Effects of Musical Mnemonics on the Division Skills of Students with Math Difficulties

Matthias Grünke[1], Nicole Müllerke[2], Jennifer Karnes[1], Ellen L. Duchaine[3], Anne Barwasser[1]

[1] University of Cologne, Germany
[2] Special School Geisbach, Hennef, Germany
[3] Texas State University, USA

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CORRESPONDING AUTHOR:
Matthias Grünke;
matthias.gruenke@uni-koeln.de

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ABSTRACT:

The aim of this study was to assess the effectiveness of musical mnemonics in improving division skills among sixth-grade students with severe math difficulties. This experiment builds upon previous work in this field to mitigate the replication crisis in special education. A multiple-baseline design (AB) was implemented, consisting of 3-6 baseline sessions followed by 9-12 intervention sessions. The findings reveal that the training produced an immediate and notable impact on the participants' capacity to solve division problems involving 7s and 9s, which were particularly challenging for them prior to the intervention. All four student participants expressed highly positive evaluations of the strategy instruction. While this research is subject to certain limitations, it serves as a valuable option to assist students struggling in math during the early stages of secondary education, to prevent them from falling behind in the critical area of division. Further research is warranted to explore the generalizability of these findings and to address the limitations encountered in this study.

Keywords: mnemonics, struggling math students, single-case research, secondary school, division

INTRODUCTION

The Significance of Math and Division Skills

Mathematics provides an effective way to foster cognitive discipline, logical reasoning, and mental rigor. Moreover, a basic understanding of mathematical concepts plays a pivotal role in comprehending various academic subjects to include science, social studies, music, and art (Gurganus, 2021). Therefore, it is crucial to not only grasp the fundamental principles of basic mathematical operations such as addition, subtraction, multiplication, and division, but also to cultivate fluency in these areas. Proficiency in rapidly recalling math facts reduces the cognitive load on one's working memory, enabling the individual to allocate their mental capacities to solving higher-order problems (Bouck & Long, 2022; Gliksman et al., 2022).

Among the four primary arithmetic functions, division is often regarded as the most challenging (Smith, 1958), yet it holds significant importance. It serves as a progression from the fundamental skills of addition, subtraction, and multiplication. Establishing a solid conceptual grasp of division is paramount, as it lays the groundwork for more advanced concepts such as fractions and proportions. By the age of 11, students should have acquired proficiency in two-digit division (Posamentier & Spreitzer, 2018).

The Incidence of Severe Math Problems

While most students typically acquire sufficient foundational math skills, including division, by the end of 4th grade (Nesher, et al., 2006), a notable proportion still struggle in this area at the age of 13 or 14 (Noël, 2022). Disturbing setbacks in mathematics have been observed among U.S. children and youth across various states and demographic groups, as revealed by the latest the National Assessment of Educational Progress (NAEP; NCES, 2022). These results signify the sharpest declines ever recorded in the history of the NAEP, which assesses a representative sample of fourth and eighth graders and dates back to the early 1990s. In the aftermath of the pandemic, merely 26% of eighth graders demonstrated proficiency in math, a decline from the 34% recorded in 2019. Fourth graders fared slightly better, although with only 36 percent of them exhibiting math proficiency, down from 41% (NCES, 2022).

This trend extends beyond the United States and is observed in many other Western nations. In Germany, for instance, there has been a dramatic deterioration of math skills among fourth-graders. The gap between socially disadvantaged children and those with an immigrant background, and their more privileged counterparts has further widened. Nationally, just over half of all students (54.8%) meet the minimum standards, leaving nearly 22% of fourth graders falling below the minimum level (Stanat et al., 2022).

Methods to Remedy Math Problems

Fortunately, a robust body of research exists on how to support students struggling with math in general, and division in particular. Several meta-analyses provide specific insights into the most effective strategies for fostering basic skills in this area. Jaspers et al. (2017) have summarized the current knowledge on this subject, highlighting that systematic instruction (effect size of d = 1.19), self-instruction (effect size of d = 0.98), visual representation (effect size of d = 0.50), and peer-assisted learning (effect size of d = 0.62) are among the most effective tools for promoting arithmetic functions. In addition, An, et al., (2013) found music to be powerful as a learning and memory technique. However, of all the options, one specific approach appears to hold exceptional potential in building arithmetic fluency: the utilization of mnemonic devices. Mnemonics serve as strategies designed to enhance memory retention of new information by connecting it to their prior knowledge through visual or acoustic cues. These tools have proven effective across a wide range of student abilities and grade levels. Mnemonics are particularly beneficial for students with disabilities who struggle to recall verbal and content-area information, as they can be effectively applied to any type of verbal content (Boon et al., 2019; Lubin & Polloway, 2016; Wolgemuth et al., 2008).

