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Promoting Handwriting Fluency in Fifth Graders with Slow Handwriting:

A Single-Subject Design Study

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Abstract

This study used a multiple-probe design across three participants to test the effectiveness of a handwriting intervention for fifth graders (age 10-11) displaying less handwriting fluency than their peers, but without spelling disorders. The 5-hr handwriting intervention provided students with explicit instruction and intensive practice in writing cursive letters, words, and sentences, through fast-paced alphabet and copying activities. Intervention effects were examined on handwriting fluency, written composition (i.e., text length, clause extension, and story elements), and self-efficacy beliefs. Results showed that the handwriting intervention was highly effective in increasing students' handwriting fluency. There were also improvements in written composition in terms of clause extension and number of story elements. After the intervention, students also reported strengthened self-efficacy beliefs for grammar and usage skills. Overall, this study showed that handwriting interventions can effectively help students with limited handwriting skills to become fluent handwriters. Critically, findings are in line with the proposition that achieving handwriting fluency is important to support the development of writing.

Keywords: handwriting fluency, written composition, self-efficacy beliefs, handwriting intervention, single-subject design

Promoting Handwriting Fluency in Fifth Graders with Slow Handwriting: A Single-Subject Design Study

During text production, expert writers are expected to enact demanding high-level writing processes, such as idea generation or language formulation, in parallel with automatic low-level processes, such as transcription (McCutchen, 1996; Olive & Kellogg, 2002). Transcription is the externalization of language in the form of written text. It involves the retrieval, assembling, and selection of orthographic symbols (i.e., spelling) along with the programming and execution of motor movements required by a particular writing tool to produce those symbols (Abbott & Berninger, 1993). Because pen (or pencil) is the preferred tool for learning to write and most texts produced at school are written by hand (Santangelo & Graham, 2015), handwriting is one of the first skills that children need to develop, so it can operate automatically, with minimal effort and attentional requirements.

It takes students a long time to develop their handwriting fluency at that expert level. Research suggested that handwriting fluency continues to increase well beyond primary grades, at least until Grade 9 (Alves & Limpo, 2015b; Graham, Weintraub, Berninger, & Schafer, 1998). Unfortunately, some children seem to face severe difficulties in becoming fluent handwriters. Indeed, data from the study of Alves and Limpo (2015) indicated that 10% of fifth, sixth, and seventh graders displayed a handwriting fluency similar to the average performance of third graders. These results are of concern because these youngsters did not develop their handwriting ability at a similar pace of their peers, the severity of their handwriting difficulties may not be enough for them to be entitled for special education, and writing instruction after primary grades does not specifically target handwriting. It seems likely that, without tailored supplementary support, these slow writers will be harshly constrained in their ability to enact high-level processes during text production. This may, in turn, cultivate detrimental beliefs about writing and themselves as writers. It is thus important

to develop evidence-based practices to support the development of these older students' handwriting fluency, who are at a marked disadvantage in terms of writing development and, ultimately, school achievement. This was the main purpose of the present study, in which we implemented a handwriting intervention in fifth graders identified to display slow handwriting fluency in the absence of spelling disorders, and examined its effects not only on handwriting fluency but also on written composition and self-efficacy beliefs.

The Problem of Slow Handwriting

Until becoming automatic, handwriting is a major constraint to writing performance. There is an increasingly amount of research showing that lower handwriting fluency is associated with poorer writing performance not only in primary but also in middle grades (Graham, Berninger, Abbott, Abbott, & Whitaker, 1997; Limpo & Alves, 2013a; Limpo, Alves, & Connelly, 2017). There are at least three ways through which slow handwriting can hamper text production and arrest the development of expertise in writing.

First, until becoming automatic and fluent, handwriting will require attentional resources (Bourdin & Fayol, 2000; Olive & Kellogg, 2002), which are known to be conspicuously limited (Baddeley, 2007). Attention devoted to the execution of fine-motor movements to produce letters and words means no attention allocated to important high-level writing processes, such as idea generation and language formulation (Fayol, 1999; Kellogg, 1996; McCutchen, 2000). Indeed, by limiting the writers' ability to enact other processes concurrently with transcription, slow and effortful handwriting may impede the recursiveness (Hayes & Flower, 1986) and interactivity (McCutchen, 1988) among writing processes that characterizes expert writing. The high cognitive cost of non-efficient handwriting may additionally constrain the enactment of self-regulated strategic behaviors in writing (Limpo & Alves, 2017a). These behaviors are fundamental to produce high-quality texts by helping

writers to set goals and action plans to orient writing as well as to monitor their effectiveness and adjust them when needed.

Second, slow handwriting impedes writers to keep pace with the speed at which language is generated in their minds. This is well exemplified by the seminal finding that, in beginning and struggling writers, spoken texts are of better quality than written texts (Graham, 1990; Hayes & Berninger, 2010; Scardamalia & Bereiter, 1983). This means that slow writers struggle with the huge asymmetry of production rates between spoken and written languages, as the pace at which they are able to produce speech is considerably faster than the pace at which they can record it (Graham, 1990). Such disparity, reflected in the common complaint that "slow hands do not progress at the same speed as fast thought", can easily hamper text production. For example, writers may be forced to interrupt their writing frequently or may forget already developed ideas. This may reduce the amount of information written down and affect text coherence.

Finally, the physical effort and cognitive demands associated with slow handwriting, sometimes coupled with poor instruction (Santangelo & Graham, 2016) and unsupportive writing environments (Alves & Limpo, 2015a; Camacho & Alves, 2017), may turn text production into a difficult, strenuous, and even painful activity. As a consequence, children may lose interest and enjoyment in writing, thus facing a potentially downward spiral conducing to low writing achievement, anxiety and avoidance behaviors, and arrested writing development (Berninger, Mizokawa, & Bragg, 1991; Berninger et al., 1997; Graham & Harris, 2000). Slow handwriting may also negatively affect students' self-efficacy beliefs for writing (Limpo & Alves, 2013a). Indeed, given that young writers consider linguistic and mechanical factors as among the most important ingredients in good writing (Olinghouse & Graham, 2009), slow writers may be more prone to hold negative appraisals of their ability to

compose text. Such negative beliefs are associated with poorer writing performance (Pajares, 2003).

Promoting Handwriting in Primary Grades and Beyond

Intervention research has supported the importance of acquiring fluent handwriting for producing good writing. Several studies showed that instructional programs targeting handwriting are effective in improving students' handwriting fluency and written composition in terms of text length, sentence construction, bursts of written language, and text quality (Alves et al., 2016; Berninger et al., 1997; Graham, Harris, & Fink-Chorzempa, 2000; Jones & Christensen, 1999). As recently reported in a comprehensive meta-analysis (Santangelo & Graham, 2016), handwriting instruction seems to have strong and consistent effects on handwriting fluency (ES = 0.63) as well as on the amount (ES = 1.33), quality (ES = 0.84), and fluency (ES = 0.48) of students' writing.

