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The Effects of Student Peer Review on the Efficacy of Computer-Aided System of Instruction to Teach Discrete Trials Teaching

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Abstract

Student peer-reviewing (SPR) contributes to their own learning and that of the students they are grading. More research is needed on the effects of SPR on the reviewer's knowledge and skills of behavioural instructional skills such as Discrete Trials Teaching (DTT). The present study evaluated the effects of adding SPR to an online teaching method, Computer-Aided Personalized System of Instruction (CAPSI). Following CAPSI in DTT, participants (N = 32) were randomly assigned to receive SPR or not. Both groups showed statistically significant increases in DTT knowledge and applied performances from baseline, with no between group differences. This study supports the use of computer-assisted self-instruction in teaching applied behaviour analysis knowledge and skills.

Autism spectrum disorder (ASD) is a neurodevelopmental disorder, characterized by repetitive and restrictive behaviours and impairment in social communication and social interactions (American Psychiatric Association, 2013). Given that prevalence rates of ASD are climbing at unprecedented rates in recent years (Ouellette-Kuntz et al., 2014; Zablotzky, Lindsey, Maenner, & Schieve, 2015), effective methods are needed to train professionals on empirically validated treatments for persons with ASD.

Several meta-analyses have indicated that the most researched and effective interventions to improve performance on standard measures such as adaptive behaviour, IQ, communication, socialization, and daily living skills in children with ASD is Early Intensive Behavioural Intervention (EIBI) (Makrygianni & Reed, 2010; Reichow, 2012; Reichow, Barton, Boyd, & Hume, 2014; Reichow & Wolery, 2009; Virués-Ortega, 2010). The effectiveness of EIBI programs relies on behaviour analytic principles and techniques (Lovaas, 1987). A major procedure in most EIBI programs is Discrete Trials Teaching (DTT). This is a structured instructional method that simplifies the teaching of foundational skills – for example, matching, pointing, and imitation (Sarokoff & Sturmey, 2004). DTT involves presenting many trials, each including an antecedent, a response, and a consequence (Fazzio & Martin, 2012). DTT on its own increased social-emotional functioning (e.g., social skills, adaptability), and adaptive behaviour development (e.g., daily living skills, communication) in children with developmental disabilities (Downs, Downs, Johansen, & Fossum, 2007).

Training staff to implement DTT with high levels of fidelity can require extensive training and direct supervision (Pollard, Higbee, Akers, & Broadhead, 2014). Alternative methods to teach DTT have been developed, including online training that can be as effective and may be more efficient than face-to-face training methods (Eldevik et al., 2013; Randell, Hall, Bizo, & Remington, 2006). One such online program, Computer-Aided Personalized System of Instruction (CAPSI) (Pear, Schnerch, Silva, Svenningsen, & Lambert, 2011) is based on Keller's (1968) Personalized System of Instruction (PSI). As in PSI, the core features of CAPSI are: (1) small portions of the course or training material are delivered at a time and according to each student´s progress in the course, (2) immediate and detailed feedback on the mastery of the study materials is provided throughout, and (3) students at more advanced levels have the opportunity to do peer reviewing (Pear et al., 2011). Preliminary studies have shown that CAPSI is effective in teaching DTT (Zaragoza Scherman et al., 2015) and other behavioural procedures (Hu, Pear, & Yu, 2012; Oliveira, Goyos, & Pear, 2013). These preliminary findings are extremely promising, but additional research with larger samples would be desirable.

