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ORIGINAL PAPER

Math Preference and Mastery Relationship in Middle School Students with Autism Spectrum Disorders

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Abstract We conducted this study to determine the relationship between math preference and mastery for five middle school students with autism spectrum disorders. We randomly presented several math addition and subtraction problem formats to determine the students' preferences. Results indicated that preference was idiosyncratic across students. In addition, preference was not related to mastery in some students. Results are discussed within a theoretical framework of matching law. Implications for practitioners are discussed.

Keywords Math · Choice · Preference · Mastery · Addition · Subtraction · Matching law · Interspersal · Autism

Learning and behavior problems in persons with disabilities pose a serious challenge for teachers and parents. Researchers must develop intervention strategies to improve a broad range of social and academic behaviors. In the early years of applied behavior analysis (ABA), emphasis was placed on consequence-based interventions (Dunlap, Kern, & Worcester, 2001). Recently, some researchers have begun advocating antecedent-based interventions, including modifying instructional environments and curricula (Dunlap et al.). Antecedent-based interventions are less-intrusive and are likely to decrease environmental conditions that occasion problem behaviors (Dunlap, 1984; Hinton & Kern, 1999). Interventions may include providing choices (Dyer, Dunlap, & Winterling, 1990; Umbreit & Blair, 1996), incorporating students' interests (Clarke et al., 1995; Hinton & Kern, 1999), and modifying curricula

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(Lee, Sugai, & Horner, 1999) to increase academic productivity and also to reduce problem behaviors. Two other antecedent research-based behavioral approaches used to increase academic behaviors are interspersed requests and high-probability (high-*p*) request sequences.

The interspersal intervention involves mixing brief problems (e.g., 1-digit by 1-digit multiplication) with more difficult problems (e.g., 5-digit by 5-digit multiplication). This mixing of problem types, or interspersing, results in increased problem completion rates, and students choosing to complete more work (e.g., Cates & Skinner, 2000; Cooke & Reichard, 1996; Skinner, Fletcher, Wildmon, & Belfiore, 1996; Wildmon, Skinner, McCurdy, & Sims, 1999). In high-*p* request sequence interventions, a series of requests with high-probability compliance (e.g., "give me five," "give me hug") are delivered to a child before a request with low-probability (low-*p*) of compliance (e.g., "clean your desk"). Similarly, high-*p* request sequences use preferred academic tasks to increase compliance with non-preferred academic tasks (e.g., Belfiore, Lee, Scheeler, & Klein, 2002). Results of research on high-*p* sequences has shown increased problem completion, decreased latency to initiate tasks, and enhanced levels of compliance (Belfiore et al., 2002; Belfiore, Lee, Vargas, & Skinner, 1997; Hutchinson & Belfiore, 1998; Lee & Laspe, 2003).

Systematically identifying brief or preferred tasks is crucial for interspersal or high-*p* request sequence strategies before either technique can be used. Thus, if researchers and practitioners are to use the approaches effectively, preference assessment is one of the critical components of and prerequisite to interspersal and high-*p* interventions. Research indicates that there are several remaining questions regarding identification of brief/preferred tasks in interspersal or high-*p* interventions. Analysis of high-*p* research studies suggests that investigators have systematically examined preference, but have not assessed and/or reported participants' skill level or accuracy prior to conducting preference assessments; thus, they have made an assumption that students prefer easier tasks (Belfiore et al., 1997; 2002; Hutchinson & Belfiore, 1998; Wehby & Hollahan, 2000). Thus, although students may express a preference, their preferences may not directly and consistently relate to the difficulty of the tasks. Direct assessment is the most viable method to determine the task difficulty for the participant. Historically preference assessments may not have been regarded as critical to interspersal techniques based on assumptions that the presumed mechanisms, such as momentum and reinforcer density did not involve task preference.

Likewise, interspersal research has at least two limitations. First, researchers in a majority of studies did not conduct prior task accuracy assessments with participants (see Cooke & Reichard, 1996; Logan & Skinner, 1998; Skinner, Fletcher et al., 1996; Skinner et al., 1999; Wildmon et al., 1999; Wildmon, Skinner, & McDade, 1998). Second, in some studies no systematic preference assessments were conducted to determine participants' preference for interspersal tasks (e.g., Robinson & Skinner, 2002; Cates & Skinner, 2000; Wildmon et al., 1998, 1999). Thus, much of the literature rests on an assumptive foundation about preference and task performance accuracy (i.e., students prefer developmentally easier tasks). Systematic assessment of task mastery (90% or above accuracy in a given task; Salvia & Ysseldyke, 2004) and preferences (60% or greater choice for a particular task; Romano & Roll, 2000) through direct observation and examination of the relationship between task mastery and preference are important issues for both practitioners and researchers. The matching law may help explain student preference and provide a framework under which these issues can be more fully examined (Herrnstein, 1961).

