

第二言語の文法習得における インターリービング効果

Interleaving Effect for Second Language Grammar Acquisition

横澤 聡子

ABSTRACT

Interleaving Effect for Second Language Grammar Acquisition

Satoko Yokosawa

Advisor: Dr. David Aline

This study explored the optimal schedule of practice for developing procedural knowledge, focusing on the acquisition of relative clauses, and the role of pre-existing knowledge on the effectiveness of practice. In this study, two types of practice were tested: blocked practice and interleaved practice. Participants were 69 Japanese college students, who were learning English as their second language (L2). They were assigned to two groups: (a) a blocked practice group and (b) an interleaved practice group. Thirty-five participants were assigned to the

interleaved practice group, and the other 34 participants were assigned to the blocked practice group. In order to counterbalance the practice order effect in the blocked practice group, the blocked practice group was further divided into three subgroups: Group A (12), Group B (14), and Group C (8). The amount of prior-knowledge of relative clauses was assessed according to a test with sorting questions. There was no significant difference between each group in terms of the average scores of the sorting questions. The participants were asked to describe pictures that appeared on a computer screen using appropriate relative pronouns or the relative adverb where. Participants performed the pretest, training tasks, and posttest individually in a computer room. The pretest and the training session followed by the posttest were conducted in Week 1, and one week later, a delayed posttest was administered after the first training session to measure the retention of participants' grammatical knowledge. Each test contained 20 items, with the test lasting approximately five minutes. The training session consisted of 50 items, which took roughly 20 minutes for each participant. Presentation duration of all test and picture items was fixed. The major difference between the tests and the training session was that the training session provided feedback to participants after they responded.

The results of this study showed an advantage of the interleaved practice format over the blocked practice format. Specifically, the participants with higher prior-knowledge of relative clauses tended to benefit from interleaved practice more than from blocked practice, while no difference was found between the two practice schedules for participants with lower prior-knowledge. These findings suggest that it is necessary to assess

the level of learners and adopt the best possible effective practice catering to their individual differences.

For my dear parents and family members

ACKNOWLEDGMENTS

I would like to express my deep sense of gratitude to my main advisor Professor David Aline for academic support, encouragement and engagement through the learning process of this master's thesis. Without his great academic support throughout a four-year master's program, I would not have been able to go through all the difficulties, and this work would not have been accomplished. I learned so much from him while spending the years studying beside him. I am deeply grateful to him having been my main advisor for the entire period of my master's program.

I would also like to express my sincere thanks to Professor Kazuyuki Takahashi for guiding me throughout the four years of the master's program to become deeply involved with English education in Japan. His enthusiasm toward English education inspired and encouraged me to chase my dream of becoming an English teacher no matter the difficulties I had to face. I will never forget everything I learned from his teaching courses and the positive attitude he showed me as a teacher. I cannot express how grateful I am for his great support during the entire period of my master's program

Furthermore, my sense of gratitude goes to Professor Yuichi Suzuki for the great support he provided me in the process of this work by giving me insightful comments, helpful critique, and enthusiastic encouragement. The door to Professor Suzuki's office was always open whenever I encountered trouble or had difficulties about my work. He also provided me with an opportunity to conduct research and give a presentation regarding this work Kantokoshinetsu Association of Teachers of English at Niigata

National University, which would have never been possible without his academic support. I am thankful to him for his suggestions, timely help, kindness, and patient guidance, without which the research and this thesis would not have been completed.

I would like to show my appreciation to my fellow graduate students and undergraduate students, particularly Professor Baikuntha Bhatta, Masashi Kunisawa, Atsushi Miura, and Atsushi Kimura, for assisting me to complete my work and showing me sympathy and kindness. Their great support helped and encouraged me to complete my assignments. I would like to thank them for all the support they gave me throughout the time we studied together.

This thesis would not have been accomplished without the cooperation of the participants of the experiment. Therefore, I would like to express my appreciation to all the participants who engaged in my experiment for providing me their precious time.

I have greatly benefited from the teaching course department of Kanagawa University for providing me the opportunities to learn and gain practical teaching skills. The opportunities and support I received from them helped me to fulfill the qualifications needed to earn a license to work as an English teacher and to complete my master's program.

I have no words to express my gratefulness to Professor Susumu Iwasaki at Fort Lewis College, my best friends Mymee Tokuda, Miki Hirayama, Hiromi Hirabayashi, and Yumi Nakahata, who have supported me whenever I ran into difficulties. I would not have been able to take the first step into studying at graduate school and complete this program without their continuous close support and thoughtful advice.

Moreover, my heartfelt deep appreciation goes to Hikaru Shirai

for the continuous support, kindness, sympathy and love shown to me, and for providing me with the strength to overcome the hardest time of my studies. I cannot express how supportive he was and I deeply appreciate all the encouragement he provided me with to complete my work and realize my dream to become an English teacher.

Finally, I would like to express my very profound gratitude to my parents and all family members who afforded me the wonderful opportunity to earn a bachelor's degree in the United States and to begin my graduate studies at Kanagawa University. Without their unfailing support and continuous encouragement throughout my years of study, it would not have been possible to accomplish this work, and my dream, to become an English teacher, would not have been realized. No matter what happened, they were always here beside me, and provide me strength to go through all the difficulties. I cannot express how thankful I am to them. Their continuous close support, encouragement, and unfailing deep love are incomparable.

Thank you.

TABLE OF CONTENTS

ABSTRACTS	iii
DEDICATION	v
ACKNOWLEDGEMENTS	vi
TABLE OF CONTENTS	ix
LIST OF TABLES	xi
LIST OF FIGURES	xii
CHAPTERS	
1. INTRODUCTION	1
2. LITERATURE REVIEW	2
2.1. Blocked Practice versus Interleaved Practice	2
2.2. Role of Prior Knowledge on Effectiveness of Blocked versus Interleaved Practice	4
2.3. Research Questions and Hypothesis	6
3. METHOD	7
3.1. Participants	7
3.2. Target Structure	7
3.3. Instruments	8
3.3.1. Training Materials	8
3.3.2. Training Schedules	10
3.3.3. Outcome Tests	12
3.4. Procedures	12
4. RESULTS	13
4.1. Accuracy Measures	13
4.1.1. Performance Change During the Training Session	13
4.1.2. Pretest, Posttest, and Delayed Posttest	14
4.2. Prior-Knowledge and Practice Condition Effect	17
5. DISCUSSION	18

6. DIRECTIONS FOR FUTURE RESEARCH.....21

6.1. Further Studies.....21

6.2. Limitations of This Study.....21

7. CONCLUSION.....22

REFERENCES.....23

APPENDIXES.....26

A. Sorting Questions.....26

B. Mean Accuracy Scores and Standard Deviation of Practice Opportunities During The Training Session.....31

C. Items Used for Pretest.....32

D. Items Used for Posttest.....33

E. Items Used for Delayed Posttest.....34

F. Items Used for Training Session.....35

LIST OF TABLES

Table 1. Mean Score, Standard Deviations, Minimum Scores, Maximum Scores, and 95% Confidence Level.....16