Feedback provided by student peer reviewers can be as effective as that provided by faculty in producing performance improvement in a course (Batchelder et al., 2010; Martin, Pear, & Martin, 2002a, 2002b; Ten Cate, van de Vorst, & van den Broek, 2012; Tolsgaard et al., 2007). Furthermore, the experience of peer reviewing results in improved performance in the reviewers themselves (Cho & MacArthur, 2011; Ensergueix & Lafont, 2010; Springer & Pear, 2008). Two CAPSI studies incorporating peer reviewing found that (1) peer reviewers provide accurate feedback that improves subsequent student responses (Martin et al., 2002a & 2002b) and that (2) peer reviewers in CAPSI-taught courses demonstrated higher course progress rates when compared to non-peer-reviewers in that same course (Lambert, 2009). These studies suggest that peer-reviewing may be a strong component to incorporate in DTT training packages using CAPSI. The present study evaluated the effects of a simulated peer-reviewing component in CAPSI on providing DTT training to university students. A secondary purpose of the study is to extend previous research on using CAPSI to teach practical skills with a larger sample.

Materials and Methods

Participants and Setting

Forty-five potential participants were recruited from two university sites in Canada. From these participants, 32 participants (Site 1 = 17, Site 2 = 15, Dropouts = 13) completed the study. Participants were randomly assigned to either the Student Peer Review (SPR) condition (n = 16) or the No SPR (NSPR) condition (n = 16). Participants completed baseline, training, and post-training sessions in university research laboratories or in a private room at the treatment centre in Winnipeg, under the supervision of a trained research assistant (RA). Participants completed the training through WebCAPSI (http://www.capsiresearch.org/) for which a personal username and password were provided. Ethical approval was received from the Research Ethics Boards of both university sites.

A set of abbreviated instructions, a pen, materials appropriate to teach each one of the three tasks (see *teaching tasks and stimulus sets*), edibles, one datasheet for each task being taught, written knowledge assessments, a video camera, and a tripod were used in baseline and post-training.

Training was based on an 84-page self-instructional manual about how to teach DTT to children with developmental disabilities (Fazzio & Martin, 2012). The manual contains 12 chapters each of them accompanied by study questions covering the topic being described. Each chapter was associated with a unit assignment in WebCAPSI, except for chapters 11 and 12, which were merged together due to their limited length. Additional questions that were developed specifically for the purposes of this study were also used (see *supplemental questions*). The WebCAPSI system was accessed through a computer connected to the Internet.

Measures

Demographic questionnaire. This questionnaire asked 11 questions pertaining to the participant's age, gender, university courses taken, previous applied behaviour analysis (ABA) training and whether English was their first language. Table 1 summarizes the demographic information of the two groups.

Table 1. Characteristics of Participants

	Student Peer-Review Group	*Non-Student Peer-Review Group*
N	16	16
Females/males	10/6	12/4
Age range (years)	18 – 40	18–29
Mean years in university	3.6 (SD = 2.09)	2.7 (SD = 2.92)
English is first language	*N* = 10	*N* = 13
Participants with ABA course experience	*N* = 4	*N* = 5
Participants with ABA training	*N* = 1*	*N* = 4

*Note: * Represents intervention plan training*

Supplemental questions. In order to assess and teach higher-order thinking as originally defined by Bloom's Taxonomy (1956), and later modified by Crone-Todd, Pear, and Read (2000), additional questions called supplemental questions were developed and incorporated to the study questions in the manual (i.e., manual-original questions). Bloom's Taxonomy allows for classifying questions by their level of difficulty, which ranges from 1-6. The first three levels of Bloom's Taxonomy are characterized as "lower level." Level 1: *Knowledge,* involves recalling facts, terms, and basic concepts. Level 2: *Comprehension,* involves understanding the meaning of information. Level 3: *Application*, involves using knowledge in novel situations. The next three levels are characterized as "higher level." Level 4: *Analysis*, involves examining information and generating relations between pieces of information. Level 5: *Synthesis*, involves compiling information and proposing alternative solutions. Finally, Level 6: *Evaluation*, involves cogently arguing opinions and making judgments.

