A Comparison of Math Cover, Copy, Compare Intervention Procedures for Children with Autism Spectrum Disorder

Reeva C. Morton¹ · Daniel L. Gadke¹

Published online: 5 April 2017

© Association for Behavior Analysis International 2017

Abstract Cover, Copy, Compare (CCC) and Copy, Cover, Compare (MCCC) procedures are effective interventions for improving math fluency. However, there is a gap in literature exploring the use of these interventions for children with autism spectrum disorders (ASD). The purpose of the current study was to compare the use of CCC and MCCC for children with ASD using a multi-component single-case experimental design. The results showed no notable difference between the interventions. Implications and limitations, particularly surrounding experimental control, are discussed in detail.

Keywords Math intervention · Math fluency · Autism spectrum disorder

Introduction

Teaching basic math skills to children with autism spectrum disorder (ASD) is critical because it aids children in their ability to function independently (Su, 2003). In fact, increasing math skills helps increase employment opportunities and other daily routines (Brown & Snell, 2000). However,

- Copy, Cover, Compare and Cover, Copy, Compare procedures are useful interventions in providing math gains.
- Copy, Cover, Compare procedure involves an additional step than Cover, Copy, Compare.
- Math fluency was measured using digits correct per minute.
- Interventions were compared over time using a multi-component design.

✉ Daniel L. Gadke
dgadke@colled.msstate.edu

¹ Department of Counseling, Educational Psychology, & Foundations, Mississippi State University, Box 9727, 508 Allen Hall, Mississippi State, MS 39762, USA

research suggests that children with ASD may have difficulty with math problem-solving and reading comprehension (Minshew, Goldstein, Taylor, & Siegel, 1994). These academic skills are important because they help increase academic success; however, unlike research for reading interventions, there is a limited amount of research in math interventions for children with ASD (Burns, Coddington, Boice, & Lukito, 2010). While there are a small number of academic interventions for math skills, there is an even smaller amount of research supporting academic interventions for children with ASD. Given the growing number of children with ASD in the schools and the relatively small research base of evidence-based math interventions for children with ASD (Whitby & Mancil, 2009), it is important for researchers to evaluate and identify effective interventions.

Two common math interventions include Cover, Copy, Compare (CCC) and Copy, Cover, Compare (MCCC). These interventions have been used to improve academic skills in typically developing children and in children with disabilities for multiple academic areas (Joseph et al., 2012). CCC is an effective intervention used to improve fluency and accuracy (Skinner, Turco, Beatty, & Rasavage, 1989). MCCC is also an effective intervention for providing gains related to math skill deficits (Stading, Williams, & McLaughlin, 1996). Both interventions are self-managed and allow each individual multiple opportunities for success. Grafman and Cates (2010) conducted a study comparing these two procedures and found that each of the interventions led to significant improvements in math fluency when pre- and post-test conditions were compared. Additionally, they noted that CCC was more effective at improving fluency when compared to MCCC, while neither intervention improved accuracy. At this point, to our knowledge, no studies have been conducted examining CCC and MCCC math interventions for children with ASD. Thus, there is a need for researchers to determine if these interventions are

effective for children with ASD. The purpose of the current study was to replicate and possibly extend Grafman and Cates by comparing the relative effects of CCC and MCCC on math performance of children with ASD.

Methods

Participants and Setting

The participants were three children with a diagnosis of autism spectrum or a related disorder. The participants attended a university-based clinic for children with autism and developmental disabilities. Intervention services were provided through the clinic 4 days per week across a 4-week time period.

Measurement

Dependent Variable The primary dependent variable for the current study was digits correct per minute (DCPM). A correct digit was defined as the participant writing the correct number on the provided math probe.

Determining Instructional Level Curriculum-based measurement (CBM; Deno, 1985) procedures were completed using AIMSweb® math probes to determine each participant's instructional level. Probes varied in length between approximately 38 and 40 possible math problems. Participants were provided with a probe and given 2 min to complete as many problems as possible. Brian, an eighth grade student, was instructional at second grade math. Wayne, a fifth grade student, was instructional at fifth grade math. Steven, a third grade student, was instructional at third grade math. All intervention procedures were delivered at instructional level. All procedures, including progress monitoring, were completed using AIMSweb® probes.

Baseline When instructional level was determined, two additional instructional level probes were conducted using procedures identical to the CBM procedures used when determining instructional level, for a total of three instructional level probes per participant.

Cover-Copy-Compare CCC procedures involved participants reviewing the presented math problem and answer. Initially, the participants were told to copy the math problem and correct answer next to the presented math problem. Then, participants were instructed to cover up the problem and answer. Next, participants were instructed to write the problem and answer from memory. Participants then uncovered the problem. Finally, the participants compared the attempted problem to the problem that was covered. If incorrect, the participants completed the same problem again. If correct,

the participants moved on to the next problem. Similar to Grafman and Cates (2010), participants were provided with 2 min to complete as many problems as possible.