Grounded on prior research placing handwriting as a building block of writing development (Alves & Limpo, 2015a; Limpo & Alves, 2013a, 2017b; Limpo et al., 2017), promoting this skill with evidence-based materials is particularly important in the initial years of learning to write. Adequate handwriting instruction may set the stage for the acquisition and development of high-level skills and positive beliefs, and critically prevent future writing problems emerging from limited handwriting skills (Graham, Olinghouse, & Harris, 2009). However, when slow handwriting is identified in teenage school years, supplementary instruction should be provided as well. There is some evidence on the effectiveness of handwriting interventions for older typical and struggling writers (Santangelo & Graham, 2015), but the amount of evidence-based practices to promote handwriting beyond initial school years is still reduced. For the above-detailed negative effects of slow handwriting on cognitive and motivational dimensions of writing, it seems critical to develop and empirically

test brief handwriting interventions that upper-elementary and middle grade teachers can have at their disposal and implement with students displaying slow handwriting.

Present Study

The purpose of this study was to test the effectiveness of a handwriting intervention for students in Grade 5 identified to exhibit slower handwriting fluency compared to their peers. For that, we shortened a handwriting program designed for second graders (Limpo & Alves, 2017a) and adapt it to match the needs and motivations of older students. This program combined explicit instruction with intensive and systematic practice in writing cursive letters, words, and sentences fluently and accurately, through fast-paced activities to write the alphabet and copy words or sentences. Using a multiple-probe design across three participants, intervention effects were examined on a set of measures tapping handwriting fluency, written composition (viz., text length, clause extension, and story elements) and self-efficacy beliefs. We put forward the following research questions:

1. Will a brief handwriting intervention improve handwriting fluency of slow fifth-grade writers to the level of their peers?
2. If the handwriting intervention improves students' handwriting fluency, will this effect show positive transfer to written composition?
3. If the handwriting intervention improves handwriting and written composition, will these benefits be accompanied by higher self-efficacy beliefs?

Stemming from the research previously surveyed, we anticipated that the handwriting intervention would show consistent and strong improvements in students' handwriting fluency, which would in turn result in enhanced written composition and strengthened self-efficacy beliefs for writing.

Method

Screening Procedure

Participating students were identified through a screening procedure administered to all fifth graders attending an urban middle school in Porto Metropolitan Area (N = 139). The screening procedure involved two tasks to measure students' handwriting fluency and one task to measure students' spelling ability. The handwriting measures were the alphabet task, in which students were asked to write the lowercase letters of the alphabet during 60 s, fast and legibly, as many times as possible (Berninger et al., 1991); and a copy task, in which students were asked to copy a sentence containing all letters of the alphabet during 90 s, fast and legibly, as many times as possible (Alves & Limpo, 2015b). The spelling measure was a writing through dictation task, in which the experimenter dictated 40 words at intervals of 10 s. These words belong to five categories representing some complexities of the Portuguese spelling system: silent letter *h*, contextual effect, position effect, inconsistency, and consonantal group (Limpo & Alves, 2013a).

On average, students were able to write 42.50 letters in the alphabet task (SD = 12.83), to copy 24.21 words in the copy task (SD = 5.21), and to correctly spell 26.05 words in the dictation task (SD = 5.45). We set the following inclusion criteria: absence of a diagnosis of learning disabilities and scores of 1 *SD* below the mean in the alphabet and copy tasks. Because we aimed to target students with specific difficulties in handwriting but not in other transcription skills such as spelling, we set as an exclusion criterion to score 1 *SD* below the mean in the spelling task. Four students fully met these criteria, but only three got permission from their mothers to participate in the study. These three students were additionally identified by their teachers as slow writers.

Participants' Characteristics

The three participating students were all male and Caucasian. They are described below under fictitious names in terms of their performance in the screening measures, school achievement in three subjects assessed in a scale from 1 (*lowest score*) to 5 (*highest score*),

and intellectual functioning assessed by all sub-scales of the Wechsler Intelligence Scale for Children – Third Edition (WISC-III; Wechsler, 1991).

Bruce. At the beginning of the intervention, Bruce was 10 years and 7 months old. He was able to write 23 letters in the alphabet task, to copy 17 words in the copy task, and to correctly spell 21 words in the dictation task. Concerning school achievement, Bruce marks in Portuguese, Mathematics, and Natural Sciences were, respectively, 2, 3 and 2. As measured by the WISC-III, his IQ was of 98.

James. At the beginning of the intervention, James was 10 years and 8 months old. He was able to write 28 letters in the alphabet task, to copy 16 words in the copy task, and to correctly spell 22 words in the dictation task. Concerning school achievement, James marks in Portuguese, Mathematics, and Natural Sciences were, respectively, 2, 3 and 3. As measured by the WISC-III, his IQ was of 108.

Alfred. At the beginning of the intervention, Alfred was 11 years and 1 month old. He was able to write 25 letters in the alphabet task, to copy 16 words in the copy task, and to correctly spell 26 words in the dictation task. Concerning school achievement, Alfred marks in Portuguese, Mathematics, and Natural Sciences were, respectively, 3, 2 and 3. The legal representative of this student did not authorize the administration of the WISC-III.

Experimental Design and Procedure

Intervention effectiveness was examined with a multiple-probe design across three participants, who were randomly assigned to one of three tiers (Gast, 2010). After the intervention has started with Bruce, it was introduced to James, and then to Alfred in a staggered way. According to single-subject design procedures, we pinpointed two criteria for staggering the introduction of the intervention to the next tier in the design. Specifically, for introducing the intervention to a new student (e.g., James in Tier 2), the student in the previous tier (Bruce in Tier 1) should have (a) been enrolled in the program for a minimum of

two weeks (i.e., total of six lessons completed), and (b) achieved at least one score at or above the group average on the alphabet task (i.e., 42 letters). This second criterion was considered as indicative of preliminary evidence on intervention effectiveness to improve students' handwriting fluency to the level of their peers.

The study involved four phases: baseline, intervention, post-intervention, and maintenance. During baseline, post-intervention, and maintenance phases, participants did a set of three handwriting tasks plus a story writing task (for greater detail, see Measures section below). Only on the first baseline and post-intervention sessions, students also filled in a scale on self-efficacy beliefs. During the intervention phase, participants attended 10 in-school lessons (for greater detail, see Handwriting Intervention section below), in which the handwriting program was implemented (total of five weeks). Immediately after each intervention lesson, participants did the same handwriting tasks administered in the baseline, post-intervention, and maintenance phases. During baseline, we collected three probes for Bruce and four probes for both James and Alfred. During the intervention, we collected 10 probes for the three students. During post-intervention, we collected three probes for both Bruce and James and one probe for Alfred. Finally, during maintenance we only collected one probe for Bruce and James, collected 6 and 4 weeks after the last post-intervention session, respectively. There were only two post-intervention sessions and no maintenance sessions for Alfred – the last student starting the intervention – because the school year was ending.

