Repeated Acquisition with Developmentally Disabled Adults: Some Methodological Improvements

Thomas M. Rueber
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REPEATED ACQUISITION WITH DEVELOPMENTALLY DISABLED ADULTS: SOME METHODOLOGICAL IMPROVEMENTS

by

Thomas M. Rueber

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Arts
Department of Psychology

Western Michigan University
Kalamazoo, Michigan
August 1991
This study obtained repeated-acquisition data from four developmentally disabled adults. The procedure was a refinement of one used earlier by Madsen (1988) and a comparison was made between the two. Verbal praise, edibles, and money were used to reinforce correct responding. In addition, an informal comparison was made between individual repeated-acquisition performance and IQ scores. The refinements of the Madsen procedure included: (1) using a 10-second timeout as the consequence of an error, (2) placing poker chips in die-cut holes, (3) using different colored construction paper backgrounds, (4) limiting each session to one sequence, (5) using percent correct responses as the primary dependent variable, and (6) adjusting the number of sets to keep performance accuracy within a specified range.

In general, percent correct responses seemed a better dependent variable than errors-to-criterion. The task adjustment procedure successfully kept the subjects’ performances within the moderate (60% correct responses) to high (85% correct responses) accuracy range. The apparent relation between performance and test scores found by Madsen (perfect rank order relation for four subjects) was replicated by this study.
ACKNOWLEDGEMENTS

I wish to acknowledge and express my sincere appreciation to my advisor and committee chairperson, Dr. Jack Michael, for his assistance, patience, support, and forbearance throughout the course of my study. Appreciation is also due to David A. Ray for his assistance and feedback provided during this study. Finally, I would like to extend my thanks to all the subjects who participated either in the practice for, or the actual running of, this study.

Thomas Rueber
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Repeated acquisition with developmentally disabled adults: Some methodological improvements

Rueber, Thomas M., M.A.
Western Michigan University, 1991
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INTRODUCTION

Repeated Acquisition

Ever since researchers have investigated learning they have searched for accurate behavioral measurement procedures. The repeated-acquisition technique is an assessment method that was first described by Boren in 1963, and has since been used to study a variety of phenomena, especially the effects of pharmacological agents on the ability to learn new stimulus-response relationships. With this technique a single organism repeatedly learns various versions of the same kind of task, and thus can be exposed to different values of an independent variable. That is, the subject serves as his/her own control, which eliminates the necessity of working with large groups of subjects to offset the effects of possibly large individual differences between subjects.

There are many variations of this procedure, but all have the following features:

1. A subject is exposed to several (usually two, three or four) sets of response operandia, and learns to make a correct response choice for each set.
2. Some stimulus condition, such as lights over the operandia, indicates which set is to be responded to at any particular time.
3. When a correct response is made in the first set, the stimulus condition then changes indicating the next set, and so on, until the last set when some form of reinforcement occurs, and the sequence starts over again.

For example, four sets of three levers might be placed in a row, and spaced so that the three levers in each set are close to each other but clearly separated from adjacent sets. Prior to the beginning of the session it has been determined that the correct sequence of responses is to press the left lever in the first set, next to press the
right lever in the second set, then the middle lever in the third set, and finally the right lever in the fourth set. When the session starts, the lights over the first set of three levers are illuminated. When the organism presses the correct lever in that set (e.g., the left lever) the lights over that set go out and the lights over the next set to the right go on. When the correct lever in that set (e.g., the right lever) is pressed that set's lights go out and the lights over the next set go on; and so on until the correct lever of the fourth set is pressed which results in delivery of some form of reinforcement (food, money, etc. depending on the organism), the lights over the last set go off, the lights over the first set go on again, and another sequence of responses can be made.¹

This continues either until some specified number of completed sequences is reached, or until the subject reaches some criterion of performance adequacy. For subsequent sessions the procedure is exactly the same except that a different pattern of correct response levers is in effect for each session. That is, the organism has to learn a new pattern of correct responses during each session. The most common dependent variables have been total number of errors during the fixed number of sequence completions (e.g., Boren & Devine, 1968; Boren, 1969; Thompson, 1975), or percent errors during the fixed number of sequence completions (e.g., Hursh, 1977; Moerschbaecher, Boren, & Schrot, 1978). Typically, the organism improves during the first several sessions, and then the total errors or the trials-to-criterion becomes fairly stable, and can be used as a baseline to study other independent variables. For example, it might be found that when a particular dosage of a particular drug is administered prior to the session the number of errors per session increases to a point

¹In some versions an erroneous response has no consequence except that it took time and effort that was wasted. More commonly, errors are punished in some way, such as with a brief stimulus change during which no responding is effective (called a time out).
and then remains at that level, until the condition is reversed and the drug is no longer administered, at which time the errors per session returns to its former lower level.

