated accurately? Yes or No
How many accurate main ideas?
How many inaccurate main ideas?
How many accurate factual details were included from source?
How many inaccurate factual details were included from source?
How many irrelevant statements (e.g., personal remarks or factual background knowledge) were included?

Data Analyses

A three-prong approach to data analyses was adopted. First, the frequency of the occurrence of each of the coded translation strategies at Level I and Level II across the lessons was tallied for the whole group (N = 33) for each summary writing task. These are summarized in Table 1 to show both the nature and frequency of the most common ones used and used in testing the first hypothesis. Second, individual profiles were analyzed for each of the 33 students. Results of the profile analyses are summarized in Table 2 for the integrated reading-writing task and the integrated listening-writing task to provide an overview of both the intraindividual differences (single rows) and interindividual differences (across rows) under column headings. These were relevant to the second and third hypotheses. An Appendix that contains the summary profile for each individual student for both the personal narratives and summary writing across lessons and modes is available by request from the second author. Third, ANOVAs were performed to test the second and fourth hypotheses.

Results

First Research Question and Tested Hypothesis

Examination of the translation coding frequency results for the sample as a whole (Table 1) showed that overall only two taught strategies were not used by any student in writing summaries for either read or heard source material or both: *Define What Something is Not* (IA10) and *Make a Plan for Reaching that Goal* (IA14). These findings, summarized across 12 different lessons, provide descriptive data showing that students with specific learning disabilities in transcription did use computer-taught translation strategies for generating summaries based on source material. Overall, almost all the strategies were used by at least one student. Strategies used only for Integrated Reading-Writing were *State a Goal/Plan* (IA 13), *Create Dialogue* (ID1), and *State Outcome of Sequence* (IIB4). The strategy used only for Integrated Listening-Writing was *Tell the Next Step or Procedures* (IA 7). The results for individuals are summarized in Table 2 to provide an overview of both intraindividual differences (within rows) and interindividual differences (across rows) for variables in column headings relevant to both read source material (IIA) and heard source material (IIB).

Overall, the findings summarized in Table 1 and Table 2 show that the computer taught translation strategies, based on what typically developing writers used in their writing, were used in integrated reading-writing tasks and integrated listening-writing tasks by students with SLDs in transcription. Thus, the first tested hypothesis was confirmed.

Second Research Question and Tested Hypothesis

Repeated measures ANOVAs with writing tasks (personal narratives, integrated reading-writing, or integrated listening-writing) and frequency of coded Level I or Level II Translation Strategies were conducted. The main effect for the writing task was statistically significant for frequency of Level I translation strategies, $F(2,31)=13.08$, $p<.001$. Means showed highest use of Level I translation strategies in Personal Narratives, $M = 55.33$, $SD = 28.40$, next highest use in the integrated reading-writing summarization task, $M = 36.54$, $SD = 24.00$, and next highest use in the integrated listening-writing summarization task, $M = 29.76$, $SD = 22.45$. Likewise, the main effect for the writing task was statistically significant for frequency of Level II translation strategies, $F(2,31)=16.94$, $p<.001$. The means showed highest use of Level II translation strategies in personal narratives, $M = 22.79$, $SD = 13.08$, next highest use in the integrated reading-writing summarization task, $M = 11.58$, $SD = 11.58$, and next highest use in the integrated listening summarization task, $M = 9.18$, $SD = 11.14$.

Overall, these analyses showed that Level I and Level II strategies were used across all writing tasks, but more so in personal narratives than writing summaries, and more so in summaries when the source material was read rather than heard. Thus, the second tested hypothesis that both Level I and Level II strategies would be used in personal narratives as well as written summaries of source material was confirmed.

Third Research Question and Tested Hypothesis

A clinical approach was adopted in which patterns in individual students' written summaries were examined to address the third research question. As shown in Table 1 for group use and Table 2 for individual use of the integrated reading-writing and integrated listening-writing tasks, Level I strategies were observed more than Level II strategies. This finding confirmed the third hypothesis and is consistent with the means reported for the results of the data analyses for the second research question. The two exceptions to this group finding were one seventh grade girl who used more Level II strategies on her listening-writing summaries and one seventh grade boy who could not produce any writing on the listening-writing summary task. The most frequently used Level I translation strategies for the whole group in rank order were *State Fact or Facts, State an Opinion or Belief, Make an Editorial Comment to the Audience, Illustrate with Examples or Counter Examples, Provide an Explanation,* and *Qualify a Prior Statement.* Sometimes both Level I and Level II strategies were evident in the sentence written next, but which Level I and which Level II translation strategies were used by individual students varied enormously across students.