First, all manual-original questions were classified from levels 1-6. Chapters 1, 7, and 12 were then excluded because the content being described in those chapters was not sufficiently substantial for the development of higher-order questions (i.e., were either introductory or about the practical components of DTT procedures). Additional 1-6 level questions were then developed and divided into supplemental and reserved questions. The former set of questions was used as study questions along with the manual-original questions and inserted into the WebCAPSI system. The latter was used as part of the questions in the written knowledge assessments. The number of supplemental questions per chapter ranged from 6 to 22 questions covering all of the 6 levels. The question classification was done by two undergraduate students in psychology, one master's student, and one Ph.D. student who were carrying out research in applied behaviour analysis. The question development was done by the Ph.D. student and a postdoctoral fellow who was also carrying out research in applied behaviour analysis.

DTT knowledge assessment. To measure DTT knowledge, two versions – A and B of a written knowledge assessment – were delivered, one at baseline and one at post-training. Participants answered 10 short-answer comprehension questions covering the material in an 84-page self-instructional manual about how to teach DTT to children with developmental disabilities (Fazzio & Martin, 2012) plus the supplemental questions provided through handouts.

Assessment questions used in this study were assigned a difficulty level based on Bloom's Taxonomy (1956). A Ph.D. student and a postdoctoral fellow in ABA created the questions, while two undergraduate students in psychology, one master's student, and one Ph.D. student in ABA independently rated the questions according to their classification level. Interobserver agreement (IOA) checks were conducted for 25% of the questions and per-

cent agreement was calculated by dividing the number of agreements by the number of agreements plus disagreements, and multiplying by 100. IOA on question levels averaged 94% (range = 88% to 100%). See Appendices A and B for the test questions (and their levels). IOA for the DTT knowledge assessment was conducted on 38% of the tests and was determined by comparing the marking of eight RAs on each assessment using an answer sheet. The RAs were arbitrarily divided in pairs and independently marked the tests. An agreement occurred when the two RAs in each pair scored the answer to a question the same (e.g., correct or incorrect), and a disagreement occurred when one RA said the answer was correct and the other RA said the answer was incorrect. IOA was calculated by dividing the number of agreements by the number of agreements plus disagreements, and expressing the result as a percentage. IOA on the DTT knowledge assessment across all pairs of RAs averaged 88% (range = 76% to 100%).

DTT performance assessment. The Discrete-Trials Teaching Evaluation Form (DTTEF) developed by Fazzio, Martin, Arnal, and Yu (2009) was used to score the DTT performance of each participant during baseline and post-training. The DTTEF contains 21 items to measure performance on how to: (a) prepare to conduct a teaching session defined by arranging teaching task, materials, reinforcer, and inviting the child to the table; (b) manage antecedents defined by checking task arrangements, securing child´s attention, and presenting instruction and prompt; (c) manage consequences and record data on standard trials; and (d) manage consequences and record data on error correction trials. A complete list of skills measured is available from the first author. The percentage of correct responses in the applied assessments was obtained by dividing the number of correct responses by the total number of components in the DTTEF. The DTT performance assessment was scored as the percentage of correct responses across three teaching tasks (matching, pointing, and imitation), with a RA role-playing an individual with ASD. This RA was given scripted cards that instructed them: (a) whether to attend to the participant, (b) what prompting level was required in order to respond to the participant, and (c) whether to respond correctly on each of the 12 trials. The scripts allowed the participant to experience different types of "learner" responses across the three tasks.

