THE UNIVERSITY OF MANITOBA

A COMPARISON OF BACKWARD AND FORWARD CHAINING TO TEACH PACKAGING AND ASSEMBLY TASKS TO SEVERELY AND MODERATELY RETARDED CLIENTS IN A SHELTERED WORKSHOP

by

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Submitted to the Faculty of Graduate Studies

In Partial Fulfillment of the Requirements for the Degree

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ABSTRACT

The present study compared backward and forward chaining procedures to teach different workshop tasks to retarded individuals. Nine retarded clients, five from a group home and four from a ward in an institution, were studied. A multi-element design with counterbalancing across clients and tasks was used. After a baseline was collected, the clients were taught two tasks concurrently, using the backward chaining procedure for one task and the forward chaining procedure for the other task. Two additional tasks were taught subsequently.

The relative effectiveness of the two procedures was judged on the basis of number of sessions and trials to reach criterion, the number of errors made during training, and the number of trials over and above the minimum required to learn each task. Results indicated that there was no difference between the two procedures for very simple tasks, in the dependent measures used in this study. A task effect was observed throughout the experiment and the comparisons. For the two more-complex tasks, the bicycle brake and fishing reel assemblies, the backward chaining procedure appeared to be slightly superior. For this procedure, fewer trials over the minimum number required to learn the tasks were necessary and fewer retraining trials were observed for several of the subjects. The results also showed a task effect with the bicycle brake assembly being the "easier" task than the fishing reel assembly.

ACKNOWLEDGEMENT

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INTRODUCTION

In a recent review of the literature concerning behavior modification training procedures for the retarded, Martin and Pallotta (1977) cited several demonstrations that the severely retarded are able to acquire very complex vocational skills such as bicycle brake assembly (Gold, 1972); oscioloscope cam switch assembly (Bellamy, Peterson & Close, 1975); electromechanical relay panel assembly (Tate & Barhoff, 1967); and cable harness construction (Hunter & Bellamy, 1976). Concerning comparisons of training procedures across tasks, however, there is relatively little research. Although all the demonstrations cited above used one of three training formats (backward chaining or forward chaining or total task presentation), these formats have not been compared as to their effectiveness in teaching workshop tasks to the retarded. Moreover, it is surprising to find that the different chaining procedures, although described in basic research (Kelleher & Gollub, 1962), behavioral texts (e.g., Keller & Shoenfeld, 1950; Skinner, 1938; Martin & Pear, 1978) and in behavioral applications (e.g., Martin, England & England, 1971; Martin, Kehoe, Bird, Jensen & Darbyshire, 1971) they have received almost no comparative evaluation to each other. Only one study was found where a comparison between backward and forward chaining procedures was made. Nelson (1977) compared the two different procedures to train six squirrel monkeys to press three response keys in four particular response sequences to obtain food. The required response sequence was changed after each session and a measure of response acquisition was obtained for each session in which either forward or backward chaining was used. The results showed that both groups learned the sequences and that there was an overlap in the acquisition of the responses by the two groups.

Although the median number of errors was consistently lower for the forward chaining procedure, the best performance was obtained by one of the monkeys on backward chaining. Nelson concluded that under the conditions of this experiment, forward chaining was at least as effective in establishing response chains as backward chaining.

The specific purpose of the present study was to compare the effectiveness of backward and forward chaining techniques in teaching packaging and assembly tasks where the components of each sequence were heterogeneous.

METHOD

Subjects

Clients were selected from the wards at the Manitoba School for Retardates and from a group home in Portage la Prairie. Their characteristics are summarized in Table 1.

Insert Table 1 about here

Basic Design

The basic research design was a multi-element design within clients with counterbalancing of procedures and tasks across clients (for descriptions of this design, see Martin & Pear, 1978; Ulman & Sulzer-Azaroff, 1975). Specifically, several tasks were involved and each client learned some of the tasks under backward chaining procedures and other tasks under forward chaining procedures. Backward versus forward chaining were then compared within each client. The tasks utilized are listed in Table 2.

Insert Table 2 about here

Table 1

Some Characteristics of the Clients

	Client	Age	I.Q. (Test)	Diagnosis	Years of Institutionalization
Experiment I (group home)	1. Gail	19	41 (S-B)	Moderately retarded	10
	2. Louise	15	42 (S-B)	Moderately retarded	9
	3. Agnes	20	22 (S-B)	Severely retarded	14
	4. Giselle	20	31 (S-B)	Severely retarded	9
	5. Rodeena	27	20 (S-B)	Severely retarded	20
Experiment II (ward of institution)	6. Sam	42	39 (P.P.V.T.)	Moderately retarded	23
	7. Ross	29	20 (P.P.V.T.)	Severely retarded	23
	8. Barry	23	38 (P.P.V.T.)	Moderately retarded	7
	9. Abbie	39	33 (P.P.V.T.)	Severely retarded	15

Table 2

Experimental Tasks

Airline Coffee Pack Assembly	- this task involves stuffing a plastic bag with a folded serviette, coffee mate, and a plastic stick.
Seat Cover Hook Pack Assembly	- this task involves putting seat cover hooks into a paper bag and stapling it.
Bicycle Brake Assembly	- this task involves putting together a 13-part bicycle brake.
Fishing Reel Assembly	- this task involves putting together a 13-part fishing reel.
Light Clip Assembly	- this task involves packing 12 light hangers and the tool to attach Christmas lights to the exterior of a house.
Camping Toaster Assembly	- this task involves putting together a 5-part camping toaster and folding it to put into a box.

These experiments used several experimenters and several clients. The specific arrangement of clients, experimenters, tasks, and forward and backward chaining used for each task and client are described in Table 3 which shows the basic comparisons for Experiments I and II.

Insert Table 3 about here

Procedures Followed for Experiment I, Comparison I

The first comparison of Experiment I, as indicated in Table 3, utilized two tasks and four clients. The tasks were the Coffee Pack Task and the Seat Cover Hook Pack Task (see Figure 1 for detailed sequence of steps of tasks).

Insert Figure 1 about here

To equate the tasks for difficulty, the two sequences were analyzed into the same number of steps. The number of movements involved in each step were then counted. After that, the steps were rearranged in such a way that each of them would involve two or three movements.

With these final sequences equated for number of steps and movements, experienced people working within workshops with workshop tasks for severely and moderately retarded clients subjectively evaluated the difficulty of each step on a scale from 1 (very easy) to 5 (very difficult) for a social validation measure of the comparability of the two sequences.

Recording procedure. All data were scored on baselines and training trials using the following code:

- Client responded correctly to verbal instructions only (command) . Score 4

Table 3. Basic design for Experiments I and II: Multi-element design within clients with counterbalancing of procedures and tasks across clients.