LIST OF FIGURES

Figure 1. The materials used in the training session.....8

Figure 2. An example of the practice order for each condition.....10

Figure 3. The order of the relative pronouns and relative adverb, where that the participants of each group encounter during the training session.....11

Figure 4. The whole procedure of this experiment.....12

Figure 5. The mean accuracy score of the blocked practice group and the interleaved practice group during the training

session.14

Figure 6. The mean accuracy scores of the two practice conditions:
The interleaved practice group versus the blocked
practice group.....15

Figure 7. The scores of all the participants on the pretest and
their respective practice conditions.....17

Figure 8. My prediction of the outcome, and the right side of the
graph displays the results of the present study.....21

1. Introduction

One of the goals of English education is often said “to be able to use English.” What it means by “to be able to use English” is not simply “knowing about” the language. The knowledge about grammatical rules is called declarative knowledge. In contrast, having knowledge of how to do something is critical for using English fluently (DeKeyser, 2015; Lyster & Sato, 2013). The knowledge that enables the fast execution of language processing is called procedural knowledge (Mitchell & Myles, 2004). However, in general, it is not very easy for Japanese learners of English to develop their grammatical knowledge they gained during the 6-years-of-English-education into procedural knowledge. Then, how should learners study and practice English in order to gain procedural knowledge effectively? This study explored the optimal schedule of practice for developing procedural knowledge, focusing on the acquisition of relative clauses. The Japanese language does not have relative clauses in its grammatical system, which makes it hard for Japanese learners of English to acquire. In addition, this study also investigated the role of pre-existing knowledge on the effectiveness of practice.

In this study, two types of practice were tested: blocked practice and interleaved practice. Generally, when L2 learners of English practice target grammar in school settings or work on a grammar exercise book, it is quite normal to perform activities concerning one single category of the target grammar (e.g., the subjective relative clause *who*) for a certain amount of time until they get used to using it, and then move on to another category (e.g., the objective relative clause *which*) and practice it in the

same manner. This type of practice is called blocked practice. This is probably the most commonly adopted way of practicing grammar in school settings in Japan. This study casts a spot light on a different type of practice schedule, which is possibly more effective on developing procedural knowledge. This is interleaved practice. Unlike blocked practice, multiple categories of the target grammatical structures are intermixed and practiced altogether in interleaved practice. For instance, when the first question asks learners to use the subjective relative pronoun *who*, the next question asks them to use the objective relative pronoun *which*.

Many of the studies in psychology have reported that it is more effective to practice through interleaved practice compared to blocked practice when people acquire knowledge (Del Ray, Wughalter, & Whitehurst, 1982; Guadagnoli, & Lee, 2004; Guadagnoli, Holcomb, & Weber, 1999; Guzman-Munoz, 2017; Hebert, Ladin, & Solomon, 1996; Mayfield & Chase, 2002; Olina, 2006; Sana, Kim, & Yan, 2017; Rau, Aleven, & Rummel, 2010; Rohrer, 2012; Rohrer & Taylor, 2007; Rohrer, Dedrick, & Stershic, 2015; Taylor & Rohrer, 2010;).

Although a number of studies that explore the effect of interleaved practice have been conducted in psychology, there has been little research that tested the effects or benefits of interleaved practice in second language grammar acquisition. In the present study, I investigated the effect of interleaved practice in the area of second language acquisition, and also examined if I could see the same effect on all the learners regardless of their amount of pre-existing knowledge of relatives.

2. Literature Review

2.1. Blocked Practice Versus Interleaved Practice

The effect of interleaved practice has been found more effective than that of blocked practice in cognitive psychology research. Previous research covered a wide range of learning materials and skills such as of mathematical formulas (Taylor & Rohrer, 2010), mathematic exercises (Mayfield & Chase, 2002; Rau et al., 2010; Rohrer, 2012; Rohrer & Taylor, 2007; Rohrer et al., 2015), and sports skills (Del Ray et al., 1982; Guadagnoli, & Lee, 2004; Guadagnoli, Holcomb, & Weber 1999; Guzman-Munoz, 2017; Hebert et al., 1996; Olina, 2006; Sana et al., 2017). For example, Taylor and Rohrer (2010) examined the effect of interleaved practice using four types of mathematic formula to solve four parts of a prism: a face, corner, edge or angle. Participants received the training session and learned how to apply the appropriate formula to solve each aspect of a prism. The result of the posttest, which was conducted one day after the tutorial session, showed that those participants who received the tutorial session through the interleaved condition gained higher scores compared to those who received the blocked practice condition. In addition to the study presented above, Mayfield and Chase (2002) also suggest the benefits of interleaved practice. They provided three different types of mathematic instructions to college students in order for them to be able to apply the appropriate rule and solve mathematic problems, and examined what type of instruction was most effective. The participants were assigned to three different groups: cumulative practice group (participants practice two different rules separately, and then practice them

altogether (interleaved practice), simple review group (participants practice two different rules separately, and review only the first rule after mastering the second rule, which is equivalent to blocked practice type), and extra practice group (participants practice one particular rule, and each rule was reviewed immediately after participants mastered it, which is equivalent to the blocked practice type). The result showed that those participants who received the instruction under the cumulative (interleaved) practice condition got higher scores on the final test than those who were under the simple review and extra practice (blocked practice) condition. Another study conducted by Rohrer et al. (2015) also confirmed the advantage of interleaved practice. In this study, the participants, 126 seventh-grade students, were provided graph problems and slope problems, and they had problem-solving trainings either by blocked practice or interleaved practice over a three-month period. The results showed that interleaved practice showed higher scores on both intermediate and delayed posttests than blocked practice did.

It seems likely that interleaved practice is a panacea that applies to a wide range of knowledge and skills; however, not all the studies support the effect of interleaved practice. Carpenter and Muller (2013) conducted a study that explored the interleaved effect on acquisition of French pronunciation for native speakers of English, who had no exposure to French before the experiment. To the best of my knowledge, this is the only published study that examined the interleaved effect in second language acquisition. In this study, Carpenter and Muller adopted a task that have participants hear and see groups of French words on a computer screen. Then they were asked to figure out a certain rule from a

different combination of words and associate the words with the pronunciation. For instance, if participants see and hear a combination of words like *bateau*, *fardeau*, *rameau*, they need to analyze and find the rule that *eau* is pronounced /o/. The result of this experiment revealed that blocked practice was more beneficial than interleaved practice. Hence, it can be assumed that blocked practice is likewise effective depending on the features of the target skills or knowledge that learners acquire.