Matching law states that when given a choice of two incompatible responses, an organism engages in the behavior that is likely to result in relatively higher rates of reinforcement (Johns, Skinner, & Nail, 2000; Skinner, 2002; Skinner, Fletcher et al., 1996). For instance, completing brief math problems may enhance reinforcement rates in children because they are more likely to result in correct responses that produce more opportunities for reinforcement. Thus, students might prefer six 1-digit addition problems over one 6-digit addition problem because of the higher reinforcement rate. According to matching law, students' choice behaviors can be predicted and controlled (Skinner, Robinson, Johns, Logan, & Belfiore, 1996). Herrenstein's matching law has proven to be an effective method of exploring several factors (e.g., rates of reinforcement, see Neef, Mace, & Shade, 1993; Belfiore et al., 2002; schedules of reinforcement, see Skinner, Fletcher et al., 1996; work requirements, demand, and effort, see Cates & Skinner, 2000) that may influence preference. However, investigators have not systematically examined the role of respondent's accuracy (mastery) in preference. Noell, Whitmarsh, VanDerHeyden, Gatti, and Slider (2003) were the only investigators who conducted a study using a systematic preference assessment. Noell et al. compared contingent access to a preferred academic task with noncontingent access to the similar activity with five children with delayed language development. Results indicated that in all of the five participants, preference was related to response accuracy; response accuracy was higher on the preferred academic tasks. The investigators speculated that preference might be related to response accuracy as it was found during the visual inspection of baseline data. However, these data did not clarify the relationship between task difficulty and preference. To further clarify the assumption that preference is related to mastery, we conducted this study with children with autism spectrum disorders (ASD) who demonstrated difficulties in two math content areas, addition and subtraction.

Students with ASD display skill deficits in communication, socialization, and behavior. Also, they may display excessive behaviors including stereotypic behaviors, aggression, self-injurious behaviors, etc. In addition, students with ASD are likely to have academic difficulties in reading, writing, language, and math (Minshew, Goldstein, Tylor, & Siegel, 1994). Thus, we conducted this study with students with ASD who had math problems to investigate the relationship between math mastery and preferences. Specifically, two research questions were addressed in this study.

1. Do students express preference for mastered tasks or nonmastered tasks?
2. Do students express preference for digit facts or word problems when similar mastery level problems are presented simultaneously?

Method

Participants

Five middle school students with ASD from a small town in Pennsylvania participated in the study. All students attended the general education classroom and received support through an autism support class. The participants were selected based on the teacher's recommendation that all students had math goals in their IEP and they preferred brief math problems over word problems. The teacher wanted to increase the students' preferences for word problems. The five participants[1] were Teresa, Victor, Scott, Mike, and Tom.

Teresa, an 11-year-old female 6th grade student with autism and speech language impairment, attended the general education classroom and received instruction in language arts

[1] For all participants, we could only obtain grade equivalents, which is a severely suboptimal approach for reporting student characteristics. We assume that grade equivalents do provide some descriptive information despite their poor psychometric properties and the fact that some may make misleading inferences from these scores.

and math in an autism support class. On the Texas Assessment of Academic Skills (TAAS), she functioned at grade level 2.0 in reading and math and at 3.0 in writing. On the Behavioral Assessment System for Children (BASC; Reynolds & Kamphaus, 1992), she scored at the 99th percentile in the Anxiety domain and met the criteria for Externalized Anxiety Disorder. All other scores on the BASC were age appropriate. On the Gilliam Asperger's Disorder Scale (GADS; Gilliam, 2001), her Asperger's Disorder Quotient for teacher rating indicated a high functioning level of autism spectrum disorder. Teresa displayed behavioral problems including making inappropriate comments to classmates, interrupting conversations, calling out, engaging in repetitive activities (writing words frequently from adult conversations), repetitive questions, and talking about a subject excessively (i.e., maps and roads).

Victor, a 12-year-old male 6th grade student with autism, attended the general education setting for all subjects with the exception of math. On the Stanford-Binet Intelligence Scale-Fourth Edition (SB-IV; Thorndike, Hagen, & Sattler, 1986), his cognitive scores were within average range. On the Wechsler's Individual Achievement Test (WIAT-II; Wechsler, 2001), his reading and math levels were below average with major difficulties in mastering addition and subtraction facts. On the Gilliam Autism Rating Scale (GARS; Gilliam, 1995), he displayed Asperger's disorder and scored at a high functioning level of autism spectrum disorder. He displayed emotional and behavioral difficulties in the school setting, particularly aggression, odd behaviors and poor study skills. Victor received learning support services for assistance with math, autism support services for social skills and adaptive coping skills, and speech therapy services on a weekly basis. Additionally, he received counseling services to address self-esteem, coping, depression, and anxiety.

Scott, a 14-year-old male 7th grade student diagnosed with autism, received speech therapy and occupational therapy services once a week. He attended the general education classroom and received supplementary instruction in the autism support class in the areas of math, reading, and writing. On the KeyMath-Revised (Connolly, 1998), he scored below the 30th percentile across all domains and had difficulty in operation subtests including addition, subtraction, multiplication, and division. Scott scored below his age at grade level of 2.0 in reading and basic reading skills on the Woodcock Johnson – III Tests of Achievement (WJ-III; Woodcock, McGrew, & Mather, 2001). Scott had problems with social language skills and paraphrasing/explaining sentences.

Mike, a 15-year-old 8th grade male student with autism, participated in general education activities except for math and English. On the Wechsler's Intelligence Scale for Children – III (WISC-III; Wechsler, 1991), his cognitive level was within the average range. On the school district curriculum based assessment, his performance was at grade level 2.0 in reading comprehension and 4.0 in instructional math. He received one-on-one instructional support in reading, spelling, and math and itinerant speech and language services for improving social language skills. Mike exhibited stereotypical behavior (e.g., hand flapping, object twirling), and poor peer relationships. At the time of the study, Mike was on Adderall (medication for AD/HD).