Stimulus sets for each teaching task were: (a) identity matching involving pictures of a cat, a house, and a tree; (b) pointing to pictures of a dog, balloons, and bananas upon hearing the spoken name of each picture; and (c) motor imitation (arms up, clap hands, and hands on lap). Each teaching task, if performed correctly, was carried out as follows. For the matching task, three cards were placed in a horizontal array on the table and a card identical to one of those cards along with the instruction *"Match"* was delivered. A correct response consisted of paring the sample to its correct comparison (i.e., the picture of a cat with the other picture of a cat). For the pointing task, three cards were placed in a horizontal array on the table and the spoken name of one of the pictures in the array was delivered. A correct response consisted of paring the sample to its correct comparison (i.e., the sound "cat" with the picture of a cat). For the imitation task, the model of the response to be emitted along with the instruction "*Do this*" was delivered. A correct response consisted of correctly imitating the action modeled. Most to least prompting (full physical guidance, light physical guidance, gestural, and no prompt) were used to encourage correct responding and were faded out across trials. Correct responses were followed by praise and edibles and incorrect responses were followed by an error correction procedure that included a 10-s pause with neutral facial expression, repetition of the trial, and prompt at the previous level to ensure correct responding. Correct responses on error correction trials were followed by praise. IOA checks were conducted on 29% of the test sessions across baseline and post-training sessions in both groups and were calculated by comparing the marking of eight RAs on each DTT task using the DTTEF. The RAs were arbitrarily divided in pairs and independently scored participants DTT applied performance. An agreement occurred when the two RAs in each pair scored an item in DTTEF the same (e.g., correct or incorrect), and a disagreement occurred when one RA scored the item as correct and the other RA scored as incorrect. IOA was calculated by dividing the number of agreements by the number of agreements plus disagreements, and expressing the result as a percentage. IOA for

the performance assessment across all pairs of RAs averaged 88% (range = 58% to 98%).

Participant evaluation. This questionnaire, given immediately after the last training session, consisted of seven Likert-type questions measuring the subjective effectiveness of the intervention package received (SPR or NSPR). For example, the questions asked about whether the participants found the material easy and helpful in learning DTT, whether they felt prepared to use DTT with an actual child with ASD and whether they would complete future courses using CAPSI.

Procedure

Baseline. During the first session, all participants were asked to complete (a) a written DTT knowledge assessment, and (b) a role-played application of DTT assessment. The order of assessments was alternated across participants. Each participant was given 60 minutes to complete the 10-question knowledge assessment. The two versions of this assessment were randomly assigned across participants by alternation such that each version was used an equal number of times.

Before beginning the application assessment the participant was given 10 minutes to read one page of instructions about how to teach each of the three tasks (matching, imitation, and pointing). After reading the instructions, the participant was asked to teach each of the three tasks to the RA role-playing a child with ASD. For each task, the DTT application assessment continued until (a) 15 minutes elapsed, or (b) the participant taught 12 trials, or (c) the participant indicated that he wanted to stop. RAs did not give participants any feedback or respond to their questions. In total, each participant taught three tasks (12 trials each), with the order of the three tasks counterbalanced across participants and remained the same for baseline and post-training. All sessions were video recorded for later scoring. After completing all assessments in the baseline phase, each participant received a $10 honorarium regardless of their performance.

DTT CAPSI training for NSPR group. After baseline both the NSPR and SPR groups were provided with the DTT self-instructional manual. The NSPR participants were instructed to read the manual, stopping at the end of each chapter to write the corresponding three short-answer question mastery-based CAPSI unit assignment. Participants were given 60 minutes to write each assignment. The three question assignments were randomly generated by the WebCAPSI program from a pool ranging from 6 to 14 questions per chapter. A research assistant would immediately grade and give feedback to the participant via WebCAPSI. The mastery criterion for each unit assignment was 100%. In cases where mastery was not met, the participant studied the chapter again and rewrote the assignment until 100% was achieved. If a participant disagreed with the RA's grading they could submit an appeal. In total the NSPR group needed to pass 11 unit assignments.

DTT CAPSI training for SPR group. The participants in the SPR condition followed the same procedure as the NSPR group, but after each regular unit assignment, SPR participants were instructed to complete an additional assignment that required them to review answers to three study questions and provide feedback on the answers if errors were detected. The additional assignment was intended to simulate the process of peer-review. Participants in the SPR group did not receive information on the process that generated the SPR assignments. A guideline for determining the level of correctness of answers to those questions was developed (available from the first author). The overall number of correct, partially correct, and incorrect answers to the training questions were equal. When the SPR participants passed 11 unit assignments and completed 11 SPR assignments (whether they passed all 11 SPR assignments or not) they entered the post-training phase.

Post-training. The post-training procedure was identical to baseline, plus the participants completed the Participant Evaluation Questionnaire described above. After completing the post-training phase, each participant received an honorarium of $90 regardless of their performance.