**Nonhuman Research**

The repeated-acquisition technique has been used with nonhumans to study procedural variables such as the duration of the timeout for errors (Boren & Devine, 1968), the effects of stimulus cueing of the different sets of operanda (Thompson, 1970), and others (Boren, 1963, 1969; Hursh 1977; Moerschbaecher et al., 1978; Thompson, 1971). The procedure has also become a standard assay in drug research, because the ability to learn new stimulus-response relations is often more sensitive to disruption than is the continued use of already-learned relations; and such disruption is important to behavioral pharmacologists concerned with harmful side effects of drugs developed to alleviate various behavioral and physical abnormalities.

Thompson (1973) used the repeated-acquisition technique to study the effects of drugs on learning. In 1974 and 1975, Thompson continued this line of research and by now a number of studies of this sort are available (e.g., Delaney & Poling, 1987; Moerschbaecher, Boren, Schrot, & Simoes-Fontes, 1979; Moerschbaecher & Thompson, 1980; Picker & Poling, 1984; Poling, Blakely, White, & Picker, 1986; Poling, Cleary, Berens, & Thompson, 1990; Thompson, 1980; Thompson & Moerschbaecher, 1979, 1981; Thompson, Moerschbaecher, & Winsauer, 1983;)

**Research With Humans**

**Rule-Governed Behavior**

Boren and Devine (1968), in one of the earliest uses of repeated acquisition, indicated which lever was correct (monkeys were the subjects) with a special stimulus

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during one session, and then required the subjects to perform on the same sequence in a second session, but without the special indicating stimulus. More specifically, they turned on a light over the correct lever in each set during the first session of the pair of sessions, and then required the subjects to perform on the same sequence in the next session, but with lights over all three levers when that set of levers was appropriate. The subjects quickly learned to press the lever under the light during the first session, making almost no errors in progressing through the sequence. However, this experience did not facilitate their performance on the same sequence when they did not have the special indicating stimulus. Vaughan (1985) used the Boren and Devine procedure with children, finding similarly that experience with the sequence when the correct response was indicated didn’t help in performing the sequence when no indicating stimulus was available. She then tried to teach the children to talk about the sequence during the time the correct lever was being identified to see if this verbal behavior, sort of a rule, would facilitate the performance when the indicating stimulus was absent. As with the monkeys, it didn’t help very much.

Ozuzu (1982) and Danforth (1983) continued this line of research with children, trying in various ways to bring the behavior under the control of a self-generated rule, but without much success. Danforth, Chase, Dolan, and Joyce (1990), working with college students as subjects, further studied various kinds of rules as ways of facilitating transfer from the situation where the correct response was identified to the situation involving the same sequence but without the identifying stimulus. When they included a form of rule that described the relation between the two sessions—namely that the second session used the same sequence that had been used in the first session with the indicating stimulus—the subjects did benefit from the first session. They also
studied various other aspects of the relations between performance, contingencies, and rules using the repeated-acquisition procedure.

**Children With Attention Deficit Disorder**

Starting in the late fifties or early sixties, the condition currently known as attention deficit disorder, earlier called hyperactivity, began to be diagnosed in school age children, and began to be treated with various drugs. By far the most popular medication is the drug methylphenidate with the trade name of Ritalin. Because repeated acquisition had been a sensitive baseline for studying drug effects in non-humans, and could be easily adapted to work with humans, Walker (1982) used it with children who were diagnosed as having attention deficit disorder. She found that methylphenidate, as contrasted with a placebo, decreased errors and increased correct response rate when learning new sequences. Yoder (1985) in a similar study was unable to detect any systematic effects of the kind found by Walker. More recently Giuliano (1991), using a computerized version (Giuliano, 1990) of the same repeated-acquisition procedure used in the research with children on rule-governed behavior, was also unable to obtain any systematic effects of methylphenidate.

**Intellectually Disabled Adults**

Stone (1986) tried to use repeated acquisition to measure the learning ability of persons with Alzheimer's disease. She hypothesized that if stable performances were achieved fairly quickly, it might be possible to use repeated acquisition to monitor the intellectual deterioration seen in Alzheimer's disease over time, and in this way to assess the possible effectiveness of various pharmacological agents thought to slow the progress of the disease.
Stable performances did not develop with Stone's subjects, and without a reasonably stable baseline it would not be possible to assess the effects of anything other than very powerful independent variables. Stone's failure to obtain stable repeated-acquisition performances with the Alzheimer patients led to Madsen's 1988 attempt to use the same repeated-acquisition procedure with developmentally disabled adults who were less seriously disabled than the Alzheimer patients. Her primary goal was to obtain typical performances for these subjects (four mildly to moderately retarded adults, two with Down syndrome) with special concern for stability, and as a secondary goal, to correlate the subjects' performances on the learning tasks with other available measures of their intellectual effectiveness. Madsen was also interested in a possible relation between Down syndrome and Alzheimer's disease because both populations develop neuropathological protein deposits as they age. As individuals with Down syndrome live past age 35 many begin to show intellectual deterioration similar to that seen in Alzheimer's disease. Madsen theorized that a more intense investigation of their intellectual changes, as demonstrated through performances on the repeated-acquisition procedure, might throw further light on Alzheimer's disease.