The Potential of Musical Mnemonics in Fostering Division Skills

One particularly appealing technique in this regard is the implementation of musical mnemonics. This strategy encompasses the use of music as a mnemonic tool to arrange, organize, and imbue information with meaning, pleasure, emotion, and motivation, thereby augmenting learning and recall. Rhythms, songs, rhymes, and chants enrich the learning process and heighten the likelihood of successful retention (An, et al., 2013; Gardiner & Thaut, 2014). It is posited that music may have distinct effects on processes involving the phonological loop, as proposed by Baddeley and Hitch (1974). Notably, early experiments conducted by Miller (1956) have highlighted the significance of music as a mnemonic device, demonstrating that working memory processes enable

the grouping of information into meaningful chunks based on its relationship with long-term memories. By virtue of its temporal ordering and hierarchical structure encompassing notes, phrases, motives, and rhythms, music can potentially contribute additional organization to working memory tasks, resembling Miller's observations on "chunking" (Knott & Thaut, 2018). In an early study, Scruggs and Brigham (1991) examined the beneficial effects of employing musical mnemonics and proposed that such techniques seem to utilize cognitive strategies distinct from those employed by keyword mnemonics. While keyword mnemonics primarily operate through association, musical mnemonics appear to primarily rely on rehearsal.

Despite the benefits offered by mnemonics, there exists a significant gap in the literature regarding their use in mathematics instruction. In fact, Boon et al. (2019) were only able to identify eleven studies for their systematic review on this topic, with half of them conducted in the 1980s and 1990s (and the most recent one published in 2015). A thorough literature search in reputable databases in May of 2022, including Academic Search Complete, ERIC, JSTOR, and PsycINFO, using the terms "mnemo*" and "math+" in the title, resulted in the discovery of only four papers focusing on the benefits of musical mnemonics in learning mathematics. Three of them center around multiplication, while one focuses on division.

The first study by Gfeller (1983) examined the results of an experiment involving 60 students with and without learning disabilities. Results indicate that the intervention had a significant effect on the recall of the participants who received the training. The second paper by Claussen and Thaut (1997) explored the benefits of using familiar music versus verbal rehearsal as mnemonic devices with 21 students with learning disabilities. Findings document a significant effect of treatment upon recall accuracy, with the familiar music condition displaying a higher average of recall accuracy than verbal rehearsal. In the third article, Greene (1999) investigated the impact of musical mnemonics on the multiplication skills of 23 elementary and middle school students with learning disabilities (aged 8.8–13.4 years). The number of multiplication facts recalled at posttest exceeded the one at pretest by far. In the final paper, Cade and Gunter (2002) tested the effectiveness of musical mnemonics instruction in improving division skills for three students with severe behavioral disorders within a single-subject design. Notably, these interventions resulted in remarkable performance gains, with all three participants achieving perfect division scores after no more than two interventions.

Research Question

As mentioned earlier, the scarcity and datedness of studies on mnemonic instruction in general, and musical mnemonics instruction in particular, necessitate further research in this area. According to the standards of the What Works Clearinghouse, a specific intervention method can only be labeled as evidence-based if the respective studies were conducted in at least three different geographical locations (Kratochwill et al., 2021). All previous works mentioned earlier regarding the effects of musical mnemonics on math performance originate from the U.S. This is unfortunate, especially considering the replication crisis in special education research, which is widely recognized as a significant issue (e.g., Makel et al., 2016).

In our study, we aimed to address the critical challenge issue of division skills among sixth-grade students at the onset of their secondary education. In doing so, we aimed to contribute to the establishment of musical mnemonics as a practice grounded in evidence and to mitigate the replication crisis in this context. Unlike the most recent but over 20 year old research on the subject (conducted by Cade and Gunter, 2002), the participants in our study did not exhibit any behavioral disorders. Nevertheless, they faced significant difficulties in mastering two-digit division, putting them at risk of falling behind in the curriculum. The importance of ensuring proficiency at this stage cannot be overstated, as deficits in two-digit division can have far-reaching consequences, impacting not only math but also various other subject areas. Therefore, the objective of the present research was to teach four sixth-grade students struggling with basic two-digit division skills how to effectively employ musical mnemonics to enhance their performance in this regard.

