Comparison of two teaching structures examining the effects of component fluency on the performance of related skills

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This experiment compared two teaching structures to assess the effects of component skill fluency on the acquisition of more complex tasks. A multiple baseline across tasks design was used to assess the effects that teaching a component skill to fluency had on rates of responding on a second component skill and a compound task (Condition 1), and the effects that teaching a compound task to fluency had on rate of responding on 2 component skills (Condition 2). The results show that learners in Group 1, taught under Condition 1 made better overall progress on the three tasks than learners in Group 2 taught under Condition 2. Group 1 learners not only reached fluency aim on all tasks, but did so with fewer teaching sessions, with some participants achieving fluency aim under baseline conditions with no direct intervention at all. Learners in Group 2 required more sessions to reach fluency aim on tasks under intervention and two learners did not achieve aim on the two component skills.

DESCRIPTORS: Fluency, compound behaviors, component skills

Precision teachers stress the key role fluency plays in learning, stating that cumulative dysfluency (the accumulation of dysfluent component skills) may be the most important factor in long-term student failure (Binder, 1996). They assert that in order to facilitate learner's progression through the curriculum, teachers should insure that tasks are analysed to determine prerequisite behaviours and component skills. Learner's performances on these skills can then be tested and they can subsequently be placed appropriately within the curriculum structure (Resnick, 1967; Resnick & Wang, 1969; Resnick, Wang & Kaplan, 1973: Sulzer-Azaroff & Mayer, 1991). Once taught, fluent components skills then combine to generate new composite skills with little or no formal instruction (Johnson & Layng, 1992).

Early laboratory studies using animals demonstrated that trained behaviours combined to produce new, more complex behaviours that had not been directly trained (Andronis, Goldiamond & Layng, 1983). Lutzer and Sherman (1974) observed novel, untrained sentence usage by children with learning disabilities when sentence components were trained. Johnson and Layng (1994) have observed the generative effects of fluent components in all areas of the curriculum, including language, writing and math skills. This experiment used a multiple baseline across tasks to examine the effects of two teaching structures on skill performance. It used the design to examine whether an intervention designed to increase learners' rate of responding on a component skill resulted in increased rate of responding on a second component skill and a compound task not under intervention. It also used this design to examine whether an intervention designed to increase learners' rates of responding on a compound task resulted in increased rates of responding on two components skills of this task. Normally, multiple baseline designs are used to show that changes only occur in the behaviour under intervention. In this case the design was utilised to examine whether change in rate of responding would occur in the two tasks not under intervention as a result of increased fluency in the task under intervention.

METHOD

Design

A multiple baseline across tasks design was used to assess the effects of the two teaching structures on component skill and compound task performance.

Participants and Setting

Seven primary school children (five males and two females) participated in this experiment. All had been diagnosed by educational psychologists as having mild learning difficulties (MLD). Six of the children attended a school for children with special educational needs and one child (Learner P) attended main stream primary school where he attended remedial classes for math and reading. For six of the participants, teaching and testing sessions were conducted in a small room off their main classroom. For Learner P, sessions were conducted in a quiet room at his home.

Tasks

All the children had been identified by teachers or parents as having difficulty learning and performing particular tasks in the curriculum,

notably math or reading. The tasks targeted for intervention were the following compound tasks and two components skills of these tasks.

Compound tasks. Learner M - see/write answers to x4 multiplication problems, Learners L & P - see/write answers to x2 multiplication problems, Learner C - see/write answers to +2 addition problems, Learners D, E & J - hear/see/point to isolated key words

Component Skills. Learner M - Component Skill 1 - see/dot multiples of 4 on number grid (60-80 dots per min.), Component Skill 2 - see/write answers to add 4 problems (70-90 digits per min.), Learners L & P - Component Skill 1 - see/dot multiples of 2 on number grid (80-100 dots per min.), Component Skill 2 - see/write answers to add 2 problems (70-90 digits per min.), Learner C- Component Skill 1 - see/say numbers 1-50 (60-80 numbers per min.), Component Skill 2 - see/write answers to add 1 problems (70-90 digits per min.), Learners D, J & E - Component Skill 1 - see/say letter sounds from flashcards (60-80 sounds per min.), Component Skill 2 - see/say 2 letter syllable sounds from flashcards (60-80 sounds per min.).

Group allocation

Participants were allocated to Group 1 (n-4) or Group 2 (n-3) on a random basis. Participants in Group 1 were taught Component Skill 1 then Component Skill 2 before moving on to the Compound Task. For the participants in Group 2, the order in which tasks were taught was reversed. They were taught the Compound task first before moving on to Component Skill 2 and then Component Skill 1.

PROCEDURE

Figure 1 shows the procedure followed in this experiment..

Intervention. Participants were taught separately and each attended two, thirty-minute sessions per week. During teaching sessions participants received instruction, practice, error correction, and feedback on the particular component skill or compound task under intervention. They were then asked to perform the task for several 1-minute timings and the best score of the session was recorded. Performance was reinforced using a token economy where 10 stickers could be exchanged for 1 item chosen from a range of edibles and small toys. Reinforcement was contingent upon reaching a daily aim, set at the beginning of the session, for the task under intervention.

Testing. At some point during the session, the participants performance on the remaining Component skills (Group 2) or the remaining Component Skill and Compound Task (Group 1) were tested during a 1-min. timing. During the testing period no instruction or feedback was given. Testing was carried out either before teaching on the target skill, or after it had taken place. The order in which skills were taught or tested was alternated across sessions for all participants to control for practice effects. As each participant reached fluent performance on the task under intervention and maintained it for 3 consecutive sessions teaching began on the next component skill or compound task. Again, performance on the remaining the remaining skill not under intervention was tested during each session. When fluency aim was achieved and maintained for 3 sessions, teaching began on the final component skill or compound task.