The Madsen Procedure

Because it is so closely related to the present research, Madsen's procedure will be described in some detail. The general procedure was derived from Boren's (1963) repeated-acquisition study. The actual testing apparatus was similar to that developed by Ozuzu (1982) using red, white, and blue poker chips. In Madsen's study the investigator began each approximately 15-minute session by placing sets of same-colored chips face down on a table in front of the subject. The chips in each set were close to each other, but clearly separated from the other sets, and manually laid out in a
straight line. The number of chips in each set was always three and the number of sets was determined by each subject's performance. An arrangement with three sets of chips is shown below.

![Poker Chip Arrangement in Madsen's Study.](image)

Prior to the session the investigator randomly determined the placement of one chip in each set that had a pressure sensitive sticker on its underside. This marked chip, with the mark unseen by the subject, would be placed in the same position (i.e., left, right, or center) for the duration of a session. To start each session the subject was asked by the investigator to find the marked chip in the first set of chips. The subject turned the chips over in the first set until the correct (marked) chip was found. After each correct response the subject proceeded to the next set of chips to the right until the marked chip in the last set on the right was found. When an incorrect response was made (turning over an unmarked chip), the trial would begin again. That is, if an error occurred in the second set, the subject was required to start again at the first set of chips. When unmarked chips were turned over, when a sequence was completed correctly, or at any time when the chips became misaligned, the investigator manually realigned them.

A correct sequence consisted in the subject turning over the marked chips in the appropriate order with no errors. For example, if the correct order were center (for the white set), right (for the red set), and left (for the blue set), and the subject turned over the chips in that sequence with no errors, it would be scored a correct sequence. When
four consecutive correct sequences were obtained, the response chain was considered learned. The next day/session the subject would be presented with the same experimental situation except the placement of the marked chips in each set would be changed. As the study progressed, the subject would begin to exhibit a pattern of initially making a number of errors and in most cases eventually learning the sequence. It was the number of errors that each subject would make until the sequence was learned and the stability of that responding that was of interest to Madsen.

**Performance Stability**

Although Madsen's procedure resulted in performances that were somewhat stable, as can be seen from the figure for one of her four subjects (Figure 2),

![Figure 2. Errors Per Sequence for Madsen's Subject 1.](image)


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there were some procedural factors that could have reduced the degree of stability. (The experimental manipulations related to the four different phases marked on the above figure are not relevant to the present issue.)

One possible source of variability in performance was the fact that when subjects made an error they were required to start the entire sequence over. In earlier research, as mentioned above, a brief timeout was usually made contingent upon erroneous response choices. It was found (Boren, 1969) that this timeout procedure eliminated accidental chaining and reduced the number of trials required for the development of an accurate pattern of responding. The timeout procedure had also been used in the research with children, but Madsen was concerned (1988, p.17) that a timeout consisting of covering the chips so that the subject had to wait for a few seconds before resuming responding, as with the child research, would be seen by the subjects or by others as inappropriately childish for use with adults and would be incompatible with the efforts at normalization with these clients. It was essential, however, that something happen when errors occurred, or the subject could quickly turn over each chip until the correct one was found, and there would be no need to learn the sequence. To Madsen, it seemed that starting the sequence over when a mistake was made was more like the ordinary interaction with tasks, and would constitute enough of a disadvantage for errors to generate accurate responding.

With Madsen's procedure, however, when only two or three sets of chips were being used, subjects could correct an error almost immediately, and obtain reinforcement almost as quickly as with an initially correct response, which might have worked against the development of accurate responding. Also, with a low functioning subject who was having considerable difficulty learning the sequence, it is possible that starting over when an error occurred in the second or third set of chips delayed the development
of an accurate response in that set. In any case, it was decided to use a brief timeout in the present research.

Another possible source of instability relates to Madsen’s manual realignment of the chips after the correct chip in a set of three had been identified. As the subject worked through the sets of chips, the last chip handled in each set was typically the correct one. It is possible that the subject could sometimes identify the correct chip by it's not being perfectly aligned with the other chips in the set, which would retard the development of control by the color or location of the set of chips. For the present study a set of die-cut holes in construction paper would be used as a method for realigning the chips after one had been selected by the subject.

