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Identifying Interventions for Improving Letter Formation: A Brief Experimental Analysis of Students with Intellectual Disabilities

E. Rüya ÖZMEN [a] *

Zehra ATBAŞI [b]

[a] *Gazi University, Turkey*

[b] *Necmettin Erbakan University, Turkey*

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Abstract

As a group, students with intellectual disabilities display difficulties in a wide range of academic skills, including the acquisition of basic academic skills such as literacy. Early writing and reading skills must be supported to prepare students with intellectual disabilities to learn to read and write. The goal of this study was to replicate and extend the current research on Brief Experimental Analysis with letter formation. Three students with intellectual disabilities participated in the study. A brief multi-element design was used to test effectiveness of four interventions on letter formation. These interventions included goal setting plus contingent reinforcement, graphical feedback, error correction and modeling. For one student, modeling was effective; for the two remaining students, goal setting plus contingent reinforcement was effective. The results of this study extend the BEA literature by investigating the effects of interventions for improving letter formation in students with intellectual disabilities. The study findings suggest that using BEA to assess the relative contribution of each intervention can identify the most effective interventions for improving letter formation in students with intellectual disabilities.

Keywords: Brief Experimental Analysis, letter formation, early writing, students with intellectual disabilities.

Introduction

In the development of literacy, early writing skills are as important as reading skills (Berninger et al., 2006; Graham, MacArthur, & Fitzgerald, 2007). When learning how to write, students are first taught how to form letters (Güzel-Özmen, Yakın, & Kalkan, 2010). The crucial criteria for forming legible letters include abilities to draw letters within borders of the line, to draw a letter by following the right direction and to draw a letter properly (Güzel-Özmen, 2010). The literature identifies a number of instruction methods for teaching students to form letters, including those based on these criteria. Among the most commonly used methods, direct instruction is frequently used to teach handwriting skills. The extant research indicates that direct instruction in handwriting skills effectively

* Corresponding author: E. Rüya Özmen, Gazi University, Gazi Education Faculty, Ankara, Turkey. E-mail: ruyaozmen@hotmail.com Phone: +90 312 2021699

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increases the legibility of letters and improves overall writing development in first- and second-grade students (Berninger et al., 1997, 2006; Graham, Harris, & Fink-Chorzempa, 2000; Jones & Christensen, 1999). Direct instruction involves verbally and visually modelling how to write each letter, allowing the student to practice by looking at examples and by providing feedback and correction during practice (Graham & Harris, 2005).

Similar to the acquisition of other academic skills, the student's ability to form letters legibly and in accordance with formation rules is influenced by the establishment of appropriate goals for the student's writing performance, the modelling method used, the frequency of modelling, the number of practice sessions, the feedback and correction provided, and activities that enhance student motivation. Daly, Witt, Martens, and Dool (1997) have identified five functional explanations that cause academic failure which include: (a) students do not want to do it, (b) students have not spent time enough time doing it, (c) students have not had enough help to do it, (d) students have not had to do it that way before, and (e) it is to hard. These causes would be adapted in terms of letter formation as follows: (a) difficulty motivating the student to perform the task; (b) insufficient practice; (c) insufficient/inadequate modelling, feedback and correction; (d) asking the student to exhibit improved skills before providing the student with a sufficient number of examples and before the student has achieved the prerequisite writing proficiency; (e) presenting target letters that are difficult to draw or beyond the student's skill level.

A variety of instructional factors might contribute to student failure. Evaluating the student's academic performance and/or conducting problem analysis interviews provide a basis for developing hypotheses regarding the source of a student's problems (Burns, Ganuza, & London, 2009). The literature recommends that Brief Experimental Analysis (BEA) should be used to test such hypotheses and to identify the most effective intervention for the student. BEA is an evaluation process that analyses the instructional factors affecting a student's academic success and identifies an effective intervention for the students (Daly et al., 1997). During BEA, the student's baseline is identified; several evidence-based techniques for improving the target skill are applied in turn based on a brief multi-element design; and the student's responses to the different intervention conditions are observed. The student responses are then compared to ascertain the most effective intervention technique (Wilber & Cushman, 2006).