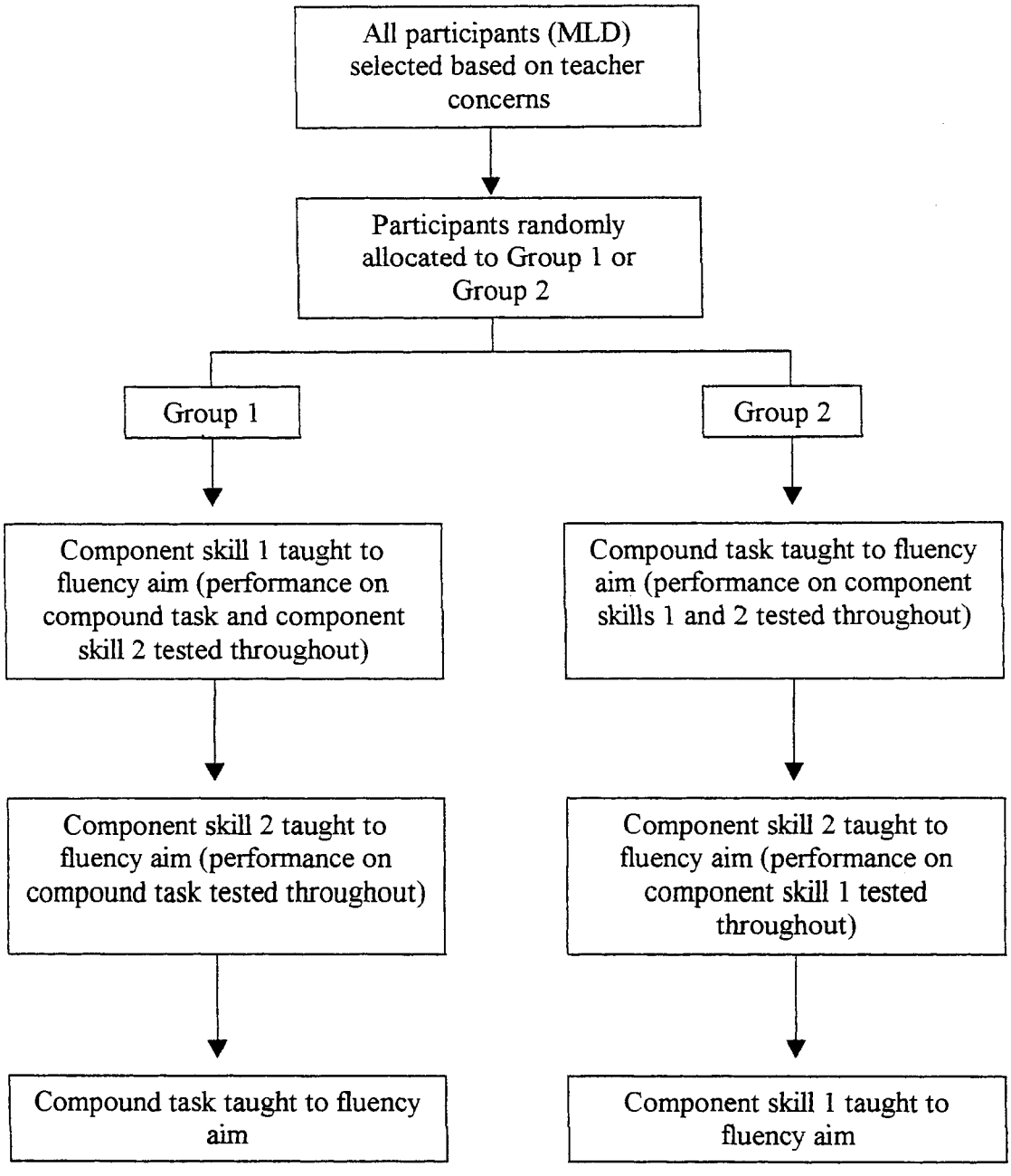
RESULTS

Group 1 and Group 2 participants' baseline rates of responding, celerations and number of teaching sessions to fluency aim for the component skills and compound tasks are shown in Table 1. Each learner's rate of responding on 2 component skills and one compound tasks are shown on Figures 2 – 7.

Group 1 (Condition 1). Math Tasks. Figure 2 shows learner M's rate of responding on all tasks under Condition 1. The top panel shows rate of responding on Component Skill 1 under baseline and intervention conditions. Intervention resulted in 3 consecutive sessions at fluency aim (60-80 dots per minute) being achieved in 16 teaching sessions. Rate of responding accelerated at x1.1 under intervention. The middle panel shows Learner M's rate of responding on Component Skill 2 under baseline and intervention. Under baseline conditions, rate of responding increased from 13 correct responses per minute to 38 correct responses per min., a learning celeration of x1.15. Intervention resulted in fluency aim (70-90 digits per min.) being achieved in 12 teaching sessions. The bottom panel shows learner M's rate of responding on the Compound Task under baseline and intervention conditions. Under baseline conditions, rate of responding increased from 25 correct responses per min. to 61 correct responses per min., a learning celeration of x1.1 Fluency aim (70-90 digits per min.) was achieved in 6 teaching sessions.

Figure 3 shows learner P's rate of responding on all tasks under Condition 1. The top panel shows rate of responding on Component Skill1 under baseline and
intervention conditions. Intervention resulted in 3

Figure 1


All participants (MLD) selected based on teacher concerns
Participants randomly allocated to Group 1 or Group 2
Group 1
Group 2
Component skill 1 taught to fluency aim (performance on compound task and component skill 2 tested throughout)
Compound task taught to fluency aim (performance on component skills 1 and 2 tested throughout)
Component skill 2 taught to fluency aim (performance on compound task tested throughout)
Component skill 2 taught to fluency aim (performance on component skill 1 tested throughout)
Compound task taught to fluency aim
Component skill 1 taught to fluency aim

consecutive sessions at fluency aim (60-80 dots per min.) being achieved in 13 teaching sessions. Rate of responding accelerated at x1.15 under intervention. The middle panel shows learner P's rate of responding on Component Skill 2 under baseline and intervention. Under baseline conditions, rate of responding increased from 24 correct responses per min. to 41 correct responses per min., a learning celeration of x1.15. Intervention resulted in fluency aim (70-90 digits per min.) being achieved in 11 teaching sessions. The bottom panel shows learner P's rate of responding on the Compound Task under baseline and intervention conditions. Under baseline conditions, rate of responding increased from 14 correct responses per min. to 75 correct responses per min., a learning celeration of x1.2 Fluency aim (70-90 digits per min.) was achieved under baseline conditions without teaching sessions.