Tom, a 13-year-old 6th grade student with PDD/Asperger's disorder attended the general education setting and received support for math and supplementary speech/language services. On the Kaufman Assessment Battery for Children (KABC; Kaufman, & Kaufman, 1983), he scored at the 50th percentile for his age in all domains. On the school district curriculum-based assessment, his grade equivalent in reading and math was 3.0. On the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Remler, 1986), his functioning level was at the high range of autism spectrum disorder. In addition, Tom displayed language deficits in the areas of problem solving. He displayed unpredictable behaviors, quick mood changes, denied mistakes, and had problems in developing peer relationships and initiating and sustaining conversations.

Setting

The study was conducted in a resource room (8 m × 4 m) at the students' school. The class had an autism support teacher, three paraprofessionals and five students with disabilities who received instruction in math. A table and chair were placed in one of the corners and a mini-digital video camera was placed approximately 1 m from the table. The camera was installed one week prior to the study to acclimate participants to its presence. During the experiment, the student sat across the table facing the video camera. The investigator sat to the right side of the student and conducted all sessions. A majority of the sessions were conducted during the math instructional period that occurred between 8–10 a.m. All of the mastery and preference assessments were video taped.

Materials

Two sets of materials were developed for each content area (addition and subtraction); one for mastery assessment, the second for preference trials. For both the mastery assessment and preference trials, digits were selected from a random numbers table avoiding digits 0s, 1s, and 2s to better equate task difficulty level (Belfiore et al., 1997, 2002). The Flesch-Kincaid formula (available in Microsoft© Word 2002) was used to assess the reading grade level and a grade level of 3.0 or below was used for all word problems. Additionally, the classroom teacher had checked the items for appropriateness and difficulty level for the use with the students. After reviewing the items, the teacher stated that the students had the adequate reading level and ability to solve the problems included in the assessments.

For mastery assessments, white sheets of paper (21.6 cm × 27.9 cm) were used to print addition and subtraction problems. Each mastery assessment consisted of a packet of 7 pages with each page containing either 5 to 10 word problems and/or 15 digit facts. Fifteen problems in each of the six content areas were developed: 1 × 1 digit facts, 1 × 1 digit word problems, 2 × 2 digit facts without regrouping, and 2 × 2 digit word problems without regrouping, 2 × 2 digit facts with regrouping, and 2 × 2 digit word problems with regrouping.

For preference trials, problems were printed on flash cards (12.7 cm × 20.3 cm). A single problem was printed on each card leaving some blank space for writing the answer. Problems used in preference trials were identical to the content used in mastery assessments.

Dependent variables

Percentages were used for both mastery and preference as dependent measures. For the mastery assessments, percent correct was calculated by dividing number of problems accurately completed by the total number of problems attempted and multiplying by 100. When a student demonstrated 90% or above accuracy in a given task (e.g., single-digit word problem), it was considered a "mastered" task for that student (Salvia & Ysseldyke, 2004, p.102). When a student demonstrated accuracy less than 90%, it was considered a "nonmastered task." Participants' accuracy levels ranged from 0 (e.g., 2 × 2 digit fact/word addition problems with regrouping for Teresa and Scott) to 100 (e.g., 1 × 1 digit facts for Mike and Victor) for both addition and subtraction problems. For more details of accuracy levels, please contact the first author.

For preference trials, percentages were calculated with the number of each type of problem cards (either digit facts or word problems) chosen by the student divided by the total number of trials presented to the student (10 trials each session) and multiplied by 100. For the purpose of this experiment, preference is defined as 60% or greater choice for a particular task (see Romano & Roll, 2000). Also, when a student demonstrated 41–59% of choice for either format, it was considered as "no task preference."

Independent variables

Independent variables were determined by the initial mastery assessments. Four types of problems were identified: mastered digit facts, mastered word problems, nonmastered digit facts, and nonmastered word problems. Six independent variables (formats) were developed combining the four types of problems: mastered digit facts vs. nonmastered digit facts, mastered digit facts vs. nonmastered word problems, mastered word problems vs. nonmastered digit facts, mastered word problems vs. nonmastered word problems, mastered digit facts vs. mastered word problems, nonmastered digit facts vs. nonmastered word problems. The first four problem formats were used to assess preference for mastered or nonmastered tasks. The last two formats were used to assess preference for digit facts or word problems.

Experimental design

A concurrent-schedule design was used to assess each participant's task preference (Hersen & Barlow, 1976). In this design, the participant was simultaneously exposed to two formats (mastered vs. nonmastered or digit vs. word). The concurrent design schedule demonstrated which of the available formats affected preference across the six problem formats. Problem formats were presented in a random order across days.

All six addition problem formats were administered to three students: Teresa, Scott, and Mike. Victor was exposed to only three formats (mastered digit facts vs. nonmastered word problems, mastered word problems vs. nonmastered word problems, and mastered digit facts vs. mastered word problems) because he had mastered all digit facts, thus limiting appropriate comparisons. We did not conduct addition preference assessment for Tom because he accurately completed all of the problems presented in the addition mastery assessment.