Portuguese Instructional Context

In Portugal, basic education comprises three stages: Grades 1–4 (age 6–10), Grades 5–6 (age 10–12), and Grades 7–9 (age 12–15). Participants were thus attending the first year of the second stage, in which they have 11 courses taught by different teachers. Writing is the preferred learning and assessment tool across all courses, but explicit writing instruction only

occurs in Portuguese language classes. Explicit teaching and guided practice of handwriting mainly occurs in Grades 1 and 2. Students are introduced to the cursive letters and practice them with letter models and sample words and sentences. Also, fine motor skills and capitalization rules are usually trained through letter writing and text copying with "careful calligraphy". As Portuguese is a romance language with a simple syllabic structure and several orthographic inconsistencies and complexities (Seymour, Aro, & Erskine, 2003), spelling is the main focus of writing instruction from Grade 1 onward. Though there is some national variability, second-stage Portuguese language lessons typically occur four times a week and last 50 min. Teachers organize class time autonomously around oral language, reading, and writing (Buesco, Morais, Rocha, & Magalhães, 2015). Writing instruction is predominately devoted to the teaching of grammar based on traditional whole-class methods and to independent text production of multiple genres (e.g., argumentative texts, expository texts, poems, syntheses). Teachers are recommended to adopt a process-oriented approach to text production, but few guidelines are provided on how to explicitly teach major cognitive writing processes, such as planning. Text production instruction may involve pre-writing activities, such as brainstorming, but is barely supported by the teaching of writing strategies. Also, due to the extensiveness of the curriculum, there are limited opportunities for individualized feedback and progress monitoring during writing practice.

Handwriting Intervention

The second author, who was a graduate student majoring in Education for Health, implemented the intervention to the three students from April to June, after the regular instructional school period. The intervention program included one unit per week repeated across five weeks. Each unit included three 20-min lessons: Lesson 1 was individually implemented in the school library, Lesson 2 was implemented as homework, and Lesson 3 was individually implemented in the school library under time constraints. Whereas Lessons

1 and 3 were implemented by the second author, Lesson 2 was completed without supervision, even though homework completeness and correctness was regularly checked by the instructor. These three lessons had a similar structure composed of two parts: alphabet warm-up (5 min) followed by single-word or sentence copying (15 min). Across lessons and units, alphabet and copying exercises involved varying contexts and layouts in order to avoid repetition and boredom, and therefore enhance students' motivation for the tasks.

The alphabet warm-up aimed to promote fast access to representations of letter forms in an ordered set in memory as well as to automatize their retrieval and production in writing. There was a different activity in each lesson. In the first lesson of each unit, students wrote the lowercase alphabet starting from different letters. In the second lesson, they wrote the letter coming before and/or after other letters in the alphabet. In the last lesson, they wrote the lowercase alphabet during 60 s and self-monitored the number of letters correctly written.

The copying activities aimed to increase students' handwriting accuracy and speed. There was a different copying activity in each lesson. In the first lesson of each unit, students made a written sort of 20 words into two groups according to superficial features of the words (e.g., color, font). In the second lesson, students were given 10 incomplete sentences and a list of the words missing (one per sentence). After filling in the blank, students copied the whole sentence. In the last lesson, they copied a set of 10 sentences under time constraints (60 s per sentence) and self-monitored the number of words correctly copied in the last sentence.

The implementation of the intervention followed key principles of explicit instruction (Archer & Hughes, 2011; Harris & Graham, 2009):

- Motivated practice: Students' motivation to write was promoted by creating a positive and collaborative instructional environment, by proposing appealing and enjoyable activities, and by positively reinforcing students' progress and effort.

- In-context practice: In addition to practicing the target skills in isolation, students were prompted to apply them in the context of authentic writing as well as in their regular classes.
- Guided practice: The introduction of new content was accompanied by high levels of guidance, which were gradually reduced once students were able to work autonomously. They also received continuous and individualized feedback on their performance and progress.
- Hierarchical and distributed practice: The target skills addressed over the program and the activities implemented within each unit followed an increasing-difficulty sequence. Throughout the intervention, students also had multiple practice opportunities.

Measures

Except text length and self-reported measures, all other measures were re-coded by a second judge. Inter-rater agreement, calculated with the Intraclass Correlation Coefficient, was high for all measures (> .94).

Handwriting fluency. In all sessions across the four phases (i.e., baseline, intervention, post-intervention, and maintenance), students were asked to do three tasks to measure handwriting fluency. In addition to the alphabet task and to the copy task (hereafter referred as fast copy task) used in the screening procedure, students were asked to do the same copy task in 90 s but with a different focus, that of producing the best possible handwriting, hereafter referred as the best copy task (Barnett, Henderson, Scheib, & Schulz, 2007). For the alphabet task, the final score was the number of correct letters written. A letter was counted when it was legible out of context and in the right alphabetical order. For the two copy tasks, the final score was the number of correct words copied. A word was considered correct when its letters were legible and copied without any mistakes.

Written composition. At baseline, post-intervention, and maintenance sessions, students were given 10 min to write stories. Respectively, Bruce, James, and Alfred wrote a total of seven, eight, and five stories. Therefore, to assure that each student always wrote on a different topic, we created eight equivalent written prompts (e.g., *Tell a story about a child who lost his/her pet* or *Tell a story about a child who broke his brother's toy*) unknown to students and administered in a random order. Students' stories were assessed in terms of text length, clause extension, and text elements. For text length, we counted the total number of words written in each story, which was provided by the Computerized Language Analysis software (CLAN; MacWhinney, 2000). For clause extension, after dividing the texts into clauses (i.e., unit with a unified predicate and expressing a single situation, Berman & Slobin, 1994), we calculated the average number of words per clause with CLAN (MacWhinney, 2000). For story elements, we examined the presence and elaboration of eight major story parts: characters, time, space, initiating event, attempt, internal response, consequence, and reaction (Stein & Trabasso, 1982). For each element, it was awarded one point if it was present, and two points if it was present and elaborated.

Self-efficacy beliefs. Students' self-efficacy beliefs were assessed with the Writing Skills Self-Efficacy scale (Pajares & Valiante, 1999) adapted to Portuguese by Limpo and Alves (2013a). The scale has 10 items, which measure students' confidence about being able to accomplish specific writing skills. The answers are given in a scale ranging from 0 (*no chance*) to 100 (*completely certain*). Though typically used as an unidimensional scale, there is evidence suggesting that the scale is composed of two factors, with five items each (Pajares, 2007). These factors tap self-efficacy beliefs for grammar and usage skills (e.g., spelling, punctuation, grammar), and self-efficacy beliefs for advanced composition skills (e.g., paragraphs organization, ideas development, use of topic sentences). Respectively,

Pajares (2007) reported coefficient alpha reliability of .88 and .86. In this study, we examined students' self-efficacy beliefs for these two dimensions separately.