Group 1 (Condition 1) Reading Tasks. Figure 4 shows learner D's rate of responding on all tasks under Condition 1. The top panel shows rate of responding on Component Skill1 under baseline and intervention conditions. Intervention resulted in 3 consecutive sessions at fluency aim (60-80 responses per min.) being achieved in 22 teaching sessions. Rate of responding accelerated at x1.1 under intervention. The middle panel shows learner D's rate of responding on Component Skill 2 under baseline and intervention. Under baseline conditions, rate of responding increased from 24 correct responses per min. to 66 correct responses per min., a learning celeration of x1.1. Intervention resulted in fluency aim (60-80 responses per min.) being achieved in 2 teaching sessions. The bottom panel shows learner D's rate of responding on the Compound Task under baseline and intervention conditions. Under baseline conditions, rate of responding increased from 8 correct responses per min. to 52 correct responses per min., a learning celeration of x1.15 Fluency aim (40-50 responses per min.) was achieved under baseline conditions without teaching sessions.

Figure 5 shows learner E's rate of responding on all tasks under Condition 1. The top panel shows rate of responding on Component Skill1 under baseline and intervention conditions. Intervention resulted in 3 consecutive sessions at fluency aim (60-80 responses per min.) being achieved in 10 teaching sessions. Rate of responding accelerated at x1.1. The middle panel shows learner E's rate of responding on Component Skill 2 under baseline and intervention. Under baseline conditions, rate of responding increased from 16 correct responses per min. to 66 correct responses per min., a learning celeration of x1.4. Intervention resulted in fluency aim (60-80 responses per min.) being achieved in 5 teaching sessions. The bottom panel shows learner E's rate of responding on the Compound Task under baseline and intervention conditions. Under baseline conditions, rate of responding increased from 8 correct responses per min. to 39 correct responses per min., a learning celeration of x1.2 Fluency aim (40-50 responses per min.) was achieved in 3 teaching sessions.

Group 2 (Condition 2) Math Tasks. Figure 6 shows learner L's rate of responding on all tasks under Condition 2. The top panel shows rate of responding on the Compound task. Intervention resulted in fluency aim (70-90 digits per min.) being achieved after 19 teaching sessions, a learning celeration of x1.1. The middle panel shows L's rate of responding on Component Skill 2. Under baseline conditions, rate of responding increased from 3 correct responses per min. to 37 correct responses per min., a learning celeration of x 1.05. However, despite 8 sessions under intervention, fluency aim was not achieved. The bottom panel shows rate of responding on Component Skill 1. Under baseline conditions, rates of responding increased from 22 correct responses per min. to 85 correct responses per min., a learning celeration of x1.1. Fluency aim (80-100 responses per min.) was achieved under baseline conditions.

Figure 7 shows learner C's rate of responding on all tasks under Condition 2. The top panel shows rate of responding on the Compound task. Intervention resulted in fluency aim (70-90 digits per min.) being achieved over 3 sessions after 33 teaching sessions, a learning celeration of x1.1. The middle panel shows C's rate of responding on Component Skill 2. Under baseline conditions, rate of responding increased from 19 correct responses per min. to 34 correct responses per min., a learning celeration of x 1. No intervention occurred on this skill as it required the entirety of the experiment to reach fluency on the Compound Task. Therefore fluency aim was not achieved. The bottom panel shows rate of responding on Component Skill 1. Under baseline conditions, rates of responding increased from 19 correct responses per min. to 23 correct responses per min., a learning celeration of x1. Again, due to time constraints no intervention took place therefore fluency aim was not reached.

Group 2 (Condition 2) Reading Tasks. Figure 8 shows Learner J's rate of responding on all tasks under Condition 2. The top panel shows rate of responding on the Compound task. Intervention resulted in fluency aim (40-50 responses per min.) being achieved over 3 sessions after 28 teaching sessions, a learning celeration of x1.2. The middle panel shows C's rate of responding on Component Skill 2. Under baseline conditions, rate of

Table 1

Math Tasks

Learner M (Group 1)	Component Skill 1	Component Skill 2	Compound Task
Baseline	13/0 13/0	12/0 13/0	12/2 25/0
Aim achieved	16 teaching sessions	12 teaching sessions	6 teaching sessions
Celeration	X 1.1	X 1.15	X 1.1
Learner P (Group 1)	**Component Skill 1**	**Component Skill 2**	**Compound ask**
Baseline	27/2 31/3	19/0 24/0	14/0 14/1
Aim Achieved	13 teaching sessions	11 teaching sessions	Achieved in baseline
Celeration	X 1.15	X 1.1	X 1.2
Learner L (Group 2)	**Compound Task**	**Component Skill 2**	**Component Skill 1**
Baseline	6/3 12/1	8/2 3/0	20/1 22/0
Aim Achieved	19 sessions	Not reached	Achieved in baseline
Celeration	X 1.1	X 1.05	X 1.1
Learner C (Group 2)	**Compound Task**	**Component Skill 2**	**Component Skill 1**
Baseline	3/14 15/14	19/2 19/2	22/2 19/12
Aim Achieved	33 sessions	Not reached	Not reached
Celeration	X 1.1	X 1	X 1

Reading Tasks

Learner D (Group 1)	Component Skill 1	Component Skill 2	Compound Task
Baseline	24/4 26/2	13/5 24/2	5/3 8/4
Aim Achieved	22 teaching sessions	2 teaching sessions	Achieved in baseline
Celeration	X 1.1	X 1.1	X 1.15
Learner E (Group 1)	**Component Skill 1**	**Component Skill 2**	**Compound Task**
Baseline	26/6 26/6	9/1 16/3	6/4 8/5
Aim Achieved	10 teaching sessions	Aim reached in baseline	3 teaching sessions
Celeration	X 1.1	X 1.4	X 1.2
Learner J (Group 2)	**Compound Task**	**Component Skill 2**	**Component Skill 1**
Baseline	7/4 6/5	3/4 4/5	22/5 34/4
Aim Achieved	25 teaching sessions	Aim not reached	Aim not reached
Celeration	X 1.2	X 1.1	X 1

responding increased from 4 correct responses per min. to 48 correct responses per min., a learning celeration of x 11.However, despite 4 sessions under intervention, fluency aim was not achieved. The bottom panel shows rate of responding on Component Skill 1. Under baseline conditions, rate of responding increased from 34 correct responses per min. to 51 correct responses per min., a learning celeration of x1. Again, due to time constraints no intervention took place therefore fluency aim was not reached.

DISCUSSION

The purpose of this experiment was to investigate the effects that two different teaching structures would have on learners' performance of component skills and related compound tasks. The results from both groups of learners clearly show differences in the acquisition of skills under Condition 1 (Component 1, Component 2, Compound Task) generally made greater progress across all 3 tasks than Group 2 participants taught under Condition 2.