Teresa and Victor were administered all six subtraction problem formats. Tom was administered three formats because he mastered all digit facts (mastered digit facts vs. nonmastered word problems, mastered word problems vs. nonmastered word problems, and mastered digit facts vs. mastered word problems). Scott was administered three formats because he did not master word problems (mastered digit facts vs. nonmastered digit facts, mastered digit facts vs. nonmastered word problems, and mastered word problems vs. nonmastered word problems). We did not conduct subtraction preference assessment for Mike because he accurately completed all of the problems presented in the subtraction mastery assessment.

Procedure

Mastery assessment

The investigator first conducted addition mastery assessments for all students prior to conducting subtraction mastery assessments. For addition mastery assessment, the investigator presented a set of worksheets, each containing math addition problems to each student. The student was asked to solve the problems as quickly and accurately as possible. No feedback was provided to the student. If a student did not solve all of the problems in the assessment in a single session (within 20 min), an additional session was conducted to get student responses for all sections of the mastery assessment. A similar procedure was followed in conducting mastery assessments for subtraction problems. Each mastery assessment lasted for about 15–20 min. On average each student took approximately 24 minutes to complete each content area (range 15 min to 39 min). Three students, Teresa, Scott, and Tom had taken at least two sessions to complete each content area; the subsequent session for each of these participants was scheduled in the same week.

Preference assessment

A paired-stimulus procedure (forced-choice) was used to determine the participant preference between two formats (Mithaug & Hanawalt, 1978) for both addition and subtraction problems. The investigator first conducted preference assessment in the addition content area followed by the subtraction content area. In each condition, the experimenter simultaneously presented two cards depending upon the format. For example, in the format mastered digit facts vs. nonmastered digit facts, the investigator presented a flash card with mastered digit facts and the other card with nonmastered digit facts to the student. The investigator asked the student to pick the card he liked and to solve the problem. The student's selection was then recorded. In each trial, when the student chose a card and completed the problem it was recorded as a "preferred" task for that student. For each student, a total of 10 trials were conducted in each session and each day. No feedback or assistance was provided to the student either during the selection or completion of problems. At the end of 10 trials in each session, the experimenter provided general praise (e.g., "thanks for working"). A total of three sessions were conducted in each format for a period of 3 days resulting in a maximum of 30 trials. A random order of presentation of formats was done across days and also the positions of the cards (left or right) were counterbalanced across trials to reduce sequence/placement bias (Belfiore et al., 1997, 2002). A similar procedure was used in all six formats to determine participant preferences.

Interobserver agreement

Interobserver agreement data were collected for 40% of mastery assessments. Interobserver agreement was calculated on the point-by-point basis using the formula: number of agreements divided by number of agreements plus disagreements multiplied by 100. The interobserver agreement for the mastery assessment was 98.3% (range 90–100%). Similarly, an independent observer coded 30% of trials for interobserver agreement. Interobserver agreement for preference assessments was 99.3% (range 90–100%).

Procedural integrity

Procedural integrity data were collected for 40% of mastery assessments and 30% of preference trials. Separate checklists were developed for preference trials and mastery assessments, and the independent observer checked the experimental procedures following viewing of video tapes. Percentage of procedural integrity was calculated by using the formula of total number items actually followed (i.e., "yes") by the total number of items in the procedural integrity checklist. Procedural integrity for both the accuracy assessment and for the preference trials was 100%.

Results

Teresa

Figure 1 shows in the mastered and nonmastered problem formats, Teresa preferred mastered tasks over nonmastered tasks in 7 of 8 formats presented in both addition and subtraction areas. However, Teresa expressed no preference for the other subtraction problem format (mastered word problems vs. nonmastered word problems). When similar mastery level tasks were presented, Teresa expressed no clear preference for 2 of 4 formats presented; nonmastered digit facts vs. nonmastered word problems in the addition problem format and mastered digit facts vs. mastered word problems in subtraction problem format. However, Teresa expressed a clear preference for the remaining two formats; for mastered digits in the mastered digit facts vs. mastered words addition problem format and for nonmastered words in the nonmastered digit or nonmastered words subtraction problem format.