Previous research has indicated that BEA can be used to identify the most effective student intervention in the areas of reading fluency (e.g., Chafouleas, Martens, Dobson, Weinstein, & Gardner, 2004; Daly, Murdoch, Lillenstein, Webber, & Lentz, 2002; Eckert, Ardoin, Daly, & Martens, 2002) and mathematics (e.g., Carson & Eckert, 2003; Codding et al., 2012; Duhon et al., 2004; Mong & Mong, 2012). Notably, the results of BEA studies indicate that the effectiveness of each teaching technique varies across students. This suggests that the causes of academic failure are different for each student and that hypotheses regarding the causes of student failure should be tested before subjecting the student to a more involved intervention process.

Although a meta-analysis of BEA studies in the area of fluent reading found that BEA identified effective intervention techniques (Burns & Wagner, 2008), few BEA studies have investigated early writing skills. Three studies noted that BEA provided effective spelling intervention (McComas et al., 1996; Parker, Dickey, Burns, & McMaster, 2012), and one study noted that it provided effective writing production intervention (Duhon et al., 2004). The BEA results were confirmed by an extended analysis. These studies revealed that BEA could also be used in the area of early writing skills and that effective interventions varied across students. Only one study, which focused on a second-grade student, has used BEA to identify effective intervention techniques for improving letter formation skills in students with handwriting difficulties (Burns et al., 2009). An incentive intervention tested the hypothesis that the student's difficulty might be due to lack of motivation; modelling was used to test the hypothesis that the student required more assistance to master the skill; and a promoting intervention tested the hypothesis that the student had not previously been required to perform the task in that manner. The BEA results found that modelling was the most effective intervention for the student, and a subsequent extended analysis confirmed this result.

As a group, students with intellectual disabilities display difficulties in a wide range of academic skills, including the acquisition of basic academic skills such as literacy. Early writing and reading skills must be supported to prepare students with intellectual disabilities to learn to read and write. The goal of this study was to replicate and extend the current research on BEA with letter formation by comparing the responses of students with intellectual disabilities to the goal setting plus contingent reinforcement (GS+CR), graphical feedback (GF), error correction (EC) and modelling (ML) intervention methods.

Method

Participants and Setting

Study participants were selected from a public school for students with moderate intellectual disabilities. This school teaches students ranging from preschool to the third year of secondary school. Students attending primary and elementary school classes receive instruction in reading and writing readiness skills, language and communication skills, daily life skills, concept formation skills and mathematics skills.

Three female students participated in the current study. In order to identify prospective study participants, firstly interviews were conducted with second-, third- and fourth-grade elementary teachers. Teachers reported seven students who exhibit difficulty with letter formation skills. Secondly, the letters that had been drawn by the identified students to their notebooks were examined according to visual appearance. Three students whose letters have shape distortions and went outside the line were chosen as research participants.

Although the students' IQ scores could not be obtained, information about their levels of intellectual disability was available. All the students were able to initiate and maintain communication and understand instructions. They were able to speak in sentences consisting of three to four words. None of them demonstrated behavioural problems.

The study participants included a second-grade student exhibiting moderate intellectual disability due to hydrocephaly (age 9 years, 1 month); a fourth-grade student with a moderate intellectual disability (age 11 years, 1 month); and a fourth-grade student with a moderate intellectual disability caused by Down syndrome (age 10 years, 6 months).

The experimental procedures were performed in a school classroom used for individualized study. The classroom contained a table, two chairs and a video camera to record the experimental sessions. To ensure procedural integrity, the experimental sessions were video recorded.

Selection of Target Letters

A minimum of six target capital letters was selected for each study participant. To determine the target letters, the notebooks of participating students were examined according to visual appearance. The letters that the student both could not consistently have drawn inside the line and with proper shape were chosen.

The following criteria were used to control for internal validity when selecting the target letters: (a) a different letter was used for each intervention condition; (b) the letters followed formation rules that involved different drawing movements to ensure that the intervention techniques did not influence each other; and (c) only letters formed by straight lines. The selected letters were randomly assigned to the intervention conditions. Table 1 presents the target letters used in the study.

Table 1. *Target letters used in the intervention conditions*

Intervention Condition	***Student 1***	***Student 2***	***Student 3***
GS+CR	Z	T	L
GF	T	E	Z
EC	F	K	H
ML	K	N	M
Replication	E	H	T

Selection of Intervention Techniques

In the current study, to select the intervention techniques, the researchers first observed classroom activities in the early writing class. It was noted that, when teaching a target letter, the teachers used a limited number of examples as models without describing how they performed the actions and then instructed students to use 1 to 3 pages of their notebooks to write the letters repeatedly.