Experiment I

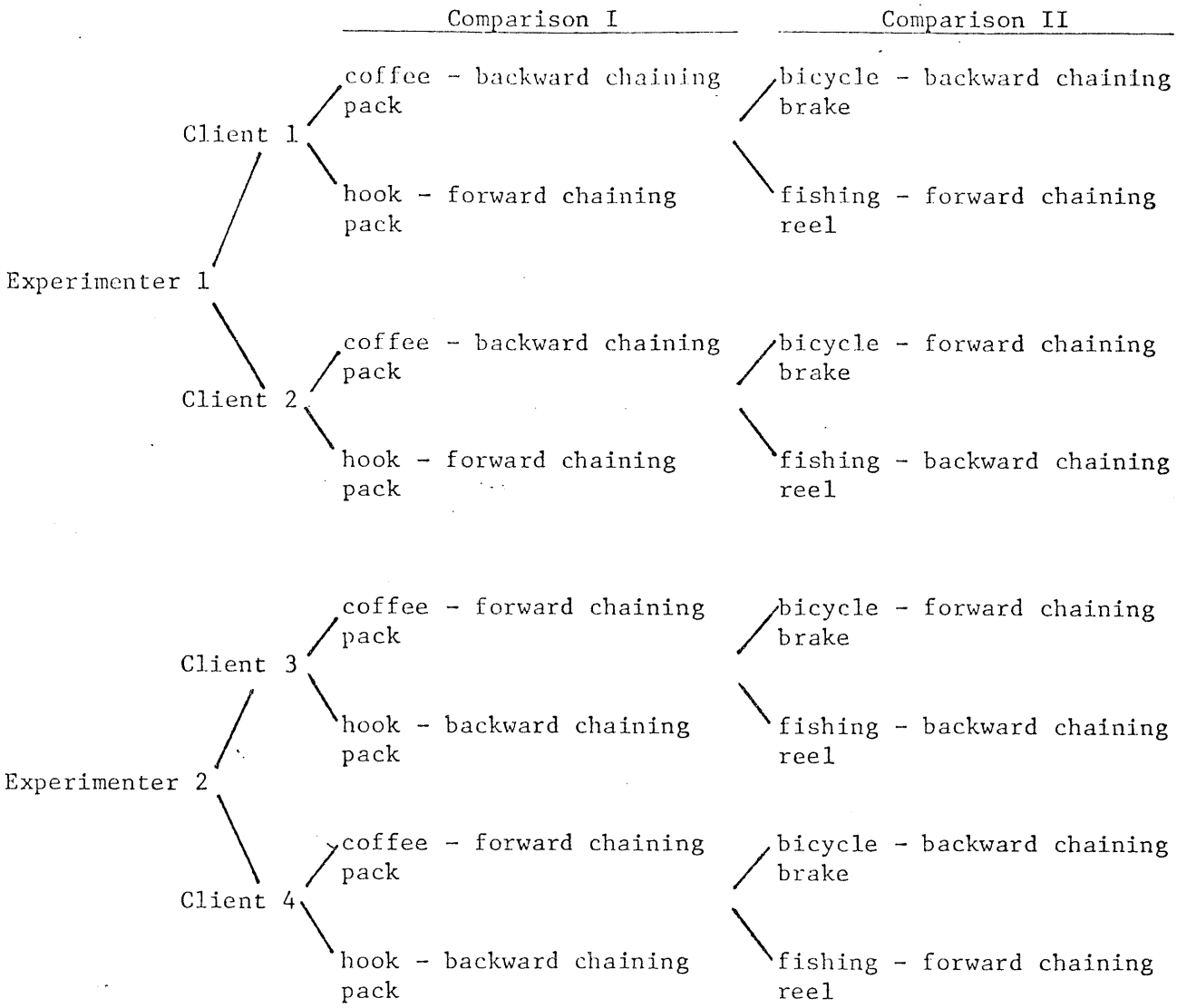
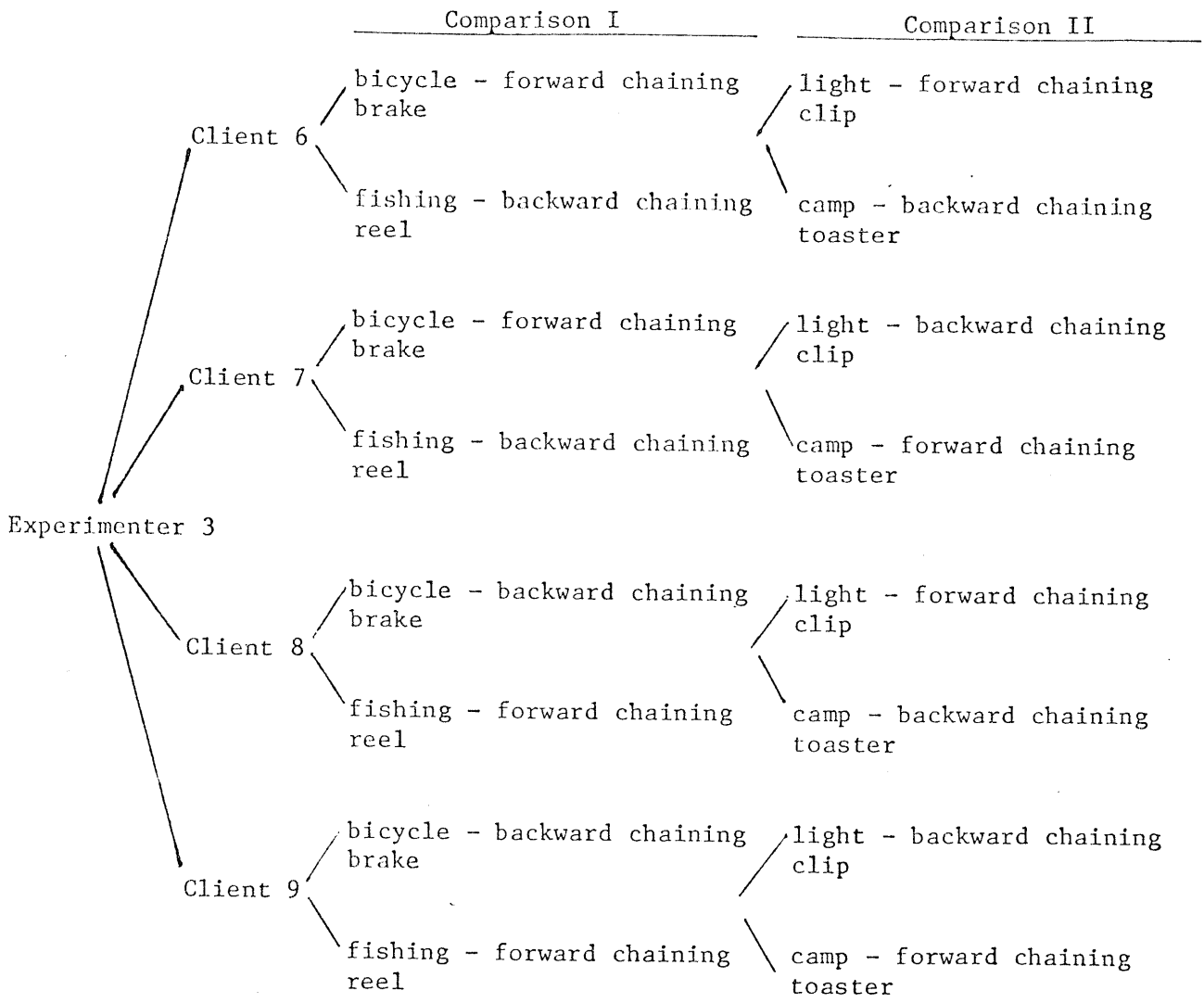