Procedural integrity. All RAs video-recorded themselves carrying out the procedures during all sessions in each phase (i.e., providing participant with a brief study summary, baseline, and

post-training). Procedural integrity was measured for 24% of the sessions across all phases and averaged 92.2% (range = 79.09% to 100%).

Results

A mixed-design ANOVA was used to compare the mean scores of the SPR and NSPR groups in baseline and post-training. Table 2 provides the means and standard deviations for scores on both the DTT knowledge and DTT performance assessments. All measures showed statistically significant main effects of time (baseline vs. post-training) on knowledge, $F[1, 30] = 146.6$, $p < .001$, and on performance, $F[1, 30] = 62.32$, $p < .001$. No assessment showed a statistically significant main effect of condition (SPR vs. NSPR) nor a significant interaction between time and condition. The mean number of minutes to complete a CAPSI Unit was 10.00 ($SD = 3.23$) and 10.48 ($SD = 5.55$) for SPR and NSPR groups, respectively. The average time SPR participants ($N = 16$) spent completing baseline, training, and post training phases in minutes was 82, 447, and 60, respectively. The average amount of time NSPR participants ($N = 16$) spent completing baseline, training, and post training phases in minutes was 115, 350, and 60, respectively.

Discussion

The results indicate that the self-instructional manual delivered through WebCAPSI is an effective method for teaching students DTT knowledge and applied performances. Supplemental training using simulated peer review did not yield greater improvement in the SPR group compared to the NSPR group. The latter finding is not consistent with other CAPSI studies that have found SPR to be beneficial in university courses (Lambert, 2009; Martin, Pear, & Martin, 2002). Unlike peer review in previous studies, our participants did not have a vested interest in the course (Lambert, 2009; Martin et al., 2002) or had a choice whether to do peer reviewing (Zaragoza Scherman et al., 2015).

The peer-review component did not produce differences between groups and this explains, to a large extent, why written-knowledge performance improvement was not observed during post-training. Therefore, it appears that the SPR training in this study was insufficient and it would not be expected to have an effect on DTT knowledge and performance. Future research should augment SPR training with more and varied training trials and add stronger reinforcement for correct responding. SPR training effects might also be enhanced by including participants who are more motivated and knowledgeable of ABA (e.g., EIBI trainees) rather than research volunteers, making peer reviewing an optional part of CAPSI, adding mastery criterion to the SPR training, offering real life opportunities for peer review and providing feedback on actual peer review performance. For instance, Zaragoza Scherman et al. (2015) found that peer-reviewing became more likely after it was made optional rather than mandatory in a DTT CAPSI-taught course. Also, Iwata, Furmedge, Sturrock, and Gill (2014) observed that experience in a course, as measured by the comparison between veteran and beginner students, accounted for peer-review effects.

Table 2. Mean Percentage on DTT Knowledge, DTT Performance (%) and SPR Video Assessments (Raw Numbers) in the SPR and NSPR Groups

Condition	*Mean Baseline (SD)*		*Mean Post-training (SD)*	
DTT Knowledge Assessment				
SPR	17.98%	(15.35)	51.25%	(15.17)
NSPR	19.12%	(15.35)	55.43%	(15.17)
DTT Performance Assessment				
SPR	41.18%	(10.91)	66.54%	(17.92)
NSPR	45.39%	(10.91)	73.72%	(17.92)

This study had several limitations including relatively small sample sizes. Also, the fact that the supplemental materials were provided in handouts may have limited the contact of the participants with the supplemental questions to a large extent, as information obtained through non-systematic observation revealed; in other words, we noticed that many participants would study questions in the manual only and not interact with the supplemental questions. Other limitations included lack of mastery criterion for SPR training, and lack of feedback and contingencies for SPR performance. Future research should investigate how feedback and progressing through the course contingent on mastery in each unit assignment affect SPR knowledge and applied performances. A final limitation was that the study consisted of a simulated training rather than an actual DTT staff training. The rationale for this was that the simulated peer-review was arranged in a particular way in order to be evaluated (e.g., was a requirement rather than optional, consisted of made up questions and were administered during supervised sessions); the simulated training was the way that the researchers found to maintain the experimental environment constant with respect to the remaining programmed variables.