Although, as predicted, the students with specific learning disabilities in transcription generally used more Level I than Level II translation strategies, further examination of the written summaries showed that they often contained inaccurate main ideas or inaccurate details, and/or irrelevant statements that were simply unrelated to what was in the read or heard source material. Based on these observations, a posthoc coding system was developed to code for these variables for individuals. See Table 2.

Table 1

Frequency of Each Translation Strategy by Tasks Involving Read or Heard Sources

I-A	Frequency of Each Translation Strategy in Written Summaries about Read Sources	
IA1	State fact(s)	761
IA2	State an opinion/ belief	93
IA3	Describe - Paint picture with words	17
IA4	Describe state of mind/ feelings	10
IA5	Describe function or use	16
IA6	Describe observable behavior	16
IA7	Tell the next step or procedure	0
IA8	Tell next event	22
IA9	Define what something is	13
IA10	Define what something is not	0
IA11	Illustrate - example/counter-example(s)	91
IA12	State a wish	4
IA13	State a goal/plan	0
IA14	Tell a plan for reaching the goal	0
IA15	Make a prediction	3
IA16	State conditions If…then (may be implied)	7
IA17	Pretend/ Imagine what could be	2
IB	Provide an explanation	36
IC1	Qualify a prior statement	31
IC2	Evaluate content/organization of writing	16
IC3	Repeat part of prior text with substitution	6
IC4	Paraphrase prior text	4
ID1	Created dialogue among characters	2
ID2	Pose question for reader	18
ID3	Make editorial comment for reader	86
ID4	Issue direct/indirect command for reader	2
IIA1	Tie sentences with word and/or sentence	303
IIA2	Make a comment that interrupts idea in progress and continue with that idea	21
IIB1	State a topic sentence for sentences that follow	55
IIB2	Summarize main ideas or points so far	1
IIB3	Draw conclusion	4
IIB4	State outcome of a sequence	5
IIB5	Compare - how same and/or how different	4
IIB6	Make an ending statement for text	17
Total Level I		1462
Total Level IIA		324
Total Level IIB		86
Total Combining Levels		410
Was a main idea stated accurately?	Yes 67 No 48 None stated	141
How many accurate details from source?		892
How many inaccurate details from source?		206
How many irrelevant statements?		239

Table 1 (cont.)

I-B Frequency of Each Translation Strategy in Written Summaries about Heard Sources

IA2	State an opinion/ belief	79
IA3	Describe - Paint picture with words	18
IA4	Describe state of mind/ feelings	15
IA5	Describe function or use	30
IA6	Describe observable behavior	15
IA7	Tell the next step or procedure	2
IA8	Tell next event	7
IA9	Define what something is	10
IA10	Define what something is not	0
IA11	Illustrate - example/counter-example(s)	91
IA12	State a wish	2
IA13	State a goal/plan	0
IA14	Tell a plan for reaching the goal	0
IA15	Make a prediction	1
IA16	State conditions If…then (may be implied)	4
IA17	Pretend/ Imagine what could be	1
IB	Provide an explanation	35
IC1	Qualify a prior statement	34
IC2	Evaluate content/organization of writing	8
IC3	Repeat part of prior text with substitution	10
IC4	Paraphrase prior text	5
ID1	Created dialogue among characters	0
ID2	Pose question for reader	14
ID3	Make editorial comment for reader	59
ID4	Issue direct/indirect command for reader	3
IIA1	Tie sentences with word and/or sentence	230
IIA2	Make comment that interrupts idea in progress & continue with that idea	20
IIB1	State a topic sentence for sentences that follow	58
IIB2	Summarize main ideas or points so far	2
IIB3	Draw conclusion	3
IIB4	State outcome of a sequence	0
IIB5	Compare - how same and/or how different	2
IIB6	Make an ending statement for text	16
Total Level I		1150
Total Level IIA		250
Total Level IIB		81
Total Combining Levels		331
Was a main idea stated accurately?	Yes 97 No 28 None stated	99
How many accurate details from source?		675
How many inaccurate details from source?		129