Both participants in Group1 (Condition 1) who performed math tasks reached aim on all 3 tasks with fewer teaching sessions than Group 2 participants who performed these tasks. Learner P achieved aim on the Compound Task without any direct teaching. Learner L (Group 2) required more teaching sessions to reach aim on the Compound Task than either Group 1 participants, and did not reach aim on Component Skill 2. Learner C (Group 2) required more teaching sessions than either of the Group 1 participants to reach aim on the Compound Task and did not reach aim on either Component Skill 1 or 2. Learning celerations were generally higher across tasks for Group 1 participants (Mean x1.19) than Group 2 participants (Mean x1.05).

One unexpected finding was that learner L reached fluency aim on Component Skill 1 under baseline conditions. Learning on this task accelerated at x 1.1 without any direct teaching. This effect was not observed in any other Group 2 participants' performance on component skills. One explanation for this finding may lie in the nature of the task itself – see / dot multiples of 2 on a number grid. The practice effect of completing this task during the testing phase of each session may have been enough to allow performance to become fluent. While the effects of achieving fluency aim on the Compound Task may have had some influence on this learner's performance of Component Skill 1, the fact that learner L did not reach fluency aim on Component Skill 2 indicates that fluency in performance of the Compound Task did not have the same effect on the performance of all the components of this task.

Both Group 1 (Condition 1) participants completing reading tasks achieved aim on all tasks with fewer teaching sessions than the Group 2 (Condition 2) participant. Both Group 1 learners reached aim on one task without any direct teaching. Learner J (Group 2) required more sessions under intervention to reach aim on the Compound Task and did not reach aim on either Component Skill 1 or Component Skill 2. Learning celerations on all tasks were generally higher across tasks for group 1 participants (Mean x 1.17) than Group 2 (Mean x 1.1).

While it is impossible to control for all variables when conducting research in applied settings, there are two areas of concern when interpreting these results relating to a possible weakness in the design of this experiment. The repeated exposure to task materials allowed learners many opportunities to perform each task. This would no doubt have resulted in practice effects influencing all participants' performances over time. As stated earlier, practice effects played a role in learner L's performance of Component Skill 1 as she reached fluency aim under baseline conditions. However, the fact that participants in Group 2 did not reach fluency aim on several tasks, and generally had lower learning celerations across tasks rules out the fact the practice effects alone can account for all progress made on tasks.

A second area of concern is that the instruction and practice learners received in their normal classroom setting on a daily basis may have had some effect on their performance of these skills. Again however, the fact that participants in group 2, performing under Condition 2 did not reach fluency aim on several tasks, and had lower learning celerations across tasks indicates that classroom activities did not play a crucial role in performance.

The results for both groups seem to indicate that those participants who were taught each component skill in succession before moving on to a higher-level skill made better progress. They generally required less teaching to achieve fluency aim as they progressed through the programme. On three occasions, aims were achieved without any teaching at all. Learning celerations were higher as a result of less time being required to acquire these skills. Conversely, Group 2 participants required more teaching to reach fluency aims, or did not reach fluency at all in the course of the experiment. Learning celerations were generally lower as more time was required to acquire each skill.