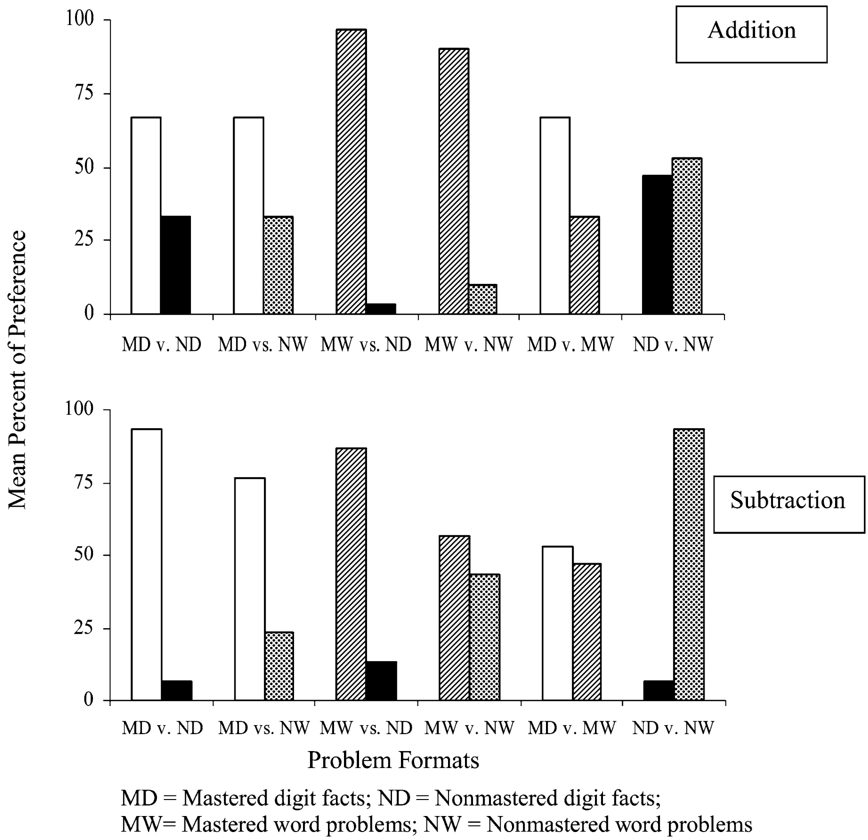


Fig. 1 A bar graph displaying the mean percent preference for Teresa in addition and subtraction problem formats

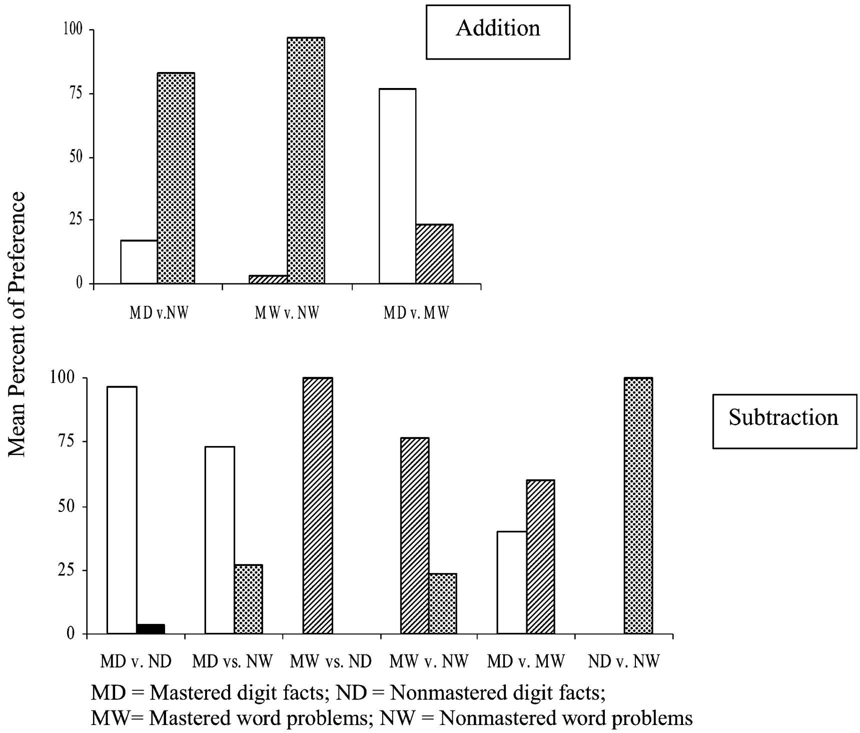


Fig. 2 A bar graph displaying the mean percent of preference for Victor in addition and subtraction problem formats

Victor

Figure 2 indicates that in the mastered and nonmastered problem formats, Victor preferred 4 of 6 mastered problem formats over nonmastered problem formats. However, Victor also preferred two nonmastered formats over mastered formats in addition area. In contrast, for the subtraction problem formats, Victor preferred 4 of 4 mastered problem formats over nonmastered problem formats. When similar mastery level tasks were presented, Victor expressed a preference either for mastered or nonmastered problem formats in both addition (mastered digit facts in the mastered digit facts vs. mastered word problem format) and subtraction (mastered word problems in the mastered digit facts vs. mastered word problem format and nonmastered word problems in the nonmastered digit facts vs. nonmastered word problem format).

Scott

Figure 3 shows that in the mastered vs. nonmastered problem formats, Scott preferred 3 of 6 nonmastered problem formats over mastered problem formats and expressed no preference for the remaining three problem formats. This indicates that Scott's preferences were mixed when mastered and nonmastered problem formats were presented. For similar mastery level formats, Scott expressed no clear preferences for two formats (mastered digit facts vs. mastered word problems in the addition problem format and nonmastered digit