Table 3 (continued)

Experiment II



COFFEE PACK TASK	SEAT COVER HOOK TASK
1. Pick up one serviette.	1. Pick up one hook from the container.
2. Fold serviette in half (making it thinner).	2. Put the hook on a circle.
3. Sharpen crease with forefinger.	3. Pick up second hook from the container.
4. Fold serviette in half (making it shorter).	4. Put second hook on the other circle.
5. Pick up one plastic bag.	5. Pick up one paper bag.
6. Open plastic bag.	6. Open the paper bag.
7. Pick up folded serviette.	7. Pick up one hook from cardboard.
8. Put serviette into plastic bag with folded end first.	8. Put hook into paper bag.
9. Slide serviette into bag.	9. Pick up second hook from cardboard.
10. Pick up one sugar pack.	10. Put second hook into paper bag.
11. Put sugar pack into bag over serviette.	11. Fold top end of paper bag.
12. Pick up one stick.	12. Sharpen crease with forefinger.
13. Put stick into the bag.	13. Pick up the stapler.
14. Lift plastic bag (contents go to bottom).	14. Staple the bag.
15. Put coffee pack in the box in front.	15. Put paper bag in the box in front.

Figure 1. The sequence of steps of the Coffee Pack Task and the Seat Cover Hook Task.

- Client responded correctly when the experimenter provided instructions as well as gestures (pointing, modelling, etc.) (Guidance A) . . . . . Score 3
- Client responded correctly when the experimenter provided instructions plus physical guidance (by touching the client with two fingers) to initiate movements (Guidance B) . . . . . Score 2
- Client responded correctly when the experimenter provided instructions and physically guided each movement (Guidance C). . . Score 1.

Baseline procedure. Having all the necessary items to complete one task in front of the client, the experimenter gave a command such as: "Arrange the coffee pack. Do all you can. Make it like this", while showing a prepared coffee pack. If the client correctly assembled the entire task to this instruction, he received a score of 4. The client was allowed one minute to respond. If the client did not score 4, then the experimenter tested each step of the two tasks individually, with steps presented randomly. Prior to testing a step of a task, up to the point that the client was being tested, the experimenter completed the steps. For example, for Step 7 in the "coffee pack" task, the experimenter would have completed the first six steps and then tested Step 7 which was picking up a folded serviette from the table. Verbal instructions were given to perform the step in order to determine if the client could have obtained a score of 4 on that step. If the client did not respond within 10 seconds, made a mistake, or emitted any undesirable behavior, the experimenter would have taken the set of items from him, interrupted the client in the case of an error or undesirable behavior, waited 5 seconds, and presented another test trial with instructions and Guidance A. If the client performed correctly, he would have received a score of 3; if not, the experimenter would have repeated the

instructions with Guidance B. If the client performed correctly, he would have received a score of 2; if not, the experimenter would have presented the same step again and increased the amount of help, giving Guidance C. In this way, each step of a sequence was individually tested.

No consequences were applied for performing the behaviors of a specific task correctly during baseline. However, every 3 minutes on the average, the experimenter asked the client to do one other behavior, different from the task, and reinforced him for doing so with social reinforcement and/or edibles of his preference. Those behaviors could have been something like following a command such as "stand up", or "say 'ah'", or engaging in any type of adequate conversation or social interaction, etc.

Description of backward chaining. Training began following the score obtained for each specific step in baseline and, as described by Martin and Pear (1978) went from the last to the first step. The experimenter arranged the items corresponding to the last step for one of the tasks and began the training giving the level of help defined by the score obtained in baseline. After the client responded correctly with this level of help twice in a row, the experimenter gave the training using the next level of help. That was, he then decreased the amount of help. For example, if the experimenter was using Guidance C, then he would go to Guidance B. The criteria of two correct responses in a row was applied through the levels of help until the client was performing the step on command only.

As in baseline, every command for a specific step was followed by the general instruction, "Do all you can".

After the client mastered the last step, i.e., performed it for two consecutive trials correctly on command only, the experimenter introduced the

set corresponding to the second last step and began the training using the same procedure, starting with the score obtained in baseline. The client was also required to perform the steps which he had previously learned. So, while giving the training to the second last step, after the client performed it with the appropriate level of help, he had to perform the last step upon the command, "Do all you can". The experimenter prompted the last step (i.e., the most recently acquired step) for two trials. On subsequent trials, the client should have performed the rest of the sequence (i.e., that part already learned) by himself, otherwise it was considered a mistake.

If at any point of the part of the sequence that had been learned, the client needed help, even if it was just a command, the experimenter retrained the sequence beginning from the step that the client was not able to emit by himself. The experimenter returned the client to the training step he was at before the error was emitted only after the client had performed the retrained part of the sequence two correct times in a row with no help.

Reinforcement, social and edible, occurred after the completion of the last step in each trial.

The entire task was considered learned when the client performed it correctly three consecutive times.

Description of forward chaining. The training began following the score obtained for each specific step in baseline, going from the first to the last step. The experimenter arranged the items corresponding to the first step for one of the tasks and began the training giving the level of help defined by the score obtained in baseline. After the client responded correctly for two consecutive trials, the experimenter decreased the level of help on subsequent trials as described for the backward chaining procedure.

In the baseline and the backward chaining procedure, every command for a specific step was followed by the general instruction, "Do all you can". For the forward chaining procedure, this command was the first one to be given and was then followed by the command and appropriate level of help required by the specific step the experimenter was training.

On each trial, the client was required to perform the steps he had already learned. So, for example, when receiving the training for the second step, the client was required to perform the first step which he had already learned.

After the client reached criteria on the first step, the experimenter prompted the beginning of the sequence for two trials. On the subsequent trials, the client should have begun the sequence by himself. If any prompt was needed, that was considered a mistake.