2.2. Role of Prior Knowledge on Effectiveness of Blocked Versus Interleaved Practice

In addition to those experiments that simply compared the effect of interleaved practice versus blocked practice, some studies took into account individuals' pre-existing knowledge or skills, and examined whether prior knowledge would moderate the effectiveness of blocked and interleaved practice. Hebert et al. (1996) investigated the influence of prior experience on the practice schedule effect using the forehand stroke and backhand stroke in playing tennis, and compared two practice conditions: a blocked practice condition and an alternating practice condition (which is equivalent to interleaved practice). The outcome of this study showed that for the low-skilled participants (i.e., participants who are inexperienced or have little experience in tennis or open sport skills) the blocked practice condition yielded significantly higher scores on posttests than the interleaved condition; whereas for the high-skilled participants (i.e., participants who are highly experienced in tennis or other open sport skills) who practiced through the interleaved condition scored higher than in the blocked condition. Del Ray et al. (1982)

also presents evidence that the practice schedule effect is relevant to the individuals' abilities. They tested the acquisition and transfer effect of motor skills using a Bassin Anticipation Timer, which consisted of two 16-lamp runways attached end-to-end, and explored whether the practice condition effect is related to participants' motor skills. The participants were asked to push a button at the same time as a moving light reached the last lamp of the second runway, and the speed of the moving light was adjusted for each group condition: For the participants in the blocked practice group, the speed was presented in the following order: 13, 11, 5, 7 mph, while each speed of the moving light was randomly assigned for the participants in the random practice group, which is equivalent to interleaved practice. The results of this study revealed that the experienced participants, who had regular involvement in open sports skills, made greater progress under the random practice condition; while the novice participants, who had no involvement in open sports skills, showed improvement under the blocked practice condition. Furthermore, besides the acquisition of motor skills reported by Herbert et al. (1996), and Del Ray (1982), another study, conducted by Rau et al. (2010) examined the relations between the practice condition effect and learners' prior knowledge of fractions for fifth and sixth grade students. They provided four different types of conditions in the tutorial session: (a) blocked condition, (b) moderate condition (almost equivalent to blocked condition, but the blocks were smaller), (c) interleaved condition, and (d) increased condition (the length of the blocks was gradually reduced towards the end of the session), and the participants were randomly assigned to one of these

groups. The participants were asked to identify and order fractions, and also asked to apply algorithms for some problems. The results showed the advantage of the blocked condition and increased condition over the interleaved condition on the immediate and delayed posttests, and this phenomenon was particularly significant for the participants with low prior knowledge of fractions.

From the findings presented above, it can be assumed that it is necessary to apply the optimal practice schedule depending on prior level of knowledge pertaining to the target skill. Moreover, it is possible to infer that the blocked practice condition is probably more effective for the learners with low prior knowledge, while the learners with high prior knowledge might require a more challenging condition, like interleaved practice, in order to improve their skills more effectively as “the optimal challenge point represents the degree of functional task difficulty an individual of a specific skill level would need in order to optimize learning” (Guadagnoli & Lee, 2004).

2.3. Research Questions and Hypotheses

The present study investigated the optimal practice schedule for developing grammatical procedural knowledge of English, and particularly focuses on relative clauses. I addressed the following two research questions:

1. Is interleaved practice more effective than blocked practice for the acquisition of the procedural knowledge of relative clauses?
2. Does the effectiveness of different practice schedules differ depending on learners' prior knowledge of relative

clauses?

It was hypothesized that interleaved practice would be more effective than blocked practice for participants acquiring the procedural knowledge of relative clause as the previous studies showed the benefits of interleaved practice (Mayfield & Chase, 2002; Rau et al. 2010; Rohrer, 2012; Rohrer & Taylor, 2007; Rohrer et al., 2015;). The feature of the task that was adopted for the present study is similar to those found in previous studies. The participants were required to distinguish one item from among similar concepts so as to achieve comparability between prior research and the current study. For instance, participants in previous studies were asked to apply the appropriate formula to solve one aspect of the particular diagram, so that they were required to distinguish one item from among similar formulas. Similarly, participants in the current study were asked to distinguish one of the relative pronouns which was appropriate for the given context. In addition, from the point of view provided by previous studies (Del Ray et al., 1982; Guadagnoli & Lee, 2004; Guadagnoli, Holcomb, & Weber 1999; Hebert et al., 1996; Javier, 2017; Olina, 2006; Rau et al., 2010; Sana et al., 2017), it was predicted that learners with higher prior knowledge would benefit from interleaved practice whereas the blocked practice would work more effectively for learners with lower prior knowledge.

3. Method

3.1. Participants

Participants were 69 Japanese college students, who were learning English as their second language (L2). They were assigned

to two groups: (a) a blocked practice group and (b) an interleaved practice group. The amount of prior knowledge of relative clauses was assessed according to the test with sorting questions (See Appendix A). The maximum score of the sorting questions was 24. The test consisted of eight sorting problems regarding subjective relatives, eight problems regarding objective relatives, and eight problems regarding relative adverbs. This test was given prior to the experiment in order to assign participants into the two groups by controlling the prior knowledge of relative clauses. The average score for the blocked group was 13.36 while the average score for the interleaved practice group was 13.46.

3.2. Target Structure

Five different kinds of relative clauses were used as the target structures in this experiment:

- (a) subjective-relative clause using *who* (e. g., *That is the girl who is washing the bird.*),
- (b) subjective- relative clause using *which* (e. g., *That is the cat which is watching the bird.*),
- (c) objective relative clause using *whom* (e. g., *That is the girl whom the cat is watching.*),
- (d) objective relative clause using *which* (e. g., *That is the dog which the woman is carrying.*),
- (e) relative adverb using *where* (e. g., *That is the park where the boy is watching the bird.*)

3.3. Instruments

3.3.1. Training Materials

The participants were asked to describe the pictures that

appeared on a computer screen using appropriate relative pronouns or relative adverb *where* (See Figure 1). All the lexical items necessary for oral description (i.e., the action doer, recipient, and verbs) were shown in the picture so that participants could focus on practicing relative clauses. The first part of the sentence (the subject, *be* verb, and the antecedent) was provided both visually and aurally. The participants were given 12 seconds to respond. After that, feedback was provided both visually and aurally and the example sentence remained on the screen for 8 seconds (See the right panel in Figure 1). In sum, the practice trial lasted 20 seconds across all trials so that the time on training task was equal between the groups.

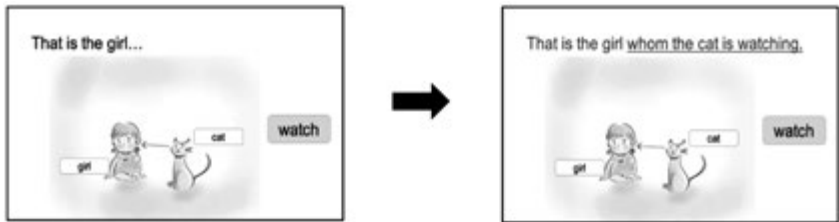


Figure 1. The figure illustrates the materials used in training session.