Copy-Cover-Compare The MCCC procedures also involved the participants reviewing the presented math problem and the correct answer. Initially, participants were instructed to cover up the math problem and answer. Similar to CCC, participants were instructed to write the problem and answer from memory. Participants were then told to uncover the problem and answer. Lastly, participants were told to compare their answers to the written problem/answer. If incorrect, the participants completed the same problem again. If correct, the participants moved on to the next problem. As with CCC, participants were provided with 2 min to complete all problems.

Progress Monitoring Following the completion of each intervention session, the participants completed a single, grade level progress-monitoring probe. During the progress-monitoring condition, participants were given 5 min to complete as many problems as possible.

Interobserver Agreement Interobserver agreement (IOA) was calculated across five intervention trials for Brian (i.e., 33.3% of intervention trials). Steven and Wayne's interobserver agreement was calculated in 33.3% of trials and 37.5% of intervention trials, respectively. IOA was calculated by dividing the number of agreements with digits written correctly by the total number of agreements plus disagreements; the resulting number was multiplied by 100. IOA for all three participants was 100%. Treatment integrity was checked during 66.7% of baseline trials and was 100%. Treatment integrity was checked between 33.3 and 37.5% of trials, depending on the participant, and was 100% across all participants and trials.

Design and Procedures

A multi-component single-case experimental design (A/BC) was used to compare the relative effects of CCC and MCCC interventions and baseline. We typically alternated conditions across days; however, in some cases, participants completed up to two sessions per day. Regardless of the condition, participants were not told how much time they had to complete the probe. Rather, they were told to work until they finished or were instructed to stop, which was at 2 min when working on intervention probes or 5 min when working on progress-monitoring probes. The experimenter started timing when the participant began writing the first digit of the probe and stopped when the participant finished writing the last digit of the probe or the trials' time limit was reached, whichever came first. The participants were never provided with the same probe more than once to control for learning effects. Each

probe was marked as a trial. There was at least one trial per session.

Results

Brian No notable differences were observed in the effects of the interventions with Brian. Across CCC ($M = 5.08$ DCPM) and MCCC ($M = 2.75$ DCPM), Brian's DCPM gradually decreased to below baseline levels ($M = 6.25$ DCPM). However, progress-monitoring results indicated an increase in math fluency, following a delayed increase in trend during the intervention phase ($M = 9.77$ DCPM). Brian's (as well as the other participants') rates of improvement across the progress-monitoring data were calculated using linear regression procedures (i.e., slope). Brian's rate of improvement was 0.69 DCPM across progress-monitoring trials (Fig. 1).

Wayne No notable differences were observed in the effects of the interventions with Wayne; however, Wayne's DCPM remained at or above baseline levels ($M = 4.17$ DCPM). During CCC ($M = 6.38$ DCPM), there was an initial increase in level, followed by a decreasing trend in the data, which converged with the MCCC data. Wayne's performance on MCCC ($M = 5.75$) remained stable. Wayne's progress-monitoring data ($M = 7.3$) gradually increased in trend across time. Wayne's rate of improvement was 0.43 DCPM.

Steven Data indicated that Steven performed slightly better using the CCC ($M = 7.49$ DCPM) compared to the MCCC ($M = 5.72$ DCPM) intervention; however, the difference was small. Regardless, neither intervention was necessarily an improvement to the baseline condition ($M = 5.67$ DCPM), which had an increasing trend prior to implementing the interventions. Unlike the previous participants, Steven's progress-monitoring data ($M = 7.53$ DCPM) indicated a steady decrease in performance over time, with a rate of improvement of -0.59 DCPM across the intervention phase.

Discussion

The primary goal of the current study was to evaluate the relative effects of CCC and MCCC for increasing math fluency in individuals with ASD. Overall, the results did little to support one being a more effective intervention than the other. Additionally, there was no evidence to suggest either intervention was effective at improving math fluency with any of the participants. However, both Brian and Wayne's performance on their grade level progress-monitoring probes increased over time. This is particularly odd given that Brian's intervention performance decreased over time and Wayne's performance essentially decreased on CCC and remained stable

for MCCC. It is not possible, within the framework of the current design, to determine what produced their increased performance on the progress-monitoring probes.

One potential explanation is that time and exposure to math facts led to an increase in math fluency in the absence of an intervention. It is also possible that sequence effects could have impacted the results. As described above, progress-monitoring probes were conducted following each intervention session. It is possible that practice effects impacted their performance during progress-monitoring probes. That is, the interventions, which included several steps, may have acted as a "warm-up" to the progress-monitoring probes, which included fewer steps. In hindsight, randomizing the presentation of the progress-monitoring probe (e.g., before or after intervention procedures) may have helped control for possible sequence effects.