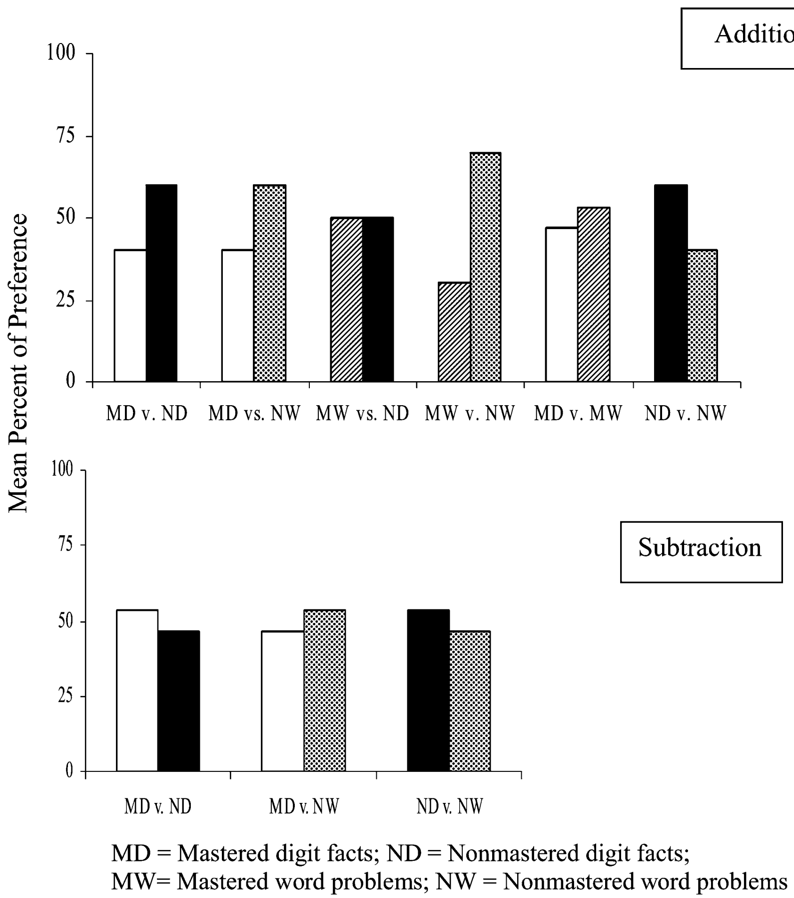
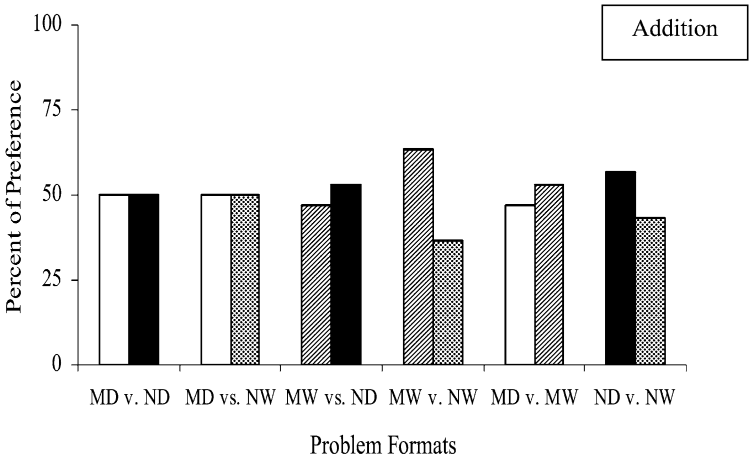


Fig. 3 A bar graph displaying the mean percent preference for Scott in addition and subtraction problem formats

facts vs. nonmastered word problems in the subtraction problem format). For the remaining nonmastered digit facts vs. nonmastered word addition problem format, Scott expressed preference for the nonmastered digit facts. In general, Scott's results show a mixed pattern of preference indicating little or no influence of task mastery.

Mike

Figure 4 shows that in mastered vs. nonmastered addition problem formats, Mike did not express clear preferences for the 3 of 4 formats presented: mastered digit facts vs. nonmastered digit facts, mastered digit facts vs. nonmastered word problems, and mastered word problems vs. nonmastered digit facts. However, Mike preferred mastered word problems over nonmastered word problems in the mastered word problems vs. nonmastered word problem format. This reveals that in the majority of the formats, task mastery did not influence preference for Mike. Also, Mike expressed no preference for any format in the mastered



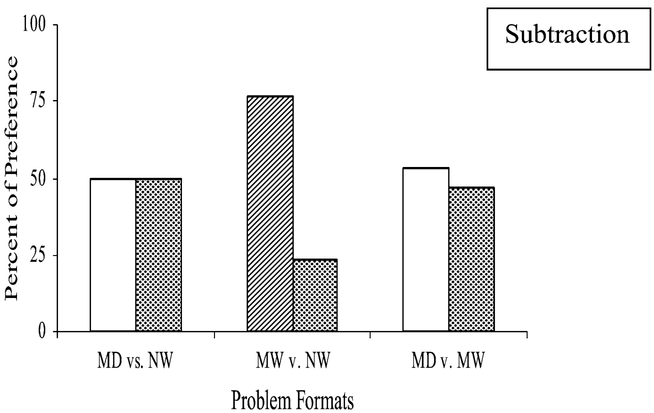
MD = Mastered digit facts; ND = Nonmastered digit facts;
MW= Mastered word problems; NW = Nonmastered word problems

Fig. 4 A bar graph displaying the mean percent preference for Mike in addition problem format

digit facts vs. mastered word problems and nonmastered digit facts vs. nonmastered word problem formats.