In the Madsen study and also in the child research, the different sets of chips were of different colors. This feature plus the spatial location of the sets were the stimulus characteristics that ultimately had to control differential responding to the different sets. Although these stimulus features are probably adequate, it was decided for the present research to use red chips and to place them on different colored construction paper backgrounds for each of the different sets of chips. Red chips were used because there was a small but nonzero possibility that the sticker on the back of a white chip could be detected in some lighting conditions. Also, using different colored squares of construction paper as the distinctive cue in addition to spatial location made it easily possible to increase the number of sets of chips beyond three (ordinary poker chips come in only three colors), and in addition seemed to the investigator more distinctive than the different colored chips. The construction paper was also easy to cut the holes in for the purpose of chip alignment.

Another aspect of the Madsen study that may have worked against highly stable responding was that, on a number of occasions, she trained more than one sequence in
a single session. That is, when criterion was reached with one sequence, and there was still time to work with that subject, a new and different sequence would be given to the subject. This means that on some occasions a new sequence was being started almost immediately after a different sequence had been learned, which might well interfere with learning the new sequence. On other occasions, a new sequence was being attempted after one or more days since the last sequence, where less interference by the previously learned sequence would be expected. For the present research the subjects learned only one sequence per session, and had only one session per day.

Finally, the dependent variable used by Madsen was errors-to-criterion, where the criterion was four correct sequences in a row. There were several instances in Madsen’s data where the subject accumulated a large number of errors because of taking a large number of trials to reach criterion, but was actually performing at a relatively high level of accuracy if judged on some basis such as percent errors or percent correct responses. Pilot data obtained in practice sessions with other developmentally disabled adults during the development of the present research methodology showed some similar instances where an overall accuracy score might be fairly good, but many errors were accumulated before criterion was met. For that reason it was decided to consider percent correct responses as the primary dependent variable of the present study. Errors-to-criterion was available from the same data, which permitted a comparison of these two different measures.

The Purpose of the Present Research

The purpose of the present study is to investigate the repeated-acquisition performance of subjects like those studied by Madsen, but to try to refine the procedure
in an attempt to reduce the variability of each subject's performance. These refinements will include:

1. Using a 10-second timeout as the consequence of an error rather than starting the sequence over. (The actual timeout duration will be reduced if the 10-second value proves to cause the subjects to lose interest in the task or become distracted in some way.)

2. Placing the chips in die-cut holes in construction paper so as to eliminate the possibility of a misalignment functioning as a cue.

3. Using same-colored chips, but placing them on different colored construction paper backgrounds for each set of chips as an attempt to make the sets more distinctive from one another.

4. Using only one sequence per day to standardize the possible interference of previously learned sequences on the learning of a new sequence.

5. Relying on percent correct responses as the primary dependent variable.

6. In addition to these changes from the Madsen study, it was also decided to develop a formal procedure for adjusting the number of sets of chips so as to keep performance accuracy for all subjects in a moderate to high range (as described in more detail in the next section).

Secondary goals were to see to what extent performance on the repeated-acquisition task was correlated with other formal measures of intellectual functioning already available for subjects used in this study, such as test scores.
METHOD

Subjects

Subject characteristics are shown in Table 1 below. They were chosen from clients at the Adult Activity Center, Sturgis, Michigan; or Youth Opportunities Unlimited, Kalamazoo, Michigan. Subjects 1 and 2 were not on any medication during the course of the study. Subject 3 was on Norpramin (an anti-depressive agent) 25 mg twice a day during the entire course of the study. Subject 4 was on Mellaril 100 mg twice a day (used for behavior management), Xantac 150 mg twice a day (used for the management of stomach disorders), Dilantin 300 mg twice a day (used for seizure control), and Artane 2.5 mg twice a day (used to counter side effects of the medication regimen) during the entire course of the study.

Table 1
Subject Characteristics

<table>
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<th>Gender</th>
<th>Age</th>
<th>IQ</th>
<th>Diagnosis</th>
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<tr>
<td>Subject 1</td>
<td>male</td>
<td>28</td>
<td>50 (WAIS R²)</td>
</tr>
<tr>
<td>Subject 2</td>
<td>female</td>
<td>29</td>
<td>59 (WAIS R)</td>
</tr>
<tr>
<td>Subject 3</td>
<td>male</td>
<td>42</td>
<td>41 (WAIS³)</td>
</tr>
<tr>
<td>Subject 4</td>
<td>female</td>
<td>32</td>
<td>48 (WAIS R)</td>
</tr>
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²Wechsler Adult Intelligence Scale–Revised, Wechsler, 1981
³Wechsler Adult Intelligence Scale, Wechsler, 1955.
Risks were minimal, if not nonexistent, to the subjects who participated in the study. Overall, the individual subjects seemed to enjoy the opportunity to work in close proximity to the investigators, often asking when the next session was going to be. Informed consent (see Appendix B for the consent forms) was obtained for each subject. The study was approved by the Western Michigan University Human Subjects Institutional Review Board (Appendix A).