The training session consisted of 50 instances. Ten different verbs were used for the relative clauses so that the participants were able to practice ten times for each target structure, which means 50 sentences were used in the training session (10 verbs X 5 structures). The ten verbs used in this experiment were the following: carry, hit, hug, kick, kiss, massage, push, touch, wash, watch. These ten words were familiar to the participants because they are taught at the very early stage of English

education in Japan or adopted into the Japanese language. In addition, these verbs require two objects so that they can be used for both subjective relative pronouns and objective relative pronouns. The verbs used within the relative clause were specified to participants because the purpose of this experiment was to see the effect of the practice condition, so it was necessary to eliminate any possible distraction that would prevent the participants from producing relative clauses.

The training conditions for the blocked practice group and for the interleaved practice group were as follows. For the blocked practice group, each grammatical item was designed to be studied as a set. For example, if one participant practiced producing sentences using the relative pronoun *who* 10 times first, he or she then practiced using the relative pronoun *which* 10 times, and then practices using relative pronoun *whom* 10 times. In contrast, the category of target grammar was intermixed for the interleaved practice group. No practice items using the same grammatical structure appeared in a row. For instance, if one participant encountered a question for which he or she had to use the relative pronoun *who*, he might have to use *whom* for the next question, and maybe for the third question, he might need to use *which* or maybe the relative adverb *where* (See Figure 2).

Blocked Practice									
S-who	S-who	S-who	S-who	S-who	S-who	S-who	S-who	S-who	S-who
S-which	S-which	S-which	S-which	S-which	S-which	S-which	S-which	S-which	S-which
O-whom	O-whom	O-whom	O-whom	O-whom	O-whom	O-whom	O-whom	O-whom	O-whom
O-which	O-which	O-which	O-which	O-which	O-which	O-which	O-which	O-which	O-which
RA-where	RA-where	RA-where	RA-where	RA-where	RA-where	RA-where	RA-where	RA-where	RA-where

Interleaved Practice									
S-who	S-which	O-whom	O-which	RA-where	O-which	S-who	O-whom	S-which	RA-where
S-who	O-which	O-whom	S-which	RA-where	S-who	S-which	RA-where	O-which	O-whom
S-which	S-who	RA-where	O-which	O-whom	S-which	O-which	S-who	O-whom	RA-where
S-who	O-whom	O-which	S-which	RA-where	S-which	RA-where	S-who	O-which	O-whom
S-who	O-whom	S-which	RA-where	O-which	S-who	S-which	O-whom	O-which	RA-where

Figure 2. The figure shows an example of the practice order for each condition.

3.3.2. Training Schedules

Thirty-five participants were assigned to the interleaved practice group, and the other 34 participants were assigned to the blocked practice group. In order to counterbalance the practice order effect in the blocked practice group, the blocked practice group was further divided into three subgroups: Group A (12), Group B (14), and Group C (8) (See Figure 3). It is generally considered to be the case that subjective relative pronouns are easier to learn than objective relative pronouns and, therefore, that subjective relative pronouns are usually taught prior to objective relative pronouns in most syllabi in schools in Japan. For this reason, the order of subjective relative pronouns and objective pronouns was fixed in all the groups (i.e., subjective relative pronouns always appeared before objective relative pronouns). The only difference between the three groups was the

placement of the relative adverb *where*. Again, there was no significant difference between each group in terms of the average scores of the sorting questions (Appendix A).

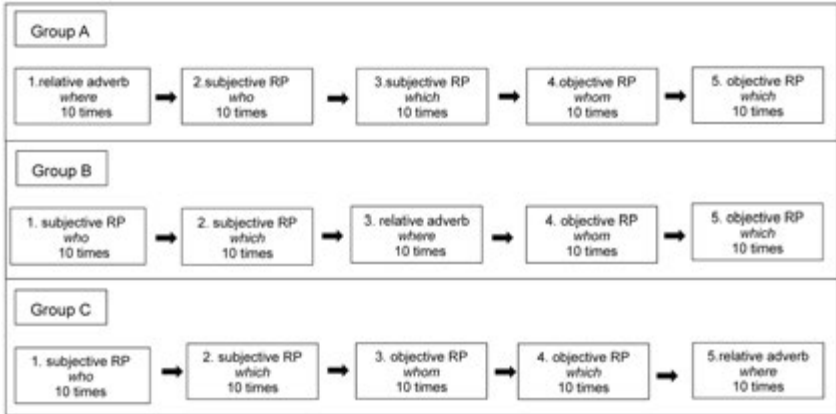


Figure 3. The figure displays the order of the relative pronouns and relative adverb, *where* that the participants of each group encounter during the training session.

3.3.3. Outcome Tests

The participants were asked to take a series of three tests: pretest, posttest, and delayed posttest. The tests consisted of 20 items each. (Four questions were created for each target structures: five target structures x four questions = 20 questions.) Each test took approximately five minutes to administer. No feedback was provided for any of the three tests. In order to reduce the practice effect, three tests used different items. The questions were randomly assigned so that the participants were required by themselves to select the appropriate relative pronoun or adverb which would precisely describe the picture displayed on the screen.

3.4. Procedures

Participants performed the pretest, training tasks, and posttest individually in a computer room. The pretest and the training session followed by the posttest was conducted in Week 1, and one week later, the delayed posttest was administered a week after the first training session to measure the retention of the participants' grammatical knowledge (See Figure 4). Each test contained 20 items, which lasted approximately five minutes. The training session consisted of 50 items, which took roughly 20 minutes. Presentation duration of all test and picture items was fixed. The major difference between the tests and the training session was that the training session provided feedback to the participants after the responding time.

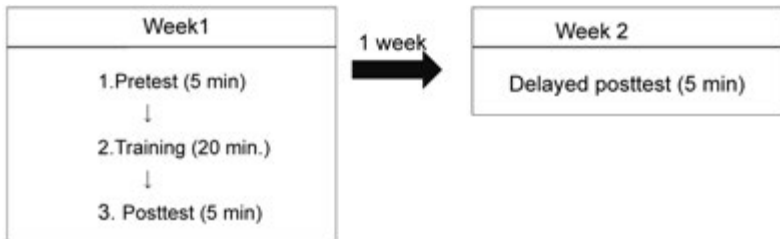


Figure 4. The figure shows the whole procedure of this experiment.

4. Results

4.1. Accuracy Measures

4.1.1. Performance Change During the Training Session

Figure 5 shows the mean accuracy scores and performance change during the training session (For numerical data, see Appendix B). The accuracy score of the first practice opportunity was 38.18 % and 37.71% for the blocked practice group and the interleaved

practice group, respectively. However, the mean accuracy score of the second practice opportunity presented a significant difference between the practice conditions; the blocked practice group achieved 74.55 % of accuracy while the interleaved practice group was 40% and did not show much progress from the first practice opportunity. The mean accuracy score of the blocked practice group reached 90% quickly on the third opportunity. The mean accuracy score of the blocked practice group reached 90% quickly on the third opportunity. The final accuracy rate was 97.58% on the 10th practice opportunity. Although the change for the interleaved practice group was not as pronounced as for the blocked practice group, the interleaved practice group slowly improved its mean accuracy score. There was a spike from the second (40%) to the third practice opportunity (64%), and after that, the improvement was gradual but consistent. The final accuracy rate was 86.29% for the interleaved practice group, which significantly lower than for the blocked practice group.