Tom

Tom's results in Figure 5 show that in the mastered vs. nonmastered subtraction problem formats, his preferences were mixed. Tom expressed no preference either for mastered or nonmastered task in the mastered digit facts vs. nonmastered word problem format. However, in the mastered words problems vs. nonmastered word problems format, he preferred



MD = Mastered digit facts; MW= Mastered word problems;
NW = Nonmastered word problems

Fig. 5 A bar graph displaying the mean percent preference for Tom in subtraction problem format

Table 1 Group comparison across students for the mastered vs. nonmastered problem formats in both addition and subtraction areas

Student	Number of formats presented ∗	Selected mastered formats	Selected nonmastered formats	No preference
Teresa	8	7 (88%)	1 (12%)	
Victor	6	4 (66%)	–	2 (33%)
Scott	6	1 (16%)	3 (50%)	2 (33%)
Mike	4	1 (25%)	–	3 (75%)
Tom	2	1 (50%)	–	1 (50%)

*Mastered digit facts vs. nonmastered digit facts, mastered digit facts vs. nonmastered word problems, mastered word problems vs. nonmastered digit facts, and mastered word problems vs. nonmastered word problems for addition and/or subtraction problem areas.

mastered word problems over nonmastered word problems. This indicates that Tom expressed preference for mastered tasks for 1 of 2 formats presented. Tom expressed no preference for either format in the nonmastered digit facts vs. nonmastered word problems format. In general, Tom's results show a mixed pattern of preference with the exception of one format indicating an equivocal role of mastery on preference.

Study summary

Table 1 presents a summary of results for all five students across several formats indicating that they selected 14 of 26 mastered problem formats over nonmastered formats in both content areas. However, the students also expressed preferences for 4 nonmastered problem formats and no preferences for the remaining 8 formats. As a whole, the students preferred mastered problem formats in half of the total formats presented indicating a weak and equivocal relationship between the task mastery and preference.

Table 2 shows a summary of results across participants for similar mastery level problem formats in both content areas. Students expressed no preference for 7 of 13 problem formats presented and showed preferences for 3 digit problem formats and for 3 word problem formats. Overall, results indicate a mixed pattern of preferences across participants.

Table 2 Group comparison across students for similar mastery level problem formats in both addition and subtraction areas

Student	Number of formats presented*	Selected digit problem formats (preferred)	Selected word problem formats (preferred)	Equal selection (no preference)
Teresa	4	1 (25%)	1 (50%)	2 (50%)
Victor	3	1 (33%)	2 (66%)	–
Scott	3	1 (33%)	–	2 (66%)
Mike	2	–	–	2 (100%)
Tom	1	–	–	1 (100%)

*Mastered digit facts vs. mastered word problems and nonmastered digit facts vs. nonmastered word problems for addition and/or subtraction problem areas.

Discussion

We conducted this experiment to investigate the role of mastery in preference. Overall, results show that student preferences are idiosyncratic across all of the participants, indicating a weak role of task mastery in determining preference. Furthermore, results in this study are preliminary and tentative with regard to the role of mastery in determining preferences. We presume that several variables, in addition to or other than mastery may have influenced preferences in students. In this section, the two major research questions are discussed based on the results obtained and analyzed within the context of existing literature and theory.

Do students express preference for mastered tasks or nonmastered tasks?

Results show that Teresa in addition and subtraction problem formats and Victor in addition problem formats consistently expressed preference for mastered tasks over nonmastered tasks. For those students, these findings are consistent with an earlier study by Noell et al. (2003). For example, Noell et al. found that students' preference in academic assignments was related to the accuracy with which the five students completed those assignments. Also, in Noell et al., response accuracy was higher on the preferred task for each of the students. The investigators speculated that preference in children may be related to the student's accuracy for a given assignment (e.g., number identification).

Present findings provide some empirical support for the assumption that preference may be related to accuracy in some participants. There may have been several possible explanations why students sometimes prefer mastered tasks over nonmastered tasks. First, participant students may have received higher rates of reinforcement from teachers during the completion of mastered tasks in the past (see Johns et al., 2000; Logan & Skinner, 1998; Skinner, 2002; Skinner, Robinson et al., 1996). Therefore, problem completion for each task may serve as a conditioned reinforcer (see Skinner et al., 1999). Also, mastered word problems, despite the fact that they contained more words may have provided denser schedules of reinforcement (Johns et al., 2000; Koegel & Koegel, 1986; Skinner & Fletcher et al., 1996). It cannot, however, be concluded that task mastery resulted in higher rate or quality of reinforcement from this study because we did not investigate the role of reinforcement. Additional studies are needed to determine how different schedules and histories of reinforcement affect preferences.

The results in this study however are less than convincing for the role of mastery (accuracy) as some students also preferred nonmastered tasks over mastered tasks, indicating an uncertain connection of mastery over preference (e.g., for Scott in addition problem formats). Additional evidence for an inconsistent relationship between mastery and preference arose during an informal interview. Scott revealed that he liked doing challenging problems. Thus, for Scott, nonmastered problems were challenging and provided higher levels of reinforcement than mastered problems. Alternatively, he may have received reinforcement for completing more difficult problems from multiple sources—attempting challenging tasks may have resulted in reinforcement from classroom teachers or significant others (e.g., "You are a smart kid"). Thus, his reinforcement history may determine his preference for difficult problems. Likewise, students with superior mastery or skill development may engage in behaviors that require more effort (see Cates & Skinner, 2000). Therefore, it is important for future researchers to examine individual preferences for academic tasks through multiple sources. Assessing academic preferences through interviews is one way to strengthen preference assessment.