If at any point in the sequence, the client needed help in a step already trained to criteria, the experimenter retrained the sequence from the first step to that step where the error was emitted, until the client performed it two correct times in a row with no help.

The reinforcement procedure was the same as for the backward chaining procedure.

The task was considered learned when the client performed it correctly three consecutive times.

Dependent variables. The following dependent measures were taken: number of errors, number of sessions needed to learn the task following criterion, number of steps learned per session, number of trials to criterion per step, number of trials to criterion to learn the whole task, the ratio of the number of trials to criterion over the minimum number of trials required calculated from the first trial. In addition, a measure of efficiency of the program was

defined as: the minimum possible number of trials to learn the task over the actual number of trials to learn the task times 100.

Procedures Followed for Experiment I, Comparison II, and Experiment II, Comparisons I and II

These procedures were essentially the same as described above for Experiment I, Comparison I, except that they involved different clients (see Table 1) and different tasks (see Tables 2 and 3 and Figures 2 and 3).

Insert Figures 2 and 3 about here

Data Evaluation

As described above, the design was a multi-element within-clients design. Judgements about the relative effectiveness of backward vs. forward chaining were based on considerations typical to most behavior modification studies, and which were reviewed by Martin and Pear (1978, pp. 313-315).

The interobserver reliability of these data was computed at least once for each client on every task. The observer recorded the score obtained on each trial during a session. The data sheets were then compared, trial by trial. Percent agreement between the experimenter and the independent observer was defined as the number of agreements divided by the number of agreements plus disagreements and multiplied by 100.

RESULTS

The interobserver reliability scores of the data from Experiment I had a mean of 92.2% with a range of 70% to 100%, and for Experiment II the reliability was always 100%.

BICYCLE BRAKE TASK

1. Pick up part 1 (housing).
2. Pick up part 2 (axle).
3. Put part 2 into 1.
4. Turn part 1 upside down (keeping 1 & 2 together).
5. Pick up part 3 (dust cap A).
6. Screw 3 onto 2.
7. Pick up part 4 (nut A).
8. Screw part 4 onto 2.
9. Turn 1 over with 2 touching table.
10. Pick up part 5 (planet cage).
11. Put 5 onto 2 and into 1.
12. Pick up part 6 (washer A).
13. Put 6 onto 2 and into 1.
14. Pick up part 7 (washer B).
15. Put 7 onto 2 and into 1.
16. Pick up part 8 (washer C).

(...continued)

FISHING REEL TASK

1. Pick up part A (body assembly).
2. Move part B and C pointing outside (cover and upper flap).
3. Pick up part D (crank shaft).
4. Put D into A sideways.
5. Move part B (lower flap) to the edge of the center opening of A.
6. Pick up part E (center shaft).
7. Put part E into A through the center and give to E (while locking into B).
8. Move C (upper flap) over E.
9. Turn A over.
10. Pick up part F (spool).
11. Lift part G (side lever in A) and hold.
12. Put F into A and release G.
13. Pick up part K (spinner head).
14. Move the small part under K to clear away from circle.
15. Put K into E and over F.
16. Pick up part L (spinner head nut).

(...continued)

Figure 2. The sequence of steps of the Bicycle Brake Task and the Fishing Reel Task.

Figure 2 (continued)

BICYCLE BRAKE TASK	FISHING REEL TASK
17. Put 8 onto 2 and into 1.	17. Screw L into D.
18. Pick up part 9 (gear ring).	18. Turn A over.
19. Put 9 onto 2 and into 1.	19. Pick up part H (back cover).
20. Pick up part 10 (inner dust cap).	20. Put A into H with parts K and L facing out.
21. Screw 10 into part 1.	21. Turn H over such that K and L face away from palm.
22. Pick up part 11 (driver).	22. Pick up part M (front cover).
23. Put 11 onto 2 and into 10.	23. Screw M into H.
24. Pick up part 12 (dust cap B).	24. Pick up part I (crank handle).
25. Screw 12 onto 2.	25. Put I into B which is extended out of H.
26. Pick up part 13 (nut B).	26. Pick up part J (crank nut) and give to E.
27. Screw 13 onto 2.	27. Screw J into B.
28. Put finished product into box.	28. Put finished product into box.

LIGHT CLIP ASSEMBLY TASK

1. Pick up the box.
2. Put the box in the jig in front of you.
3. Pick up the first set of clips.
4. Put it on the left side in the middle part of the box.
5. Pick up the second set of clips.
6. Put it right beside the first set, in the middle part of the box.
7. Pick up the third set of clips.
8. Put it at the side of the second set, in the middle part of the box.
9. Pick up the tool to fix the clips.
10. Put it on the box below the second set of clips.
11. Pick up the plastic cover.
12. Put it over the sets and the tool, according to shape.
13. Pick up the upper cover of the box.
14. Fold it over the plastic cover according to shape.

(...continued)

CAMPING TOASTER ASSEMBLY TASK

1. Pick up the metal plate.
2. Put the plate on the table in front of you.
3. Pick up one wire.
4. Plug one of the ends in any hole.
5. Plug the other end in the hole straight in front (3rd hole to the left).
6. Pick up a second wire.
7. Plug one end in the hole beside the first wire end.
8. Plug the other end in the hole across, making the wire parallel to the first.
9. Cross the wires in the middle of the plate.
10. Turn the place, such as the crossed wires are vertical in relation to you.
11. Pick up a third wire.
12. Plug one end in one of the holes that were left.
13. Plug the other end in the hole straight in front, over the crossed wires.
14. Pick up a fourth wire

(...continued)

Figure 3. The sequence of steps of the Light Clip Assembly Task and the Camping Toaster Assembly Task.

Figure 3 (continued)

LIGHT CLIP ASSEMBLY TASK

15. Put the upper and lower ends of the box together.

16. Pick up the stapler.

17. Staple below the plastic cover.

18. Put the product on the table by your side.

CAMPING TOASTER ASSEMBLY TASK

15. Plug one end in one of the remaining holes.

16. Plug the other end in the hole across, making the wire parallel to the third one.

17. Cross the third and fourth wires over the first two wires.

18. Put the product on the table by your side.

Comparison of Backward and Forward Chaining in Terms of Cumulative Steps Acquired per Session

Figure 4 shows the cumulative steps acquired per session for Comparisons

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Insert Figure 4 about here

I and II in Experiment I and Figure 5 shows the cumulative steps acquired per

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Insert Figure 5 about here

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session for Comparisons I and II in Experiment II.

As can be seen in Figure 4 for Comparisons I and II, there is a task effect. That is, regardless of the procedure used, backward or forward chaining, the hook pack task was acquired faster than the coffee pack, and the bicycle brake assembly had a higher rate of acquisition than the fishing reel for all subjects. However, for Experiment II, Figure 5 shows that there was little or no difference in the rate of acquisition of the tasks either for Comparison I or II, with the exception of Subject 8 in Comparison II who needed more sessions and more trials to reach criterion for the light-clip assembly task taught with forward chaining. Therefore, at least for the relatively simple tasks, no difference between the two procedures could be identified.

