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THE EFFECTS OF TIME-CORRELATED BEHAVIOR ON RESPONDING UNDER A PEAK-INTERVAL TRIALS PROCEDURE

by

DAPHNA EL-ROY

A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor in Philosophy, The City University of New York

2004

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Abstract

THE EFFECTS OF TIME-CORRELATED BEHAVIOR ON RESPONDING UNDER A PEAK-INTERVAL TRIALS PROCEDURE

by

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Human adult performance under Fixed-Interval (FI) reinforcement schedules has been hypothesized to be affected by counting or similar time-correlated behavior emitted by the subjects. In this study, the type of time-correlated stimuli that were available was manipulated. Undergraduate Psychology students typed "win" under an FI schedule as they performed a concurrent number-reading task -- pronouncing three-digit numbers that appeared successively on a computer monitor during FI trials. The independent variable was the sequence of these numbers -- a sequential order designed to resemble counting during one experimental condition, and random order to potentially interfere with counting during a second experimental condition. Under a Peak-Interval (PI) trials procedure, unreinforced probe trials were interspersed within blocks of FI trials. These trials allowed for the examination of performance before and after the FI value elapsed. For all four participants in Experiment 1, temporal control of responding was greater during the consecutive-numbers condition versus the random-numbers condition. The mean latency to the first response was closer to 30-s from the beginning of the trial (when 20 numbers had appeared), as opposed to when a reinforcer was first available during FI trials (20-s from the beginning of the trial) across experimental conditions. This outcome suggests that the cumulative number of numbers presented during the trial, rather than elapsed trial duration, controlled participant

performance. To permit dissociation of control of responding by these two variables, the rate at which the number stimuli were presented was manipulated in Experiment 2. Both number sequence (consecutive versus random) and number presentation rate were manipulated. Control by number of seconds was suggested in two of ten participants' data. Control by number of numbers was suggested in three participants' data. The source of control with respect to rate was unclear in the data of five participants.

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The effect of including all names of everyone who had anything to do with the completion of this dissertation, either directly or indirectly, would resemble movie credits – you know it's a production but you realize just how many people were actually involved when you see the scroll-down (and no, I didn't have body doubles…). I tried keeping this mostly to people directly involved in the dissertation though more people would be mentioned if I would account for all those who helped me through the other hurdles, err… requirements to get to this point.

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Some did lots of essential grunt work.
Some were not directly involved, but taught me so I could get to this point.
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THE EFFECTS OF TIME-CORRELATED BEHAVIOR ON RESPONDING UNDER A PEAK-INTERVAL TRIALS PROCEDURE

The Effects of Time-Correlated Behavior on Responding Under a Peak-Interval Trials Procedure

Adult human participants have responded differently from human infants and non-human animals under reinforcement schedules under certain conditions. Several researchers have hypothesized that the difference between the response patterns may be accounted for by adult human verbal regulation, for example, counting (e.g., Laties & Weiss, 1963; and Lowe, Harzem, & Hughes, 1978). In addition to species and age-group differences, there were also individual differences between data within the same age group within species, and within-subject differences. Sources of stimulus control that have been identified for human adult responding under Fixed-Interval (FI) schedules of reinforcement (Ferster & Skinner, 1957) include: (a) performance feedback (e.g., Baron, Kaufman & Stauber, 1969); (b) instructions (e.g., Buskist, Bennett, & Miller, 1981); (c) elapsed time since a reinforcer or a trial onset (e.g., Barnes & Keenan, 1989); (d) concurrent activities (e.g., Barnes & Keenan, 1993); and (e) time-correlated stimuli, both experimenter-provided (e.g., Lowe, Harzem & Bagshaw, 1978), and subject-generated (e.g., Lowe, Harzem & Hughes, 1978). The present study addresses suggestions in the literature that patterns of responding under FI schedules may be affected by verbal mediation strategies, an example of self-generated time-correlated stimuli. Of the variables known to affect response patterns of adult humans on FI schedules, little attention had been directed to experimenter control of verbal mediation strategies (such as counting). This is not surprising, because use of these strategies may be inconsistent and covert.

The role of a verbal mediation strategy has mostly been inferred when its presence and absence were merely correlated with specific response patterns, rather than directly manipulated. The purpose of the present experiments was to analyze performance of human

adults under an FI schedule as they performed a concurrent task involving time-correlated stimuli. During one condition, the stimuli were similar to those produced when participants count (consecutively-ordered numbers). The comparison condition included stimuli that could impede counting, namely, randomly-ordered numbers.

When participants count at a constant rate while performing an operant under an FI schedule, numbers uttered toward the end of the interval are correlated with reinforcement delivery for responding; therefore, those numbers could function as discriminative stimuli for reinforced responding. In this way, counting may result in temporal control of FI responding. Stimulus control is demonstrated when the response pattern varies systematically within the time interval. When participants do not count, there may be no such signals for availability of reinforcement, unless the experimenter provides them. Stimulus control can be shown using a number of measures, such as long post-reinforcement pauses followed by responding when the reinforcer is available, rather than consistent rates of responding throughout the duration of the trial. When long post-reinforcement pauses occur consistently, and participants report counting, it can be inferred that counting might have facilitated stimulus control.

Studies reviewed for this report included human adult (not children or nonhuman) participants responding under simple FI schedules or under the Peak-Interval (PI) Procedure. The instruction to count or the presence of tasks that might interfere with counting was manipulated in these studies, and participants reported counting or engaging in other time-correlated behavior. In previous related research (Laties &Weiss, 1963; Lowe & Hughes, 1979, experiment 5; Barnes & Keenan, 1989, 1993), human adult performance under FI schedules was studied by manipulating concurrent tasks that could potentially affect the likelihood of counting, and by obtaining participant reports of self-initiated counting and other related behavior during FI trials. When no concurrent activity was available 50%-100%

of participant post-reinforcement-pauses were shorter than when a concurrent activity was available and 83%-100% of the participants reported counting.

Although researchers directly measured operant responding under an FI schedule, they did not obtain direct measures of participant counting. Also, when researchers instructed participants to perform concurrent tasks (e.g., Laties & Weiss, 1963), or made activities available (e.g., Barnes & Keenan, 1989, 1993), they did not measure engagement in those activities. Additionally, despite data suggesting that when people count, temporal control of their responding is greater than when they do not count, there were problems in experimental designs that limit the extent to which conclusions can be drawn regarding the effects of concurrent counting on FI performance. One of these flaws was introduction of experimental conditions in the same order across participants, thereby risking sequence effects (e.g., Laties & Weiss, 1963; Lowe & Hughes, 1979, experiment 5; Barnes & Keenan, 1989). Another limitation was that during some conditions, no concurrent task was available and participants reported counting, and in others a task was available and participants did not report counting (e.g., Barnes & Keenan, 1993). It cannot be determined whether the presence of one variable or the absence of the other affected performance under the FI schedule. El-Roy (2001) conducted a study of variables controlling adult human performance under an FI schedule. Participant performance of a concurrent task designed as an analog to counting, and performance of a comparison concurrent task designed to prevent counting were both directly measured. The order of experimental conditions was randomized across participants. Responding of three of six participants was more variable when they performed the task designed to compete with counting, compared to when they performed the analog to counting. The three other participants generally responded at high, constant rates across phases.

A notable limitation in studies during which participants were exposed to FI trials was that the FI trials ended with the reinforced response (e.g., Laties & Weiss, 1963; Lowe & Hughes, 1979, Experiment 5; Lowe, Harzem & Hughes, 1978; Lowe, Harzem & Bagshaw, 1978; Barnes & Keenan, 1989, 1993; El-Roy, 2001). Responding until and during the time when the reinforcer is available can be examined; however, responding cannot be examined after the reinforced response occurs, because the reinforced response ends the trial. This limits the extent to which stimulus control can be examined. To overcome this problem, the Peak-Interval (PI) Trials procedure (Roberts, 1981) was used in the present study. This procedure allows for analysis of responding following the FI target time in addition to responding before and during the FI target time. This procedure involves interspersing probe trials among FI trials. FI and probe trials are identical until the first response after the FI target time occurs. After that response FI trials are terminated, whereas probe trials are terminated at a time pre-determined by the experimenter, independently of participant responding, typically at three times the duration of the FI value. Responding during a probe trial after the time at which a response would have been reinforced during an FI trial provides an opportunity to examine the extent of temporal control over responses as shown by the shape of the probe-trial function.

The highest level of responding (the peak) typically occurs near the time during which a reinforcer is available during FI trials. Rakitin, Gibbon, Penney and Malapani (1998, Experiment 2) conducted a modified version of a PI procedure. Participants were shown a stimulus on a screen and they were instructed to estimate its duration by pressing a key prior to and following the time during which the stimulus had appeared. Rather than interspersing probe trials among FI trials as is typical of the PI procedure, they conducted a training phase followed by a testing phase. During the training phase, the color of a stimulus on a computer

screen was changed from one color to another at the same time during each trial. Participants were instructed to attend to the duration of the stimulus before it changed color. During a subsequent block of probe trials, the stimulus did not change in color. Participants were instructed to center a window of responses before and after the time they thought was identical to the time that the stimulus had appeared before changing color during previous trials. They were instructed to do so by pressing the space bar on the computer keyboard at least four times. Performance feedback was given by the presentation of a graph showing the temporal location of the estimate relative to the actual duration of the stimulus following all trials. Trials terminated independently of responding. Rakitin et al. manipulated the instruction to count or not to count, and presence or absence of a task intended to prevent counting (pronouncing aloud random digits). There were four experimental conditions: (a) count and pronounce numbers; (b) count and don't pronounce numbers; (c) don't count and pronounce numbers; and (d) don't count and don't pronounce numbers. Each participant was exposed to all combinations of these conditions. Rakitin et al. hypothesized that counting would increase the precision of participants' estimation of a time interval. The percent of maximum response rate was plotted as a function of the difference from peak time of responding. All trials of a session were combined into one frequency distribution. The width of the peak function was used to determine the extent of temporal control. For five of seven participants, peak width was narrower during both counting conditions, and narrower still when only estimating without pronouncing digits. These findings suggested that counting enhances temporal control, especially when an activity intended to prevent counting was not required. The occurrence of counting was not directly measured in the Rakitin et al. study, therefore, conclusions regarding its effects on estimating a time interval are limited.