Steven's data were particularly unexpected given that his progress-monitoring performance decreased over time. His results suggested that the intervention procedures were possibly counter-productive to his performance over time. Again, given that sequence effects were not controlled for, his results on the progress-monitoring probes could have been the result of fatigue. Given his decrease in performance over time, which is counter to his increase in baseline performance, it is possible Steven's data are the result of a performance deficit (i.e., lack of reinforcement) rather than a skill deficit; however, given the framework of the design, it is difficult to draw any conclusions as to why his performance gradually decreased.

Limitations

While the current study presents a novel exploration of math intervention procedures for individuals with ASD, there are a number of limitations. The primary limitation is the lack of experimental control. Given that there was no return to baseline conditions nor a control condition included in the alternating treatment component of the design, clear conclusions cannot be drawn regarding the effectiveness of either intervention in relation to each other or to baseline conditions. Relatedly, the progress-monitoring procedures simply evaluated improvement in math fluency in general and also did not allow for a clear evaluation of which intervention procedure may have contributed to math fluency gains. As mentioned previously, progress monitoring was also implemented at the end of each session with each participant, which could have produced sequence effects in relation to the intervention procedures. Progress-monitoring probes could have been randomized in presentation at either the start of the sessions or end to promote greater control.

An additional limitation pertains to the use of digits correct per minute (i.e., fluency) as the dependent variable. While these procedures replicated Grafman and Cates (2010), it is possible, given the extra steps involved the use of CCC and

Fig. 1 Digits correct per minute for Brian, Wayne, and Steven

MCCC in comparison to the no intervention progress monitoring, fluency would naturally occur at lower levels during the intervention conditions. However, this difference does not explain why some participants improved during progress-monitoring conditions and decreased in performance over time during intervention conditions.

Finally, a clear measure of motivational versus skill deficits was not completed. That is, all participants were simply evaluated for the level of skill related to math fluency. It might have been beneficial to complete a preference assessment for each participant to all for the use of potential reinforcers to assess access to a high-preference items contingent on performance.

Conclusion

The current project, despite its limitations, contributes to the literature base by demonstrating an attempt to extend the use of widely accepted math fluency interventions to children with ASD. While the current results differed from those found by Grafman and Cates (2010), they are nonetheless interesting and valuable. Given the limited literature exploring the use of math interventions for children with ASD, it is essential researchers begin to more actively explore the use of evidence-based interventions with this population. Future research should continue to compare these interventions with greater experimental control.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Funding This study was not funded by a grant or any other external sources.

Ethical Procedures All procedures performed in studies involving human participants were in accordance with the ethical standards of the

institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

This article does not contain any studies with animals performed by any of the authors.

Informed Consent Informed consent was obtained from all individual participants included in the study.

References

- Brown, F., & Snell, M. E. (2000). *Instruction of students with severe disabilities*. Upper Saddle River, NJ: Prentice Hall.
- Burns, M. K., Coddling, R. S., Boice, C. H., & Lukito, G. (2010). Meta-analysis of acquisition and fluency math interventions with instructional and frustration level skills: evidence for a skill-by-treatment interaction. *School Psychology Review*, 39, 69.
- Deno, S. L. (1985). Curriculum-based measurement: *The emerging alternative Exceptional Children*, 52, 219–232.
- Grafman, J. M., & Cates, G. L. (2010). The differential effects of two self-managed math instruction procedures: cover, copy, and compare versus copy, cover, and compare. *Psychology in the Schools*, 47, 153–165.
- Joseph, L. M., Konrad, M., Cates, G., Vajcner, T., Eveleigh, E., & Fishley, K. M. (2012). A meta-analytic review of the cover-copy-compare and variations of this self-management procedure. *Psychology in the Schools*, 49, 122–136.
- Minshew, N. J., Goldstein, G., Taylor, H. G., & Siegel, D. J. (1994). Academic achievement in high functioning autistic individuals. *Journal of Clinical and Experimental Neuropsychology*, 16, 261–270.
- Skinner, C. H., Turco, T. L., Beatty, K. L., & Rasavage, C. (1989). Cover, copy, and compare: a method for increasing multiplication performance. *School Psychology Review*, 18, 412–420.
- Stading, M., Williams, R. L., & McLaughlin, T. F. (1996). Effects of a copy, cover, and compare procedure on multiplication facts mastery with a third grade girl with learning disabilities in a home setting. *Education and Treatment of Children*, 19, 425–434.
- Su, H. F. (2003). Don't be puzzled by math. *NCSM Journal of Mathematics Education Leadership*, 6, 1–7.
- Whitby, P. J. S., & Mancil, G. R. (2009). Academic achievement profiles of children with high functioning autism and Asperger syndrome: a review of the literature. *Education and Training in Developmental Disabilities*, 44, 551–560.