Problems During Task Acquisition: Excessive Number of Trials Necessary for Retraining

As can be seen in Figure 4 for Client 2, Louise, in the acquisition of the coffee pack task, no progress was evident between the second and the third sessions. This is indicated by the flat position of the graph between these two

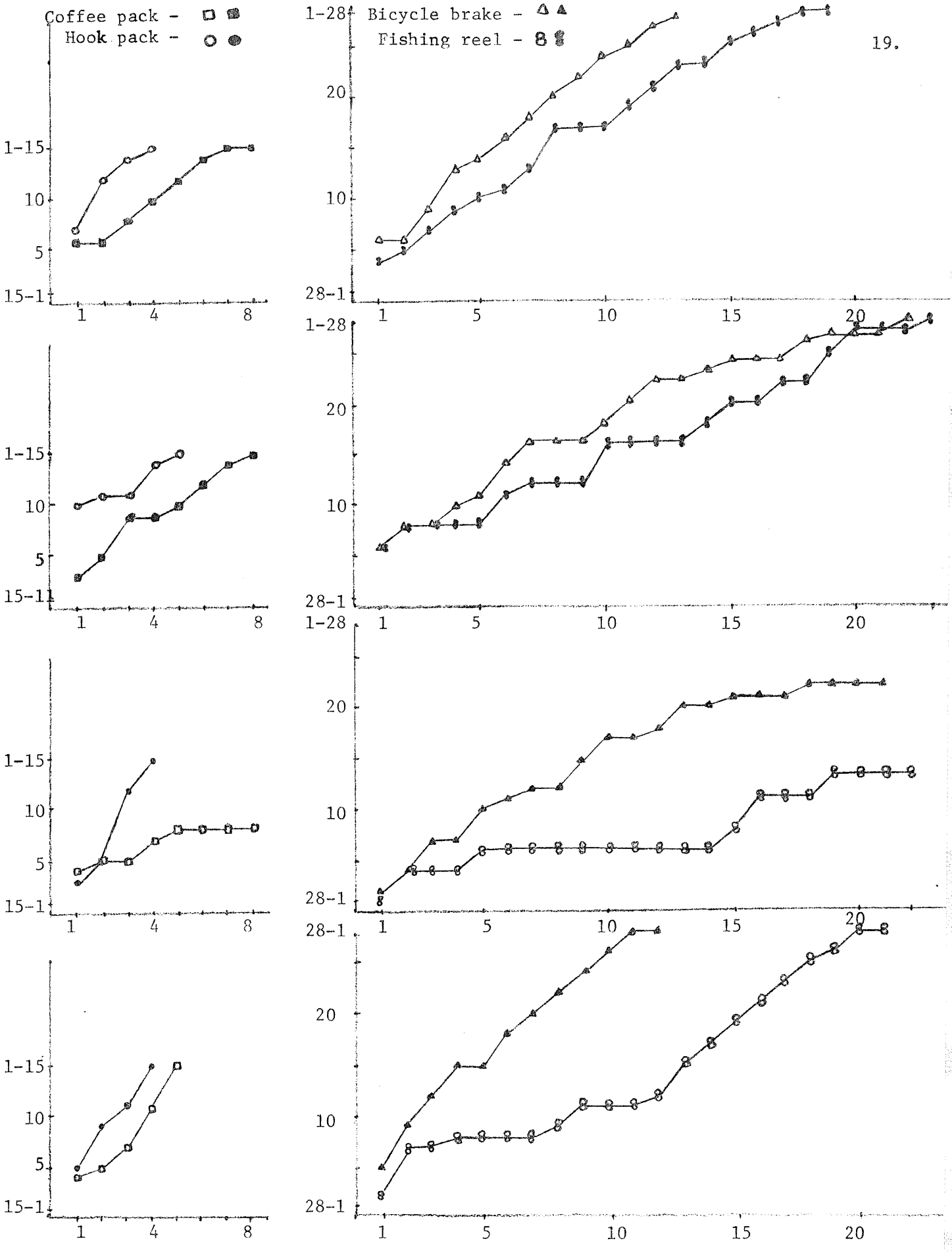

Figure 4. Cumulative steps acquired per session in Experiment I. All open-ended data points refer to forward chaining and all solid ones to backward chaining.