In the two current experiments, participants' responding under a PI procedure was measured, as was performance of a concurrent number-reading task. This direct measurement extends the literature in which researchers: a) relied on participants' reports as evidence of counting, b) provided participants with the opportunity to engage in concurrent tasks, and c) instructed participants to count or to perform a different concurrent task while participants responded under an FI schedule or PI trials procedure. Performance under conditions during which participants performed an analog to counting, was compared to their performance of a structurally similar task that could compete with counting. As an analog to counting, participants pronounced aloud numbers that appeared successively in consecutive order in one experimental condition. They pronounced randomly-ordered numbers during the other condition. Number and rate of number presentation under both conditions was held constant during Experiment 1, so that the number of stimuli per trial was equal but the sequence was different across conditions. During FI trials, typing under an FI schedule was reinforced and terminated trials, when it occurred within the limited hold. During probe trials, interspersed among FI trials, responding was not reinforced and did not terminate the trial. Probe trials provided an opportunity to assess temporal control by examining responding after the time at which a reinforcer was available for responding during FI trials. Consistent with results of previous FI studies in which participants reported counting during one experimental condition and were instructed to perform a concurrent task during another (e.g., Barnes and Keenan 1989, 1993), latencies to begin responding were expected to be longer when participants pronounced consecutive numbers than when they pronounced random numbers in the current experiments. The distribution of response rates is expected to be narrower during the consecutive-numbers condition. Because results of Experiment 1 suggested that participants' responding was controlled by both the structure of the task and the number of numbers presented, the rate at which numbers appeared was manipulated in a second experiment.

Experiment 1

Method

Participants. Participants were four female undergraduate students (age range 18-20) who participated to fulfill a requirement of their introductory Psychology course. All either spoke English as their first language, or had been speaking English for at least ten years. When the participants were recruited, the study was described as a human operant conditioning study.

Setting and Materials. Experimental sessions were conducted in a 284 cm x 223 cm experimental room. No timing instruments were in the room, and participants were asked to remove their personal ones (i.e., watches, beepers, and cellular phones) prior to the experimental session. The participant was seated in front of a computer monitor, keyboard, and mouse. A tape recorder was on the table near the mouse. A bottle of commercially prepared water was available to each participant, should s/he become thirsty. Each student participated once for approximately three hours. Prior to experimental sessions, participants met the experimenter in a separate room for a review of experimental procedures and explanation of the motivational system. Between sessions they returned to the separate room after receiving a message to do so on the computer monitor in the experimental room. The experimenter returned to the experimental room to set up the subsequent experimental session. Following experimentation the experimenter provided items the participant chose in exchange for points earned during the session and debriefed the participant.

Trial and Session Structure. After the experimenter left the instructions on the screen, the participant began every practice trial and the first experimental trial in each session by pressing the space bar. Subsequent trials began with the press of the space bar, but were not preceded by instructions on the screen. A blue rectangle appeared after the participant

pressed the space bar. White three-digit numbers were superimposed on it, appearing successively in the center of the computer screen at a constant rate of .67 numbers per second. Each number remained on the screen until the next number appeared. Numbers either appeared in a random or consecutive order. Trials either ended when the participant typed "win" or after a prespecified time interval.

Experimental Variables and Design. The operant response was typing "win" under a peak-interval trials (PI) procedure. This procedure included fixed interval (FI) 20-s limited hold (LH) 40 s trials, and unreinforced probe trials. Probe trial duration (60 s) was 3 times the FI value. During all trials, participants were required to perform a concurrent number-reading task in which they pronounced three-digit numbers as they were presented on the computer monitor. The two experimental conditions were differentiated by the structure of the number-pronouncing task. The structure of the task was the independent variable. During the sequential trials, the last two digits within the numbers appeared in consecutive order, (e.g., 600, 101, 902 etc.) and during the random trials, the numbers appeared in entirely random order (e.g., 731, 124, 307, etc.). The number range across trials was 100-999, and a computer program was used to create a different random sequence of numbers across trials; random with replacement within each trial. The order of trial type (FI or probe, and consecutive or random number-sequence) was block randomized in four-trial blocks under each experimental condition. There were ten trials of each type, 40 total trials in each of three sessions. The dependent measures calculated from probe trial data were a Discrimination Index, The Semi-Interquartile Range, latency to the first response, peak location and peak frequency. The calculation of these measures is described in the results section.

Procedure.

Motivational System. Prior to experimentation, the experimenter explained to the participants that they could earn points exchangeable for snacks and/or money. Tickets for a lottery were also given, based on the number of points earned. The script used appears in Appendix A. The experimenter provided the verbal explanation as she pointed to the printed menus on the table that matched the verbal description, and to the snack items on the table. The point value of items was labeled. The roll of numbered tickets and colorful bag in which the tickets were to be placed were displayed. Following experimentation, the experimenter informed the participant of the total number of points earned. The tickets were placed in the bag with the tickets of the other participants. The point-exchange menus were repeated, the participant told the experimenter what s/he preferred to receive, and the experimenter gave the participant the requested items.

Training. The participant read instructions printed on the monitor. A typed copy of the instructions was also posted next to the computer monitor where participants could read it during the session, and the letters "win" were posted in the middle of the top frame of the monitor as well. Instructions specified; (a) that the participant was to type "win", (b) that the response needed to be typed only once, if it was typed after 20 seconds from the beginning of the interval (though more responses were allowed), (c) that a message and a cheer would be provided by the computer when the participant typed at the specified time, (d) that numbers seen on the computer screen were to be read aloud with place names (see Appendix B for instructions), and (e) points would not be available during some of the trials. The participant then answered questions the experimenter asked about the instructions (Appendix C) before each practice trial (e.g., "How many times do you have to type "win" to get points?").

The experimenter asked the questions one at a time. If the participant answered a question correctly, the experimenter acknowledged the answer with a praise statement (e.g., "Good") or immediately posed the next question. If the participant answered incorrectly, the experimenter immediately provided the correct answer, until all eight questions were answered. If the participant made any errors, the experimenter reviewed the answers to the questions that had been answered incorrectly and asked the questions again, following the same procedure. The question session continued until the participant made no errors on any of the eight questions, after which one training trial was presented while the experimenter observed.

The participant began the trial by pressing the space bar. An FI 20-s LH 40 s was used during all training trials. During each trial, three-digit numbers appeared successively in the middle of the computer screen at the rate of .67 numbers per second. Each number remained on the screen until the next number appeared. The structure of the task was randomized across training trials.

When the participant finished typing "win" within 20 to 60 seconds from the beginning of the trial, a message superimposed on a light green rectangular background immediately appeared on the computer screen, that read, "Congratulations! You earned a point! Total points: *n*" (where *n* refers to the total number of accumulated points during the session). So long as "n" (the last letter of "win") was typed within 20 to 60 seconds from the beginning of the trial, and was preceded by "wi," the response was reinforced during FI trials. On the same screen was the following statement, "Press the space bar to continue to the next trial." The sound of a crowd cheering accompanied the message. On FI trials during which the participant did not type "win" within 20 to 60 seconds from the beginning of the trial, a message superimposed on a gray rectangular background appeared on the computer screen

when 60 seconds had elapsed. This message read, "Press the space bar to continue to the next trial." No sound accompanied this message. If, during a training trial, the participant did not pronounce the numbers on the screen, the experimenter immediately said, "Remember to say the numbers out loud." Also, if the participant did not type "win," the experimenter waited until after the trial ended, then said, "Remember you need to type "win" after 20 seconds to get points."

If the participant asked how he/she would know when to type, the experimenter referred the participant to the instructions, saying that he/she should try to follow them as well as possible. If needed, the experimenter read the instructions aloud to the participant, and referred the participant to the relevant part of the instructions. Also, when the participant asked when to type, if he or she asked during a practice trial other than the first one, the experimenter repeated the feedback messages that had appeared on the computer monitor when reviewing the instructions. After the participant completed three practice trials during which; a) the participant pronounced numbers with place names aloud without being reminded to do so during the trial and b) the participant received a point, the experimenter said:

> OK, so you completed __ practice trial(s) and you earned 3 points. Here are 3 tickets for the points you earned. Now you're going to work on your own. I'm going to set up some trials for you.

When the instructions for the next condition were on the screen, the experimenter set up the next condition and said:

> Please come out of the room only when the program tells you to come and get me and I'll give you your points. I'll be in the room where we met.

Experimental Trials. Performance feedback on FI trials during experimental trials was identical to that of training trials. On all probe trials, whether the participant typed "win" or

not at any time in the trial, a message superimposed on a gray rectangular background appeared on the computer screen when the trial ended. This message read, "Press the space bar to continue to the next trial." The total number of points for each session was displayed on the screen following the last FI trial within that session. Then the following message appeared on a white background: "Please call the experimenter."

When the participant called the experimenter to the room, the experimenter verified the number of points earned by checking the data file in the computer, said, "You earned __ points, here are the tickets for the points you earned," and gave the participant the tickets. The participant kept the accumulating tickets until the end of the experiment. After a break lasting approximately 5-10 minutes, the participant completed the next session, followed the above-mentioned procedure, until all three sessions were completed. Participants could choose to exchange points for snacks and/or money during each break or at the end of the entire session, most chose snacks at the end of the entire session. During the break, the experimenter changed the audiotapes on which number-reading was recorded. During the next session, the experimenter listened to portions of the tapes to assure that participant had pronounced numbers during the previous session, to determine whether to continue with or terminate experimentation. All participants pronounced numbers, therefore no sessions were terminated by the experimenter.

Interview and Debriefing. At the end of the entire experiment, the experimenter (a) thanked the participant for participating, (b) asked the participant questions about the strategies s/he used (Appendix D), (c) recorded the answers verbatim, and (d) debriefed the participant.