Table 2

Translation Strategy, Best Mode (1=Stylus, 2=Keyboard), Inaccuracy for Main Ideas and Details, Irrelevant Statements , Gender (1=Male or 2=Female), and Grade for Individual Students for Writing about Read and Heard Source Material on History of Math or World Geography and Culture

II A Writing about Read Source Material

Gender	Grade	I Next Sentence	II Text in Process	Best Mode	Inaccurate Main Ideas	Inaccurate Details	Irrelevant Statements
1	5	61	15	2	4	8	10
1	6	11	3	1	0	0	4
1	6	26	14	2	4	0	10
2	9	29	12	1	3	6	1
1	6	14	1	2	1	0	0
1	5	54	3	2	2	1	1
1	6	10	0	2	0	2	4
1	6	31	12	1, 2	1	5	12
1	6	62	19	1	1	57	5
1	5	47	17	1	0	6	29
2	7	67	34	2	1	2	2
1	7	62	16	2	2	35	4
1	5	36	9	2	1	4	0
1	7	8	0	2	0	2	0
2	7	15	4	1	0	0	8
1	6	61	35	1,2	2	15	40
1	7	9	4	2	0	2	4
2	7	79	26	2	1	18	11
1	6	6	2	1,2	0	2	0
1	6	84	44	2	1	8	3
1	6	62	41	2	4	21	21
2	6	8	0	1	1	2	1
1	6	27	7	2	1	4	6
1	6	48	8	1	0	6	5
1	6	45	18	1	1	7	20
1	8	35	8	2	2	1	4
1	8	40	7	1	0	4	5
1	6	42	6	2	4	3	13
1	6	24	23	2	2	10	15
1	6	27	7	2	1	5	5
1	6	51	20	1,2	0	3	11
1	6	8	0	2	0	4	3
1	6	14	4	2	0	10	5

Table 2 (cont.)

II B Heard Source Material

Gender	Grade	I Next Sentence	II Text in Process	Best Mode	Inaccurate Main Ideas	Inaccurate Details	Irrelevant Statements
1	5	34	10	2	0	5	4
1	6	7	2	2	0	2	2
1	6	24	12	2	0	5	4
2	9	38	16	1	1	2	7
1	6	21	7	1	1	3	5
1	5	45	14	2	0	6	6
1	6	4	0	2	0	0	2
1	6	29	8	1	2	4	5
1	6	42	17	1	0	6	29
1	5	42	23	1,2	0	4	2
2	7	28	13	1	0	16	5
1	7	28	11	1	0	6	5
1	5	19	1	1,2	0	2	2
1	7	22	0	2	0	1	1
2	7	15	5	1	0	0	6
1	6	30	18	2	3	1	10
1	7	0	0				
2	7	9	11	1	1	3	7
1	6	16	2	1	0	1	2
1	6	93	58	2	2	9	14
1	6	36	19	2	0	7	13
2	6	10	1	1	1	6	3
1	6	20	3	2	1	1	4
1	6	26	3	2	0	6	19
1	6	48	8	2	0	5	19
1	6	35	14	2	0	1	4
1	8	26	16	1	0	6	6
1	6	62	5	2	0	4	25
2	6	95	23	2	0	3	5
1	6	13	5	2	0	3	5
1	6	25	7	2	1	6	7
1	6	12	0	2	0	1	5
1	6	7	1	1,2	0	3	7

Repeated measures ANOVAs showed that errors in main ideas occurred more often on average on the integrated reading-writing task (M = 1.25, SD = 1.32) than on the integrated listening-writing task (M = 0.44, SD = 0.76), $F(1, 31)=9.24$, $p < .005$; and errors in factual details occurred more often on average in the integrated reading-writing task (M = 7.59, SD = 10.62) than on the integrated listening-writing task (M = 4.00, SD = 3.17), $F(1, 31)=4.44$, $p = .043$. However, average number of irrelevant statements was not related to either the integrated reading-writing task (M = 7.28, SD = 8.11) or the integrated listening-writing task (M = 7.50, SD = 7.12), $F(1,31)=.02$, $p = .88$. Irrelevant statements occurred on both. ANOVA with one between subject variable (presence or absence of ADHD diagnosis) did not yield a significant difference in number of irrelevant statements, $F(1, 30)=.01$, $p > .05$. Neither was the presence or absence of an ADHD diagnosis significantly correlated with number of irrelevant statements, $r = -.078$, $p > .05$.