Apparatus

Testing apparatus was similar to that first used by Ozuzu (1982) and later by Madsen (1988) but included some modifications. The apparatus consisted of 21 by 28 cm pieces of different color construction paper. Each had three die-cut holes just big enough to hold ordinary poker chips measuring 3.8 cm in diameter. The holes were centered and laid out horizontally in a straight line. A sticker measuring 1 cm in diameter was affixed to one chip in each set of chips, identifying the correct chip choice. The sets of chips were placed face down in the die-cut holes, each chip flush with the table. Sets were approximately 12 cm apart with a within-set chip distance of approximately 1 cm. Chips were put in place manually by the investigator. An approximately 30 by 75 cm blank strip of chipboard was used to cover the entire sequence of chips when an error was made. A prepared recording sheet was used by the investigator to record correct and incorrect responses. A digital stopwatch was used to measure the duration of each session and each individual 10-second timeout period. Verbal praise, nickels, dimes, and edible treats were used as reinforcement.
Procedure

Sessions were conducted up to a maximum of 15 minutes each at Youth Opportunities Unlimited in Kalamazoo or at the Adult Activity Center in Sturgis. While the sessions were in progress, each subject sat at table opposite the experimenter. The basic procedure was quite similar to that of Madsen (1988), which was in turn derived from the Ozuzu (1982) study with children, and ultimately from Boren’s (1963) procedure. There was only one session per day and each session was limited to one sequence. Sessions were not always on consecutive days.

Before each session began, the investigator randomly determined the sequential placement for each marked chip within each set. The random assignment was with the additional restrictions that the correct chip was never placed in the same position more than two times in the same sequence, and was never in the same position consecutively within each sequence. The number of chips in each set was always three (except for a brief decrease to two chips for Subject 2) but the number of sets varied according to each subject’s prior performances.

The subject was then brought into the testing room and seated across from the investigator. The chips in their current sequential order had been placed in the die-cut holes in the construction paper. A 15-minute timer was then activated and the investigator asked the subject to locate the marked chip in the first set of chips to his/her left. A correct response was defined as the subject’s correctly turning over the marked chip in each set. A correct sequence was defined as the subject’s correctly turning over the marked chips in the pre-determined order with no errors. The subject could not see the marks until the chips were turned over. If the correct order was the left chip (for the first set), the right chip (for the second set), and the center chip (for the third set) the
subject must turn the chips over in that order to constitute a trial at 100% accuracy. When the subject responded at 100% accuracy for three consecutive sequences the response chain was considered learned. Any time the subject turned over an unmarked chip it was scored as an incorrect response.

An incorrect response resulted in the investigator covering all the chips for a 10-second timeout period. At the end of the 10 seconds the subject was asked to choose again. If the subject picked incorrectly again, the 10-second timeout period was instituted again. If the subject picked correctly, the investigator provided social praise and told the subject to go to the next set. This continued until the subject proceeded through the entire sequence.

The length of each subject’s sequence was determined by his/her prior performances. If a subject were correctly turning over marked chips at greater than or equal to 85% accuracy (calculated for the entire session), and had done so for two different sessions with no more than three sessions of less than 85% accuracy between them, another set was added to his/her sequence. On the other hand, if a subject were turning over marked chips at less than or equal to 60% accuracy on two out of his/her last five sessions, a set was dropped from the sequence. The above formula was developed after numerous practice sessions with other developmentally disabled adults before the formal study began. It represents an attempt to adjust the number of sets in each subject’s task so that all subjects would be performing within a range of accuracy that would be considered moderate to high for that subject, and also to get the subject working at that level as soon as possible, but without changing the sequential length as the result of a single bad or good session. Percentages were determined by dividing the

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4Madsen (1988) had required four consecutive correct sequences, but her data showed that after subjects had completed three correct sequences they seldom made an error on the fourth sequence.
If the subject went through the sequence but made errors doing it, he/she earned a nickel or an edible paired with verbal praise at its completion. If the subject proceeded through the entire sequence with no errors, he/she received a dime or an edible paired with the social reinforcement. Three consecutive sequence completions with no errors prior to the 15-minute time period terminated the session. The next session with the same subject would start with a new sequence following the above procedure. This continued until one of three things happened: (1) The subject met the two-out-of-five 85% accuracy requirement, at which point another set was added to subsequent sequences; (2) the subject responded at less than or equal to 60% accuracy 2 out of the last 5 sessions, at which point a set was dropped from the subsequent sequences; or (3) the subject continued to respond between 60% and 85% correct for a 15-minute session. When this occurred, a new sequence with the same number of sets was introduced on the next session and tested.