Measurement and Interobserver Agreement. The number of complete correct "win" responses occurring within 3-s consecutive time bins within PI trials was calculated. The

audiotapes were scored to determine the number of numbers pronounced with place names. The means and ranges of the percentages of numbers pronounced with place names during all 10 probe trials appear in Table 1. The means were 94.25-99.75% across participants 1-3, and were 48.25-87.25% for participant 4. Although the mean percentage of numbers pronounced was higher during the consecutive-numbers condition for all sessions for all participants, the difference was not significant ($p>.05$). Interobserver agreement was calculated for number of numbers pronounced correctly with place names by dividing the lower number by the higher number of numbers judged to be pronounced per trial during 30% of probe trials (selected using a random-number table) by two independent observers during all three sessions for all participants. These data appear in Table 2. The means were 90.83-100% across participants 1-3, and were 78.25-95.64% for participant 4.

Results

Discrimination Index

As a preliminary measure of temporal discrimination during probe trials, a discrimination index (Meck & Church, 1984) was used. It was calculated by dividing highest mean number of responses within a 3-s time bin across probe trials by the mean number of responses in all 3-s time bins for each participant in each session. The higher the value, the higher the temporal discrimination. Discrimination index data appear in Table 3. The discrimination index (DI) was higher during the consecutive-numbers condition for all participants during all sessions with the exception of session 1 for participant 3, the only statistically significant effect was the main effect for session ($p<.05$). Across participants, the DI increased across sessions. This characterized most of the data for participants 1-3 but not for participant 4.

Semi-interquartile range

To examine variability of responding as shown by spread of the function, the Semi-Interquartile Range (SIQR) was calculated by calculating the difference between elapsed trial duration of the 25th and 75th percentile of cumulative responses, and dividing that difference by 2. The higher the SIQR value, the larger the spread of the function it was calculated from, the more variable the data.

Semi-interquartile range data for participants 1-4 appear in Table 4. Although the SIQR was mostly higher during the random-numbers condition (exceptions occurred during session 1 for participants 1, 3, and 4), the main effect of task structure was not statistically significant ($p>.05$). There was a significant main effect of session ($p<.05$). The SIQR decreased across sessions across participants. This characterized most of the data for all four participants. There was a significant interaction between session and task structure ($p<.05$). Across participants, the SIQR was higher during the consecutive-numbers condition compared to the random-numbers condition during session 1, and lower during sessions 2 and 3. The only exception to this data pattern was session 1 for participant 2. There was a significant negative correlation between the DI and SIQR measures; the higher the DI, the lower the SIQR.

Latency to the First Response

The latency to the first response was calculated as latency from the spacebar press until the first time in the trial during which "n" was typed following typing of "wi." These data appear in Table 5. Although the latency to the first response during probe trials was mostly greater during the random-numbers condition compared to the consecutive-numbers condition (exceptions were session 3 for participants 1 and 4, and session 3 for participant 2), this effect was not statistically significant ($p>.05$). There was, however, a main effect of session ($p<.05$), mostly an increase in latency across sessions for all participants. Across conditions

participants mostly began responding closer to the time after which 20 numbers had appeared on the computer screen (28.5-s), rather than the time during which reinforcers were available (20-s) (El-Roy, 2003). Exceptions occurred during session 1 for participants 3 and 4, consecutive-numbers condition during session 1 for participant 1. The standard deviations of the latency until the first response are shown in Table 6. The standard deviation generally decreased across sessions (exceptions were during the random-numbers condition, from session 2 to 3 for participant 1, session 1 to 2 for participant 2). The standard deviation was mostly greater during the random-numbers condition for all four participants (exceptions were session 1 for participants 1, 2, and 4, and session 2 for participant 3).

Mean percentage of the maximum frequency of responding

In Figures 1-4 the mean percentage of the maximum frequency of Experiment 1 participants' typing "win" within 3-s time bins is shown. Data were averaged across 10 consecutive-number probe trials (filled circles) and 10 random-number probe trials (unfilled circles) for sessions for which the DI was at least 2. Data excluded from further analysis are shown in Appendix E. The time from which a reinforcer was available for responding during FI trials (20-s) is shown with an arrow labeled 20-s. A second, filled arrow indicates the time bin during which 20 numbers appeared on the computer screen since the beginning of the trial.

Peak Location

Response peaks were defined as the mean maximum percentage of responding across the ten probe trials within a 3-s time bin. When there were two such peaks, the peak location was defined as the midpoint between these peaks (3 of 20 peaks were calculated this way, as noted in Table 7). The difference between the peak locations across consecutive and random probe trials was not significant ($p>.05$). Peaks occurred later during the random-numbers

condition for participants 1 and 4; peak locations were mixed across sessions for participants 2 and 3.

Peak Frequency

The total peak frequency of responses was calculated as the total number of responses across probe trials within the 3-s during which the greatest number of responses occurred. These data appear in Table 8. The difference between total peak frequencies within 3-s bins across consecutive and random probe trials was not significant ($p>.05$). When there was a difference between the frequencies across conditions, the direction was mixed across participants. Frequency of peak responses mostly increased across sessions for participants 2-4.

Participant reports

Three participants (participants 1, 2, 3) reported typing when the number 20 appeared during the consecutive-numbers trials. During the random-numbers condition, three participants reported typing when the twentieth number appeared (participants 1, 2, and 3), counting seconds (participants 1, 2 and 3), and typing after "a bunch of numbers went by" (participant 4).

Procedural problems

Due to equipment malfunction, cheers occurred inconsistently when points were earned, but the percentage of reinforced FI trials during which cheers were presented, according to the audiotapes of the experimental sessions, between the consecutive and random conditions, was not significantly different ($p>.05$). Participant 1's number-pronunciation during the second session was not audiotaped.

Discussion

The contribution of this study is the direct measurement and control of time-correlated behavior that differentially affected performance under a PI procedure. All participants' responding under the PI procedure was differentiated across experimental conditions, showing greater temporal control during the consecutive-numbers condition. This was shown by higher Discrimination Indices and lower Semi-interquartile ranges during the consecutive-numbers sessions compared to the random-numbers condition. Less variable responding during consecutive-numbers condition, as shown by lower SIQR scores, is consistent with Rakitin, Gibbon, Penney, Malapani, Hinton and Meck's (1998) finding that response distributions of percentage of maximum response rate were narrower when participants in their modified peak-intervals trials procedure were instructed to count compared to when they were instructed to pronounce random digits. Temporal control increased across sessions, as shown by successively higher DIs and lower SIQRs.

As shown in Table 5, all participants typically began to respond later during probe trials in the random- versus consecutive-numbers condition. These results are inconsistent with findings in the human FI literature when participants responded later when a concurrent task was unavailable and they reported counting than when a concurrent task was available during FI trials (e.g., Laties and Weiss, 1963; Barnes and Keenan 1989, 1993). The standard deviations of the latency until the first response were mostly greater during the random-numbers condition. These results are consistent with the human FI literature.

Participants mostly began typing after 20 numbers had appeared on the computer screen from the beginning of the trial (approximately 30-s) during the consecutive-numbers condition, rather than at the time at which reinforcers were available for responding (20-s) and earlier during the random-numbers condition. This suggests that participants' responding

was controlled by number of stimuli that appeared on the computer screen, rather than by number of seconds from the beginning of the trials until reinforcers were first available. The participants had been specifically instructed that their responses following 20 seconds from the beginning of the trials would be reinforced. If participants attempted to time 20-s by counting the numbers, this may account for their tendency to respond after 20 numbers had appeared.

The difference between the consecutive-numbers condition and the random-numbers condition was the sequence of numbers. The difference between responding under both conditions could be attributed to the appearance of certain numbers when the reinforced response occurred during the consecutive-numbers condition. Those numbers may have signaled the availability of a reinforcer for responding. This could explain the greater temporal control of participants' responding under the consecutive-number conditions, as demonstrated by lower variability compared to the random-numbers condition. The numbers that appeared when a response was reinforced during the random-numbers condition, were different during every trial. The number of numbers was the same under both experimental conditions, therefore, the number of numbers could have potentially been a discriminative stimulus during both conditions.

The consecutive numbers that participants were required to pronounce aloud at a constant rate were intended to serve as an analog to counting. One limitation of this study is that control by time versus number of stimuli can't be separated because the stimuli are presented at a constant rate and the number of stimuli at any given time will be perfectly correlated to a given number of seconds. Presenting stimuli at an irregular rate could solve this problem, but presentation of numbers at a random rate would result in an analog that would not resemble counting to the same extent as presentation of numbers at a constant rate.

To examine whether the number of numbers, rather than time, controls responding, the rate at which the numbers that participants pronounce are presented was manipulated in Experiment 2. Location of response peaks independent of cumulative number of numbers, would eliminate cumulative number of numbers as a source of control over time-correlated responding. Response peaks that occur near the time during which a certain number of numbers appeared, varying as a function of the rate of number presentation, would implicate number of numbers as a source of control of participants' responding.

Experiment 2

Method

Participants, Setting and Materials. Participants were 16 undergraduate students (9 male, 7 female, age range 18-38) who participated to fulfill a requirement of their introductory Psychology course. When the participants were recruited, the study was described as a human operant conditioning study. The setting and materials were identical to those in Experiment 1.

Experimental Variables and Design. The two independent variables were the structure of the number-pronouncing task (consecutively- or randomly-ordered numbers), and the rate at which the numbers were presented (.67 numbers per second, or .44 numbers per second). The response, number-reading task, and feedback procedure were identical to those in Experiment 1. The PI procedure in Experiment 2 included FI 15-s LH 30-s trials and unreinforced probe trials. Probe trial duration (45-s) was 3 times the FI value. Half of all trials were FI and half were probe trials. Both FI and probe trials were further divided into four trial types: (a) fast-rate, consecutive-numbers, (b) fast-rate, random-numbers, (c) slow-rate, consecutive-numbers, and (d) slow-rate, random-numbers. Accordingly, there were

eight types of trials in all. These were block-randomized in eight-trial blocks. There were 64 trials per session, and three experimental sessions.