Based on the classroom observations, two skill-based intervention techniques were chosen: EC, which addresses student failure due to inadequate feedback, and ML, which addresses student failure due to insufficient and inappropriate modelling. In addition, because the teachers asked the students to repeatedly draw the target letter on several pages and delivered instructions in the same manner for all the letters, two performance-based intervention techniques (GS+CR and GF) were used to determine the extent to which the students' problems were caused by poor motivation.

Materials

The materials used in the baseline and the intervention conditions are explained below.

Study Notebook. The notebook used had the same features as the notebooks the students used for writing letters in class. The notebooks used in the study had 24 lines per page with a line spacing of 0.8 cm. In the study, one page and only two lines were used for each letter, leaving one line empty between these two lines. The locations at which the target letter was to be drawn were marked on these lines at intervals of 1.5 cm. In total, 14 locations for the target letter were marked on two lines for the experimental conditions. In addition, an example of the target letter was provided on the first line at the top on the page.

Chain graph. A circular graph in the form of a chain was used to display the number of letters that the students drew correctly in the GF condition.

Reward list. A list of rewards to be used in the GS+CR condition was prepared for each student. Parents and teachers were interviewed to identify items and activities that the students liked and create a set of five or six rewards for each student. The rewards included educationally relevant items (e.g., pencils and pencil sharpeners), food, drinks, jewellery and activity rewards.

Experimental Design and Procedures

A brief multi-element design was used during the BEA to assess the source of letter formation problems in the participating students (Daly et al., 1997) with the goal of identifying the most effective intervention. There are several approaches to designing BEA (Daly, Andersen, Gortmaker, & Turner, 2006). One of these approaches apply the interventions individually until a visible increase in students' skill is observed. Once an increase is observed, the effective intervention is detected and then an additional baseline is included accordingly. Later, the effective intervention is reintroduced for experimental control purposes (Daly, Martens, Dool, & Hintze, 1998). In the current study, a similar approach of BEA was utilized. Firstly, the letter randomly chosen for the experimental session was used to obtain baseline and then after a 45-minute break, same letter used for the intervention condition. This procedure was then repeated for each intervention technique. After the most effective intervention was detected, a replication session was conducted.

Following baseline, interventions were chosen in an order that attempted to minimize treatment intensity in other words interventions that easier to implement were implemented first (Daly et al., 1998). The interventions were applied in the same order for each student.

Written parental and teacher consent was obtained prior to initiating the study. The experimental procedures were performed by the second author. The experimental procedures were performed with each participant for five class days per week, with one baseline and one intervention session performed each day. All the experimental procedures were completed within two weeks. The length of experimental sessions ranged from 5 to 20 minutes.

The experimental procedures for the baseline and intervention conditions are described below.

Baseline. For each target letter, a baseline for each student was determined prior to applying the intervention technique. First, the researcher showed the student the target letter written at the top of the notebook page and said, 'Now draw this letter at the marked locations' while indicating the lines that the researcher had previously marked. The baseline procedure ended after the student had drawn the target letter 14 times.

GS+CR. After the student's baseline was determined for a target letter, the researcher identified three goals (Eckert et al., 2002) based on the student's baseline level (i.e. 3, 5 or 7 letters increase compared to student's baseline level was targeted). First, the researcher showed the list of rewards to the student, and the student selected three rewards. Second, the student was asked to identify her order of preference for the three rewards (most-preferred, second most-preferred and third most-preferred). Finally, the researcher described the goals and the rewards to be obtained when the goals were achieved. To explain the goals, the researcher stated, 'You should draw this letter at the places marked. After you finish, I will count the letters that were drawn correctly and give you a reward based on that.' Similar to the baseline procedure, the researcher asked the student to draw the letter by looking at the example provided. After the student finished, the researcher decided whether to provide the reward by counting the letters that the student drew correctly; if the student did not achieve the goal, she did not receive the reward.