METHOD

Setting

The study was conducted in an urban secondary school in a large city in Western Germany, comprising grades 5-9. It enrolled 320 students at the time of this project. Almost 70% had a migration background with Arabic, Polish, Russian, and Turkish being the most common primary languages at home. The socioeconomic status of the school (as estimated by the mean occupational status of the families of the students that attend it) has to be considered low.

Participants

This investigation included four students between 11 and 13 years of age from a sixth grade classroom that

met the following criteria: (1) addition skills above the 50th percentile, (2) single-digit division skills above the 50th percentile, (3) two-digit division skills below the 10th percentile, (4) severe difficulties solving 7s or 9s division problems (except for 7:7 and 9:9), (5) a basic understanding of the concept of two-digit division, (6) perfect attendance in the last six weeks, (7) willingness to participate in the study. Math abilities were measured with a standardized inventory (HRT 1-4 by Haffner et al., 2005), the attendance was determined by consulting the records of the classroom teacher. We conducted the test with the whole class. Accordingly, seven students met the criteria (1) to (5). Five of them were present at every school day within the last six weeks. One stated that he was not interested in participating.

The following description about the students was based on the information and the judgement that the classroom teacher provided us with. Indications of the intellectual abilities were grounded on the school records that contained respective results from the German version of the Culture Fair Test by Weiß (2006). All names were changed to protect privacy.

The first participant was Ayaz. He came from a Kurdish family and was a 13-year-old boy at the time of the study. His parents moved to Germany from Turkey when he was three years old. The predominantly spoken language at his home was Kurdish. His German language skills were below average – his general mental abilities ranged around the 30th percentile. However, he had never been diagnosed with a special educational need. The second student was a 11-year-old boy named Breda. His parents had lived in Rumania most of their lives and migrated to Germany shortly before he was born. Neither his father nor his mother spoke German fluently. Breda's German language abilities were also relatively low. His cognitive capacities ranked at the 50th percentile. The third student was Chakira, a 12-year-old girl, whose parents came to Germany from Iraq prior to her birth. She spoke mainly Arabic at home. Chakira's German language skills were fair. Her intellectual ability was within the normal range (percentile of 46). The fourth and last student was 12-year-old Daniel. He did not have an immigrant background and spoke German with his parents at home. Daniel's language abilities were within normal limits. His teacher pointed out that he got easily distracted and had an especially hard time staying on task. Daniel's cognitive skills were developed a little below age level (around the 30th percentile).

The four students in question had not received an official diagnosis indicating a special education need. This circumstance was likely influenced by the school district's reluctance to assign the "disability" label to learners. However, based on the observations of the classroom teacher and the students' performance data at our disposal, it is evident that all of them faced notable academic challenges and necessitated additional support to prevent the potential development of severe deficits in math, particularly in the domain of division. Therefore, it is deemed suitable to categorize their circumstances as falling within the purview of special education.

The interventionist was a 25-year-old female graduate student of special education. She had three years of experience working as tutor for children with severe learning problems. The interventionist received four one-hour sessions of instruction by the first author on how to conduct the treatment. In addition, a 24-year old female student research assistant was involved to take data to establish interrater agreement and procedural fidelity.

Measurement and Research Design

The number of correctly solved division problems in response to worksheets containing 10 tasks each served as the dependent variable. Students were given two minutes to complete the test. The problems were randomly drawn and allocated using a Microsoft Excel Sheet from a pool containing the following 16 tasks: 14:7, 21:7, 28:7, 35:7, 42:7, 49:7, 56:7, 63:7, 18:9, 27:9, 36:9, 45:9, 54:9, 63:9, 72:9, 81:9. Every worksheet was only used once with each student. The interventionist determined the number of correctly solved problems and documented them. To ensure reliability, 20% of randomly chosen worksheets were also were rescored by the aforementioned 24-year old research assistant. Interrater-reliability equaled 100%.