Procedure. The procedure was identical to that of Experiment 1, with the following exceptions: (a) the instructions specified that the response should be typed after 15 seconds (as opposed to 20-s) from the beginning of the trial; (b) participants were required to complete a block of four training trials (one of each trial type) in which they received points for typing "win" and during which they pronounced the numbers; (c) a debriefing question following the experiment that pertained to the rate at which stimuli were presented was added; (d) eight experimental trials of each type were presented (as opposed to 10 trials of each type); (e) no cheers were presented and no instructions regarding cheers were included in the instructions for four participants (13-16); (f) additional items were added to the snack choice menu for the four participants (13-16); and (g) Interobserver agreement data were obtained for 25% of probe trials (as opposed to 30% of probe trials).

The means and ranges of the percentages of numbers pronounced with place names during all eight probe trials appear in Tables 9 (fast-rate trials) and 10 (slow-rate trials). The means for the fast-rate trials were 80.42-100% across participants, with the exception of all but the consecutive-numbers condition during session 1 for participant 5, and all but the consecutive-numbers condition during session 3 for participant 10. The means for the slow-rate trials were 85-100%, with the exception of sessions 2 and 3 for participant 5, and the consecutive-numbers condition during session 3 for participant 10. Interobserver agreement data appear in Table 11 (fast-rate trials) and 12 (slow-rate trials). The means for the fast-rate trials were 80.16-100% across participants, with the exception of session 3, random-numbers condition for participant 15. The means for the slow-rate trials were 83.33-100% across participants, with the exception of session 2 for participant 1.

Results and Discussion

Discrimination Index

Discrimination index data, computed as in Experiment 1, appear in Table 13. The only significant effect was the main effect for session ($p<.05$). The DI increased across sessions across participants. This finding is consistent with results of Experiment 1. The DI increased across most sessions for 12 of 16 participants (participants 1-3, 5, 7, 8, 10-14, and 16). For 6 of 16 participants the DI was mostly higher during the consecutive-numbers condition compared to the random-numbers condition (participants 2, 4-6, 8, 11). Although this finding was more consistent across participants in Experiment 1, only one independent variable was manipulated in Experiment 1 versus two in Experiment 2.

Semi-interquartile Range

Semi-interquartile data appear in Table 14. There was a significant effect for session ($p<.05$), the SIQR decreased across sessions across participants. This finding is consistent with the results of Experiment 1. Fourteen of 16 participant's data mostly showed this effect (exceptions were participants 6 and 9). There was a significant interaction of session by structure ($p<.05$), across participants the SIQR was greater during the random-numbers condition compared to the consecutive-numbers condition during session 3, consistent with results of Experiment 1. As opposed to results of Experiment 1, however, the SIQR across participants was greater during the random-numbers condition during session 1, and lower during session 2. Eleven of 16 participants' data showed this for the most part (exceptions were participants 3, 6, 8, 11, and 14).

There was a significant negative correlation between the DI and SIQR; the higher the DI, the lower the SIQR, consistent with the results of Experiment 1.

Latency to the First Response

Latency to first response data appear in Table 15. There was a significant main effect for task structure ($p<.05$). Latencies during the random-numbers condition were longer than those during the consecutive-numbers condition across participants, consistent with the result of Experiment 1. This effect was evident during most of the sessions for 8 of the 16 participants (participants 1, 3, 5, 6, 7, 10, 12, and 14). These results are inconsistent with findings in the human FI literature when participants responded later when a concurrent task was unavailable and they reported counting than when a concurrent task was available during FI trials (e.g., Laties and Weiss, 1963; Barnes and Keenan 1989, 1993).

There was also a significant main effect for rate ($p<.05$). Latencies during the slow-number-presentation-rate condition were longer during most of the sessions for 11 of the 16 participants (participants 4, 5, 7, 9, and 10-16). Five participants (participants 5, 7, 10, 12, and 14) showed both of these effects. The finding of longer latency to first response during the slow-number presentation-rate condition is consistent with the hypothesis that the number of numbers presented controlled responding.

The standard deviations of the latency until the first response are shown in Table 16. The standard deviation was mostly greater during the random-numbers condition compared to the consecutive-numbers condition for nine of the 16 participants (participants 1, 2, 5, 6-9, 15, and 16). This effect was more consistent across Experiment 1 participants, but there were fewer participants and only one independent variable had been manipulated in Experiment 1.

Mean percentage of the maximum frequency of responding

Figures 5-14 show the mean percentage of the maximum frequency of typed "win" responses during consecutive-numbers trials (left panels) and random-numbers trials (right

panels) within 3-s time bins averaged across eight fast-number-presentation-rate probe trials (filled circles) and eight slow-number-presentation-rate probe trials (unfilled circles). Graphs are presented for the ten participants for whom the DI was at least 2 during all four experimental conditions within one session. For each participant, data are presented for only those sessions with DI $\geq$ 2. Data excluded from further analysis are plotted in Appendix E. The time from which a reinforcer was available for responding during FI trials (15-s) is shown with an arrow above which 15-s is typed. Two additional arrows indicate the time bin during which 15 numbers appeared on the computer screen since the beginning of the trial: a filled arrow showing that time during the fast-number-presentation-rate condition, an unfilled arrow showing that time during the slow-number-presentation-rate condition.

Peak locations

Peak location data appear in Table 17. When there were two such peaks, the peak location was defined as the midpoint between these peaks (13 of 88 peaks were calculated this way, as noted in the table). The differences in peak locations were not statistically significant. With respect to the task structure manipulation, the relative location of consecutive-numbers condition peaks compared to random-numbers condition peaks was not systematic. With respect to the rate manipulation, based on visual inspection, three patterns in peak data emerged: a) control by time, b) control by number of numbers, and c) no apparent effect of rate.

Control by numbers of seconds. Control by number of seconds is suggested by response peaks occurring at the same location, regardless of experimental condition and near the time during which reinforcers were initially available for typing "win." For participants 7 and 8, peaks occurred in the same location, during both fast and slow number-presentation-rate conditions. Participant 8's peaks occurred after 15 seconds elapsed since the beginning of the

trial and functions were narrow during sessions 2 and 3. Participant 7's peaks occurred later in the interval and functions were wider than those of participant 8. The exception was the random condition of session 1 (to be discussed further in the next section). Participant 8 reported counting seconds during sessions 2 and 3 (but not during session 1), and Participant 7 reported counting seconds.

Control by number of numbers. Control by number of numbers is suggested by peaks occurring earlier during the fast-number-presentation-rate condition, compared to peaks during the slow-number-presentation rate condition. This occurred in participant 9's data, during both consecutive and random conditions within the two sessions to which he was exposed. This participant reported typing when the number 15 appeared during consecutive-number trials. For participants 5 and 12, response peaks generally occurred earlier during the fast-rate condition compared to the slow-rate condition. Exceptions were peaks overlapping during session 1 during the random-numbers condition for participant 5, and during the consecutive-numbers condition for participant 12. Participant 5 reported typing when numbers 16 and 17 appeared during the consecutive-numbers condition and guessing during the random-numbers condition. Participant 12 reported attempting to count seconds at first, and typing when the number 8 or 9 appeared during the consecutive-numbers condition. For participant 8 the source of stimulus control of responding under the random-numbers condition could have shifted from control by number of numbers during session 1 to control by number of seconds during sessions 2 and 3. During the random condition in session 1, the peak occurred earlier during the fast condition compared to the slow condition, and peaks in the later sessions occurred closer to the time during which 15 numbers appeared since the beginning of the trial. The support for the conclusion that number of numbers as a source of

stimulus control would have been stronger, however, had peak location been differentiated during the consecutive condition as well for this participant.

Unclear source of stimulus control. Peaks occurred earlier during the fast-rate condition for the random-numbers condition only for participant 11, and overlapped during the consecutive-numbers condition. This participant reported not using any strategy to facilitate typing when 15 seconds elapsed from the beginning of the trial, aside from an unsuccessful attempt to try to count seconds. Half of the peaks for participants 1 and 2 occurred earlier during the fast-rate condition compared to the slow-rate condition, and half occurred later. Participant 1 reported unsuccessfully trying to count seconds initially and trying to count numbers as well. Participant 2 reported attempting to count seconds. For participant 3, peaks were earlier during the slow-rate condition. Though this finding is not consistent with the hypothesis that number of numbers would control responding, it is consistent with the literature on the filled-duration illusion (e.g., Buffardi, 1971), demonstrating that durations containing more stimuli were judged as longer than durations containing fewer stimuli. Participant 3 reported mostly successfully counting seconds and typing after the 14th number appeared. Finally, for participant 13, peaks occurred within the final two 3-s time bins.

Conclusions from data based on this classification of patterns of stimulus control by relative peak location during the fast-number-presentation-rate condition compared to the slow number-presentation rate condition did not systematically correspond with stimulus control based on latency to the first response. There were participants whose data belonged to the control-by-number-of-numbers (participants 5 and 12), control-by-time (participants 7 and 8), and unclear-control (participants 11 and 13) groups as well as participants whose data did not meet criteria for inclusion in the peak location analysis (participants 4, 10, and 14-16),

whose latencies to respond were mostly longer during the slow-number-presentation rate condition compared to the fast-number-presentation-rate condition.

Peak frequency

Peak frequency data appear in Table 18. There was a significant main effect for structure ($p<.05$). The peak frequency during the consecutive-numbers condition was higher compared to the random-numbers condition across participants. Of the data included in this analysis, most of the sessions for six of ten participants showed this effect (participants 1, 3, 7, 11, and 12). This is inconsistent with Lowe and Hughes' (1979, experiment 5) finding of higher response rates when participants were required to pronounced randomly-ordered numbers compared to when they were not required to do so. There was also a significant main effect for rate ($p<.05$). The peak frequency was higher during the fast-number-presentation-rate condition compared to the slow-number-presentation-rate condition across participants. Of the data included in this analysis, most of the sessions for five of ten participants showed this effect (participants 2, 5-8, and 12). Two participants' data showed both of these effects (participants 7 and 12).