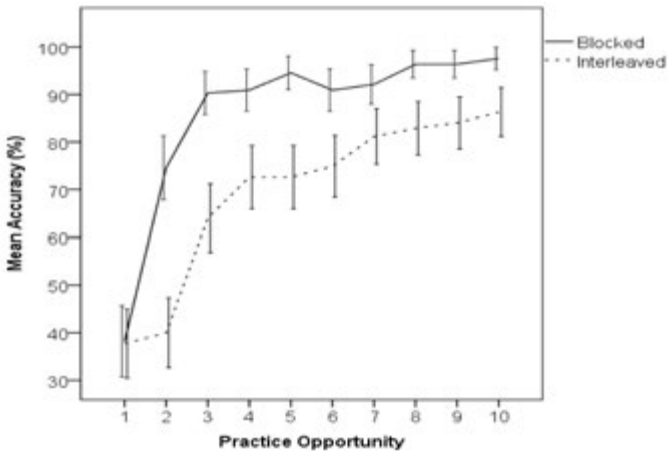


Figure 5. The figure presents the mean accuracy score of the blocked practice group and the interleaved practice group during the training session.

4.1.2. Pretest, Posttest, and Delayed Posttest

As shown in Figure 6 and Table 1, the mean accuracy scores of the pretest showed no difference between the two conditions (Blocked: $M=31.94\%$, $SD=20.03\%$; and Interleaved: $M=30.12\%$, $SD=21.58\%$). This demonstrates that the level of those two groups were nearly equal before the training session. On the immediate posttest, the interleaved practice group achieved higher scores than the blocked practice group (Blocked: $M=78.66\%$, $SD=21.47\%$; Interleaved: $M=90.36\%$, $SD=90.36\%$). The mean accuracy score of the delayed posttest, conducted after one week from Week1, still showed the advantage of interleaved practice group (Blocked: $M=62.75\%$, $SD=24.58\%$; Interleaved: $M=72.14\%$, $SD=72.14\%$). Overall, from the mean accuracy scores of the posttest and the delayed posttest, it can be observed that the interleaved practice was more effective than the blocked practice for the acquisition and retention of the procedural knowledge of relative clauses.

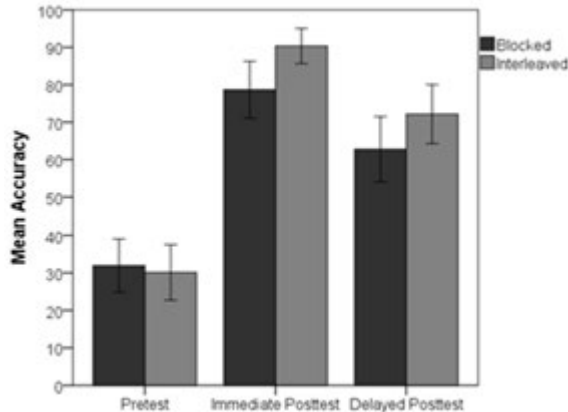


Figure 6. This figure displays the mean accuracy scores of the two practice conditions: The interleaved practice group versus the blocked practice group.

Table 1 *Mean Score, Standard Deviation, Minimum Scores, Maximum Scores, and 95% Confidence Level*

	Blocked					Interleaved				
	M	SD	Min	Max	95% CI	M	SD	Min	Max	95% CI
Pretest	31.94	20.03	0	70.83	(24.84,39.05)	30.12	21.58	0.00	87.50	(22.71,37.53)
Immediate	78.66	21.47	16.67	100.00	(71.05,86.27)	90.36	90.36	50.00	100.00	(85.66,95.05)
Delayed	62.75	24.58	20.83	100.00	(54.04,71.47)	72.14	72.14	25.00	100.00	(64.26,80.03)

4.2. Prior Knowledge and Practice Condition Effect

In addition to the comparison of the two practice schedule groups, the present study also examined whether prior knowledge of relative clauses influences the effectiveness of blocked and interleaved practice. The pretest score was used as an index of prior knowledge. Figure 7 illustrates the interaction between pretest scores and (predicted probability) of accuracy scores on the delayed posttest. Interestingly, when participants scored 30% below the median score (left end of the figure), there seems to be virtually no difference between the two groups. In contrast, as participants' pretest scores increase, they are more likely to benefit from interleaved practice compared to the blocked practice. The advantage of the interleaved practice is most reliably pronounced after achieving a score that is 20% higher than the median score. This pattern of scores suggests that interleaved practice is particularly effective for participants with higher prior knowledge.

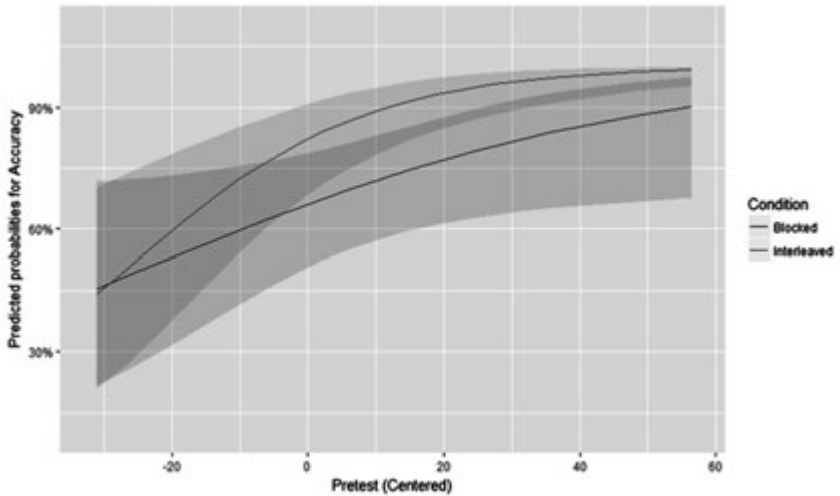


Figure 7. The figure shows the scores of all the participants on the pretest and their respective practice conditions.

5. Discussion

The present study aimed to explore the following two research questions: (1) Is interleaved practice more effective than blocked practice for the acquisition of the procedural knowledge of relative clauses? And, (2) Does the effectiveness of different practice schedules differ depending on learners' prior knowledge of relative clauses? The results of this study showed an advantage of the interleaved practice over the blocked practice, which corroborates many of the previous studies in cognitive psychology (Mayfield & Chase, 2002; Rohrer, 2012; Rohrer & Taylor, 2007; Rohrer et al., 2014; Taylor & Rohrer, 2010). Hence, the hypothesis regarding on research question (1) was supported. Interleaved practice is more effective than blocked practice in acquiring

procedural knowledge of relative pronouns.