Interobserver Agreement

Inter-observer reliability checks were conducted a total of six separate occasions. The investigator sat with the subject at the table, directly across from him/her. The reliability observer sat away from the table on the subject’s right and could not see the investigator’s data record from that position. Reliability was

5Subject #3’s initial four sessions were terminated incorrectly after only two consecutive correct sequences. As can be seen from Figures 5 and 9 the error seemed to have little effect on subject’s subsequent performance.
6For Subject 2 as an exploratory manipulation the duration of the error timeout was reduced from 10 seconds to 2 seconds during the subject’s last three sessions.
calculated as the number of agreements (as to whether the response was correct or incorrect) divided by the number of responses scored.
RESULTS

Interobserver Agreement

Reliability checks were conducted on a total of six separate occasions. Interobserver reliability was at 100% for all six sessions in which such checks were performed. It was originally planned to record interobserver agreement for several occasions with each subject used in the study, but due to unavoidable difficulties in carrying out the research in one of the applied settings, reliability observations were made on only two of the subjects.

Individual Subject Performances

The main purpose of this research was to study a similar population to that studied by Madsen, but to alter the procedure in an attempt to achieve more stable individual subject performances. In general, the methodological refinements were successful, in that all subjects learned the sequences and were kept within the moderate (60%) to high (85%) accuracy range in terms of percent correct responses. The 10-second timeout seemed to cause no difficulty in any way with the four subjects used in this study. It may be that the instruction to the effect that the subject should use that period to try to remember which was the correct chip made the procedure seem quite reasonable.

Percent Correct Responses

Percent correct responding per session for each subject is shown in Figures 3 through 6 on the following pages. Subjects 2, 3, and 4 learned the sequences throughout the
Figure 3. Percent Correct Responses for Subject 1.

Note: Data point is an asterisk when the subject did not meet criterion in the session.

Figure 4. Percent Correct Responses for Subject 2.
Figure 5. Percent Correct Responses for Subject 3.

Figure 6. Percent Correct Responses for Subject 4.

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course of the study with a relatively high degree of stability, and met criterion in every session. The data for Subject 1 were the most variable. This subject did not meet criterion in five separate sessions, and six times met the criterion for either increasing or decreasing the length of the sequence to be learned.

**Errors-to-criterion**

The errors-to-criterion for each session for each subject are shown in Figures 7 through 10. As with percent correct responses, the performance of Subject 1 shows the greatest variability. A comparison of the two dependent variables will be made in the next section.

**Performance Adequacy of the Four Different Subjects**

Subject 2 was clearly the best performer in that she consistently learned sequences involving four sets per sequence. Subject 3 was clearly the worst in that he never reached the criterion to advance beyond two sets per sequence. Subjects 1 and 4 fall in between 2 and 3, but it is not possible easily to distinguish between them. Subject 1 never reached the criterion for advancing to four-set sequences, but did advance to three sets twice as the result of 100% accuracy with two sets. Only seven sessions of data are available for Subject 4, and in terms of stability and a moderately adequate three-set performance for two sessions this subject could possibly be ranked second in learning effectiveness. Interestingly, these rankings correlate quite well with the WAIS IQ scores available for these subjects, as can be seen in Table 2 shown on page 24 below, although, of course, with only four subjects such a correlation could occur quite easily by chance.
Figure 7. Errors-to-Criterion for Subject 1.

Note: Data point is an asterisk when the subject did not reach criterion in the session, and in those cases represents errors per 15 minute session.

Figure 8. Errors-to-Criterion for Subject 2.
Figure 9. Errors-to-Criterion for Subject 3.

Figure 10. Errors-to-Criterion for Subject 4.
### Table 2
Subject Characteristics and Rank on Repeated-Acquisition Task

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>IQ</th>
<th>Diagnosis</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>S 1</td>
<td>male</td>
<td>28</td>
<td>50 (WAIS R) moderately retarded</td>
<td>3</td>
</tr>
<tr>
<td>S 2</td>
<td>female</td>
<td>29</td>
<td>59 (WAIS R) moderately retarded</td>
<td>1 (best)</td>
</tr>
<tr>
<td>S 3</td>
<td>male</td>
<td>42</td>
<td>41 (WAIS) low moderately retarded</td>
<td>4 (worst)</td>
</tr>
<tr>
<td>S 4</td>
<td>female</td>
<td>32</td>
<td>48 (WAIS R) moderately retarded</td>
<td>2</td>
</tr>
</tbody>
</table>
DISCUSSION

This study looked at a refinement of a previous repeated-acquisition study using developmentally disabled adults. It examined the procedural variables of (a) using a 10-second timeout for errors, (b) using die-cut holes in construction paper to eliminate the possibility of chip misalignment functioning as a cue, (c) using colored backgrounds to heighten stimulus control, (d) limiting sessions to one sequence, (e) relying on percent correct responses as the primary dependent variable, and (f) using a formal procedure for adjusting the number of sets of chips to keep performance accuracy for all subjects in a moderate to high range and also to move them into that range as soon as possible. It is not possible formally to determine the effectiveness of the first four procedural features above, but the 10-second timeout certainly did eliminate the possibility of an immediate corrective response followed by reinforcement, and as mentioned earlier seemed to be well accepted by the subjects. Chip misalignment could certainly not function as a cue to the correct response with the present arrangement. The value of the different color backgrounds and the single session per day cannot be determined, but these variations from earlier work caused no obvious difficulties.