GF. After the student's baseline was determined for the target letter, the researcher showed the student a chain graph with 14 beads. Indicating the first line of the notebook, the researcher told the student, 'Now I want you to draw the letter I have shown you at the places that are marked. After you finish, I will count the letters that you have drawn correctly and we will colour the number of beads on this chain to match the number of letters that you drew correctly.' To enable the student to understand the procedure, the researcher showed the student a different letter drawn in the notebook, counted the number of letters that were formed correctly and marked the corresponding parts of the graph. The researcher then repeated the instructions used during the baseline procedure. Once the student finished writing the first line letters, the researcher counted the letters that the student drew correctly (i.e., following the formation rules and drawn in the appropriate direction) and said, 'You have drawn .... letters correctly'; the researcher then instructed the student to colour the corresponding number of beads on the chain graph and indicated the graph, saying, 'Can you colour the whole chain? Look, there are beads that still need to be coloured'. Then, the researcher repeated the same procedure by indicating the second line of the page. At the end of the session, the researcher counted the coloured beads and told the student the number of letters that were formed correctly.

EC. In this condition, EC was implemented for the 14 letters. The researcher told the student, 'I will look at the letters that you have drawn and watch how you draw, and then I will tell you how you should draw them.' The researcher then repeated the baseline instructions. After the student drew the letter, the researcher provided corrective feedback by indicating the example letter and reviewing the relevant formation rules and drawing directions based on the student's mistake. The researcher also provided positive feedback when the student correctly applied letter formation rules.

ML. In this condition, the researcher modelled the appropriate way to draw the target letter seven times. After indicating examples of correctly formed letters, the researcher said, 'Look, I have this example letters. I have drawn the letters following the rules. Because I followed the rules, everyone can easily read these letters. Now I will show you how to draw this letter [indicating the target letter] and then I will ask you to draw it in the same way.' While modelling, the researcher explained how to draw the letter by clearly describing the appropriate procedure for drawing the letter (Graham & Harris, 2005). Afterwards, the researcher asked the student to draw the target letter 14 times.

Data Collection and Scoring

A checklist was composed for each letter based on the formation rules and drawing directions of the letters (Milli Eğitim Bakanlığı Tebliğler Dergisi, 1997). In all experimental conditions, the student was instructed to draw the target letter 14 times. The checklist included rows for the skill steps and 14 columns to record the number of letters drawn correctly for each target letter. For each intervention condition, the researcher marked the appropriate rows in the checklist for each target letter drawn by the student. For example, for the letter T, the formation rules and drawing direction included 'puts the pencil on the top line, draws a line to the right, removes the pencil and draws a perpendicular line from the middle of the horizontal line just drawn to the line below.' After each experimental session, the researcher counted the letters for which the student had applied all the skill steps correctly and recorded that number on the chart. A letter was scored as correct if the student had followed all of the skill steps.

Data Analysis

The study data were analysed by comparing the baseline and intervention conditions for each intervention.

Inter-observer Agreement and Procedural Integrity

Inter-observer agreement was calculated for each student for all baseline and intervention conditions. To calculate inter-observer agreement, a doctoral student in special education observed each session because it was difficult to observe the students' writing using the video recording. At the beginning of the session, the observer was introduced to the student and sat where he could easily watch the student's drawing. The observer received the checklist identifying the steps required to form the letter and was instructed to use the checklist to score how the letter was drawn. For each letter, the second author's and the observer's scores were compared. Inter-observer agreement was calculated using the following formula: agreements / [agreements + disagreements] x 100 (House, House, & Campbell, 1981). The mean inter-observer agreement was 93% (range: 85% - 100%) for Student 1, 88% (range: 75% - 100%) for Student 2, and 94% (range: 88% - 100%) for Student 3.

To calculate procedural integrity, checklists were composed that included all the procedures in each experimental condition. The entire experimental session was video recorded. The observer who participated in the inter-observer agreement study was provided with the checklists and videos and asked to watch the videos and indicate which procedures on the checklist were observed in the video. The integrity of the experimental procedures was computed by dividing the number of procedures that the researcher implemented by the total number of procedures listed and then multiplying the result by 100 (Billingsley, White, & Munson, 1980). Procedural integrity was calculated for all sessions. The mean procedural integrity for each experimental condition was 100% for baseline; 90% for GS+CR (range: 85% - 95%); 100% for GF; 100% for EC; and 100% for ML.