This single-case study consisted of three weeks of daily probes. We used a multiple baseline research design (AB) to evaluate the effectiveness of the musical mnemonics intervention (Horner & Odom, 2014). The four students were randomly allocated to either receive 12 training session (with 3 baseline measurements), 11 training sessions (with 4 baseline measurements), 10 training sessions (with 5 baseline measurements), or 9 training sessions (with 6 baseline measurements). Staggering the introduction of the treatment across participants addressed the threat to internal validity.

Procedures

Baseline and treatment stretched over a period of 15 consecutive school days (Monday to Friday) with one measurement point per day. The interventionist worked with the participating students in a quiet corner of the class-

room. Each day, she attended to them individually for 15 minutes, while the rest of the class engaged in independent work with check-ins from the teacher. The order, in which she spent time on the students was determined randomly on a daily basis.

During baseline condition, Ayaz, Breda, Chakira, and Daniel played a simple shedding-type card game with the interventionist. At the end of each 15 minute-session, they were given one of the aforementioned worksheets and asked to solve as many problems as possible within the allocated time (two minutes). Ayaz was the first participant to start with the treatment, followed by Breda, Chakira, and Daniel. The time that the interventionist spent with each student stayed the same during this phase. Also, the method of conducting performance measurement was exactly the same as in the baseline assessment.

The first training session was aimed at making the students familiar with the songs and building enthusiasm in them by announcing that the following lessons will help them to make dividing by 7 and 9 fun and easy. Participants were told that if they tried to remember the songs taught during the next couple of days, they will solve significantly more problems on the worksheets than before. The interventionist then introduced the seven- and the nine-song. Both were modeled line-by-line. In the study by Cade and Gunter (2002), the first segment of the seven song went: "Seven, fourteen, twenty-one, look at me – I'm having fun!" (p. 211). Naturally, we had to come up with German lyrics instead: "Sieben, vierzehn, einundzwanzig – wir fahren mit dem Schiff nach Danzig" ("Seven, fourteen, twenty-one – we are going on a ship cruise to Danzig"). The seven song used the tunes of a famous German hit from the 1960s – "Marmor, Stein und Eisen bricht" ("Marble, stone and iron breaks") by Drafi Deutscher; the nine song the tunes of the popular folk rock song "Country Roads" by John Denver.

The interventionist sang the seven and nine song line by line and asked the students to repeat each segment twice. In case a child made a mistake, she or he was corrected. Additionally and in accordance with the procedures outlined in Cade and Gunter (2002), the interventionist tapped one finger for each number on the table (beginning with her left pinky) as she sang the song. That means that she tapped her left pinky when she mentioned "sieben" ("seven"), her left ring finger when she mentioned "vierzehn" (fourteen), her left middle finger when she mentioned "einundzwanzig" ("twentyone"), etc. Introducing the two songs in this way lasted between 8 and 10 minutes.

The remaining time was spent explaining to the students how to use the songs when dividing by 7 or 9 respectively. For this purpose, they were presented with a specific division problem (21:7) on a flashcard. The interventionist told the students that the divisor (7 or 9) was always the name of the song they needed to recall. In the case of 21:7, they were supposed to sing the sevens song and tap their fingers until they got to 21. The number of fingers they had tapped until then represented to correct solution (3). After the interventionist modelled this procedure, students were asked to repeat it.

At the beginning of the second session, the children went over the two songs again. They sang each of it three times together with the interventionist while tapping their fingers to foster memorization of the text. If they got stuck or made a mistake, they received assistance. Subsequently, the students were presented with flashcards, each of them with one of the 16 tasks on it that were listed above under "Measurement and Research Design". In each case, the interventionist modelled how to solve a particular problem (that means that she showed the students how to sing the mnemonic to solve the equation) before the children tried to recap the course of action by themselves.

The rest of the treatment sessions were dedicated to building students' fluency in performing two-digit division problems with 7 and 9 as divisors. As time went on, the children knew the correct answers to a problem presented to them on a flashcard more and more often even without having to go through the respective song. By the end of the training phase, the interventionist spent her time mostly presenting flashcards and awaiting the students' responses, which occurred increasingly faster. During the whole time, she frequently praised them for any act of compliance and effort they made to improve their division skills.