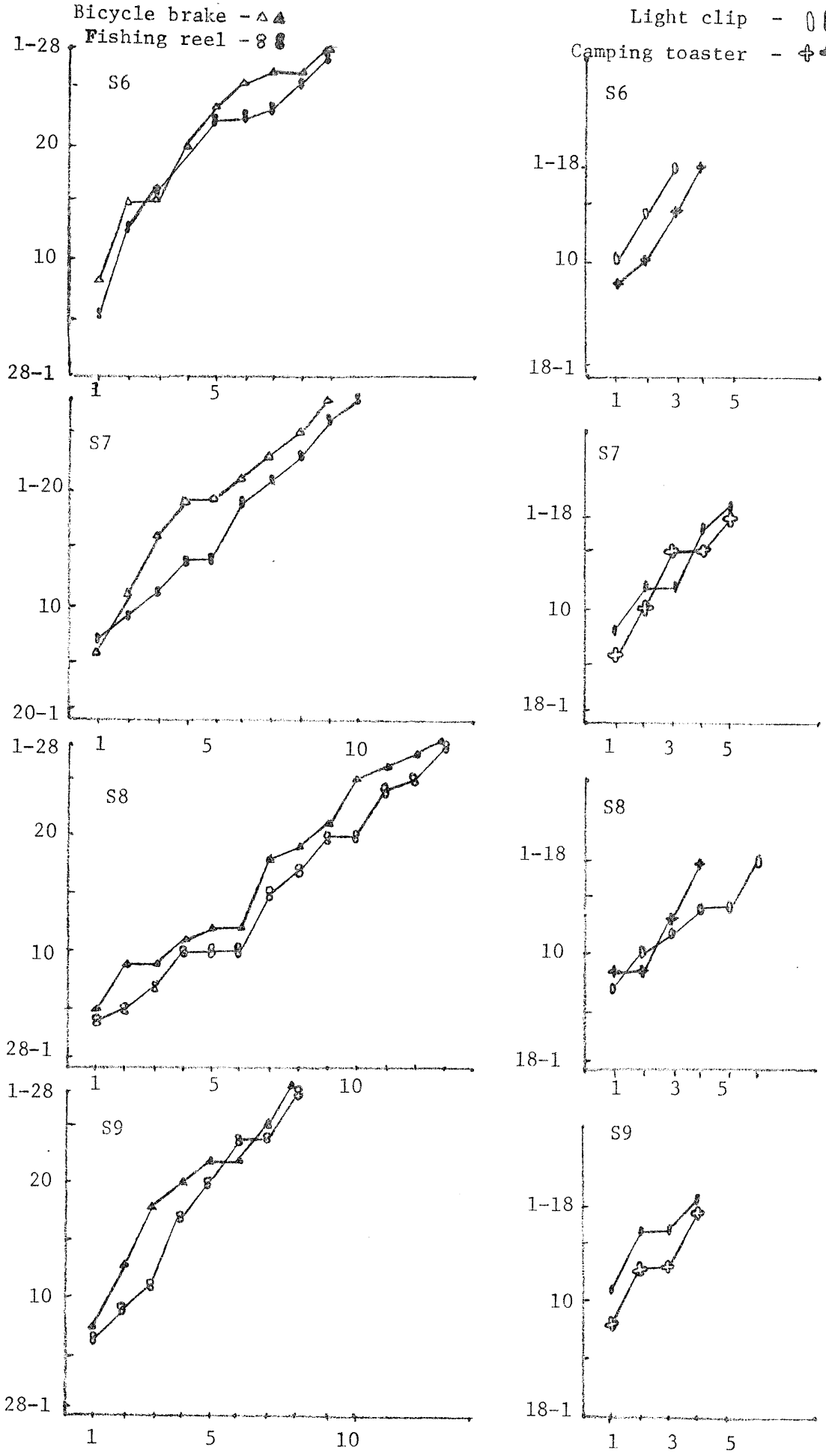

Figure 5. Cumulative steps acquired per session in Experiment II. All open-ended data points refer to forward chaining and all solid ones to backward chaining

sessions. These flat positions can be seen in Figures 4 and 5 for almost all the clients and the lack of progress in some of the sessions is due to the necessity of retraining trials. As described in the procedure section, when the client needed help or made an error in any of the steps already learned, the sequence had to be retrained, and had to perform the step being retrained twice in a row without assistance in order for the training on other steps to continue.

Some steps in some of the tasks presented more problems for retraining than other steps. Examples of this can be seen in Figures 6 and 7. These figures

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Insert Figures 6 and 7 about here

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present the number of trials to reach criterion over and above the minimum required. The minimum number of trials required to learn a specific task was calculated individually, based on the scores obtained for the first trial of each step. For each step of every task, the experimenter calculated the minimum trials that would be necessary for the client to acquire that step based on the criteria of performing the step twice in a row on command only. [For instance, the baseline score for Step 4 of the coffee pack task for Giselle (Subject 4) was level 3. Therefore, the minimum number of trials required to reach criterion in this step was 4, that is two trials in level 3 and two trials in level 4, before going to the next step.] After doing this, the actual number of trials required considering retraining for each client to reach criterion was calculated and the difference between this and the minimum number required was obtained and graphed per step. In the example of Giselle, she actually needed nine trials to reach criterion in Step 4, five trials above the minimum required

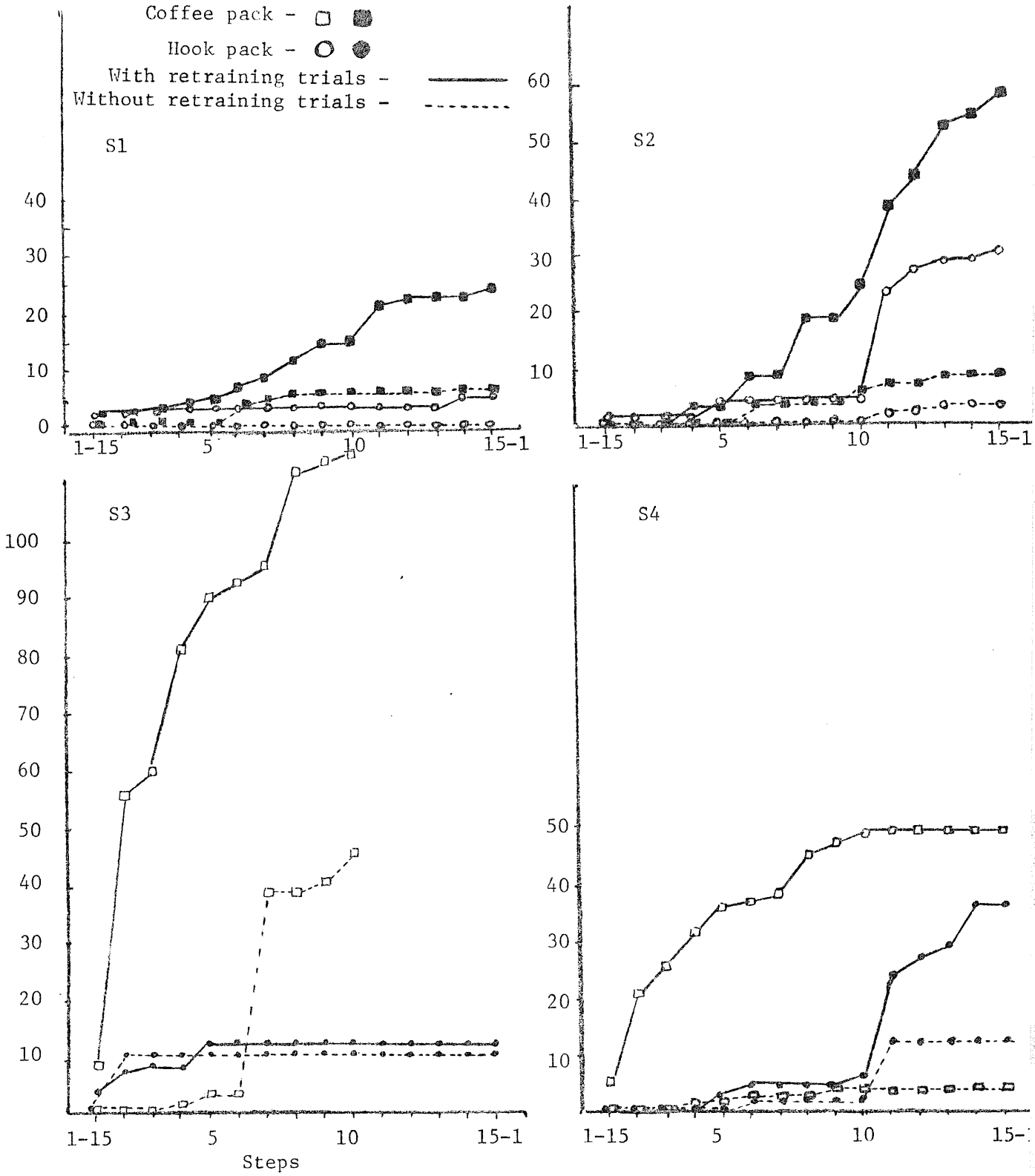

Figure 6. Number of trials over and above the minimum required to learn the task. All open-ended data points refer to forward chaining and all solid ones to backward chaining.