Practice effects aside, these results strongly

Figure 2

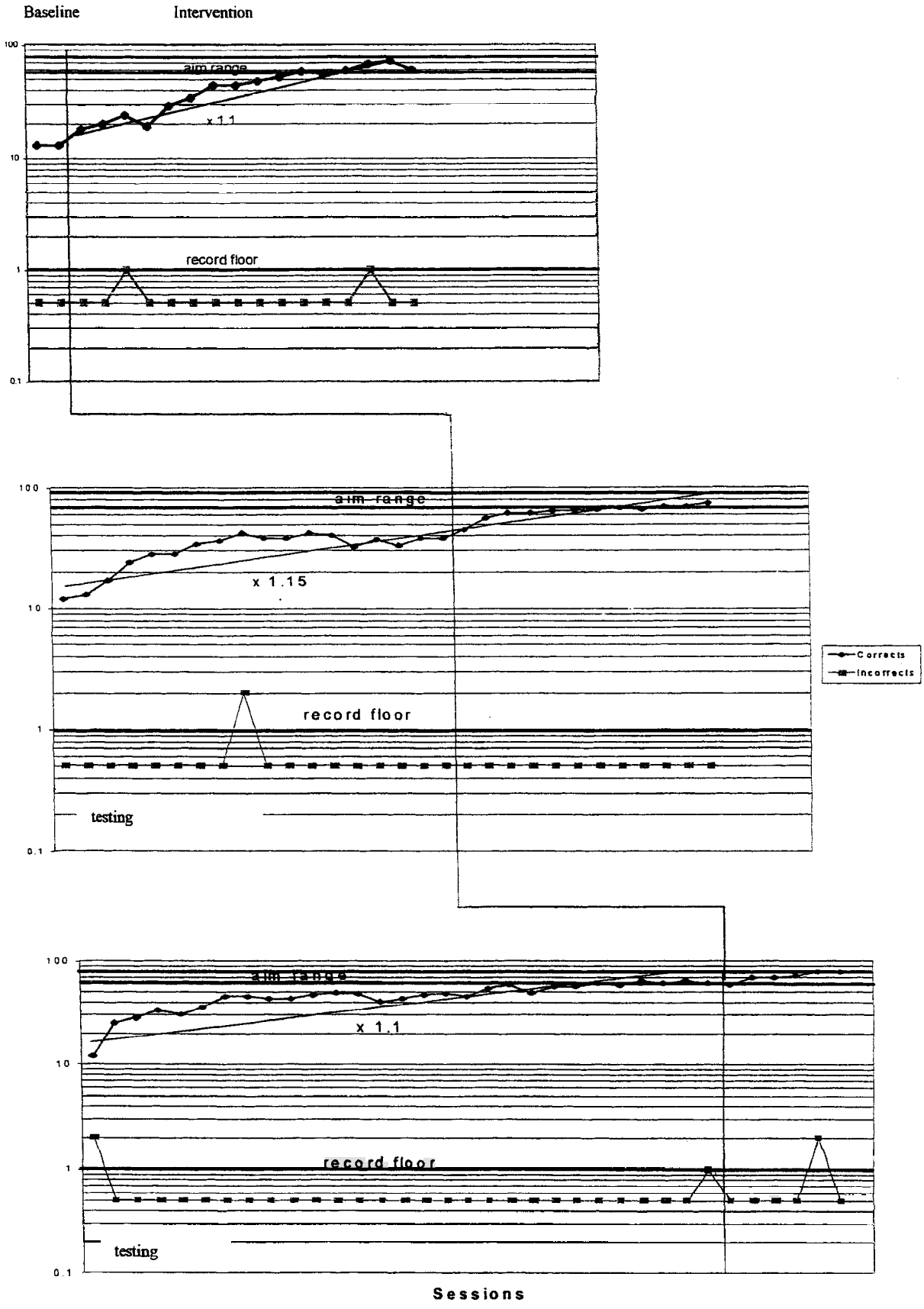

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Figure 3

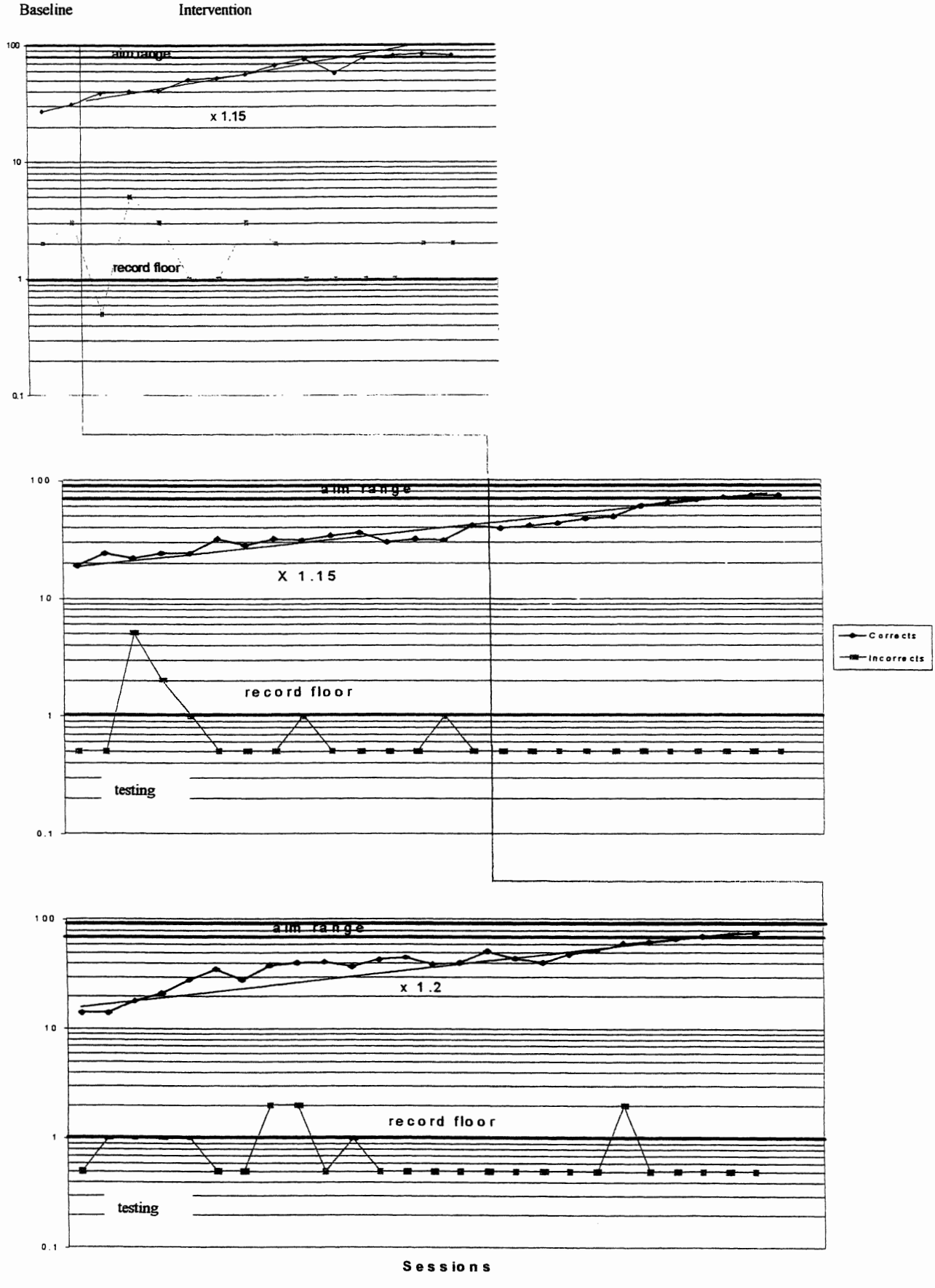
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Figure 4