Social validity. At the end of the study, participants were asked to fill out a scale to assess the perceived value of the intervention program. They rated their level of agreement (1 = *strongly disagree*; 6 = *strongly agree*) with these statements: (a) These lessons helped me to write faster; (b) These lessons helped me to write better in general; (c) These lessons helped me to finish classroom activities and assessments in the expected time; (d) These lessons were easy; (e) Slower writers should be able to participate in these lessons; and (f) I will continue to train some of the activities carried out in these lessons (adapted from Limpo & Alves, 2013b).

Treatment Fidelity

Five procedures were implemented to assure that the intervention was implemented as planned. First, the instructor participated in an 8-hr pre-intervention workshop delivered by the first author. This was aimed to introduce the theoretical and empirical basis of the program, to deliver the instructional manual, and to discuss general lesson procedures. Second, the instructor had weekly meetings with the first author to practice the next lesson and discuss the previous one. Third, across all study phases (i.e., baseline, intervention, post-intervention, and maintenance) and for the three students, the instructor was provided with a checklist with all lesson steps, and she was asked to check them off when completed. The instructor reported that during baseline, post-intervention, and maintenance phases, 100% of the steps were completed for all participants; and that during the intervention phase, 100%, 99%, and 79% of the steps were completed, respectively, for Bruce, James, and Alfred. Fourth, these same checklists were filled out by a research assistant, who examined 30% of randomly selected lessons per phase, which were audiotaped. The research assistant reported that during baseline, post-intervention, and maintenance phases, 100% of the steps were

completed for all participants; and that during the intervention phase, 100%, 98%, and 87% of the steps were completed, respectively, for Bruce, James, and Alfred. Fifth, students' notebooks were examined to assess whether the instructional activities were completed as planned. Participants did the proposed activities adequately across all phases, except in the intervention phase, where Alfred failed to complete 27% of the proposed activities, which corresponded to four homework lessons that were not completed.

Results

Following traditional single-subject design procedures (Gast, 2010), data analyses for handwriting fluency measures involved visual inspection to examine stability (criterion of 80% of data points on or within 25% of the baseline median), level, and trend. Additionally, mean changes by phase and percentage of non-overlapping data points (PND)[1] were computed to examine intervention effects not only on handwriting fluency but also on written composition measures. Scores on self-efficacy beliefs and social validity scales were examined using descriptive statistics.

Handwriting Fluency

Baseline. Before the intervention, students' performance in the three handwriting fluency tasks was low. Mean scores ranged from 23.00 (*SD* = 1.73) to 33.00 (*SD* = 6.21) letters in the alphabet task, from 15.67 (*SD* = 0.58) to 20.25 (*SD* = 2.99) words in the fast copy task, and 11.00 (*SD* = 1.54) to 15.25 (*SD* = 2.22) in the best copy task. Alfred consistently displayed a better performance than his peers. For all handwriting fluency measures, visual analysis showed that performance at baseline was stable for the three students.

Intervention. An analysis of absolute level changes indicated a positive-level change in the direction of improvement for all students and tasks. Respectively, for Bruce, James,

[1] PND scores correspond to the percentage of data points in a given phase that are above the highest datum point in the baseline phase.

and Alfred, there were increases from the first to the last intervention sessions of 27, 29, and 6 letters in the alphabet task; 9, 2, and 4 words in the fast copy task; and 7, 2, 1 words in the best copy task.

Post-intervention and maintenance. After the intervention, students' performance in the three handwriting fluency tasks was high. Mean scores ranged from 55.00 (*SD* = 5.00) to 61.33 (*SD* = 5.86) letters in the alphabet task, from 22.00 (*SD* = 1.00) to 25.67 (*SD* = 1.53) words in the fast copy task, and 16.00 (*SD* = 1.73) to 26.33 (*SD* = 1.53) in the best copy task. There were considerable increases in average performance between baseline and post-intervention phases for all students. For the alphabet ask, mean scores ranged from a 1.58-fold for Alfred to a 2.39-fold for Bruce. For the fast copy task, mean scores ranged from a 1.21-fold for Alfred to a 1.64-fold for Bruce. For the best copy task, mean scores ranged from a 1.65-fold for Alfred to a 1.45-fold for James. For all handwriting fluency measures, visual analysis showed that performance at post-intervention and maintenance phases was stable for the three students. Exception to this was James's performance in the alphabet task, where there was a very high value in the first post-intervention session (68 letters). Overall, the intervention was highly effective as evidence by PND scores at post-intervention and maintenance phases of 100% for all students on the three handwriting fluency measures.

Table 2 and Figures 1-3
about here

Written Composition

Baseline. Before the intervention, students' stories were characterized by an average total number of words ranging from 63.50 (*SD* = 17.62) to 107.74 (*SD* = 13.05), an average number of words per clause ranging from 4.53 (*SD* = 0.47) to 5.71 (*SD* = 1.46), and an average number of story elements ranging from 4.25 (*SD* = 0.96) to 6.75 (*SD* = 0.96).

Post-intervention and maintenance. After the intervention, mean scores ranged from 83.00 (*SD* = 1.41) to 105.67 (*SD* = 35.10) for text length, from 5.63 (*SD* = 0.44) to 7.23 (*SD* = 0.64) for clause extension, and 6.00 (*SD* = 1.73) to 9.00 (*SD* = 0.00) for story elements. A comparison of mean text length at baseline and post-intervention phases revealed that the stories written by James increased in 42 words, whereas those written by Bruce and Alfred decreased in 7 and 25 words, respectively. PND scores of 0% for both Bruce and Alfred on text length and of 75% (post-intervention) and 100% (maintenance) for James showed no to little effects of the handwriting intervention on the total number of words written in the stories. Nevertheless, there were consistent improvements in average clause extension and story elements between baseline and post-intervention phases. Respectively, for Bruce, James, and Alfred, mean number of words per clause increased in 1.52, 1.10, and 1.35 words; and mean number of story elements increased in 1.33, 1.75, and 2.25 elements. These moderate transfer effects of the handwriting intervention on clause extension and story elements was further supported by PND scores. For clause length, excepting PND scores for Bruce on post-intervention and maintenance phases of 75% and 0%, respectively, PND scores for James and Alfred were of 100%. For story elements, excepting a PND score for James on the post-intervention phase of 75%, all other PND scores were of 100%.