Another plausible explanation for this mixed pattern of preference may be that there was not enough difference in the quality of reinforcement available to students across the problem formats (Belfiore et al., 2002; Lee & Laspe, 2003). In other words, mastered and nonmastered problems may have resulted in equal quality of reinforcement. Since we did not seek to control reinforcement, there is no way to determine its role. Additionally, some students may not have been able to discriminate mastered tasks from nonmastered tasks. For example, when 2×2 digit problems with regrouping and 2×2 without regrouping were presented simultaneously, students may not adequately determine which they have mastered. Thus, their selections are based on variables other than mastery.

Results also show that some students expressed equal preference for both mastered and nonmastered tasks. For example, in addition problem formats, Mike expressed equal preference for mastered tasks and nonmastered tasks in two formats. During an informal interview, Mike revealed that he liked to alternate formats because he wanted to select and solve both formats equally, particularly digit and word problems. This indicates that Mike may have switched formats to get a patterned response. Additionally, accuracy levels of tasks may have affected task preference. For example, a closer examination of the Mike's accuracy data in addition problems shows that there was not a substantial difference between the accuracy of nonmastered tasks and mastered tasks (e.g., nonmastered digits $= 86\%$ and mastered digits $= 100\%$). Future researchers should assess preference using more clearly different accuracy levels. Investigating the effects of different accuracy levels could advance our understanding of the relationship between preference and accuracy.

Do students express preference for digit facts or word problems when similar mastery level problems are presented simultaneously?

In this study, it was assumed that students would express no preference when similar mastery level tasks (digit and word problems) were presented simultaneously. Contrary to the assumption, results indicate that students expressed preference either for digits or words in several problem formats that were at similar levels of mastery. Also, the classroom teacher indicated that students preferred doing digit problems over word problems. Our results, however, indicate a mixed pattern; some students preferred word problems (e.g., Teresa and Victor in subtraction problem formats) and some students preferred digit facts (e.g., Teresa and Mike in addition problem formats). There may have been several other variables influencing students' preferences other than mastery. Students with higher language skills may have preferred word problem formats over digit facts. Also, students with better computational skills may have selected digit facts over word problems. Furthermore, students may have preferred tasks based on the content in digit or word problems or length of tasks or it could be that nonmastered word problems consisted of digits that were easier (2-digit × 2-digit subtraction without regrouping) than nonmastered digits (2-digit × 2-digit subtractions with regrouping). Future researchers may want to add word problems using equally difficult operations.

It is also possible that some students with repeated practice mastered the content that was unmastered initially. Thus, nonmastery may have been changed to mastery and affected preference. Also, when problem formats are presented over an extended period of time, it possible that they may lose their reinforcing effect. Further, repeated exposure of problem formats may decrease reinforcement strength in student and alter preferences.

In general, results in the majority of the formats presented in addition problem formats show a mixed pattern of preference for the majority of the students compared to results in subtraction problem formats. During an informal interview, all students but Mike revealed that they preferred doing addition problems over subtraction problems. Specific interest in addition problems may have resulted a mixed pattern of preference because students preferred addition problems over subtraction. Therefore, interest in a specific academic content area may have resulted in inconsistent preference across the problem formats. Further examination of preference for content area is warranted.

The matching law states that when given a choice of two incompatible behaviors, an organism engages in the behavior that is likely to result in higher rates of reinforcement (Johns et al., 2000; Skinner, 2002; Skinner, Fletcher et al., 1996; Skinner, Robinson et al., 1996). Interspersal interventions based on matching law indicate that students prefer brief problems because of density of reinforcement and frequent opportunity of reinforcement associated with problem completion. Results in this study indicate that some students engaged in both word and digit problems. Therefore, both digit and word problems may have resulted in equal rates or richer schedules of reinforcement for some of the students, particularly those who had expressed mixed or no preferences For example, computing digit facts may have resulted in higher rates of reinforcement for some participants and also for some participants those who had higher language skills solving word problems may have resulted in higher quality of reinforcement. Further research is needed to clarify these conceptual issues such as why and how reinforcement rates affect student preference.

Limitations

There are some limitations of the present study. First, all six problem formats (independent variables) were not administered to all students. Therefore, group comparison of six formats was not possible due to limited selection of task difficulty levels. Second, our definition of preference and no preference was arbitrary. Third, we did not assess the participants' academic outcomes based on accuracy levels or preferences. Therefore, study results are preliminary and practitioners should use caution when interpreting results. Fourth, during preference assessments, no feedback or reinforcement was provided to the students on their accuracy. This may have confounded preference because students may have assumed that selection was the priority (i.e., the variable upon which reinforcement is dependent) and not the accuracy of problem solving. Future researchers may want provide feedback on accuracy during preference assessments; providing accuracy feedback during the trials would have significant educational implications for the students.

Implications for practice and future research

Results suggest that preference is idiosyncratic and highly variable across students. This study along with those that preceded it provides a direction for a new line of research on the potential relationship between task mastery and preference. In this study, the classroom teacher assumed that students would prefer digit facts over word problems. However, our results indicate that preference is idiosyncratic across the participants and systematic examination through direct observation is crucial to determining preferences and the role of preferences in instruction, learning, and motivation. Therefore, teachers who intend to use task preferences to enhance academic or behavioral skills of students should directly assess preference, possibly from multiple sources (e.g., direct observations and interviews). Findings also suggest that preference in students needs to be examined more systematically using multiple variables (e.g., accuracy, topography, task length) and combinations of variables.

Eventually, researchers may be able to build a complex model of preference that would be useful for optimizing learning conditions.

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