The use of percent correct responding as a dependent variable had several advantages over errors-to-criterion. One is that when criterion is not reached by the time the session terminates, errors-to-criterion is unavailable and it is not clear that errors-per-session is a reasonable substitute. Percent correct responding, however, is quite interpretable under these conditions.

Another advantage arises from the fact that errors-to-criterion depends upon the number of trials required to reach the criterion. As mentioned earlier, it is sometimes possible for a subject to accumulate quite a few errors even though he/she is responding
at a relatively high level of accuracy as measured by percent correct responding. This aspect of errors-to-criterion makes it hard to use in any simple way as a basis for adjusting task difficulty, whereas percent correct responding easily lends itself to such an adjustment procedure. In the present study such a procedure was used quite successfully to keep the subjects in the moderate to high range of repeated-acquisition performance.

The relevance of the dependent variable to stability of responding is related to this same issue. Because in the present study both variables were available, it was possible to compare them in terms of stability. For Subjects 1 and 2 the two measures seem about equal, but for Subject 3 and 4 the advantage of percent correct responding is quite clear. For Subject 3, for example, the situation described above occurred in that he accumulated a large number of errors in reaching the criterion in his 15th session (see Figures 5 and 9 on pp. 21 and 24), but was responding quite accurately nevertheless. Subject 4 showed a similar performance in her 6th and 7th session (see Figures 6 and 10 also on pp. 21 and 24).

In general, the procedure used in this study was quite satisfactory as a way to obtain performance baselines with which independent variables such as pharmacological agents, special training in general intellectual skills, and others could be assessed. The last three sessions with Subject 2 were used in this way with respect to the procedural variable of timeout duration, and appeared to show that the shorter timeout for errors would have resulted in superior performance by this subject.

A secondary goal of the study was to look at the relation of repeated-acquisition performance to other measures of subject intellectual effectiveness with this population, as Madsen (1988) did in her study. As shown in Table 2 in the previous section (see p. 24) the individual rankings correlate quite well with the WAIS IQ (Wechsler, 1955,
1981) scores. Such a relation when based on only four subjects must be interpreted quite cautiously. However, when considered in conjunction with Madsen’s very similar finding (a perfect relation between repeated-acquisition adequacy and rank on other intellectual test scores) with her four subjects, the relation between these two quite different kinds of measures of intellectual function can be taken somewhat seriously.

As this study was a refinement of the initial study using repeated acquisition with developmentally disabled subjects, there are several more refinements that could be addressed. The dependent variable used, i.e., percent correct responses, is a measure of learning when performance stops at some learning criterion. Otherwise, it is at least partly a measure of performance, which is generally less sensitive to disruption than learning. In the present, study percent correct responses was calculated over the sequences completed up to and including the learning criterion, three consecutive perfect sequences. A better measure of learning would probably be percent correct responses up to but not including the learning criterion. This would be a smaller value than the present measure, and thus the adjustment criteria would have to be changed.

The linear arrangement of the chips was simply adopted from the various earlier studies. When four or more sets of chips are being used, this arrangement requires a relatively long table surface. Arranging the chip sets vertically would be a more efficient use of space, and might not make the task significantly easier or harder. Also, the function of the ten-second timeout may be served by a considerably shorter one (as suggested by the very brief experimental manipulation with Subject 2) which would facilitate data acquisition.

The ultimate in procedural improvement, however, would be achieved by computerizing the repeated-acquisition procedure as in Giuliano’s (1990, 1991) work.
(which became available only after the present experiment had concluded). Of course, the manual procedure has its own advantage in terms of cost and simplicity, but the use of a computer permits many procedural variations, and in addition makes data acquisition and analysis automatic.

There are a number of directions for further research with repeated acquisition and developmentally disabled subjects suggested by the present study. For example, it was observed that Subject 2, who was most effective at the repeated-acquisition task, was the only subject who would rehearse the chip placement during the 10-second timeout. It would be useful to follow up the work on rule-governed behavior (Danforth, 1983; Ozuzu, 1982; Vaughan, 1985) by attempting to teach developmentally disabled subjects to engage in some form of verbal behavior regarding the position of the correct chip, as a way of performing at a higher repeated-acquisition level.