Carpenter and Mueller (2013) also investigated the effect of interleaved practice, and this is the only research that compared interleaved practice versus blocked practice in the study of second language acquisition prior to the present study. Two possibilities are discussed that might have resulted in the discrepancy in the findings between their study and the current study. First, the feature of the target item used in their study was different from that of the present study. This study targeted the acquisition of procedural knowledge of relative pronouns, and required participants to select and use appropriate relative pronouns from among the items whose forms and use are very similar. In other words, participants in the present study needed to learn to distinguish very similar syntactic structures (e.g., *The cat which is watching the bird* vs. *The dog which the woman is carrying*). On the other hand, Carpenter and Mueller focused on the acquisition of French pronunciation and the participants in their study were required to discover a particular pronunciation rule from the different combinations of words (e.g., *bateau*, *fardeau*, *rameau*), which means that the participants needed to detect the similarities from among disparate items. It is possible that the effective practice type depends on the nature of the target items and the tasks provided to the learners. Second, prior exposure to the target item is considered as one of the factors which differentiated the results of the two studies. All the participants in the present study have had some experience learning relative pronouns and relative adverbs at some point in their six years of English education in Japan, so it can be assumed that they had at least some prior knowledge of relative

clauses before participating in this experiment. In contrast to the present study, the participants in Carpenter and Mueller's study had had no exposure to the target language of French prior to the research so that all the stimulus provided during the experiment was completely novel to them. Blocked practice might have been more beneficial for novice learners like those in Carpenter and Mueller's (2013) study, because, as Guadagnoli and Lee (2004) note, "When the performer is in an early stage of learning the processing system is too inefficient to deal with multiple task elements" (p. 222). Blocked practice probably allows for more room for engaging in training of one type at a time, which may be particularly efficient for novice learners. In contrast, interleaved practice was effective for intermediate to advanced learners like the participants in our study. This is because the desirable difficulties and challenges vary depending on individuals' abilities, and advanced learners can integrate much more information based on their previously acquired knowledge and skills. They are likely to take advantage of more demanding, challenging training conditions like interleaved practice for their skill acquisition.

Regarding the second research question, it was hypothesized that learners with higher prior knowledge would benefit more from interleaved practice whereas blocked practice would work more effectively for learners with less prior knowledge was partially supported. Specifically, the participants with higher prior knowledge of relative clauses tended to benefit from interleaved practice more than from blocked practice, while there seemed to be no difference between the two practice schedules for participants with lower prior knowledge. Figure 8 displays the expected outcome

as hypothesized under the original research question on the relation between the prior knowledge and the effect of practice condition (left panel) and the current findings (right panel). On the one hand, the current data supported the expectation that the more challenging condition would enhance development for the learners with higher prior knowledge. On the other hand, no notable difference between the practice conditions was found among participants with lower prior knowledge. This was possibly due to the amount of prior knowledge they had. All the participants in the present study have had some exposure to relative clauses. They partially had basic knowledge of relative clauses prior to the experiment so that even those participants with lower prior knowledge were too advanced to show a strong effect for the practice conditions. For the sorting question (declarative knowledge), participants scored 55.35% on average and no participants scored zero. The mean score was 13.5, and the minimum score was three out of 24. Participants in Hebert et al. (1996), on the other hand, included complete beginners. This is probably the main reason why blocked practice was more effective for participants with lower prior knowledge. The same phenomenon was seen for the participants in Carpenter and Mueller's (2013) study as well. From these tendencies, it can be assumed that the blocked practice would maximize its effect at the very early stage of learning. Figure 8 illustrates my prediction of the outcome and the results of the present study. At the point of zero or little prior knowledge, the blocked practice is more effective than the interleaved practice; at the medium point, the effect of both practice conditions becomes competitive, and this is where the lower prior knowledge participants in the present study were; at

the point of high prior knowledge, the interleaved practice maximizes its effect. Based on Herbert et al. (1996), it was predicted that blocked practice would be more effective for participants with lower prior knowledge; however, all of our participants were not complete beginners unlike participants in the previous studies. In fact, lower prior knowledge participants in the present study were at the medium point, and for that reason, a notable effect for lower prior knowledge participants was not observed in either practice condition.

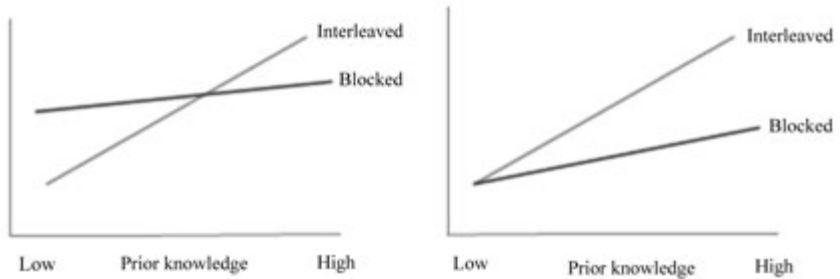


Figure 8. The left side of the graph shows my prediction of the outcome, and the right side of the graph displays the results of the present study.

6. Directions for Future Research

6.1. Further Studies

It would be worth investigating the differential effects of each practice condition on outcome scores if a wider range of participants were to be included in analysis, say novice learners such as junior high school students to native-like L2 learners of English. Moreover, it would be interesting to extend the target grammatical structures to other grammatical areas of interest such

as tense and interrogatives, which may turn out to be further assets to the generalizability of the current findings.

6.2. Limitations of This Study

This study focused on speaking ability out of a range of other aspects of in the area of English proficiency, such as reading skills, listening skills, or writing skills. Because speaking skills generally require the ability to produce sentences immediately compared to other skills, it was assumed that speaking practice could enhance the development of learners' procedural knowledge. Nevertheless, a different result could have been obtained if I had examined different English skills. In addition, the participants in the present study were all college students who had some English exposure and also the numbers of participants was limited. These two factors possibly influenced the results of this study, and that therefore a different outcome might be realized if a wider variety of participants were included and if the number of participants were expanded.

7. Conclusion

This main objective of this study was to explore the practice condition which enhances acquisition of procedural knowledge of relative clauses. It was also examined if the effects of practice conditions vary depending on the amount of prior knowledge of the participants. The results of the experiment demonstrated that participants in the interleaved practice group achieved approximately 10% higher scores over the blocked practice group on both the posttest and the delayed posttest. Furthermore, the

present study found a potential interaction between prior knowledge and the practice schedule. While no significant difference was seen in terms of the practice condition for the participants with lower prior knowledge, participants with higher prior knowledge showed significant improvement under the interleaved practice condition compared to those who studied through the blocked practice condition. These findings suggest that it is necessary to assess the level of learners and adopt the best possible and most effective practice condition that caters to their individual differences. The present study revealed the potential value of interleaved practice for facilitating L2 grammar acquisition.