Results

Figure 1 presents the number of letters that Student 1 drew correctly in the baseline and intervention conditions. In the GS+RC condition, the first student drew the target letter correctly twice in the baseline condition and 5 times in the intervention condition. In the GF condition, the student drew the target letter correctly 3 times in the baseline condition and 6 times in the intervention condition. In the EC condition, the student was unable to form any letter correctly in the baseline condition but drew the target letter correctly 4 times in the intervention condition. In the ML condition, the student was unable to form any letter correctly in the baseline condition but drew the target letter correctly 7 times in the intervention condition.

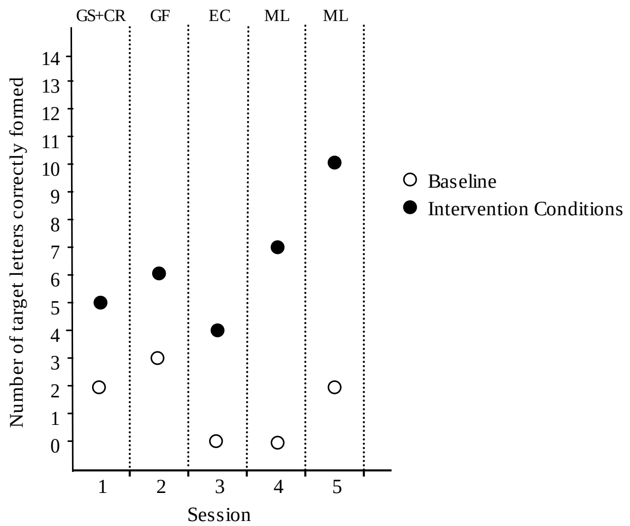

Figure 1. Number of letters correctly formed across conditions for Student 1

As Figure 1 demonstrates, the increase from the baseline was highest in the ML intervention, and the student also exhibited her highest overall level of performance in this condition. Despite the fact that there is a one letter difference between the GF condition and the ML condition, the student formed more letters correctly relative to baseline in ML condition. Consequently, the ML intervention was repeated to replicate the effect. The student formed the target letter correctly twice in the replication baseline condition and 10 times in the ML replication. These results show that ML was the most effective intervention for Student 1.

Figure 2 presents the number of letters that Student 2 drew correctly in the baseline and intervention conditions. In the GS+CR condition, the second student drew the target letter correctly 4 times in the baseline condition and 11 times in the intervention condition. In the GF condition, the student drew the target letter correctly 4 times in the baseline condition and 5 times in the intervention condition, revealing only a modest increase in performance. In the EC condition, the student drew the target letter correctly twice in the baseline condition and 5 times in the intervention condition. In the ML condition, the student was unable to form the target letter correctly in the baseline condition but drew the target letter correctly twice in the ML intervention condition, revealing only a modest increase in performance.

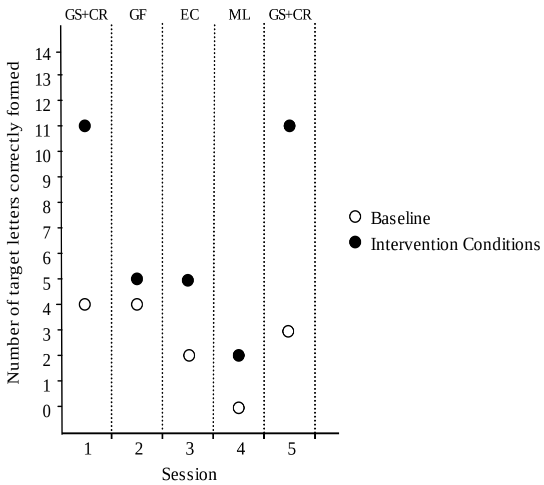

Figure 2. Number of letters correctly formed across conditions for Student 2

As Figure 2 demonstrates, the increase from the baseline for Student 2 was highest in the GS+CR intervention. This intervention was the most effective because the increase from the baseline was higher than in the other conditions, and the highest level of performance was also exhibited in this intervention. Consequently, the GS+CR intervention was repeated to replicate the effect. In the replication condition, the student drew the target letter correctly 3 times in the baseline condition and 11 times in the GS+CR condition, a significant increase.

Figure 3 presents the number of letters that Student 3 drew correctly in the baseline and intervention conditions. In the GS+CR condition, the third student was unable to form the target letter correctly in the baseline condition but drew the letter correctly 11 times in the intervention condition, a dramatic increase. In the GF condition, the student was unable to form the target letter correctly in the baseline condition but drew the target letter correctly twice in the intervention condition. Identical results were obtained in the EC and ML conditions.