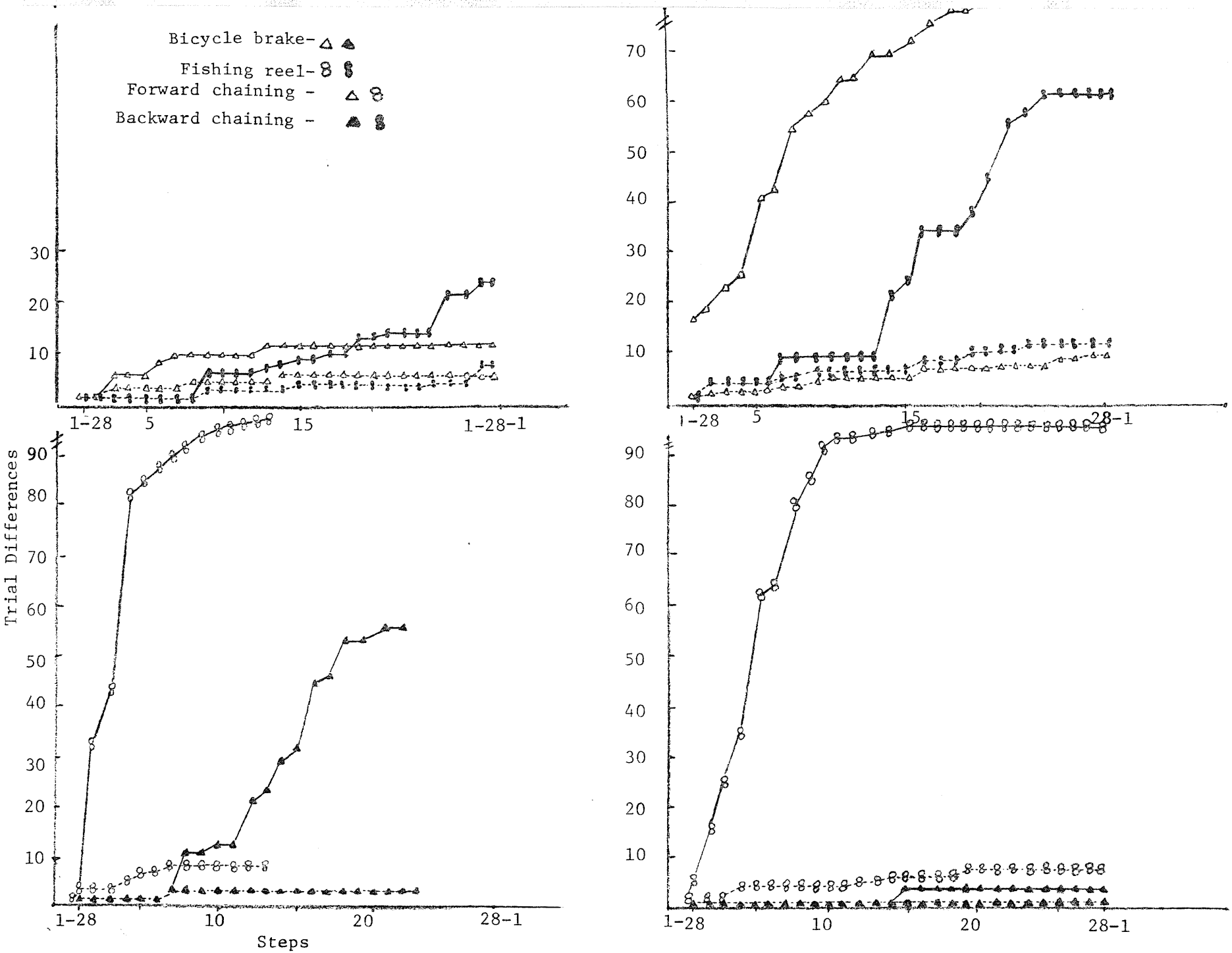

Figure 7. Number of trials over and above the minimum required to learn the task.

were necessary and five is graphed for Step 4 in Figure 6. Also, the actual number of trials required not considering retraining was calculated and the difference over the minimum required was obtained and graphed. Following this, problems with increased difficulty for some of the steps can be seen in Figure 6. Louise (Subject 2) for example, on Step 11 of the coffee pack task, required three trials over the minimum when retraining was not considered. When retraining was taken into account, it can be seen that 19 trials over the minimum required were given and that the problem was not only in training Step 11 but the majority of the trials being spent to retrain some of the previous steps acquired. Also, regardless of the procedure, the coffee pack task presented more trials over the minimum required than the hook pack, again showing evidence of task effect when retraining trials were considered.

Looking at Figure 7, when retraining trials were not considered almost no difference can be seen between the two procedures. When retraining is taken into account for three of the four subjects, forward chaining appears to need more trials over and above the minimum required to learn the task. Thus, with this measure a systematic difference between the two procedures can be observed. For all the tasks, the results were very similar in that certain steps appeared to be problem steps and the number of trials over the minimum required without considering retraining showed very little difference between backward and forward chaining procedures.

The task effect described previously is also evident when one considers the total number of errors made by the clients learning different tasks on either backward or forward chaining. This can be seen in Figure 8 for the clients