It would also be of possible significance in the training and placement of the developmentally disabled to determine the relation between repeated-acquisition adequacy and other kinds of performance in day-training centers and sheltered workshops. The effectiveness of the available measures of various abilities with this population is not so great that an additional assessment device would be superfluous. It is quite possible that repeated acquisition, although roughly related to other measures, such as the WAIS IQ test, nevertheless assesses some behavioral functions that are not well covered with other assessment tools, and which might be of considerable significance for further training and placement.

And, of course, this procedure continues to be appropriate for studying the effects of pharmacological agents where the prolonged study of the single subject is essential. Subjects could be tested before and after known drug introductions or withdrawals and within-subject comparisons easily made.
Appendix A

Research Protocol Approval
TO: Thomas A. Rueber
FROM: Ellen Page-Robin, Chair
RE: Research Protocol
DATE: March 17, 1989

This letter will serve as confirmation that your research protocol, "Repeated Acquisition Technique With the Developmentally Disabled: Methodological Improvements" is now complete and has been signed off by the HSIRB.

If you have any further questions, please contact me at 387-2647.
Appendix B

Client Consent Form
Revised Acquisition With Developmentally Disabled Adults:
Some Methodological Improvements

Thomas M. Rueber -- Principal Investigator
David A Ray -- Adult Activity Center Supervisor,
St. Joseph County Community Mental Health
Jack Michael, Ph.D. -- Academic Advisor

Informed Consent Form

Hi! Let me introduce myself. My name is Tom Rueber. I am a graduate student in the Psychology Department at Western Michigan University. I am doing a research project which I hope will improve upon a test which will tell me how you learn new things. This project has been approved by the Director of the Adult Activity Center in Three Rivers, Michigan/Youth Opportunities Unlimited in Kalamazoo, Michigan [Please note that the Adult Activity Center was moved to Sturgis, Michigan during the course of this study].

You and I will work together during your leisure time at the Adult Activity Center/Youth Opportunities Unlimited. Each time we work together, we will do so for about fifteen minutes. I will place a set of poker chips in front of you, face down. Some of the chips will have stickers on them. I will ask you to find all the poker chips with stickers on them without making any mistakes. Every time you find a chip with a sticker on it, I will tell you what a good job you're doing. Every time you find all the chips with stickers on them, and don't make any mistakes, I will give you a little reward depending on what you like. It could be a nickel, dime, or quarter, or maybe something good to eat or drink. Whenever you find all the stickers three times in a row with no mistakes, or the fifteen minutes are up, the session is over, whichever comes first. If you make a mistake and turn over a poker chip without a sticker on it, I will cover up the set of poker chips you are working on for ten seconds. I will not look at you, touch you, or talk to you during the ten seconds. You can use the time to try to remember where the chip with the sticker is. After the ten seconds is up, you can pick again.

I think you will look forward to our working together. It's very much like a game. Plus you will be able to earn extra money or good things to eat or drink. I will be able to make a new friend and get some information about how you learn new things which may help others who teach you to learn new things.

We will start working on about March 20, 1989 and will stop on about August 4, 1989. You may, at any time, take back your consent and drop out of the study. Your decision of whether or not to continue will in no way influence services you are currently receiving.

All information will be private. All information will be stored in a locked file cabinet at the Adult Activity Center/Youth Opportunities Unlimited or in my home. There will be other subjects in the study and everyone's test scores will be reported as part of a masters thesis to Western Michigan University. Your name or any other identifiable information will not be reported. A brief summary report of the study and your score will be placed in your file at the Adult Activity Center/Youth Opportunities Unlimited if it is requested.

I will also need to look at some information in record at the Adult Activity Center/Youth Opportunities Unlimited. I would also be interested in any test scores you may have.

Do you have any questions? Does this sound like it might be fun to try? Would you like to work with me? If you would like to try, I'll need you to sign this consent form which says....
Client Consent  (when client is own guardian)

I _______________________________ consent to participate in this study. I also consent to having my personal file searched for relevant information. The study has been explained to me. I have been given the chance to ask questions and have understood the answers.

______________________________  ______________________________
Date                                      Client signature

Witness

I _______________________________ have witnessed that the party consenting has done so willingly, with full knowledge, and is able to grant such consent.

______________________________  ______________________________
Date                                      Witness signature

Client Assent  (when client has a guardian)

I _______________________________ consent to participate in this study. I also consent to having my personal file searched for relevant information. The study has been explained to me. I have been given the chance to ask questions and have understood the answers.

______________________________  ______________________________
Date                                      Client signature

Guardian Consent

I _______________________________ agree that my ward may be a subject in this study.

______________________________  ______________________________
Date                                      Guardian signature
BIBLIOGRAPHY