Procedural problems

Due to equipment malfunction, cheers occurred inconsistently when points were earned, but the percentage of reinforced FI trials during which cheers were presented, according to the audiotapes of the experimental sessions, between the fast consecutive and random conditions, slow consecutive and random conditions, consecutive fast and slow conditions and between random fast and slow conditions, was not significantly different ($p>.05$). Analyses that could not be conducted due to computer problems included fast-rate data during session 2 for participant 10. The percentage of numbers pronounced across participants was higher during the consecutive-numbers conditions compared to the random-numbers

conditions (significant main effect of structure, $p<.05$). This effect was evident in most sessions for 11 of 16 participants (participants 1-7, 12, 14-16). There was also a significant interaction of session by rate ($p<.05$). The percentage of numbers pronounced across participants was higher during the fast-number presentation rate condition during sessions 1 and 3, higher during the slow number-presentation rate condition during session 2. This effect was only evident for most sessions for participant 2.

General Discussion

The purpose of this study was to provide an observable analog to covert human behavior (though also acknowledging participant reports of covert behavior) to extend the existing literature and discussion of the role of private events in overt behavior. These two experiments expand the adult human FI and PI literature in which concurrent tasks were manipulated and counting was instructed by experimenters or reported by participants. First, they demonstrate by measuring performance of the concurrent task directly, that the task was indeed performed by the participants, and the question of the effects of manipulating the concurrent task is then possible to address. Rather than characterize the data by labeling the data patterns (e.g., scallops), a subjective practice (Hyten & Madden, 1993), data were described objectively in this study.

Although the random-number-reading concurrent task was intended to interfere with participants' counting in the current study, some participants reported counting during that condition nonetheless. Further, when an analog to counting was provided, some participants reported some form of counting in addition to pronouncing the numbers on the screen (e.g., counting simultaneously, tapping foot, etc.). Counting during a task intended to disrupt counting is consistent with reports in the FI literature; four of six participants in Laties and Weiss' (1963) study reported using the remainder in the concurrent subtraction task they

performed to time the interval. One of their participants reported counting while performing the concurrent task. In Barnes and Keenan's (1993) Experiment 1, one of two participants reported using reading passages to help him type at a particular time. The extent to which participants in the present study initiated, persisted and were able to count numbers and or seconds while pronouncing numbers could have affected their response patterns, in addition to effects of manipulation of the independent variables.

Results of Experiment 1 in the current study demonstrated that when participants pronounced consecutively-ordered numbers, temporal discrimination of responding under a PI procedure was greater than when they pronounced randomly-ordered numbers. Data that showed this effect were discrimination index scores, larger during the consecutive-numbers condition, and semi-interquartile range scores (a measure of the spread of the function), smaller during the consecutive-numbers condition. During both Experiments 1 and 2 the DI increased across sessions, and the SIQR decreased across sessions, indicating increasing acquisition of stimulus control. The DIs were more consistently higher during the consecutive-numbers condition compared to the random-numbers condition during Experiment 1 compared to Experiment 2. During both experiments the latency to the first response was mostly greater during the random-numbers condition, compared to the consecutive-numbers condition.

Responding in Experiment 1 seemed to be controlled by the number of numbers that were presented for the participants to pronounce. Responding based on number of stimuli rather than number of seconds might have been a result of instructing participants to wait a specific number of seconds before beginning to type. It is possible that stimuli controlling participants' responding would have been different had the instructions not included specification of the time interval, but instruction specificity was not manipulated in this study. To examine the hypothesis that number of numbers that appeared controlled responding, the rate at which numbers were presented was manipulated in Experiment 2 and the locations of peaks of functions during the fast-rate and the slow-rate conditions were compared. The rates of number presentation during probe trials and FI trials were identical in this

study. To further demonstrate that number of numbers controlled responding, a future study could include probe trials during which the rates of number presentation were different from those during the reinforced trials.

The latency to the first response was mostly longer during the slow-number-presentation rate condition compared to the fast-number-presentation-rate condition. This supports the hypothesis that the number of numbers presented controlled responding. For three participants, peaks consistently occurring earlier during the fast-number-presentation rate compared to the slow-number-presentation-rate conditions suggested control by number of numbers. Two participants showed overlapping peaks across conditions occurring close to the time during which reinforcers became initially available, consistent with control by number of seconds. Data from the remaining five participants did not clearly implicate number of seconds or number of numbers as controlling stimuli.

There were participants whose data were unclear with respect to the stimulus rate manipulation. It is possible that response patterns would have been more consistent across participants in Experiment 2 as it had been in Experiment 1 if only rate had been manipulated. Instead, the rate manipulation was conducted in conjunction with manipulation of number sequence (consecutive and random). Rakitin et al. (1998, Experiment 2), however, manipulated two variables and data to be differentiated for five of seven participants and undifferentiated for the remaining two participants.

Because they are covert, private responses do not readily lend themselves to experimental analysis. Similarly to observable stimuli, they may exert discriminative control. Alternatively, they may merely co-vary with the operant response, or have no systematic relationship with observable responses (Anderson, 2000). Baron and Perone (1982) and Barnes and Keenan (1989, 1993) acknowledged that though covert behavior exists, it cannot be used to explain findings and that accordingly, researchers should attempt to achieve reliable measures of events that are not directly observable.

Table 1

Means and Ranges of Percentages of Numbers Pronounced Across Ten Probe Trials by Experiment 1 Participants

Participants	Session	Consecutive-numbers condition		Random-numbers condition	
		Range	Mean	Range	Mean
1	1	97.50-100	97.75	87.50-100	95.25
	2	--	--	--	--
	3	95.00-100	97.75	85.00-100	94.25
2	1	87.50-100	97.75	90.00-100	97.00
	2	92.50-100	98.25	92.50-100	97.25
	3	97.50-100	99.25	92.50-100	97.75
3	1	97.50-100	99.75	87.50-100	96.75
	2	97.50-100	99.00	92.50-100	97.75
	3	97.50-100	99.75	90.00-100	97.00
4	1	77.50-97.50	87.25	50.00-85.00	74.25
	2	52.50-82.50	72.00	27.50-85.00	53.25
	3	52.50-80.00	67.75	30.00-67.50	48.25

* DI less than 2 during one or more conditions within a session
-- Data not recorded

Table 2

Means and Ranges of Interobserver Agreement Percentages Across 30% of Probe Trials on the Number of Numbers Pronounced by Experiment 1 Participants

Participants	Session	Consecutive-numbers condition		Random-numbers condition	
		Range	Mean	Range	Mean
1	1	75.00-100	90.83	94.87-97.37	94.49
	2	--	--	--	--
	3	97.44-100	99.15	97.30-100	98.27
2	1	94.87-100	97.46	89.74-97.50	94.82
	2	97.50-100	99.17	97.30-100	98.27
	3	95.00-100	97.50	95.00-100	96.62
3	1	100	100	97.14-100	98.20
	2	97.50-100	99.17	97.30-100	99.10
	3	100	100	94.44-100	97.22
4	1	84.21-100	93.86	93.94-96.67	95.64
	2	88.24-91.30	89.73	76.19-80.77	78.25
	3	73.33-92.86	85.70	77.78-100	91.01

-- Data not recorded

Table 3

Discrimination Index (DI) of Responding Across Ten Probe Trials for Experiment 1 Participants

Participant	Session	Consecutive-numbers condition	Random-numbers condition
1	1	5.00	4.44
	2	6.00	5.16
	3	9.41	3.85
2	1	5.26	2.70
	2	7.20	4.76
	3	7.27	6.15
3	1*	1.94	2.13
	2	3.37	3.05
	3	7.00	5.67
4	1*	2.15	1.95
	2	11.67	4.43
	3	8.89	3.33

* DI less than 2 during one or more conditions within a session

Table 4

Semi-interquartile Range (SIQR) in Seconds Across Ten Trials for Experiment 1 Participants

Participant	Session	Consecutive-numbers condition	Random-numbers condition
1	1	8.83	7.22
	2	1.83	4.72
	3	1.58	7.31
2	1	7.44	7.81
	2	3.12	9.13
	3	2.70	3.32
3	1*	12.46	8.96
	2	5.97	6.25
	3	2.90	4.38
4	1*	10.61	9.06
	2	1.49	7.66
	3	2.84	6.04

* DI less than 2 during one or more conditions within a session

Table 5

Latency to First Response in Seconds Across Ten Probe Trials for Experiment 1 Participants

Participant	Session	Consecutive-numbers condition	Random-numbers condition
1	1	21.99	31.60
	2	34.77	34.66
	3	34.12	36.25
2	1	26.79	35.29
	2	31.95	35.54
	3	32.74	35.52
3	1*	4.18	4.34
	2	28.05	27.45
	3	31.12	31.52
4	1*	15.02	16.26
	2	31.56	32.10
	3	33.09	32.35

Table 6
Standard Deviation to the Latency to the First Response in Seconds Across Ten Probe Trials for Experiment 1 Participants

Participant	Session	Consecutive-numbers condition	Random-numbers condition
1	1	12.58	12.07
	2	3.57	3.78
	3	1.91	7.32
2	1	11.07	9.89
	2	0.89	15.37
	3	0.51	5.43
3	1*	9.02	9.56
	2	9.67	9.33
	3	0.27	0.13
4	1*	14.48	13.01
	2	0.79	8.32
	3	2.52	6.77

* DI less than 2 during one or more conditions within a session, these sessions do not appear in following tables

Table 7

Peak location in 3-s Bins Across Ten Probe Trials for Experiment 1 Participants

Participant	Session	Consecutive-numbers condition	Random-numbers condition
1	1	11	14
	2	12.5**	13
	3	12	13
2	1	11	18.5**
	2	11	11
	3	11.5**	11
3	2	12	11
	3	12	12
4	2	11	17
	3	11	14

** Midpoint between two maximum-frequency points

Table 8

Peak frequency in 3-s Bins Across Ten Probe Trials for Experiment 1 Participants

Participant	Session	Consecutive-numbers condition	Random-numbers condition
1	1	6	6
	2	6	8
	3	8	5
2	1	10	5
	2	9	5
	3	8	8
3	2	15	16
	3	14	17
4	2	21	15
	3	12	9

Table 9

Means and Ranges of Percentages of Numbers Pronounced Across Eight Fast-rate Probe Trials by Experiment 2 Participants