Procedural Fidelity and Social Validity

Procedural fidelity was ensured by the aforementioned student research assistant completing a checklist following the end of 20% of randomly selected sessions, indicating 100% integrity. Social validity was measured by the interventionist using a short questionnaire, asking the students (1) whether they enjoyed the training, (2) whether they believe that it helped them to improve their division skills, and (3) whether they would recommend it to their classmates.

RESULTS

Figure 1 displays the number of correct responses during both the baseline and the musical mnemonics sessions for the four participants.

Descriptive data is presented in Table 1.

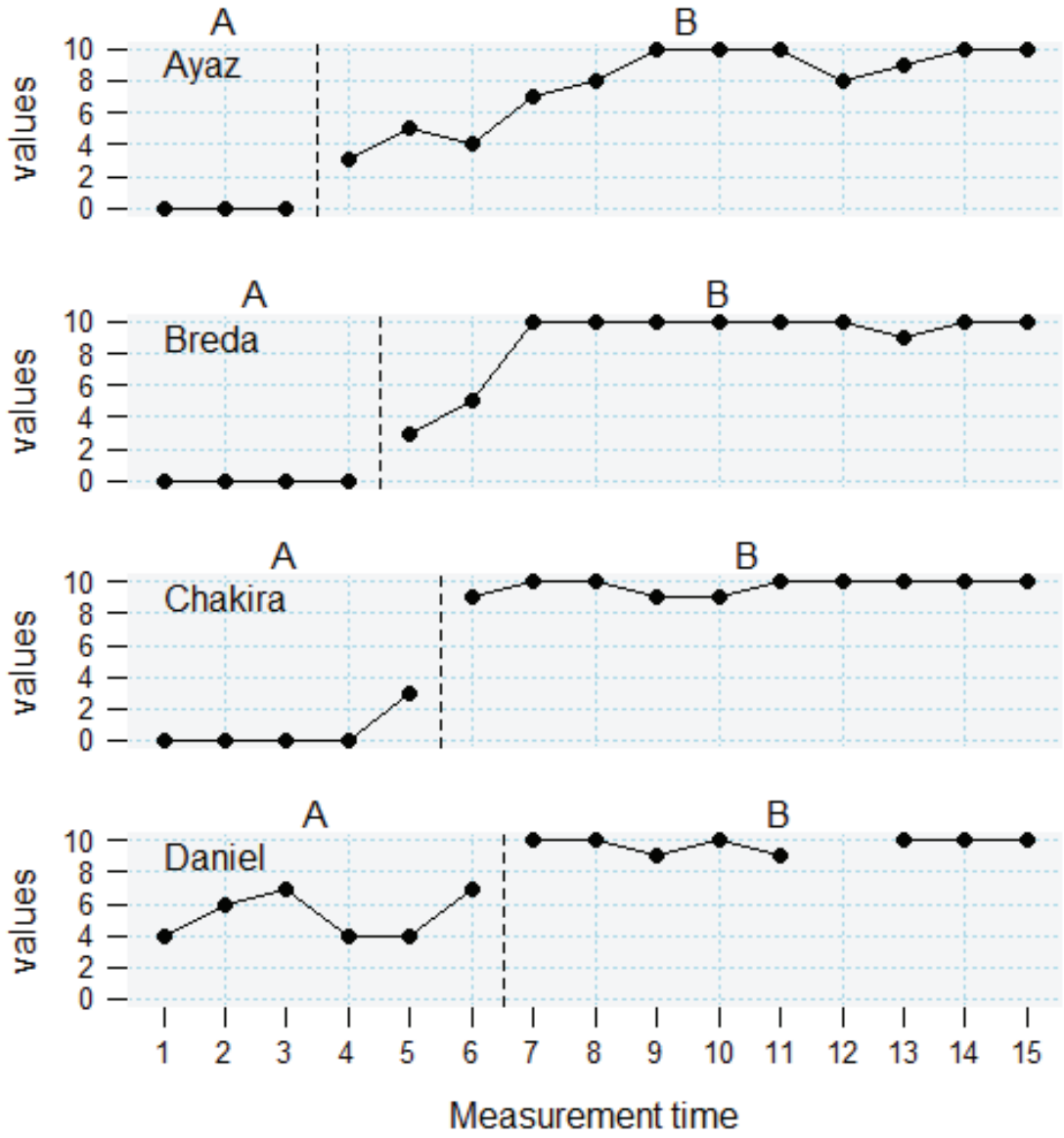

Figure 1. Division Problems Solved for Each Participant in Each Treatment Condition