References

- Bird, S. (2010). Effects of distributed practice on the acquisition of second language English skills. *Applied Psycholinguistics*, 31, 635-650.
- Carpenter, S. K., & Mueller, F. E. (2013). The effects of interleaving versus blocking on foreign language pronunciation learning. *Memory and Cognition*, 41, 671-682.
- DeKeyser, R. M. (2015). Skill acquisition theory. In B. Van Patten & J. Williams (Eds.), *Theories in second language acquisition: An introduction* (2nd ed.) (pp. 94-112). New York: Routledge.
- Del Ray, P., Wughalter, E. H., & Whitehurst, M. (1982). The effect of contextual interference on female with varied experience in open sport skills. *Research Quarterly for Exercise and Sport*, 53(2), 108-115.
- Guadagnoli, M. A., & Lee, T. D. (2004). Challenge point: A framework for conceptualizing the effect of various practice conditions in motor learning. *Journal of Motor Behavior*, 36 (2), 212-224.
- Guadagnoli, M., Halcomb, W. R., & Weber, T. (1999). The relationship between contextual interference effects and performer expertise on the learning of a putting task. *Journal of Human Movement Studies*, 37, 19-36.
- Guzman-Munoz, F. J. (2017). The advantage of mixing examples in inductive learning: a comparison of three hypotheses. *Educational Psychology*, 37, 421-437.
- Hebert, E. P., Ladin, D., & Solomon, M. A. (1996). Practice schedule effects on the performance and learning of low-and high-skilled students: An applied study. *Research Quarterly for*

Exercise and Sport, 67, 52-58.

- Lyster, R., & Sato, M. (2013). Skill acquisition theory and the role of practice in L2 development. In Mayo, M. G., Gutierrez-Mangado, J., & Martínez, M. A (Eds.), *Contemporary approaches to second language acquisition* (pp. 71-92). Amsterdam: John Benjamins Publishing Company.
- Maas, E., & Farinella, K. A. (2012). Random versus blocked practice in treatment for childhood apraxia of speech. *Journal of Speech, Language, and Hearing Research*, 55, 561-578.
- Mayfield, K. H., & Chase, P. N. (2002). The effect of cumulative practice on mathematics problem solving. *Journal of Applied Behavior Analysis*, 35, 105-123.
- Mitchell, R., & Myles, F. (2004). *Second language learning theories*. New York, NY; Routledge.
- Nakata, T. (2015). Effects of expanding and equal spacing on second language vocabulary learning. *Studies in Second Language Acquisition*, 37(4), 677-711.
doi: 10.1017/S0272263114000825
- Noh, S. M., Yan, V. X., Bjork, R. A., & Maddox, T. (2016). Optimal sequence during category learning: Testing a dual-learning system perspective. *Cognition*, 155, 23-29.
- Olina, Z., Raiser, R., Huang, X., Lim, J., & Park, S. (2006). Problem format and presentation sequence: Effects on learning and mental effort among US high school students. *Applied Cognitive Psychology*, 20, 299-309.
- Rau, M. A., Aleven, V., & Rummel, N. (2010). Blocked versus interleaved practice with multiple representations in an intelligent tutoring system for fractions, In V. Aleven, J. Kay & J. Mostow (Eds.), *Intelligent tutoring system* (pp. 413-422). Berlin/

Heidelberg: Springer.

- Rogers, J. (2015). Learning second language syntax under masses and distributed conditions. *TESOL Quarterly*, *49*, 857–866.
- Rohrer, D. F. (2012). Interleaving helps students distinguish among similar concepts. *Educational Psychology Review*, *24*, 355–367.
- Rohrer, D. F., & Taylor, K. (2007). The shuffling of mathematics problems improves learning. *Instructional Science*, *35*, 481–498.
- Rohrer, D. F., Derick, F. R., & Stershic, S. (2015). Interleaved practice improves mathematics learning. *Journal of Educational Psychology*, *107*(3), 900–908.
- Sana, F., Kim, J. A., & Yan, X. V. (2016). Study sequence matters for the inductive learning of cognitive concepts. *Journal of Educational Psychology*, *109*(1), 84–98.
- Suzuki, Y., & Dekyser, R. (2017). Effects of distributed practice on the proceduralization of Morphology. *Language Teaching Research*, *21*(2), 166–188.
- doi: 10.1177/1362168815617334

Appendix A

Sorting Questions

学籍番号 _____

氏名 _____

次の () 内の語 (句) を日本語に合うように正しく並び替えましょう。

□ □ □ □ の中から 必ず一つ選んで 文を完成させましょう。

(1) ハンバーグを食べているあの男は歌を歌うのが上手い。

a hamburger/ the man/ is /eating / sings well

who/which/where/whom (★ここからひとつ選ぶ)

(2) これが私の友人がよくコーヒーを飲むカフェだ。

the cafe/ is/ often drinks coffee /this/ my friend

who/which/where/whom (★ここからひとつ選ぶ)

(3) 授業中に寝ている生徒がいる。

in the class /is/sleeping/ a student/ is /there

who/which/where/whom (★ここからひとつ選ぶ)

(4) 太郎がバスケットボールをするジムは人気がある。

the gym / Taro / is / popular/ plays/ basketball

who/which/where/whom (★ここからひとつ選ぶ)

(5) こちらが私がパーティーで出会った女の子です。

the girl/ I/ met/ this/ is/ at the party

who/which/where/whom (★ここからひとつ選ぶ)

(6) 私はピアニストがピアノを演奏するレストランを知っている。

I know / a pianist/ plays the piano /a restaurant

who/which/where/whom (★ここからひとつ選ぶ)

(7) その女性が英語を勉強している図書館は古い。

is/ old /the woman/studying English / the library/ is

who/which/where/whom (★ここからひとつ選ぶ)

(8) 彼女が今日着ているドレスは可愛い。

she /is/ pretty/ is wearing today /the dress

who/which/where/whom (★ここからひとつ選ぶ)

(9) ステージでダンスをしたあの女の子は私の妹だ。

is /the girl /my sister /on the stage/ danced

who/which/where/whom (★ここからひとつ選ぶ)

(10) 私が買った家は岡の上に建っている。

I /stands on a hill /the house/ bought

who/which/where/whom (★ここからひとつ選ぶ)

(11) 私はフレンドリーな女性が好きです。

I/ is /friendly /like/ the woman

who/which/where/whom (★ここからひとつ選ぶ)

(12) あなたが毎日読む本が買いたい。

you/ want to buy / I / the book/read /every day

who/which/where/whom (★ここからひとつ選ぶ)

(13) 彼が愛している女性はフランス語を話す。

the woman/ loves / he/ speaks French

who/which/where/whom (★ここからひとつ選ぶ)

(14) 公園でいつも走っている犬はポチだ。

Pochi /always /in the park /the dog/ is/ runs

who/which/where/whom (★ここからひとつ選ぶ)

(15) 昨日の夜にタロウが描いた絵が好きだ。

last night /Taro/ like/the picture /I/ painted

who/which/where/whom (★ここからひとつ選ぶ)

(16) これが私の部屋に入ってくる鳥だ。

comes into / the bird/ this / my room/ is

who/which/where/whom (★ここからひとつ選ぶ)

(17) 人々の間で人気のその猫は魚をたくさん食べる。

a lot of fish/ the cat /popular among people/ is /eats

who/which/where/whom (★ここからひとつ選ぶ)

(18) これがトムがナンシーに出会った学校だ。

this /met/ the school / is /Tom /Nancy.