Table 2 about here

Self-EfficacyBeliefs

Baseline. All students reported moderate to high self-efficacy beliefs at baseline, ranging from a value of 53 (Alfred) to 78 (Bruce), in both cases, for grammar and usage skills. Both Bruce and James reported slightly higher self-efficacy beliefs for advanced composing than grammar and usage skills (respectively, 4- and 5-point difference), whereas

Alfred clearly reported higher self-efficacy beliefs for advanced composing than grammar and usage skills (22-point difference).

Post-intervention. For all students, there was an overall increase in self-efficacy beliefs between the baseline and post-intervention phases. This increase was markedly higher for self-efficacy beliefs for grammar and usage than advanced composing skills. Specifically, self-efficacy beliefs for grammar and usage skills increased 14 points for Bruce, 12 points for James, and 30 points for Alfred, whereas self-efficacy beliefs for advanced composing skills increased 2, 2, and 10 points, respectively. At post-intervention, and inverting the baseline pattern, both Bruce and James reported higher self-efficacy beliefs for grammar and usage than advanced composing skills (respectively, 16- and 5-point difference), whereas Alfred reported similar self-efficacy beliefs for grammar and usage and advanced composing skills.

Table 3 about here

Social Validity

Bruce and James were very positive about the perceived value of the intervention (M = 5.83, SD = 0.28, and M = 5.17, SD = 0.56, respectively). Both students agreed or largely agreed (scores of 5 or 6) that intervention lessons helped them to write faster, to write better in general, and to finish classroom activities and assessments in the expected time; and that those lessons were easy and slower writers should be able to participate in them. Though Bruce also agreed that he would continue to practice some activities (score of 5), James was less certain (score of 4). Alfred was considerably less positive about the value of the intervention (M = 3.33, SD = 1.44). Except agreeing that the intervention lessons were easy and slower writers should be able to participate in them (scores of 6 and 5, respectively), he did not agree with statements referring to how those lessons were helpful for himself (scores of 2 and 3).

Discussion

This single-subject design study was aimed to test the effectiveness of a handwriting intervention for fifth graders (age 10-11) displaying less handwriting fluency than their peers, but without spelling disorders. Intervention effects were examined on handwriting fluency, written composition, and self-efficacy beliefs. Overall, results showed that the handwriting intervention was highly effective in increasing students' handwriting fluency. Moreover, the intervention had moderate benefits on written composition in terms of clause extension and story elements, and strengthened students' self-efficacy beliefs for usage and grammar skills. Caution against drawing inferences about the long-term stability of these effects may however be warranted, since we only collected one maintenance probe for Bruce and James, and no maintenance probes for Alfred, who also failed one post-intervention session.

In what follows, these findings are discussed in light of the three research questions guiding this study.

Will a Brief Handwriting Intervention Improve Handwriting Fluency of Slow Writers to the Level of their Peers?

In line with extant research (Santangelo & Graham, 2015), results showed that the intervention resulted in benefits in handwriting fluency, measured by the alphabet and copy tasks. Mean post-intervention scores for the three students in the alphabet and fast copy tasks were at or above mean group scores at the screening phase. After the intervention, performance in the alphabet task for Bruce, James, and Alfred was, respectively, 0.97 *SD*, 1.44 *SD*, and 0.41 *SD* above the group mean (M = 42.50, SD = 12.83). As for the fast copy task, Bruce performance was 0.28 *SD* above the group mean (M = 24.21, SD = 5.21), whereas James and Alfred performance was slightly below (respectively 0.42 *SD*, and 0.39 *SD*). It is worthy to remember that, before the intervention, the three students were more than 1 *SD* below the group mean. Thus, for the three students and across measures, there were robust

increases in handwriting fluency. Overall, five hours of handwriting training were enough to increase these students' fluency in handwriting to the level of their peers. Effects were likely due to the explicit instructional practices that composed the program, namely, the combination of explicit instruction with intensive and systematic training, which included fast-paced exercises for writing alphabet letters as well as copying words and sentences fluently and accurately. Alphabet and copying activities are among the best practices to promote handwriting skills (Graham, 2009).

Among the three students, Alfred seemed to benefit the least from the intervention. Two reasons may have accounted for this. First, he failed to complete four out of five homework lessons. Thus, at the end, Alfred received only two thirds of the training received by his colleagues. This seems to hint at the importance of implementing the complete intervention program for robust effects. Actually, whenever possible, all activities should be implemented in the school context or, when including homework lessons as in here, one should seek to involve parents in the intervention to help guarantying lessons completion (for an example of effective parents' involvement in writing instruction, see Camacho & Alves, 2017). Second, social validity assessments indicated that this student did not find the intervention helpful. Alfred revealed to the instructor that he did not consider himself as a slow writer and therefore did not see the purpose of being enrolled in handwriting lessons. This was actually evident in his posture during the program, characterized by putting little effort into the activities. This remark highlights the role that students' beliefs may play in influencing students' responsiveness to writing interventions (for an example, see Limpo & Alves, 2014).

If the Handwriting Intervention Improves Students' Handwriting Fluency, will this Effect Show Positive Transfer to Written Composition?

Students' increase in handwriting automaticity was paralleled by benefits in written composition, except for text length. Contrary to our hypothesis and meta-analytic findings (Santangelo & Graham, 2015), there were no intervention effects on the total number of words produced in the stories. Actually, except for one student, mean change scores suggested a decreased in text length from baseline to post-intervention sessions. These results may signal a decrease in students' motivation and persistence in writing, likely due to the high number of stories that students were requested to write, as well as to the usual tiredness arising at the end of the school year. There were however positive effects in written composition in terms of clause extension and story elements, as suggested by PND scores. After the handwriting intervention, students produced longer clauses in their texts and included more story elements. These benefits of handwriting training on students' composing skills replicate past findings (Alves et al., 2016; Santangelo & Graham, 2015), and, critically, provide further support for the proposition that handwriting interferes with high-level cognitive writing processes (Fayol, 1996; Kellogg, 1996; Limpo & Alves, 2013, 2017; McCutchen, 2000; Olive & Kellogg, 2002). Once students became more fluent in handwriting, there were improvements in aspects related to the written composition, likely signaling more attention devoted to the high-level processes of generating ideas and formulating sentences.

It is worth cautioning that the benefits of handwriting interventions on high-level processes do not mean that this kind of instruction is sufficient for students to develop their ability to generate ideas and express them into syntactically-correct sentences, coherently organized in text. Though handwriting fluency may facilitate the enactment of the high-level processes underlying good writing, due to the complexity of these processes, targeting them through specific writing interventions is clearly needed as well. Prior research has already showed the effectiveness of such interventions, particularly through strategy-focused

instruction (Graham & Perin, 2007). As the acquisition and development of these high-level processes seem to partly depend on handwriting fluency (Limpo & Alves, 2013; Limpo et al., 2017), our claim is that, once implemented as supplementary training, handwriting interventions may boost the effectiveness of interventions targeting those high-level processes in slow writers. Indeed, Limpo and Alves (2017) recently showed that, in second graders, for whom handwriting is slow and demanding, the inclusion of handwriting training enhanced the effects of an intervention targeting planning and self-regulation skills. The added value of the handwriting training was particularly evident in poor writers. More research is however needed on the effectiveness of such multicomponent writing interventions in older students struggling with handwriting.