Participants	Session	Consecutive-numbers condition		Random-numbers condition	
		Range	Mean	Range	Mean
1	1	73.33-100	92.08	83.33-100	94.58
	2	93.33-100	96.25	80.00-100	92.08
	3	93.33-100	95.83	86.67-100	93.75
2	1	96.67-100	98.75	90.00-100	97.08
	2	93.33-100	99.17	93.33-100	94.58
	3	90.00-100	96.67	80.00-100	93.33
3	1	83.33-100	92.50	90.00-100	92.50
	2	83.33-100	92.92	76.67-100	90.83
	3	73.33-96.67	85.00	56.67-96.67	82.92
4	1	96.67-100	98.75	70.00-100	90.42
	2	96.67-100	98.75	90.00-100	96.25
	3	90.00-100	97.50	90.00-100	97.08
5	1	70.00-100	89.17	53.33-76.67	68.77
	2	46.67-86.67	67.08	26.67-63.33	78.75
	3	26.67-60.00	45.42	0.00-76.67	29.17
6	1	90.00-100	96.67	73.33-100	93.33
	2	93.33-100	96.67	90.00-100	95.42
	3	90.00-100	97.08	90.00-100	93.75
7	1	83.33-100	94.58	83.33-100	90.42
	2	73.33-96.67	87.92	70.00-93.33	87.50
	3	83.33-96.67	92.50	83.33-100	89.58
8	1	86.67-100	97.08	93.33-100	97.50
	2	80.00-100	92.08	90.00-100	94.58
	3	90.00-100	97.50	90.00-100	95.83
9	1	100	100	100	100
	2	96.67-100	99.58	100	100
	3	-	-	-	-

Table 9 (continued)

Means and Ranges of Percentages of Numbers Pronounced Across Eight Fast-rate Probe Trials by Experiment 2 Participants

Participants	Session	Consecutive-numbers condition		Random-numbers condition	
		Range	Mean	Range	Mean
10	1	0.00-100	69.17	0.00-93.33	49.58
	2	--	--	--	--
	3	0.00-100	84.17	0.00-96.67	70.42
11	1	100	100	96.67-100	98.75
	2	96.67-100	99.58	93.33-100	97.92
	3	100	100	96.67-100	99.58
12	1	76.67-100	90.00	60.00-96.67	80.42
	2	83.33-96.67	88.75	53.33-90.00	74.17
	3	96.67-100	98.75	73.33-93.33	86.67
13	1	100	100	100	100
	2	100	100	96.67-100	99.58
	3	100	100	96.67-100	99.58
14	1	90.00-100	97.50	80.00-100	89.58
	2	93.33-100	97.50	76.67-100	90.00
	3	90.00-100	97.92	80.00-96.67	85.00
15	1	100	100	93.33-100	94.58
	2	86.67-100	97.08	90.00-100	96.25
	3	96.67-100	99.17	93.33-100	97.92
16	1	86.67-100	95.00	86.67-100	93.33
	2	83.33-96.67	90.00	83.33-100	91.67
	3	53.33-93.33	85.42	66.67-96.67	87.50

- Session not conducted
-- Data not recorded

Table 10

Means and Ranges of Percentages of Numbers Pronounced Across Slow-rate Probe Trials by Experiment 2 Participants

Participants	Session	Consecutive-numbers condition		Random-numbers condition	
		Range	Mean	Range	Mean
1	1	95.00-100	98.13	90.00-100	96.88
	2	90.00-100	96.88	80.00-100	95.00
	3	95.00-100	95.63	85.00-100	92.50
2	1	95.00-100	98.75	95.00-100	98.75
	2	95.00-100	99.38	90.00-100	97.50
	3	95.00-100	98.75	90.00-100	97.50
3	1	90.00-100	96.25	85.00-100	93.13
	2	75.00-100	95.00	85.00-100	95.63
	3	85.00-100	93.75	80.00-100	88.75
4	1	95.00-100	99.38	95.00-100	98.75
	2	95.00-100	99.38	90.00-100	95.63
	3	100	100	95.00-100	97.50
5	1	85.00-100	92.50	75.00-95.00	82.50
	2	40.00-95.00	78.75	0.00-80.00	55.00
	3	55.00-95.00	79.38	40.00-70.00	53.13
6	1	90.00-100	98.13	85.00-100	93.75
	2	95.00-100	98.75	85.00-100	95.63
	3	90.00-100	96.25	75.00-100	91.88
7	1	75.00-100	95.63	85.00-100	95.00
	2	90.00-100	96.25	75.00-95.00	88.75
	3	90.00-100	94.38	70.00-95.00	88.75
8	1	100	100	90.00-100	96.25
	2	85.00-100	95.63	95.00-100	97.50
	3	95.00-100	99.38	90.00-100	96.25
9	1	95.00-100	98.75	95.00-100	99.38
	2	100	100	100	100
	3	-	-	-	-

Table 10 (continued)

Means and Ranges of Percentages of Numbers Pronounced Across Eight Slow- rate Probe Trials by Experiment 2 Participants

Participants	Session	Consecutive-numbers condition		Random-numbers condition	
		Range	Mean	Range	Mean
10	1	40.00-100	89.38	60.00-100	89.38
	2	--	--	--	--
	3	0.00-100	72.50	25.00-100	85.63
11	1	100	100	100	100
	2	95.00-100	99.38	100	100
	3	100	100	100	100
12	1	85.00-95.00	91.88	90.00-100	95.63
	2	85.00-100	95.63	75.00-100	90.00
	3	80.00-100	96.25	80.00-100	90.63
13	1	100	100	100	100
	2	100	100	100	100
	3	100	100	100	100
14	1	85.00-100	98.13	90.00-100	93.13
	2	95.00-100	99.38	95.00-100	96.88
	3	90.00-100	98.75	95.00-100	98.75
15	1	95.00-100	98.75	90.00-100	98.13
	2	90.00-100	97.50	75.00-100	95.00
	3	100	100	40.00-100	85.00
16	1	95.00-100	98.75	90.00-100	98.13
	2	95.00-100	99.38	95.00-100	98.13
	3	80.00-100	90.00	75.00-100	93.13

- Session not conducted
-- Data not recorded

Table 11

Means and Ranges of Interobserver Agreement Percentages Across 25% of Fast-rate Probe Trials on the Number of Numbers Pronounced by Experiment 2 Participants

Participants	Session	Consecutive-numbers condition		Random-numbers condition	
		Range	Mean	Range	Mean
1	1	75.11-96.55	85.83	86.67-100	93.33
	2	86.21-96.43	91.32	78.57-85.71	82.14
	3	73.33-93.10	83.22	85.19-96.55	90.87
2	1	93.33-100	96.67	100	100
	2	100	100	100	100
	3	100	100	95.83-100	97.92
3	1	96.67	96.67	96.30-100	98.15
	2	100	100	100	100
	3	93.10-100	96.55	95.45-100	97.73
4	1	96.55-96.67	96.61	90.00-96.67	93.34
	2	100	100	96.67	96.67
	3	100	100	96.67-100	98.34
5	1	96.15-100	98.08	91.30-94.12	92.71
	2	79.01-91.30	85.16	90.00-94.74	92.37
	3	72.22-100	86.11	60.49-100	80.25
6	1	96.67-100	98.34	100	100
	2	100	100	96.67	96.67
	3	96.67-100	98.34	96.43-100	98.21
7	1	85.19-93.10	89.15	93.10-100	96.55
	2	96.00-96.67	96.34	96.43-100	98.21
	3	96.67-100	98.34	84.00-96.15	90.08
8	1	93.33-86.67	90.00	92.86-100	96.43
	2	88.89-96.67	92.78	93.33-100	96.67
	3	86.21-96.67	91.44	86.67-96.67	91.67
9	1	96.67-100	98.34	96.67-100	98.34
	2	96.67-100	98.34	96.67-100	98.34
	3	-	-	-	-

Table 11 (continued)

Means and Ranges of Interobserver Agreement Percentages Across 25% of Fast-rate Probe Trials on the Number of Numbers Pronounced by Experiment 2 Participants

Participants	Session	Consecutive-numbers condition		Random-numbers condition	
		Range	Mean	Range	Mean
10	1	100	100	100	100
	2	--	--	--	--
	3	96.67-100	98.34	88.89-100	94.44
11	1	100	100	96.67-100	98.34
	2	100	100	96.67-100	98.34
	3	100	100	100	100
12	1	76.00-95.83	85.92	94.44-95.65	95.05
	2	96.15-100	98.08	80.00-96.00	88.00
	3	96.55-100	98.28	81.82-96.00	88.91
13	1	100	100	100	100
	2	100	100	100	100
	3	96.67	96.67	96.67-100	98.34
14	1	89.66-100	94.83	92.86-100	96.43
	2	96.67-100	98.34	100	100
	3	96.43-100	98.21	88.89-100	94.44
15	1	93.33-100	96.67	89.26-93.33	91.30
	2	79.31-93.10	86.21	71.43-88.89	80.16
	3	96.67-100	98.34	65.52-75.86	70.69
16	1	100	100	96.30-100	98.15
	2	100	100	96.00-96.67	96.34
	3	96.43-96.55	96.49	96.15-96.30	96.22

- Session not conducted

Table 12

Means and Ranges of Interobserver Agreement Percentages Across 25% of Slow-rate Probe Trials on the Number of Numbers Pronounced by Experiment 2 Participants

Participants	Session	Consecutive-numbers condition		Random-numbers condition	
		Range	Mean	Range	Mean
1	1	80.00-90.00	85.00	95.00-100	97.50
	2	5.00-78.95	41.97	63.16-75.00	69.08
	3	84.21-94.74	89.47	95.00-100	97.50
2	1	100	100	95.00-100	97.50
	2	95.00-100	97.50	94.74-100	97.37
	3	95.00-100	97.50	100	100
3	1	94.74-95.00	94.87	94.74-100	97.37
	2	100	100	94.74-95.00	94.87
	3	85.00-94.74	89.87	100	100
4	1	95.00-100	97.50	100	100
	2	100	100	90.00-100	95.00
	3	100	100	95.00-100	97.50
5	1	94.44-100	97.22	83.33-88.89	86.11
	2	95.00-100	97.50	88.24-94.12	91.18
	3	82.35-87.50	84.93	79.01-100	89.51
6	1	100	100	89.47-94.74	92.10
	2	94.74-100	97.37	100	100
	3	94.74-100	97.37	100	100
7	1	100	100	100	100
	2	100	100	94.74-95.00	94.87
	3	100	100	94.74-100	97.22
8	1	100	100	90.00-100	95.00
	2	90.00-100	95.00	89.47-100	94.74
	3	95.00-100	97.50	100	100
9	1	100	100	95.00-100	97.50
	2	95.00-100	97.50	95.00	95.00
	3	-	-	-	-