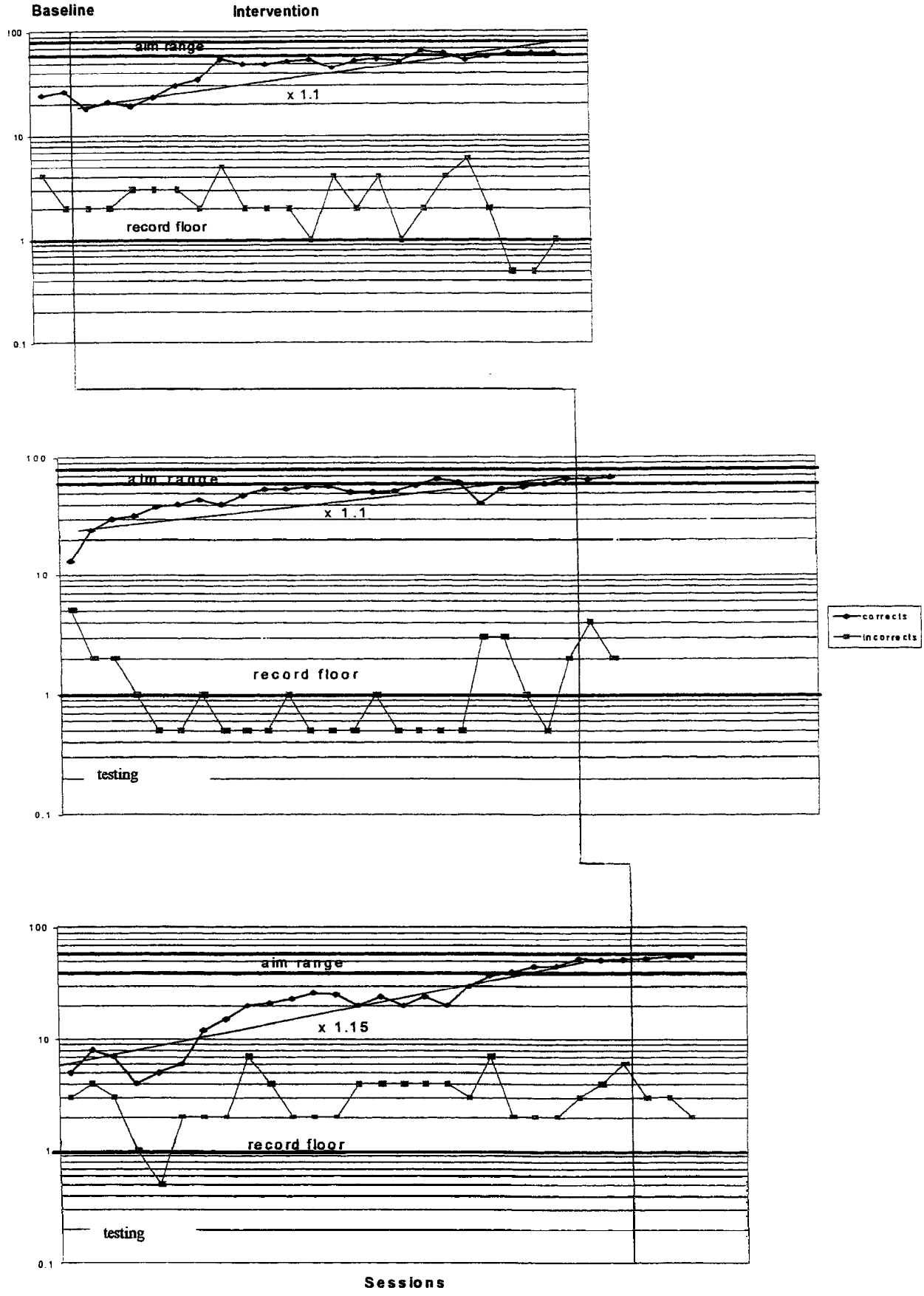
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Figure 5

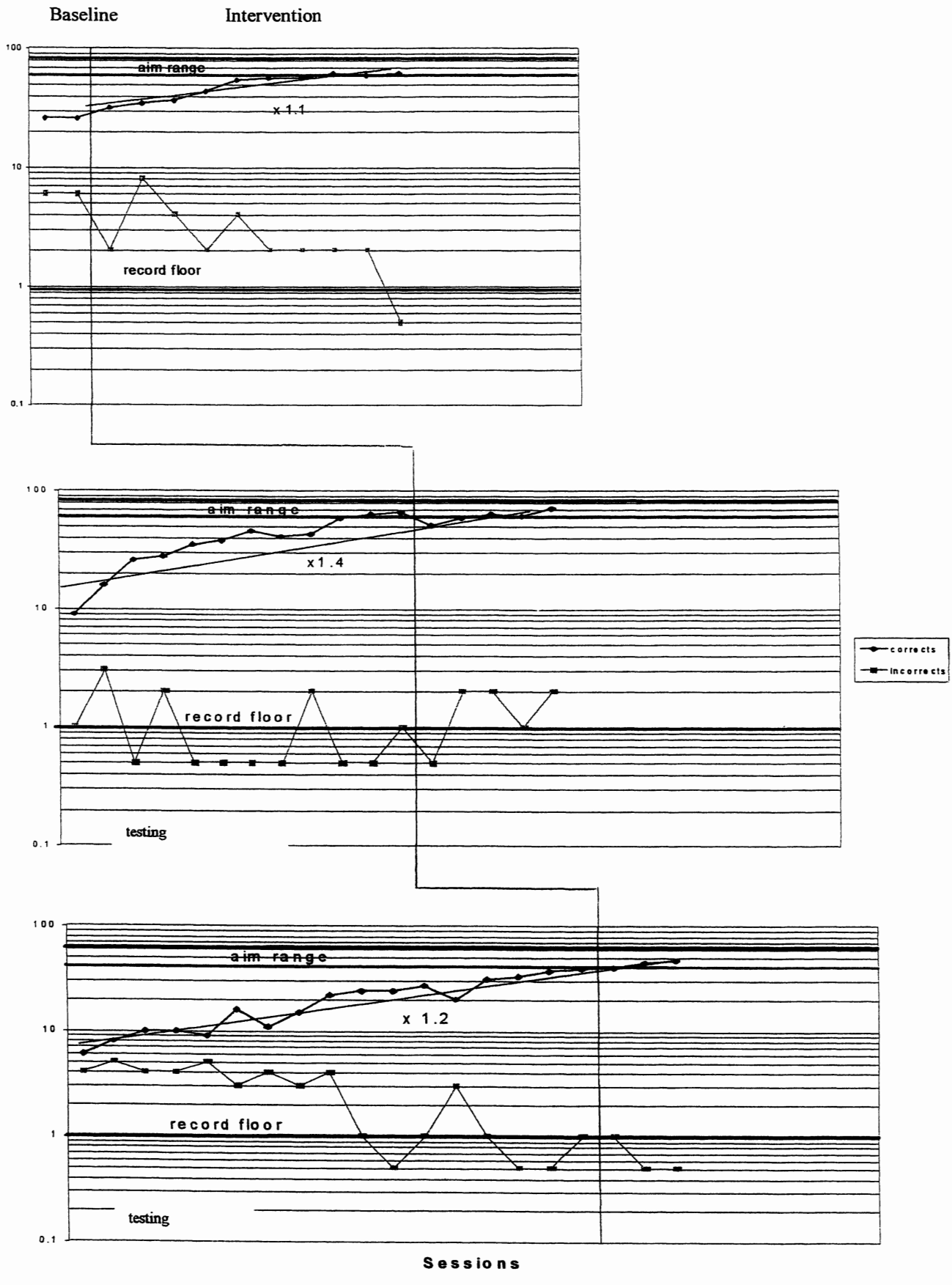
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Figure 6