In conclusion, this study furthers the research on using self-instructional online programs based on Keller's Personalized System of Instruction (Kinsner & Pear, 1998; Pear & Crone-Todd, 1999; Pear & Novak, 1996). Specifically, given the growing demand for ABA training, CAPSI can be used to teach ABA-based strategies such as DTT to a large number of individuals who need training.

Key Messages From This Article

People with disabilities. The extent with which you achieve success in your life is the extent with which we expect to be relevant to society.

Professionals. A career in this field requires not only the ability to teach but also the desire to learn.

Policymakers. Public policies measurement systems need to be constantly evaluated to ensure the quality of the data obtained and to assess the need for improvements.

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APPENDIX A
Written Test (Version A)

1. Define ABA. (level 1)
2. Describe the procedure and the result of the principle of positive reinforcement. (level 1)
3. Compare and contrast the use of social reinforcers and activity reinforcers, including what might be the advantages and/or disadvantages of each would be. (level 4)
4. What is a child required to do in a visual non-identity matching task? Give an example. (level 1)
5. Suppose that a teacher teaches a child to type a word by holding the student´s finger to press the keys. Knowing that there are other types of prompt (e.g., gestural, vocal, modelling, and environmental prompts), to what extent do you consider that the teacher chose the most appropriate type of prompt – physical prompt – for the above task? Justify your answer. (level 6)
6. What is the meaning of mastery criterion? Give an example. (Level 1)
7. What type of prompt was given on the first three trials, and did the child respond correctly or incorrectly on each trial? (level 3)

Trials	Position of Pictures on Table			Picture to Give to Child	Standard Trials*		Error Correction Trials*	
	Cat	House	Tree		Correct	Error	Correct	Error
1	R	M	L	Cat	✓F			
2	L	R	M	House	✓F			
3	M	L	R	Tree	✓F			
4	R	M	L	House	✓P1			
5	L	R	M	Tree	✓P1			
6	M	L	R	Cat	✓P1			
7	R	M	L	Cat		XP2	✓P1	
8	L	R	M	Tree	✓P2			
9	M	L	R	Cat	✓P2			
10	R	M	L	House	?			
11	L	R	M	Cat	?			
12	M	L	R	House	?			
13	R	M	L	House	?			
14	L	R	M	Tree	?			

8. How might you go about developing rapport with a child prior to a session? (level 2)
9. On a trial, a tutor claps her hands and says "Do this." Suppose that an error (e.g., waving hands) is in the process of occurring. What the tutor should do to block the error? (level 3)
10. Describe the response-cost punishment procedure. (level 1)

APPENDIX B
Written Test (Version B)

1. Who are behaviour analysts? (Level 1)
2. Define punisher and give an example. (Level 1)
3. Compare and contrast the use of social reinforcers and activity reinforcers, including the advantages and/or disadvantages of each. (level 4)
4. What is a child required to do in a visual non-identity matching task? Give an example. (level 1)
5. Describe how you would teach a child to recycle empty plastic water bottles using modeling prompts. (level 3)
6. What is the meaning of "mastery criterion?" Give an example. (level 1)
7. Suppose that a teacher opts to use DTT for educating a child with autism whereas another teacher opts to use a non-systematic method for teaching another child with autism. Assuming that both teachers have similar experience in teaching, and that both children have similar learning histories, which one of the teachers would likely be more successful in teaching the child in your opinion? Justify your answer. (level 6)
8. What is a standard DTT trial? (level 2)
9. On a trial, a tutor claps her hands and says "Do this." Suppose that an error (e.g., waving hands) starts to occur. What should the tutor do to block the error? (level 3)
10. Describe the response-cost punishment procedure. (level 1)