If the Handwriting Intervention Improves Handwriting and Written Composition, will These Benefits Be Accompanied by Higher Self-Efficacy Beliefs?

Partially supporting our hypothesis, results showed that the handwriting intervention enhanced students' self-efficacy beliefs for usage and grammar skills, but not for advanced composing skills. Compared to baseline, after the intervention students felt more confident in their skills related to the linguistic and mechanical aspects of writing, such as spelling, punctuation, or grammar. There were however no effects on students' confidence in their skills related to higher order aspects of writing, such as paragraphs organization, ideas development, or use of topic sentences. Overall, self-efficacy beliefs increased on aspects more aligned with intervention, which provided training in the low-level process of handwriting. At least two characteristics of the intervention may be related to this enhanced sense of self-efficacy beliefs for grammar and usage. First, the instructor provided regular progress feedback, so that students were aware of their improvement throughout the intervention. Second, on the last lesson of each week, students were asked to self-monitor their performance in the alphabet and fast copy tasks. Specifically, they counted and

registered the number of alphabet letters written and words correctly copied, and compared their performance to that of the week before.

Limitations

At least three limitations should be taken into account when interpreting current findings. First, because the study was implemented at the end of the school year, it was not possible to collect maintenance data for the last student receiving the intervention (Alfred). Due to the same reason, there were only two post-intervention sessions for this student, instead of the three sessions implemented with his peers. Future studies should consider start interventions earlier in the academic year and include more data points during the maintenance phase, if possible, evenly distributed across participating students. Second, after the screening procedure, four students were entitled to be enrolled in this research. Since one student was not authorized to participate, there were only three participants in the study. Further replications are therefore needed to provide additional support to findings' external validity. It would also be important to conduct larger screening assessments – eventually involving more students from different grades – so that a higher number of slow writers can be identified. Third, we restricted the assessment of handwriting to fluency measures at the letter (alphabet) and word (copy) levels. In the future, it may be worth considering the examination of the effects of handwriting training in older students on other temporal and sub-letter aspects of handwriting, such as pause and burst cycles (Alves & Limpo, 2015b; Sumner, Connelly, & Barnett, 2013), letter stroke fluency and duration (Kandel, Hérault, Grosjacques, Lambert, & Fayol, 2009), or rhythmic structure of handwriting movements (Pagliarini et al., 2017). It should also be noted that we neither assessed students' handwriting legibility, nor how goals emphasizing legibility might have affected fluency, such as in the best copy task. Such analysis could provide insights into the results on this task, mainly the high variability that tended to occur during the intervention period, particularly for James.

Finally, we did not examine whether intervention effects generalized to regular classroom activities. Given the importance of handwriting to complete writing-based assignments in most school subjects, future research should examine how increases in handwriting fluency may impact students' writing behavior during learning and assessment tasks (e.g., time to complete assignments, quality of information provided, or anxiety).

Educational Implications

This research has important implications for practice. Specifically, this study showed that it is possible to identify students with reduced handwriting fluency with simple, easy-to-implement tasks, such as the alphabet and copy tasks administered in the screening procedure. Information provided by the alphabet task, which requires access to accurate representations of letter forms in serial order in memory, followed by retrieval and written production of those forms, is complemented by information provided by the copy task, which does not require access to letter forms in long-term memory (Berninger et al., 1997; Graham et al., 1997). Research has showed these tasks to be valid and reliable measures of handwriting skill, sensitive to individual differences and change, and predictive of different aspects of writing performance (Alves et al., 2016; Limpo & Alves, 2013a, 2017a; Limpo et al., 2017). The administration and coding procedures of either the alphabet or the copy task are also straightforward and quick to implement. Both primary- and middle-grade teachers should therefore consider the inclusion of these tasks in their practice as powerful tools to assess students and, if needed, to define guidelines for supplementary support.

Another major practical implication of the findings of the present study relates to intervention effectiveness. Once identified, students with handwriting fluency below the average of their peers can strongly benefit from brief interventions, whose implementation benefits are well above its cost. After a total of five hours of training, all three fifth graders improved their handwriting fluency to the level of their peers. Importantly, this increase in

handwriting fluency was paralleled by benefits in written composition, in terms of sentence complexity and stories completeness, and enhanced self-efficacy beliefs for usage and grammar skills. Notwithstanding the above-discussed limitations, particularly in regards to the few maintenance probes, these findings are very encouraging. They indicate that teachers can effectively and efficiently help older students struggling with low-level writing skills, whose difficulties are typically ignored after primary grades. Due to their handwriting difficulties, these students may not only struggle to acquire and develop high-level cognitive writing processes (Bourdin & Fayol, 2000; Limpo & Alves, 2013a), but may also cultivate negative mindsets about writing and themselves as writers (Berninger et al., 1997; Graham & Harris, 2000). The evidence-based intervention tested here can be easily and quickly implemented as supplementary support to writing instruction for slow handwriters and strengthen the foundations for the successful development of the higher order cognitive and motivational ingredients underlying good writing.