Table 12 (continued)

Means and Ranges of Interobserver Agreement Percentages Across 25% of Slow-rate Trials on the Number of Numbers Pronounced by Experiment 2 participants

Participants	Session	Consecutive-numbers condition		Random-numbers condition	
		Range	Mean	Range	Mean
10	1	94.12-100	97.06	90.00-94.74	92.37
	2	--	--	--	--
	3	95.00-100	97.50	100	100
11	1	95.00-100	97.50	100	100
	2	85.00-100	92.50	100	100
	3	100	100	100	100
12	1	77.78-88.89	83.33	88.89-100	94.44
	2	94.12-100	97.06	100	100
	3	94.12-95.00	94.56	94.44-94.74	94.59
13	1	100	100	100	100
	2	100	100	100	100
	3	100	100	100	100
14	1	100	100	94.44-94.74	94.59
	2	95.00-100	97.50	94.74	94.74
	3	100	100	94.74-100	97.37
15	1	95.00-100	97.50	100	100
	2	90.00-100	95.00	90.00-100	95.00
	3	95.00-100	97.50	94.12-100	97.06
16	1	100	100	100	100
	2	85.00-89.47	87.24	95.00-100	97.50
	3	100	100	88.24-100	94.12

- Session not conducted

Table 13

Discrimination Index (DI) of Responding Across Eight Probe Trials for Experiment 2 Participants

Participant	Session	Fast-number-presentation rate		Slow-number-presentation rate	
		Consecutive	Random	Consecutive	Random
1	1	4.55	3.57	2.37	2.81
	2	7.20	7.86	3.10	3.46
	3	4.41	4.17	6.67	3.53
2	1	2.69	2.11	2.55	3.13
	2	7.11	2.91	2.71	2.80
	3	7.06	3.52	5.33	3.04
3	1*	1.18	1.20	1.70	1.76
	2*	2.31	2.05	3.33	1.60
	3	10.20	10.42	3.13	8.99
4	1*	1.33	1.18	1.46	1.38
	2*	1.21	1.15	1.40	1.28
	3*	1.13	1.13	1.43	1.38
5	1	4.50	4.46	3.63	3.57
	2	7.03	3.41	6.25	3.41
	3	7.86	5.29	6.56	7.00
6	1*	2.50	1.91	3.38	2.14
	2*	1.24	2.01	2.05	2.07
	3*	2.46	1.54	3.08	2.73
7	1*	1.67	2.25	1.84	1.71
	2*	2.19	2.22	1.73	1.88
	3	2.58	2.82	2.08	2.09
8	1	4.00	4.29	4.41	3.75
	2	13.13	9.38	11.25	10.71
	3	13.13	11.25	13.13	15.00
9	1	2.99	3.50	4.41	3.33
	2	3.94	2.90	4.29	5.00
	3	-	-	-	-
10	1*	1.11	1.24	1.18	1.35
	2*	--	--	1.79	2.06
	3*	1.63	1.29	1.66	1.88

Table 13 (continued)

Discrimination Index (DI) of Responding Across Eight Probe Trials for Experiment 2 Participants

Participant	Session	Fast-number-presentation rate		Slow-number-presentation rate	
		Consecutive	Random	Consecutive	Random
11	1*	2.12	1.60	3.44	2.87
	2	2.50	2.28	3.95	2.06
	3	4.12	3.69	2.54	3.24
12	1	4.19	3.28	2.70	2.39
	2	3.00	3.84	3.66	3.75
	3	4.64	4.29	3.05	3.14
13	1	1.71	1.73	2.11	2.25
	2	2.08	2.71	1.88	2.67
	3	2.09	2.39	3.00	3.18
14	1*	1.44	1.32	1.48	1.76
	2*	1.92	1.73	1.53	2.02
	3*	1.83	1.72	1.88	7.00
15	1*	1.53	2.23	1.63	1.81
	2*	1.22	1.54	2.38	1.67
	3*	1.78	1.97	2.62	1.51
16	1*	1.08	1.19	1.29	1.45
	2*	1.47	1.90	1.42	1.75
	3*	3.26	2.54	1.80	1.53

* DI less than 2 during one or more conditions within a session
- Session not conducted

Table 14

Semi-interquartile Range (SIQR) in Seconds Across Eight Probe Trials for Experiment 2 Participants

Participant	Session	Fast-number-presentation rate		Slow-number-presentation rate	
		Consecutive	Random	Consecutive	Random
1	1	4.42	4.78	5.86	4.65
	2	1.56	1.57	4.60	3.17
	3	2.87	4.24	2.69	4.84
2	1	5.89	7.71	6.60	7.35
	2	1.60	4.50	4.64	5.77
	3	1.64	4.64	2.91	4.31
3	1*	10.56	10.47	11.65	10.29
	2*	9.67	10.42	13.63	10.80
	3	1.75	0.36	6.28	0.42
4	1*	11.85	11.59	11.79	11.83
	2*	10.43	10.58	10.52	10.63
	3*	11.69	11.85	9.45	10.71
5	1	1.94	2.97	3.10	3.34
	2	1.78	4.81	2.96	6.06
	3	1.51	3.17	1.61	2.94
6	1*	8.84	7.51	8.71	11.95
	2*	10.71	10.42	9.04	11.56
	3*	10.41	10.57	11.64	10.42
7	1*	6.46	6.08	7.42	7.51
	2*	6.07	5.52	6.39	7.45
	3	4.62	4.69	6.02	7.10
8	1	4.47	4.21	5.90	4.75
	2	0.29	1.55	1.33	2.95
	3	0.29	1.33	0.29	0.25
9	1	4.92	7.48	4.59	6.31
	2	5.59	4.65	5.99	4.53
	3	-	-	-	-
10	1*	11.68	10.64	10.70	13.29
	2*	--	--	10.31	7.60
	3*	7.86	10.16	10.08	7.65

Table 14 (continued)

Semi-interquartile Range (SIQR) in Seconds Across Eight Probe Trials for Experiment 2 Participants

Participant	Session	Fast-number-presentation rate		Slow-number-presentation rate	
		Consecutive	Random	Consecutive	Random
11	1*	7.88	7.50	6.32	7.45
	2	8.76	5.93	4.59	6.35
	3	3.06	3.13	5.99	5.88
12	1	3.35	5.79	7.26	5.84
	2	6.11	4.39	5.69	3.38
	3	2.94	2.97	4.40	4.66
13	1	8.74	8.68	7.26	7.90
	2	13.11	6.76	7.15	4.69
	3	3.97	4.35	3.96	4.21
14	1*	15.12	11.21	7.26	12.59
	2*	22.78	16.08	13.43	9.31
	3*	6.11	6.83	8.77	11.22
15	1*	11.25	9.75	7.26	8.53
	2*	11.44	8.64	7.85	6.38
	3*	4.83	5.03	5.24	8.50
16	1*	11.63	10.50	7.26	8.64
	2*	13.56	7.89	8.22	5.63
	3*	2.41	3.76	3.34	4.93

* DI less than 2 during one or more conditions within a session
- Session not conducted

Table 15

Latency to First Response in Seconds Across Eight Probe Trials for Experiment 2 Participants

Participant	Session	Fast-number-presentation rate		Slow-number-presentation rate	
		Consecutive	Random	Consecutive	Random
1	1	23.10	27.87	21.98	25.67
	2	23.17	21.22	21.47	21.55
	3	20.10	21.76	19.77	22.93
2	1	19.12	16.12	19.32	20.19
	2	21.66	16.80	14.67	16.57
	3	20.64	15.44	15.34	20.13
3	1*	3.26	4.43	5.73	10.17
	2*	11.57	10.03	5.94	6.74
	3	19.44	20.29	14.99	15.14
4	1*	2.09	2.13	2.65	1.74
	2*	2.45	1.55	3.78	4.25
	3*	1.21	1.48	1.64	1.37
5	1	29.07	30.22	27.42	32.53
	2	27.35	29.46	36.61	35.10
	3	27.58	32.25	32.71	29.53
6	1*	1.65	2.65	1.91	2.49
	2*	1.84	1.88	2.23	2.35
	3*	1.84	2.50	1.47	1.71
7	1*	16.20	13.46	14.50	15.39
	2*	11.63	11.41	11.74	13.29
	3	13.52	15.28	14.03	15.75
8	1	26.65	28.22	31.39	27.01
	2	17.61	18.01	17.98	19.32
	3	16.84	16.68	16.61	16.58
9	1	28.13	29.24	33.25	31.22
	2	26.15	26.87	31.99	30.50
	3	-	-	-	-
10	1*	0.77	1.52	1.03	1.38
	2*	16.04	14.08	16.72	14.16
	3*	9.11	12.01	13.18	14.92

Table 15 (continued)

Latency to First Response in Seconds Across Eight Probe Trials for Experiment 2 Participants

Participant	Session	Fast-number-presentation rate		Slow-number-presentation rate	
		Consecutive	Random	Consecutive	Random
11	1*	15.33	14.48	14.28	14.87
	2	16.88	15.01	15.69	17.72
	3	17.85	14.80	18.30	18.46
12	1	17.06	16.55	20.01	21.23
	2	18.97	20.14	25.01	23.77
	3	16.80	20.87	21.58	25.79
13	1*	6.21	6.18	8.44	6.71
	2*	13.88	18.96	13.33	16.72
	3	22.47	21.78	24.29	26.02
14	1*	1.69	3.59	3.41	2.24
	2*	3.24	3.48	4.26	6.20
	3*	1.56	2.10	1.93	3.07
15	1*	12.45	10.79	16.59	15.50
	2*	9.51	8.19	9.74	11.42
	3*	11.99	10.21	13.40	13.02
16	1*	5.39	1.06	5.86	5.38
	2*	8.46	16.85	10.20	14.50
	3*	22.96	13.66	3.03	18.47