Table 1. **Descriptive Statistics for the Four Participants per Phase**

Student		Phase A	Phase B
Ayaz	Minimum	0	3
	Maximum	0	10
	Median	0.00	8.50
	Mean	0.00	7.83
	SD	0.00	2.55
Breda	Minimum	0	3
	Maximum	0	10
	Median	0.00	10.00
	Mean	0.00	8.82
	SD	0.00	2.44

Student		Phase A	Phase B
Chakira	Minimum	0	9
	Maximum	3	10
	Median	0.00	10.00
	Mean	0.60	9.70
	SD	1.34	0.48
Daniel	Minimum	4	9
	Maximum	7	10
	Median	5.00	10.00
	Mean	5.33	9.75
	SD	1.51	0.46

Table 2. **Regression Model for Dependent Variable Across All Participants (Level-1 and Level 2- Analysis)**

	B	SE	t	p
Ayaz				
Intercept	0.00	2.18	0.00	1.00
Trend	0.00	1.01	0.00	1.00
Level	4.02	1.57	2.56	<.05
Slope	0.59	1.01	0.58	.57
Breda				
Intercept	0.00	2.19	0.00	1.00
Trend	0.00	0.80	0.00	1.00
Level	5.98	1.89	3.17	<.01
Slope	0.47	0.82	0.58	.57
Chakira				
Intercept	-1.20	0.72	-1.67	.12
Trend	0.60	0.22	2.76	<.05
Level	7.46	0.71	10.53	<.001
Slope	-0.52	0.23	-2.27	<.05
Daniel				
Intercept	6.373	1.165	4.59	<.001
Trend	0.246	0.314	0.65	.53
Level	5.939	1.369	3.38	<.01
Slope	0.728	0.328	-0.47	.65
Overall				
Intercept	0.91	0.94	0.94	.34
Trend	0.28	0.25	1.13	.26
Level	4.74	0.82	5.81	<.001
Slope	0.10	0.26	0.39	.70

The visual inspection of the data reveals that all four students benefitted from the intervention. This progress is particularly remarkable for Ayaz, Breda, and Chakira. While no correct solutions were observed during the baseline phase (except for Chakira at the 5th data point), a significant increase in accurate answers was evident as soon as the intervention was introduced. Daniel's performance also increased. However, he already started out with a decent skill level during baseline and could thus not demonstrate an increase that was equally impressive. Overall, the students were able to solve 1.94 problems on average during baseline. During treatment, this value rose to 7.90, equaling a mean increase of 307.22%.

In all four cases, commonly used overlap indices (Percentage of Non-Overlapping Data, Percentage of Data Exceeding the Median Trend, Non-Overlap of All Pairs, Percentage of All Non-Overlapping Data, see Kratochwill and Levin, 2014) reached the highest possible value of 100. The same is true for Tau-U (1.00; $p < .01$).

We conducted a regression analysis (table 2) on an individual student basis and for all participants collectively (level 1 and level 2 analysis). Each learner exhibited a significant level effect, with beta coefficients ranging from 4.02 to 7.46. This suggests a notable improvement in performance immediately upon the introduction of the treatment. The individual outcomes are consistent with the findings from the group-level analysis. Notably, in the case of Chakira, there was a significant slope effect, albeit negative. This can be explained by the fact that her performance during the intervention phase remained consistently stable without any noticeable increase over time. However, it is worth mentioning that her last baseline measurement was 3, while the preceding four values were all 0, resulting in an average increase of 0.60 per baseline session (table 2).

Interview data indicated that all the participants were in agreement (100%) that they enjoyed the training, that they believed it helped them to improve their division skills, and that they would recommend it to their classmates.

DISCUSSION

Main Findings

The aim of this study was to examine the effects of a musical mnemonics intervention on the division performance of four sixth-grade students experiencing severe math difficulties. The results unequivocally demonstrate the remarkable impact of the treatment on the participants' ability to solve division problems involving 7s and 9s with speed and accuracy. Clearly, the musical mnemonics played a significant role in enabling students to instantly and consistently recall the relevant math facts. The average improvement from baseline to treatment surpassed 300%. Regression analysis indicate that the enhancements were not only visually evident, but also statistically significant, both at the individual and group levels. Additionally, all participants expressed high satisfaction with the intervention, as evidenced by their positive ratings in a brief social validity questionnaire. In light of the effectiveness of relevant interventions for students experiencing difficulties in basic arithmetic operations (as reported in the introduction with reference to various meta-analyses), such a significant improvement among the participants is highly noteworthy.