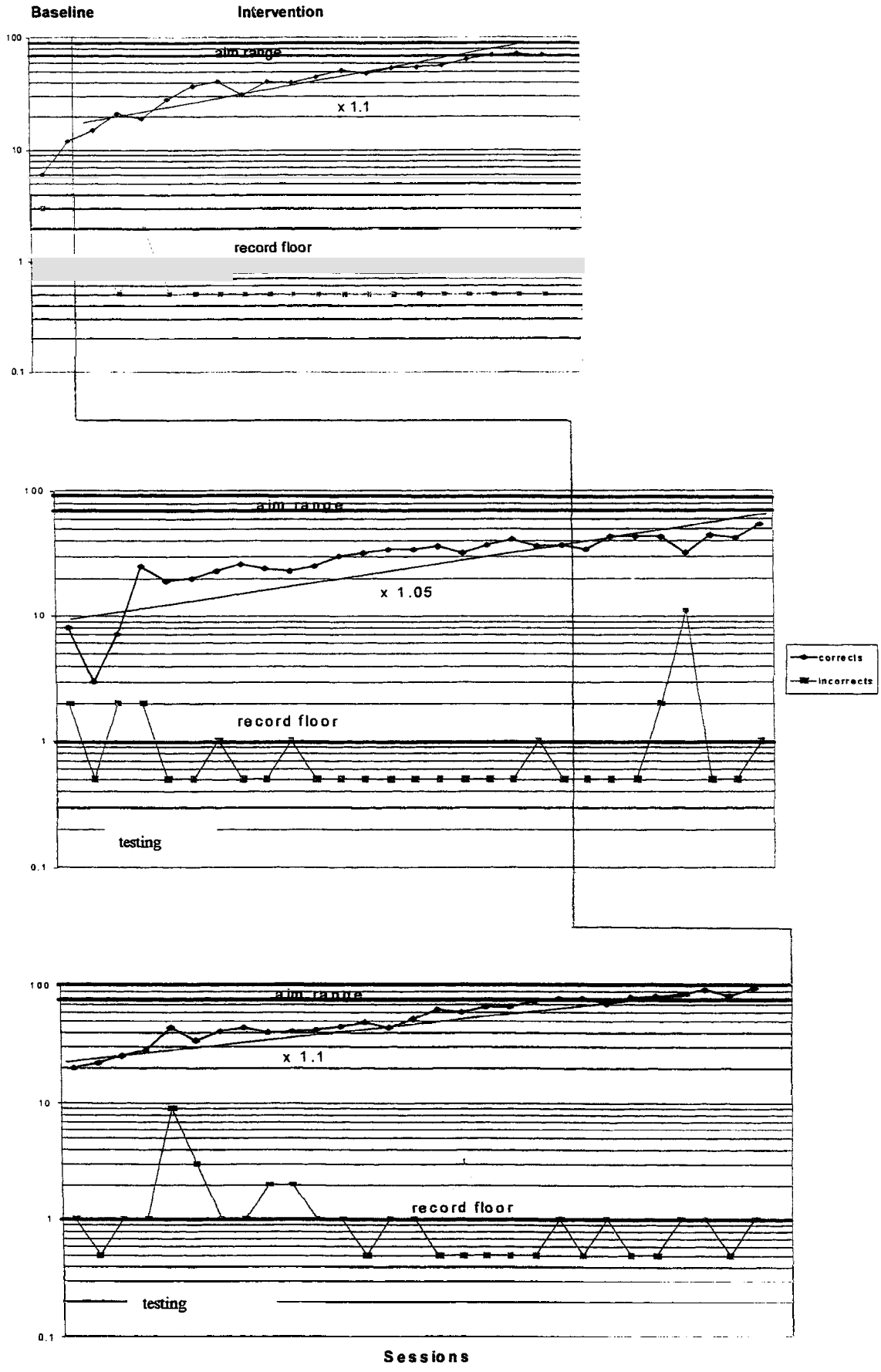
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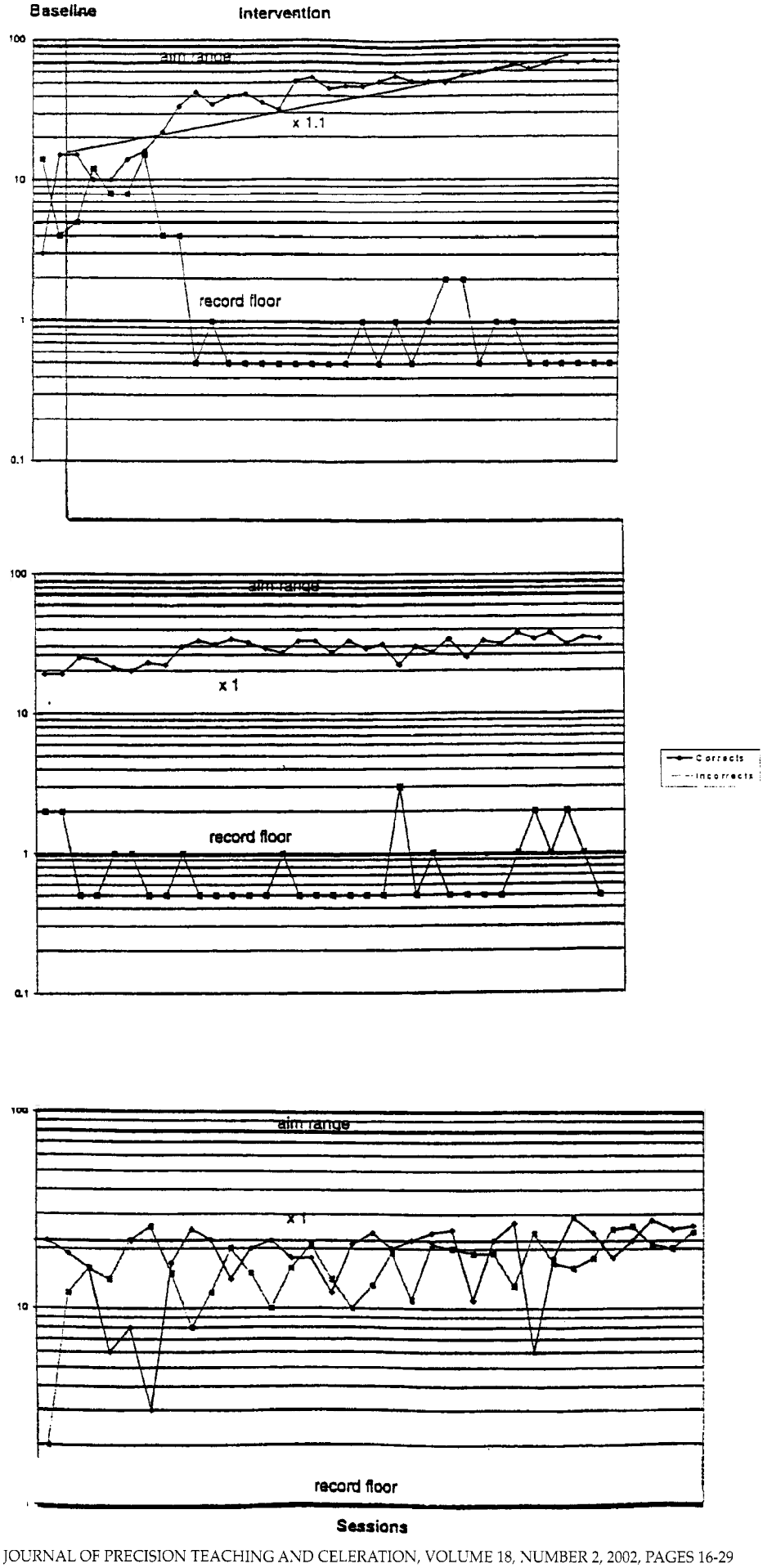
Figure 7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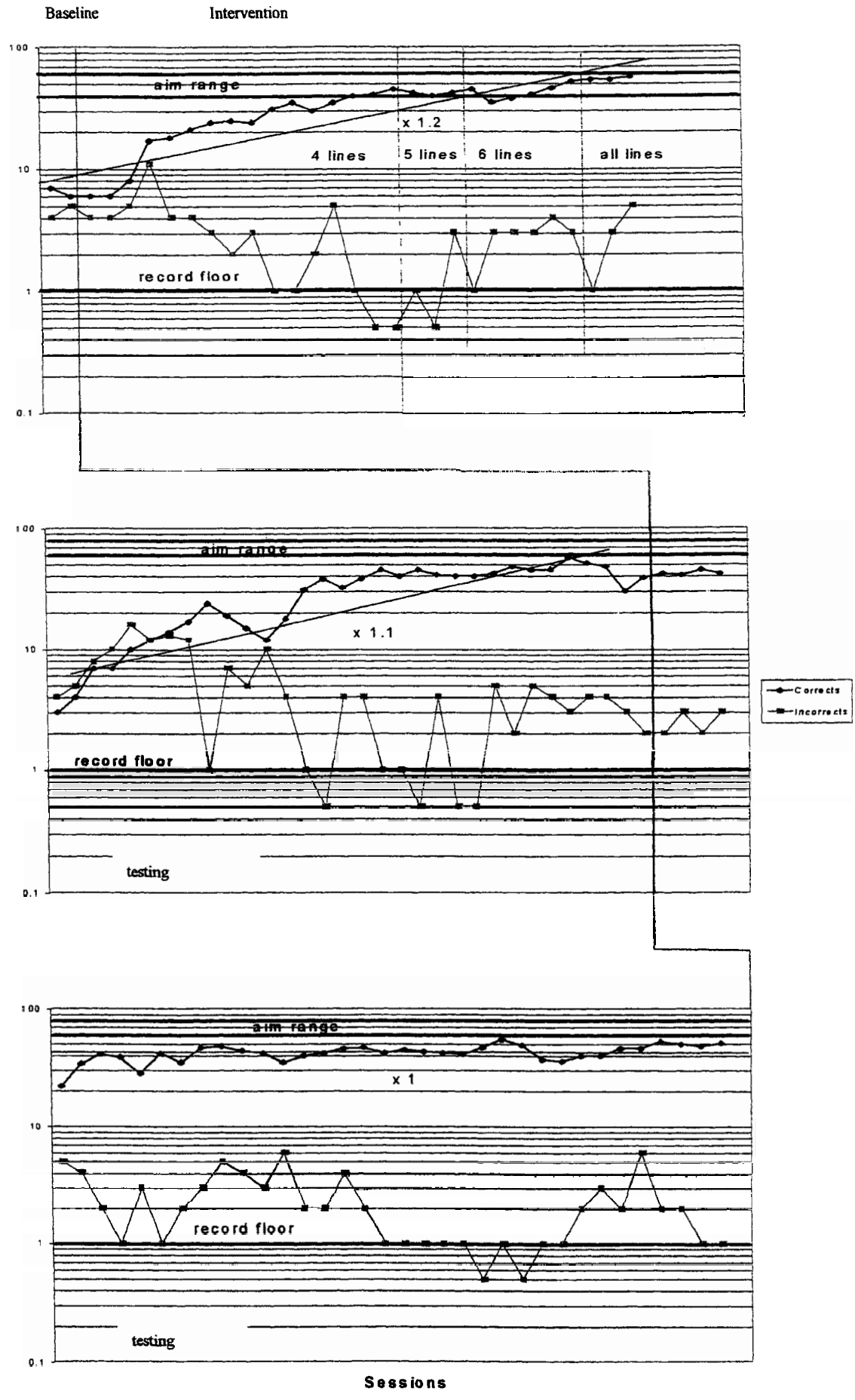
Sessions