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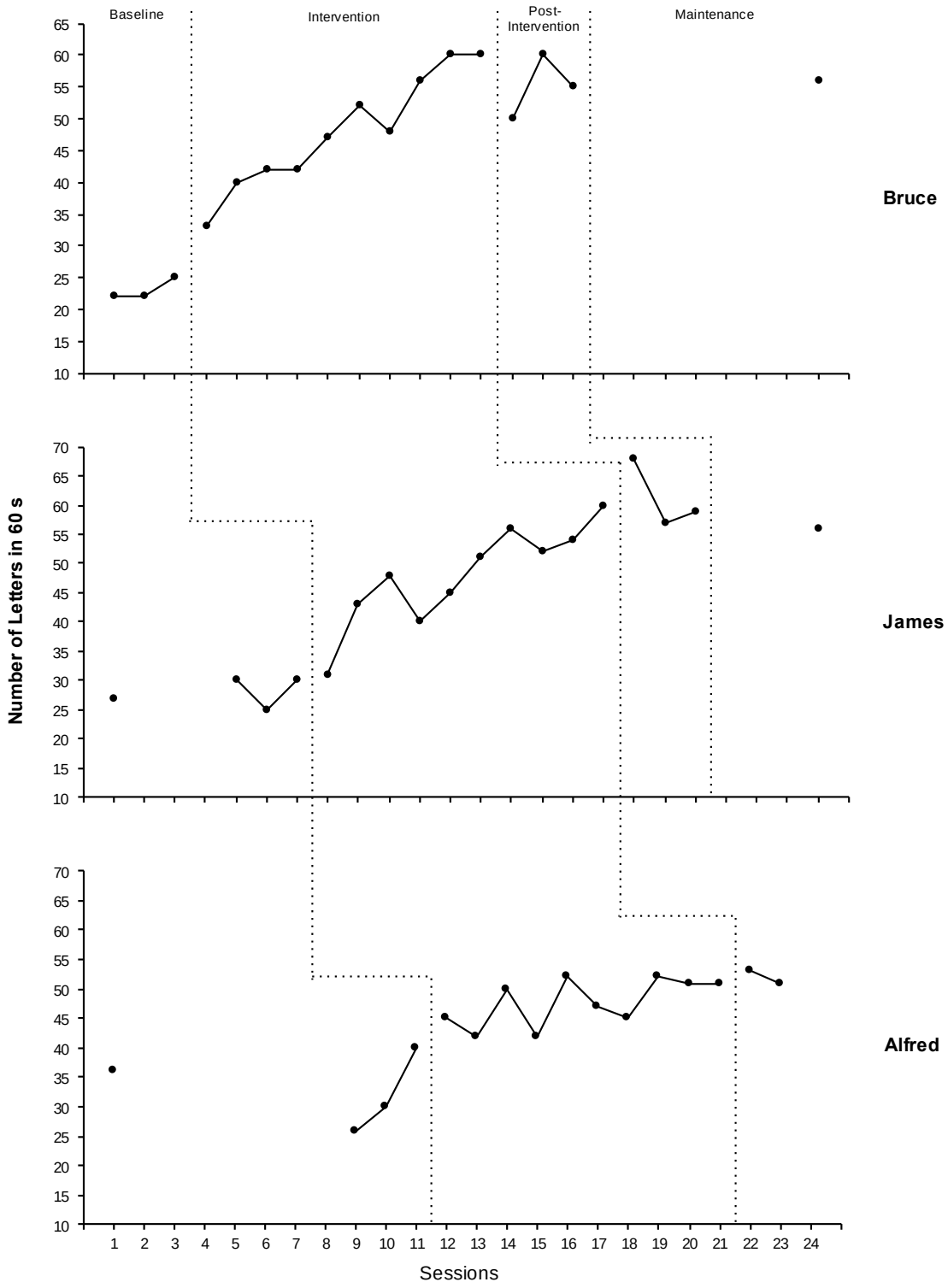

Figure 1. Number of letters written in the alphabet task across participants and study's phases. There were two sessions per week.

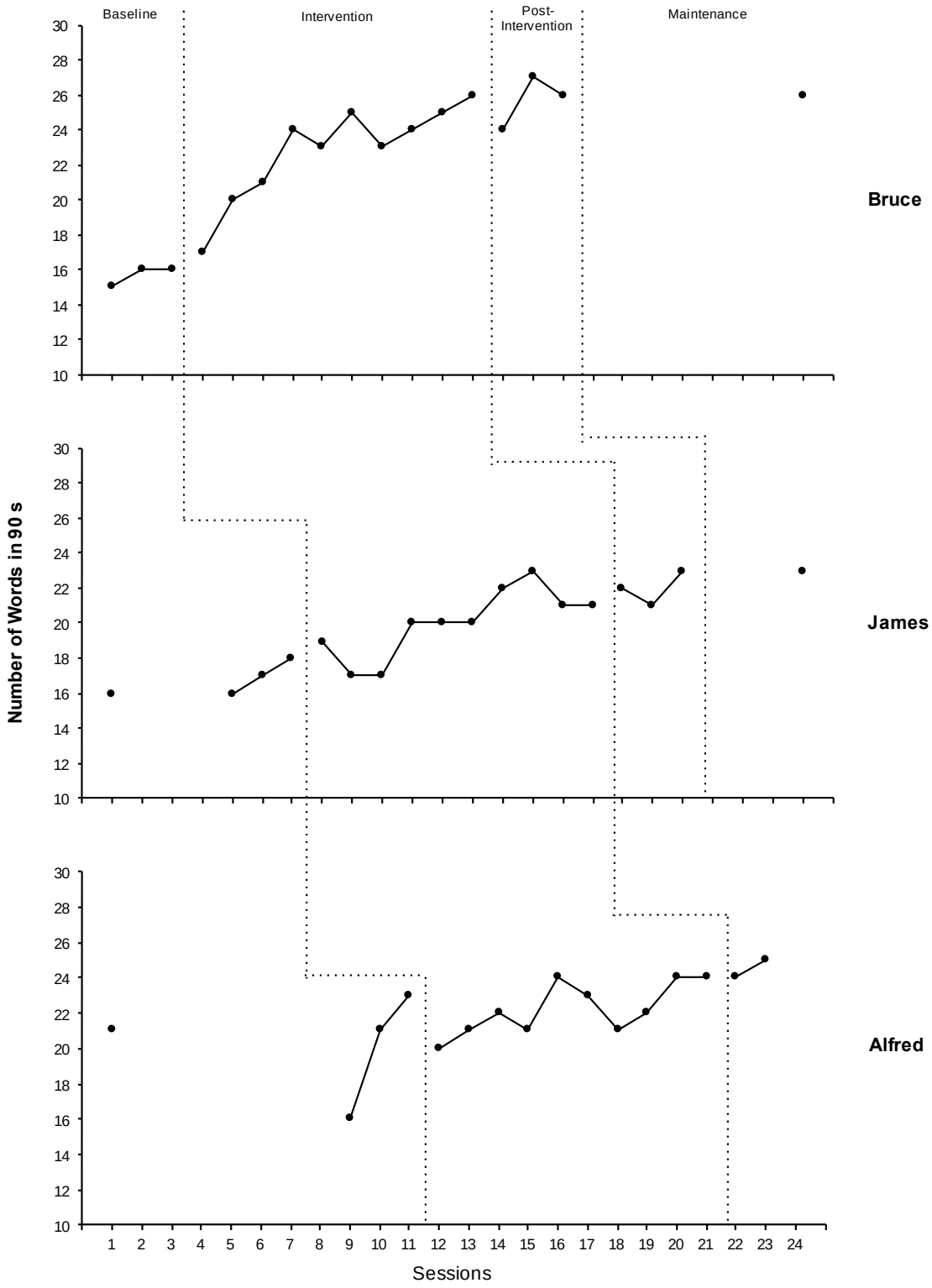

Figure 2. Number of words written in the fast copy task across participants and study's phases. There were two sessions per week.