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Insert Figure 8 about here

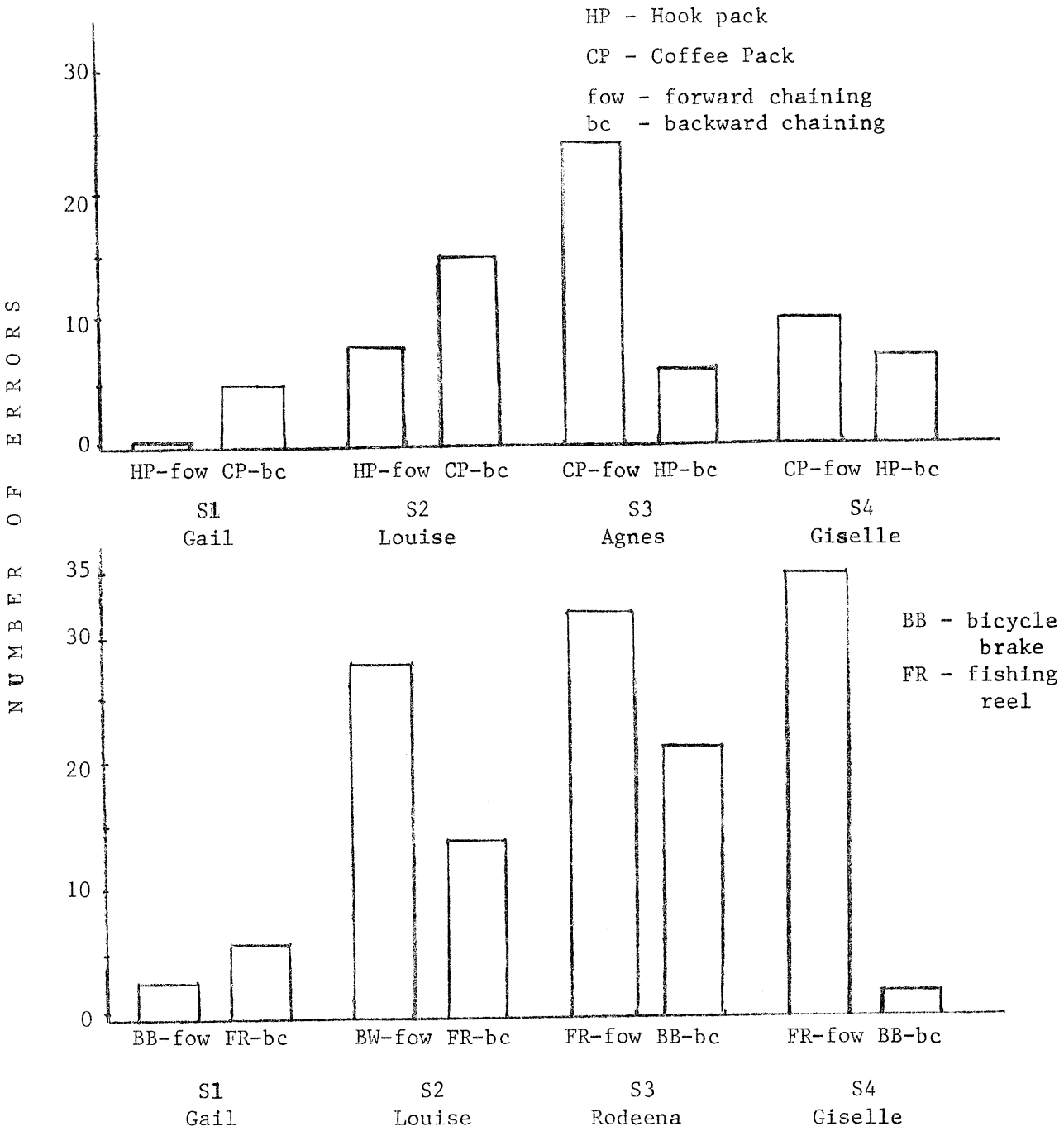

Figure 8. Total errors for Experiment I, Comparisons I and II.

in Experiment I. The results showed that regardless of the procedures, fewer errors occurred in the acquisition of the hook pack task. Gail and Louise made fewer errors learning the hook pack task with forward chaining while for the other two clients a smaller number of errors were made for the same task with backward chaining. As can be seen in Figure 8, only Gail made more errors in the bicycle brake assembly task using backward chaining. For the other three clients, more errors occurred when either the bicycle brake or fishing reel assemblies were taught with the forward chaining procedure.

Table 4 presents the total number of trials to criterion for each task for

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Insert Table 4 about here

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the clients in Experiment II, Comparison I. A task effect is also observed here where the bicycle brake assembly task required fewer trials to be acquired than the fishin reel assembly task for all the clients regardless of the procedures being used. However, one can also observe that there are greater differences in task-procedure combinations which suggest superiority for backward chaining.

DISCUSSION

There are several conclusions that can be drawn from this study. First, the differences shown by the data seemed to reflect differences in the task used more than procedural effects. This can be seen in terms of the cumulative steps acquired per session shown in Figure 4 and the total number of errors in Figure 8.

Second, for very simple tasks, differential effects of the training procedures cannot be clearly identified. This can be observed especially when look-

Table 4. Total number of trials to criterion for Experiment II, Comparison I.

Client	Task-Procedure Combination	Number of Trials To Criterion
Sam	bicycle brake - forward chaining	90
	fishing reel - backward chaining	91
Ross	bicycle brake - forward chaining	90
	fishing reel - backward chaining	98
Barry	bicycle brake - backward chaining	128
	fishing reel - forward chaining	146
Abbie	bicycle brake - backward chaining	89
	fishing reel - forward chaining	121

ing at the results from Comparison I of the first experiment, using coffee pack and seat cover hook pack tasks. The cumulative steps acquired per session in Figure 4, the number of trials over and above the minimum required in Figure 6, and the total number of errors in Figure 8 show that, independently of the procedures used, one of the tasks, the seat cover hook pack, was more easily acquired with fewer errors than the coffee pack task. The same can be said for Experiment II when looking at cumulative steps acquired per session with different tasks in Figure 5.

However, a third conclusion is that for more complex tasks, backward chaining appeared to be a more effective procedure, which can be seen in several respects: (a) looking at Figure 7 concerning the number of trials over and above the minimum required for Comparison II in Experiment I, a relatively greater difference is observed when backward chaining procedure is used to teach the bicycle brake assembly compared to forward chaining procedure being used to teach the fishing reel assembly task. This difference, however, is greater only when retraining trials are taken into account for three of the four clients. In Figure 8 concerning the total number of errors for Experiment I, and Table 4 concerning the total number of trials to criterion for the clients in the second experiment, the same larger differences can be seen when considering the same task-procedure combinations; (b) to some extent Figure 6 concerning the number of trials over and above the minimum required for Comparison I of the first experiment also shows greater differences favoring backward chaining with specific task-procedure combinations, in this case when backward chaining is combined with the seat cover hook task compared to forward chaining combined with the coffee pack task; (c) although it was clear that a task effect was observed with the seat cover hook pack and the bicycle brake assembly tasks as

"easier" tasks than the coffee pack and the fishing reel assembly tasks, respectively, the greatest differences are shown when comparing the more effective procedure (backward chaining) to teach the "easier" task to the less effective procedure (forward chaining) to teach the "harder" task. Thus, the backward chaining procedure appears to be more effective than the forward chaining procedure in this study.

A final consideration concerns a recommendation for future research of this sort. With this type of research design, a better system for equating tasks should be developed or else the differences between tasks should be quantified. When one is interested in using a design such as the multi-element design, task similarities are assumed. Considering the same task cannot be taught twice and cannot be exposed to both procedures, there are some advantages in using such a design in terms of allowing for individual control and group and individual comparisons, across subjects and across tasks. However, if the tasks are not equated, then a confounding variable, the task effect, is always present. A better procedure for selecting and equating tasks would strengthen future research that uses a multi-element baseline design to compare the relative effectiveness of backward and forward chaining techniques.

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