who/which/where/whom (★ここからひとつ選ぶ)

(19) こちらが僕が教えている学生です。

I /am /is /the student /this/ teaching/ now

who/which/where/whom (★ここからひとつ選ぶ)

(20) 私がこの本を買った本屋は閉店した。

I/ this book/the bookshop/ is/ closed/ bought
[who/which/where/whom (★ここからひとつ選ぶ)]

(21) 私は女の子を助けた犬を知っている。

I/ the girl /helped/ the dog/ know
[who/which/where/whom (★ここからひとつ選ぶ)]

(22) ここはイチローが野球をした公園だ。

Ichiro/ baseball/ the park/ is /played /this
[who/which/where/whom (★ここからひとつ選ぶ)]

(23) その男の人が夕食を作ったキッチンはいい臭いがする。

the man/ good / cooked dinner / the kitchen/ smells
[who/which/where/whom (★ここからひとつ選ぶ)]

(24) トムが好きな女の子はチアリーダーだ。

Tom/ likes /a cheer leader/ the girl/ is
[who/which/where/whom (★ここからひとつ選ぶ)]

Appendix B

Mean Accuracy Scores and Standard Deviations
of Practice Opportunities During the Training Session

Practice Opportunity

		1	2	3	4	5	6	7	8	9	10
Blocked Practice	<i>Mean</i>	38.18%	74.55%	90.30%	90.91%	94.55%	90.91%	92.12%	96.36%	96.36%	97.58%
	<i>SD</i>	26.63%	23.60%	15.10%	14.22%	11.48%	13.31%	13.17%	7.83%	7.83%	6.63%
Interleaved Practice	<i>Mean</i>	37.71%	40.00%	64.00%	72.57%	72.57%	74.86%	81.14%	82.86%	84.00%	86.29%
	<i>SD</i>	24.14%	34.30%	29.43%	25.71%	28.32%	32.66%	26.10%	21.77%	21.03%	22.63%

Appendix C

Items Used for Pretest

1. That is the boy who is kissing the lion.
2. That is the woman who is washing the monkey.
3. That is the boy who is massaging the father.
4. That is the baby who is hitting the mother.
5. That is the monkey which is kicking the cat.
6. That is the rabbit which is pushing the dog.
7. That is the dog which is watching the boy.
8. That is the rabbit which is carrying the baby.
9. That is the boy whom the dog is watching.
10. That is the baby whom the monkey is carrying.
11. That is the father whom the boy is massaging.
12. That is the father whom the girl is hitting.
13. That is the dog which the rabbit is pushing.
14. That is the cat which the monkey is kicking.
15. That is the lion which the boy is kissing.
16. That is the monkey which the woman is washing.
17. That is the room where the man is watching the movie.
18. That is the beach where the boy is hugging the girl.
19. That is the house where the mother is kissing the boy.
20. That is the park where the girl is massaging the father.

APPENDIX D

Items Used for Posttest

1. That is the man who is kissing the rabbit.
2. That is the girl who is washing the cat.
3. That is the girl who is massaging the grandmother.
4. That is the boy who is hitting the grandfather.
5. That is the mouse which is kicking the hamster.
6. That is the cat which is pushing the pig.
7. That is the monkey which is watching the baby.
8. That is the dog which is carrying the boy.
9. That is the baby whom the monkey is watching.
10. That is the boy whom the dog is carrying.
11. That is the grandmother whom the mother is massaging.
12. That is the grandfather whom the boy is hitting.
13. That is the pig which the cat is pushing.
14. That is the hamster which the mouse is kicking.
15. That is the rabbit which the man is kissing.
16. That is the cat which the girl is washing.
17. That is the house where the woman is watching the movie.
18. That is the station where the man is hugging the woman.
19. That is the park where the girl is kissing the boy.
20. That is the room where the woman is massaging the man.

APPENDIX E

Items Used in Delayed Posttest

1. That is baby who is kissing the dog.
2. That is the boy who is washing the hamster.
3. That is the girl who is massaging the mother.
4. That is the baby who is hitting the boy.
5. That is the rabbit which is kicking the monkey.
6. That is the monkey which is pushing the dog.
7. That is the bird which is watching the man.
8. That is the horse which is carrying the man.
9. That is the man whom the bird is watching.
10. That is the man whom the horse is carrying.
11. That is the mother whom the girl is massaging.
12. That is the boy whom the baby is hitting.
13. That is the dog which the monkey is pushing.
14. That is the monkey which the rabbit is kicking.
15. That is the dog which the baby is kissing.
16. That is the hamster which the boy is washing.
17. That is the theater where the girl is watching the movie.
18. That is the park where the boy is hugging the girl.
19. That is the house where the man is massaging the woman.
20. That is the where the boy is kissing the girl.

APPENDIX F

Items Used for Training Session

1. That is the woman who is kissing the hamster.
2. That is the girl who is pushing the cat.
3. That is the woman who is touching the rabbit.
4. That is the man who is washing the dog.
5. That is the girl who is watching the bird.
6. That is the man who is carrying the girl.
7. That is the girl who is massaging the grandmother.
8. That is the boy who is hitting the father.
9. That is the father who is hugging the mother.
10. That is the girl who is kicking the boy.
11. That is the monkey which is hitting the dog.
12. That is the horse which kicking is the lion.
13. That is the mouse which is pushing the hamster.
14. That is the monkey which is touching the rabbit.
15. That is the cat which is watching the bird.
16. That is the monkey which is carrying the girl.
17. That is the cat which is massaging the man.
18. That is the monkey which is hugging the girl.
19. That is the lion which is kissing the girl.
20. That is the monkey which is washing the boy.
21. That is the man whom the cat is massaging.
22. That is the girl whom the monkey is hugging.
23. That is the girl whom the lion is kissing.
24. That is the woman whom the monkey is touching.
25. That is the boy whom the monkey is washing.
26. That is the girl whom the cat is watching.
27. That is the girl whom the man is carrying.

28. That is the father whom the boy is hitting.
29. That is the boy whom the girl is kicking.
30. That is the man whom the woman is pushing.
31. That is the dog which the pig is hitting.
32. That is the lion which the horse is kicking.
33. That is the mouse which the hamster is pushing.
34. That is the rabbit which the monkey is touching.
35. That is the bird which the cat is watching.
36. That is the dog which the woman is carrying.
37. That is the monkey which the girl is massaging.
38. That is the monkey which the girl is hugging.
39. That is the hamster which the woman is kissing.
40. That is the dog which the man is washing.
41. That is the library where the man is carrying the books.
42. That is the room where the girl is massaging the mother.
43. That is the park where the boy is hitting the tree.
44. That is the station where the girl is hugging the grandmother.
45. That is the park where the man is kicking the tree.
46. That is the beach where the woman is kissing the man.
47. That is the department store where the woman is pushing the man.
48. That is the park where the girl is touching the cat.
49. That is the house where the mother is washing the dishes.
50. That is the park where the boy is watching the bird.