Overall, these analyses confirmed the third tested hypothesis that students with specific learning disabilities in transcription used more Level I than Level II translation strategies in writing summaries about source material. However, although they used more Level I translation strategies in writing summaries about read source material than heard source material, they were more likely to introduce errors about the main ideas and details for read than heard source material. Irrelevant statements not related to content of source material occurred in the summaries of both read and heard source material but are not related to presence or absence of an ADHD diagnosis.

Fourth Research Question and Tested Hypothesis

Repeated measures ANOVA for two writing tasks (personal narratives and summaries) and two transcription modes (stylus or keyboard) showed that for the sample as a whole one transcription mode was not associated with writing more, $F(1,30)=.046$, $p = .83$. For personal narratives, about half wrote more with the stylus (M = .55, SD = 0.57) and the other half wrote the most by the keyboard or keyboard and stylus. For summaries about half wrote the most with stylus (M = .055, SD = .072) and about half wrote the most with keyboard or keyboard and stylus (M = 0.52, SD = 0.68).

As shown in Table 2, however, individual differences were observed across lessons in task by transcription mode combinations that were not detected in group analyses. For *reading source and writing summaries*, nine wrote more by stylus, 20 wrote more by keyboard, and four wrote the same amount by stylus and keyboard; for *listening to source and writing summaries*, 11 wrote more by stylus, 18 wrote more by keyboard, three wrote the same amount by stylus and keyboard, and one could not write summary for heard source material. Of relevance to use of computers for accommodations or instruction, although more than half wrote more by keyboard than stylus or both modes, only 58% consistently wrote more only by keyboard across the two writing tasks. That is, 42% of the students with SLDs in transcription wrote more by stylus or comparably across the two modes in some lessons or tasks.

Overall, in group analyses students with specific learning disabilites in transcription did not differ significantly in whether they wrote more by keyboard or by stylus, as predicted. Thus, the fourth tested hypothesis was confirmed. However, analysis of individuals showed variation across lessons and writing tasks in whether they wrote more by one transcription mode or the other.

Discussion

Overall, the results for the first research question showed that the students with specific learning disabilites in transcription used the Level I translation strategies (next sentence) and Level II translations strategies (evolving text) that were taught in the computerized writing instruction. However, even though all source materials were expository rather than narrative, typical narrative elements were often used in the expository summaries such as *describing behavior* and *telling the next event*. So, the Level I and Level II strategies are not necessarily genre-specific. Also, consistent with language being a generative process (Boscolo et al., 2014; Chomsky, 2006) so is translation a generative process: There are multiple ways of translating thought into written language as the coding scheme at both Level I and Level II illustrates; and intraindividual and interindividual differences in their usage was observed. That is, there was considerable variation as to which translation strategies were used (a) across students for a specific writing task, and (b) across writing tasks within the same student (see Tables 1 and 2). Nevertheless, the same Level I and Level II translation strategies observed in typically developing writers (Niedo & Berninger, 2016) were also observed in the writing of students with specific learning disabilites in transcription. The first hypothesis was supported.