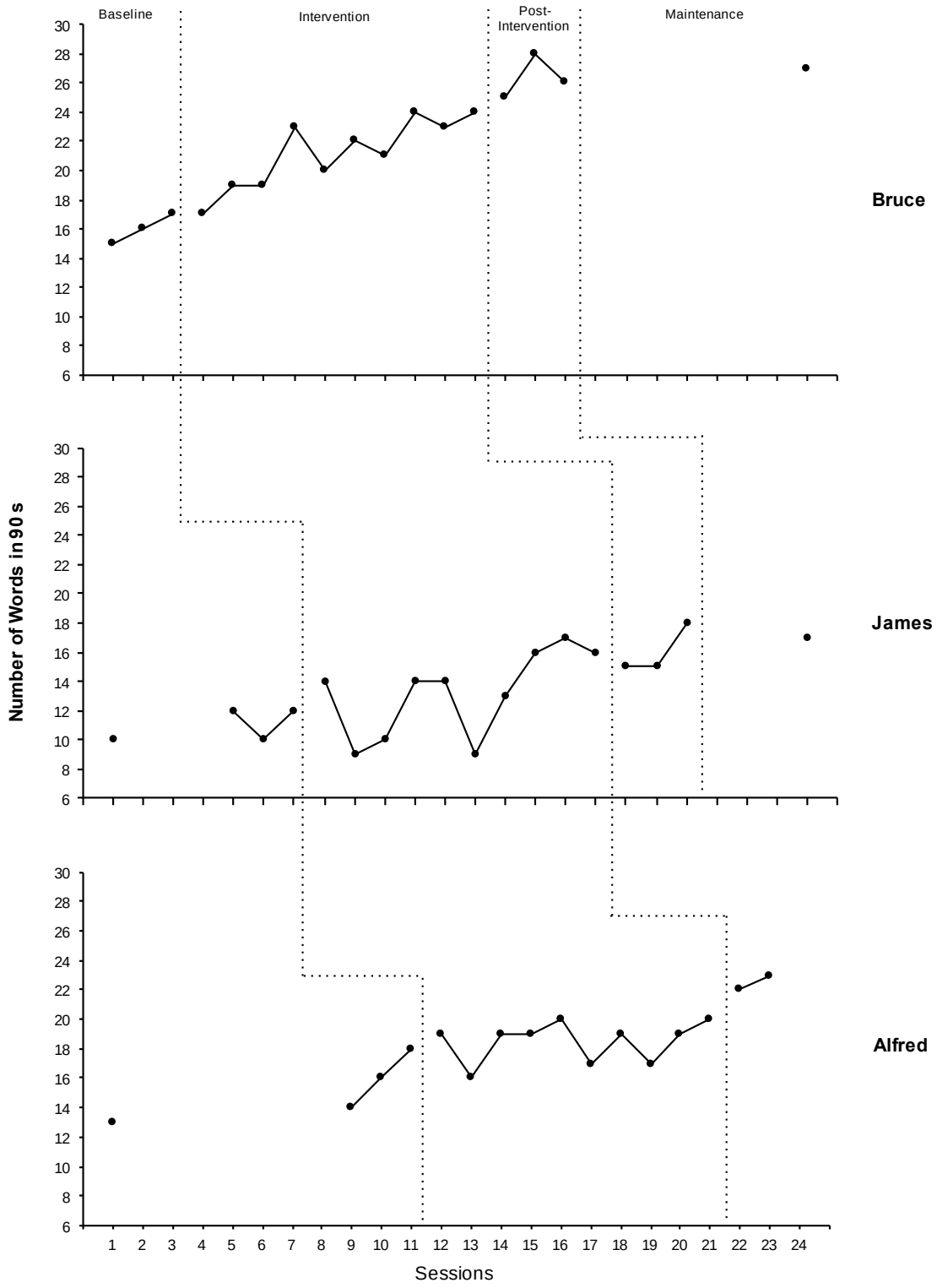

Figure 3. Number of words written in the best copy task across participants and study's phases. There were two sessions per week.

Table 1

Means and Standard Deviations for Handwriting Fluency Measures Across Participants and Study's Phase

	Alphabet			Fast Copy			Best Copy		
	M	*SD*	PND	*M*	*SD*	PND	*M*	*SD*	PND
Bruce									
Baseline (3)	23.00	1.73		15.67	0.58		16.00	1.00	
Intervention (10)	48.00	9.01	100	22.80	1.94	100	21.67	2.00	90
Post-intervention (3)	55.00	5.00	100	25.67	1.53	100	26.33	1.53	100
Maintenance (1)	56.00		100	26.00		100	27.00		100
James									
Baseline (4)	28.00	2.45		16.75	0.95		11.00	1.54	
Intervention (10)	48.00	8.54	100	20.00	1.94	80	13.20	2.94	70
Post-intervention (3)	61.33	5.86	100	22.00	1.00	100	16.00	1.73	100
Maintenance (1)	56.00		100	23.00		100	17.00		100
Alfred									
Baseline (4)	33.00	6.21		20.25	2.99		15.25	2.22	
Intervention (10)	47.70	4.00	100	22.20	1.48	30	18.50	1.35	70
Post-intervention (2)	52.00	1.41	100	24.50	0.71	100	22.50	0.71	100

Note. Values within parentheses correspond to the number of data points per phase. PND = percentage of non-overlapping data points.

Table 2

Means and Standard Deviations for Written Composition Measures Across Participants and Study's Phase

	Text Length			Clause Extension			Story Elements		
	M	*SD*	PND	*M*	*SD*	PND	*M*	*SD*	PND
Bruce									
Baseline (3)	96.00	39.40		5.71	1.46		5.00	0.00	
Post-intervention (3)	89.00	11.79	0	7.23	0.64	75	6.33	0.58	100
Maintenance (1)	78.00		0	7.09		0	7.00		100
James									
Baseline (4)	63.50	17.62		4.53	0.47		4.25	0.96	
Post-intervention (3)	105.67	35.10	75	5.63	0.44	100	6.00	1.73	75
Maintenance (1)	101.00		100	5.05		100	7.00		100
Alfred									
Baseline (4)	107.75	13.05		4.96	0.84		6.75	0.96	
Post-intervention (2)	83.00	1.41	0	6.31	0.43	100	9.00	0.00	100

Note. Values within parentheses correspond to the number of data points per phase. PND = percentage of non-overlapping data points.

Table 3

Means and Standard Deviations for each Self-Efficacy Beliefs *Dimension for each Participant Before and After the Intervention*

	Self-Efficacy Beliefs for Grammar and Usage Skills		Self-Efficacy Beliefs for Advanced Composing Skills	
	M	*SD*	*M*	*SD*
Bruce				
Baseline	78.00	25.88	74.00	23.03
Post-intervention	92.00	13.03	76.00	18.16
James				
Baseline	64.00	28.59	69.00	16.73
Post-intervention	75.80	21.70	71.20	8.25
Alfred				
Baseline	53.20	27.16	75.80	12.41
Post-intervention	84.00	15.16	84.00	13.41