Overall, our findings align with previous research on musical mnemonics, indicating that this intervention can be particularly beneficial for students struggling with basic two-digit division skills. In Germany, where this study was conducted, special education faces a significant challenge due to a substantial proportion of students having a migrant background and experiencing language disadvantages compared to native children. This often affects their academic performance, not only in language but also in mathematics classes. It is not easy to determine the need for special educational support under these circumstances. These children undoubtedly require assistance, but in many cases, it is difficult to ascertain to what extent the observed deficits are due to insufficient support or language barriers. Our study, at the very least, suggests that musical mnemonics can be universally helpful in teaching basic two-digit division skills.

Limitations

Like any experiment, this study is subject to several limitations. First, in single-case design research, generalizations are derived from a series of replication studies rather than a single large-N study (Walker & Carr, 2021). Therefore, our research can only be considered a part of a puzzle that contributes to the evidence base on the effects of musical mnemonics on the division skills of students. While the findings from this experiment cannot be broadly generalized, it needs to be noted that our study was the first experiment evaluating this kind of intervention with sixth graders struggling academically in mathematics.

Another limitation of our study is the absence of a maintenance phase in our multiple baseline design. We acknowledge that including a maintenance phase would have been desirable. It would have allowed us to assess the

durability of the observed effects over an extended period of time. However, due to an upcoming vacation, we were not able to include a maintenance phase in our study.

Furthermore, given the restricted number of tasks (a total of 16) and the daily repetition of the same ten tasks, there is a potential for the results to have improved even without employing mnemonic strategies. However, this scenario is highly improbable. The baseline values exhibited a notable level of consistency, while the enhancements observed upon implementing the treatment were sudden and remarkable. An effect solely attributable to repetition would not have manifested in such a distinct manner.

Lastly, the presence of experimenter bias cannot be completely ruled out since the interventionist conducted all of the sessions and administered all of the measures. However, 20% of the sessions were monitored and achieved the highest possible fidelity levels.

Practical Implications

Despite the aforementioned limitations, this study demonstrates the effectiveness of the musical mnemonic strategy in improving memorization skills associated with arithmetic facts. Proficiency in mathematics is vital in daily life, whether consciously or unconsciously, and is a strong predictor of overall academic success (Gurganus, 2021). Therefore, it is crucial to employ effective instructional and support methods for students who encounter learning difficulties. In reducing the load in working memory by enhancing the retrieval of derived facts overall mathematical learning increases. Musical mnemonic strategies can be implemented during personalized learning sessions or integrated into the classroom environment, such as through choral learning. The preparatory work required for instructors is manageable, and the concept can be applied repeatedly, enabling the seamless incorporation of musical mnemonic strategies into everyday school life.

Future Research

Tate and coauthors (2016) have established standards for generalizing findings from single-case studies, proposing that replication of the procedure across a minimum of three studies and in at least five different locations is necessary. Therefore, further research is required to examine the impact of music mnemonic strategies on students' mathematical performance, expanding upon the groundwork laid by Cade and Gunter (2002) and the current study in order to meet these criteria. Moreover, it would be valuable to investigate the modification of specific factors, such as the age of participants, implementation within a classroom setting rather than in one-on-one scenarios, inclusion of a second A phase, assessment of retained factual knowledge after a time delay, and exploration of the application of musical mnemonic strategies in subjects beyond mathematics.

CONCLUSION

Problems related to division and other fundamental mathematical operations are currently quite common among students during the transition from elementary to secondary education. Teachers require easily implementable strategies to assist those who are lagging behind. While musical mnemonics undoubtedly meet this criterion, their deployment becomes feasible only when suitable lyrics for the respective melodies are available. Formulating these lyrics demands time and creativity. Fortunately, language models powered by AI technology, such as ChatGPT, can be exceptionally helpful in accomplishing this task. These possibilities will hopefully contribute to the wider adoption of memory techniques like musical mnemonics in schools, thereby simplifying the acquisition of essential arithmetic skills for students facing challenges in learning the operations of numbers.

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