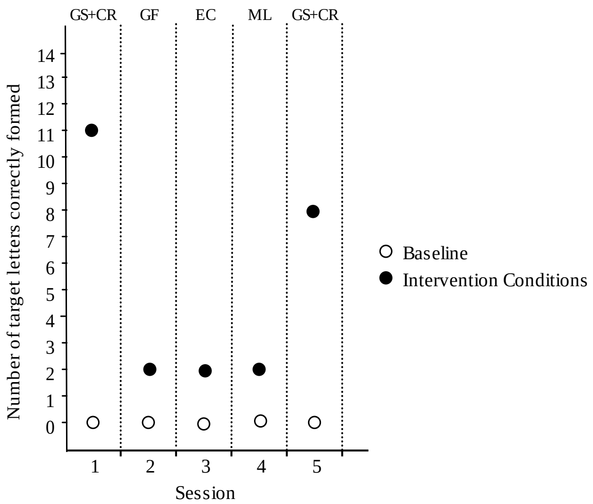

Figure 3. Number of letters correctly formed across conditions for Student 3

As Figure 3 demonstrates, the increase from the baseline for Student 3 was highest in the GS+CR intervention. Consequently, the GS+CR condition was repeated to replicate the effect. In the replication condition, the student was unable to form the target letter correctly in the baseline condition but drew the target letter correctly 8 times in the intervention condition.

Discussion

The goal of this study was to replicate and extend the current research on BEA with letter formation by comparing the responses of students with intellectual disabilities to the GS+CR, GF, EC and ML intervention methods. Previous research has found that the effectiveness of interventions differs across students and that the BEA can be used to identify the most effective interventions for students' reading fluency (Chafouleas et al., 2004; Daly et al., 1998; 2002; Eckert et al., 2002; Guzel-Ozmen, 2011; Jones et al., 2009; Orçan & Özmen, 2012), mathematics (Carson & Eckert, 2003; Codding et al., 2012; Duhon et al., 2004; Mong & Mong, 2012), and early writing skills (Burns et al., 2009; Duhon et al., 2004; McComas et al., 1996; Parker et al., 2012). The results of the present study support earlier research findings. In the current study, the students exhibited unique responses to the four intervention conditions, and the BEA procedures identified the most effective technique for each student.

The present study tested two hypotheses that were based on classroom observations, which had revealed that students did not receive sufficient assistance in performing the task and that students were not motivated to perform the task. Although the ML intervention was effective for Student 1, the GS+CR intervention was effective for Students 2 and 3. These results indicate that Student 1's difficulty in letter formation occurred because the student did not receive sufficient assistance in performing the task and that the other two students exhibited motivational problems. These results confirmed the classroom observations, which found that teachers failed to sufficiently assist letter formation and decreased student motivation by requiring students to write the letters repeatedly.

This study has several limitations that must be addressed in future research. First, the study tested only two hypotheses. Future research should identify and test additional hypotheses for students receiving other types of instruction. In addition, future research should examine the effect of different skill- and performance-based interventions on student letter formation. Second, the current study did not examine the extent to which the writing improvement observed during the interventions identified by the BEA persisted over time. Further research should examine the long-term effects of such interventions. Third, the study is limited to correcting letter formation in writing capital letters that comprise straight lines. Fourth, each intervention focused on a different letter. The difficulty of drawing these letters may have varied for each student, which might have influenced the study's results. Finally, the intervention conditions were applied in the same order, which might have influenced the letter formation skills exhibited by the students. Future research should control for the effects of the order in which interventions are performed.

Writing difficulties are frequent and widespread, particularly among elementary school students (Berninger, Mizokawa, & Bragg, 1991). Furthermore there could be individual differences among students. Therefore, considering environmental factors, applying BEA procedures and modifying instruction as necessary produces effective results in a short time without requiring students to undergo a lengthy intervention process.

The results of this study extend the BEA literature by investigating the effects of interventions for improving letter formation in students with intellectual disabilities. The study findings suggest that using BEA to assess the relative contribution of each intervention can identify the most effective interventions for improving letter formation in students with intellectual disabilities.

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