There are two possible explanations as to why both Level I and Level II Translation Strategies were used more often in personal narratives than integrated reading-writing summaries and integrated listening-writing summaries. One explanation is that although participants were not given strategy training for Level I and Level II translation prior to writing the personal narratives, the instructions for the personal narrative emphasized "flow," a construct (Kellogg, 1994) applied to composing. Flow may facilitate creativity during translation when the source of topic and supporting details is one's self and identity

rather than a read or heard source with content generated by another with which the reader or the listener may not be familiar. The story of a writer's life in the present, past, and envisioned future or in the writer's family, neighborhood, and world may facilitate idea generation during translation. Also writing personal narratives may draw on the oral tradition of some cultures and use of oral language supports translation of thought into written language. Another explanation is that integrated reading-writing and integrated listening-writing draw greatly on the academic register of language, are needed for academic success in the upper grades but require longer to master than personal narratives, and require ongoing explicit strategy instruction to master (see Silliman & Scott, 2009). Although the second hypothesis was confirmed based on group analyses, future research should address each of these alternative explanations and whether one or both have merit.

The third hypothesis was also confirmed that examination of individual profiles would also identify more use of Level I than Level II Translation Strategies. Future research should continue to address the intraindividual differences observed in Level I and Level II translation strategies as well as the higher frequency of factual errors for main idea and details in the summaries of read than heard source material. On the one hand, this finding may be due to reading problems of some but not all of the students with diagnosed specific learning disabilites in transcription by the research team. On the other hand, this finding may be due to lack of prior explicit instruction in strategies of taking notes and writing summaries, which has been shown to be effective for students with specific learning disabilites in written language, including, but not restricted to, transcription disabilities (Richards et al., 2016). That is, explicit strategies in translation at different levels of language may need to be supplemented with explicit strategies with note taking and summary writing to facilitate written summaries in students with specific learning disabilites in transcription.

The nonsignificant main effect for mode (stylus or keyboard) confirmed the fourth hypothesis that students would produce writing of comparable length by both modes. However, the follow-up descriptive analyses of profiles of individual students identified considerable individual differences within the same student across lessons and writing tasks as well as individual differences between students as to which transcription mode resulted in longer writing samples. This finding provides a cautious reminder that multiple modes of letter and word production may be effective in using technology tools to express thoughts in written language.

Applications to Instruction

Explicit instruction in translation strategies should be aimed not only at text-level, but also at sentence-level translation strategies. Teaching genre-specific strategies for planning, drafting, reviewing, and revising at the text level can be helpful in learning to self-regulate written composition. However, for both those with and without specific learning disabilites in transcription, ability to translate thoughts into the very next sentence is equally important as ability to translate thoughts into evolving text structures. As shown in the current study, students with transcription disabilities can learn and use Level I strategies taught by a computer. Human teachers could also teach those strategies as articulated in the coding scheme for this study. Future research might compare the relative effectiveness of human teachers, who can provide flexible, explicit guidance as needed if students are not paying attention to or engaging in the writing activities (see Cheung & Slavin, 2012), and computer teachers, which provide systematic, evidence-based preprogrammed instruction in teaching translation of thought into written language. A hybrid approach that draws on both human and computer teachers may be most effective.

Applications to Accommodations

Despite the observed interindividual and intraindividual differences in use of stylus or keyboard, a sizable number of individuals wrote more by keyboard than by stylus. Just because a student has identified transcription impairments in handwriting and/or spelling does not mean that the student should only be given accommodations that use laptops with keyboards. Some composed better consistently or variably by stylus. Assessment of which modes of interface with a laptop are most effective for individual students with transcription disabilities should first be conducted. Then explicit instruction should be designed that employs the transcription mode(s) found to be most effective. However, multiple tools for interfacing with laptops for writing might be taught and response to this instruction for a variety of writing tasks monitored to determine if a student with a transcription disability might benefit from being taught multiple modes of interfacing with a laptop.

In conclusion, translating strategy instruction has promise for teaching students to self-regulate their translating of thoughts from read or heard sources into written language at two levels of language—the very next sentence and the evolving discourse structure. Multiple disciplines can contribute to research on translation instruction and application of the research into instructional practice.

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Jasmin Niedo is a facilitator, University of Washington Extension Continuing Education.

Steve Tanimoto is a professor of Computer Science and Engineering at the University of Washington.

Robert H. Thompson is a PhD candidate in Computer Science and Enginnering at the University of Washington.

Robert D. Abbott is a professor of Statistics and Measurement at the University of Washington.

Virginia W. Berninger is a professor of Educational Psychology at the University of Washington.

Please send correspondence to Jasmin Niedo, j_niedo@hotmail.com