Figure 8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Sessions

suggest that fluent component skills have a major impact on learning the higher skills that depend on them. It would appear from this sample of learners that ensuring component skills are taught to fluency eases the acquisition of more complex skills, with some skills being acquired with little or no teaching at all. Oppositely, teaching compound tasks to fluency does not ensure that the learner will be able to perform the components of that skill fluently. These findings support previous evidence highlighting the importance of appropriate curriculum placement. It would appear that simply teaching a composite behaviour to fluency does not ensure that all the components of that behaviour are firmly established in the learner's repertoire of skills. This study emphasises the importance of analysing tasks, identifying each component and structuring the curriculum so that each component is taught to a specific level of fluency before moving on to the next. Rather than being seen as a lengthy, time costly procedure, the evidence from this study suggests that initially ensuring all components are in place actually reduces the time required to teach more complex skills as the learner moves through the curriculum.

Further research is necessary to strengthen this argument. Participants attended two, thirty minute sessions per week and only two component skills were targeted for intervention. Longer, more frequent teaching sessions and the inclusion of more components skills may have produced higher learning celerations on tasks under intervention, which may have resulted in higher celerations on tasks not under intervention. Future studies could also focus on larger groups and across different populations of learners. More important however is the fact that studies may need to design for more control over practice effects and classroom variables to more accurately assess the effect fluency in component skills plays in learning and performing new tasks.

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