* DI less than 2 during one or more conditions within a session
\- Session not conducted

Table 16

Standard Deviation to the Latency to the First Response in Seconds Across Eight Probe Trials for Experiment 2 Participants

Participant	Session	Fast-number-presentation rate		Slow-number-presentation rate	
		Consecutive	Random	Consecutive	Random
1	1	1.59	5.71	3.84	3.95
	2	0.67	2.19	4.80	3.86
	3	3.95	4.09	4.57	6.49
2	1	4.61	5.83	5.71	6.75
	2	2.08	1.71	6.26	7.58
	3	3.58	3.32	1.75	4.03
3	1*	4.08	3.47	5.13	10.15
	2*	10.13	9.95	5.42	6.00
	3	4.01	1.92	2.19	1.46
4	1*	2.86	2.18	2.62	0.81
	2*	2.68	0.36	5.70	8.28
	3*	0.44	0.20	1.27	0.24
5	1	2.17	2.46	13.57	14.15
	2	1.46	5.99	2.16	6.18
	3	2.55	4.24	13.33	12.93
6	1*	0.35	1.48	0.40	1.39
	2*	0.49	0.86	0.74	0.78
	3*	0.58	0.27	0.36	0.44
7	1*	5.08	5.03	4.22	6.10
	2*	0.95	1.17	1.12	3.88
	3	3.95	2.02	1.65	2.68
8	1	3.61	4.35	6.52	11.63
	2	2.33	1.64	3.92	4.42
	3	0.88	1.14	1.10	0.88
9	1	4.75	5.98	6.49	8.84
	2	1.72	4.91	13.39	14.35
	3	-	-	-	-
10	1*	0.30	1.83	0.82	1.06
	2*	5.12	7.56	9.46	5.99
	3*	3.32	8.68	7.24	4.31

Table 16 (continued)

Standard Deviation to the Latency to the First Response in Seconds Across Eight Probe Trials for Experiment 2 Participants

Participant	Session	Fast-number-presentation rate		Slow-number-presentation rate	
		Consecutive	Random	Consecutive	Random
11	1*	3.79	2.62	2.49	2.81
	2	3.25	3.03	4.16	5.49
	3	3.04	1.93	5.35	2.62
12	1	3.01	4.15	7.17	3.93
	2	6.94	5.25	4.60	3.72
	3	3.31	3.62	2.29	6.35
13	1*	5.36	3.83	5.69	5.85
	2*	9.44	5.94	8.97	7.84
	3	5.61	8.99	9.21	7.23
14	1*	0.98	1.71	4.75	2.29
	2*	4.17	3.43	6.26	9.16
	3*	1.00	1.42	1.00	2.03
15	1*	5.07	7.38	3.05	5.28
	2*	6.49	8.78	9.22	8.33
	3*	1.86	3.39	3.44	6.32
16	1*	7.91	0.89	7.47	8.57
	2*	8.57	10.52	11.21	12.90
	3*	11.96	14.74	0.80	18.42

* DI less than 2 during one or more conditions within a session; these sessions do not a appear in following tables

\- Session not conducted

Table 17

Peak location in 3-s Bins Across Eight Probe Trials for Experiment 2 Participants

Participant	Session	Consecutive-numbers trials		Random-numbers trials	
		Fast-rate	Slow-rate	Fast-rate	Slow-rate
1	1	9	9	10	11
	2	9	7	8	9**
	3	6	7	10	6.5**
2	1	9	11	13	9
	2	9	7	7	9**
	3	9	7	7	8.5**
3	3	8	6	8	6
5	1	11	13.5**	12	13.5**
	2	10	14	8	10
	3	10	13	12	12
7	3	7	7	8	8
8	1	13	13	10	14
	2	6	6	6	6
	3	6	6	6	6
9	1	12	15	8	15
	2	9	14.5**	10.5**	15
11	2	8	8	7	11
	3	8	7.5**	6	10
12	1	8	8	7.5	9**
	2	7	11	7	9
	3	7	8	8	11
13	3	13.5**	14	14.5**	14.5**

** Midpoint between two maximum-frequency points

Table 18

Peak frequency in 3-s Bins Across Eight Probe Trials for Experiment 2 Participants

Participant	Session	Fast-number-presentation rate		Slow-number-presentation rate	
		Consecutive	Random	Consecutive	Random
1	1	17	9	10	9
	2	12	6	11	6
	3	5	8	5	4
2	1	12	9	10	10
	2	27	15	13	14
	3	24	32	19	15
3	3	17	10	25	15
5	1	12	8	11	5
	2	15	15	5	5
	3	11	7	6	7
7	3	48	46	44	39
8	1	8	5	4	4
	2	7	6	5	5
	3	7	7	6	8
9	1	5	5	7	4
	2	10	6	6	6
11	2	14	15	14	7
	3	14	10	16	11
12	1	12	11	7	7
	2	9	10	10	6
	3	13	12	10	9
13	3	12	9	14	7

Figure Captions

Figure 1. Mean percentage of maximum response rates during ten 60-s probe trials in each condition within 3-s time bins for Participant 1, Experiment 1.

Figure 2. Mean percentage of maximum response rates during ten 60-s probe trials in each condition within 3-s time bins for Participant 2, Experiment 1.

Figure 3. Mean percentage of maximum response rates during ten 60-s probe trials in each condition within 3-s time bins for Participant 3, Experiment 1.

Figure 4. Mean percentage of maximum response rates during ten 60-s probe trials in each condition within 3-s time bins for Participant 4, Experiment 1.

Figure 5. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 1, Experiment 2.

Figure 6. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 2, Experiment 2.

Figure 7. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 3, Experiment 2.

Figure 8. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 5, Experiment 2.

Figure 9. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 7, Experiment 2.

Figure 10. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 8, Experiment 2.

Figure 11. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 9, Experiment 2.

Figure 12. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 11, Experiment 2.

Figure 13. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 12, Experiment 2.

Figure 14. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 13, Experiment 2.

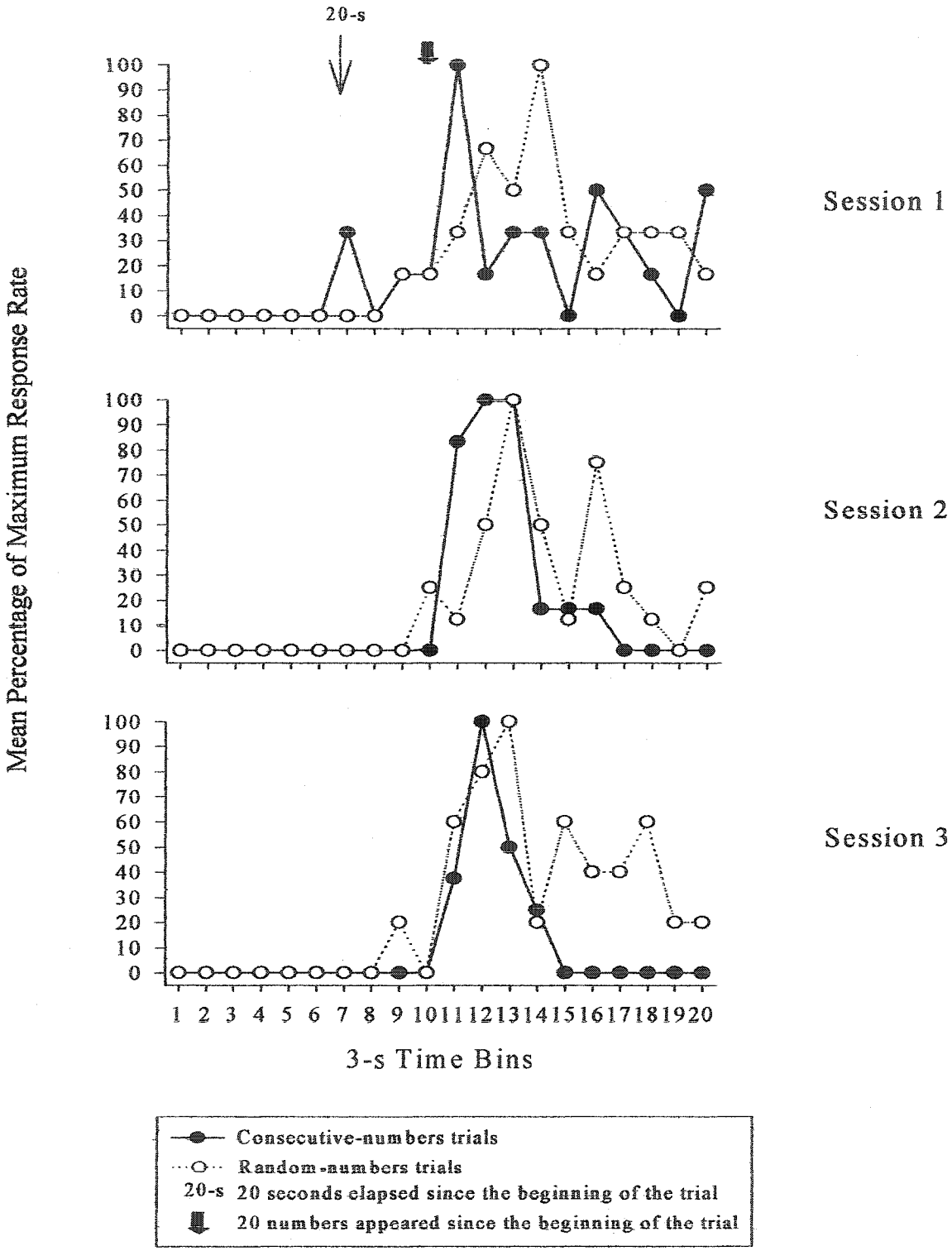


Figure 1. Mean percentage of maximum response rates during ten 60-s probe trials in each condition within 3-s time bins for Participant 1, Experiment 1.

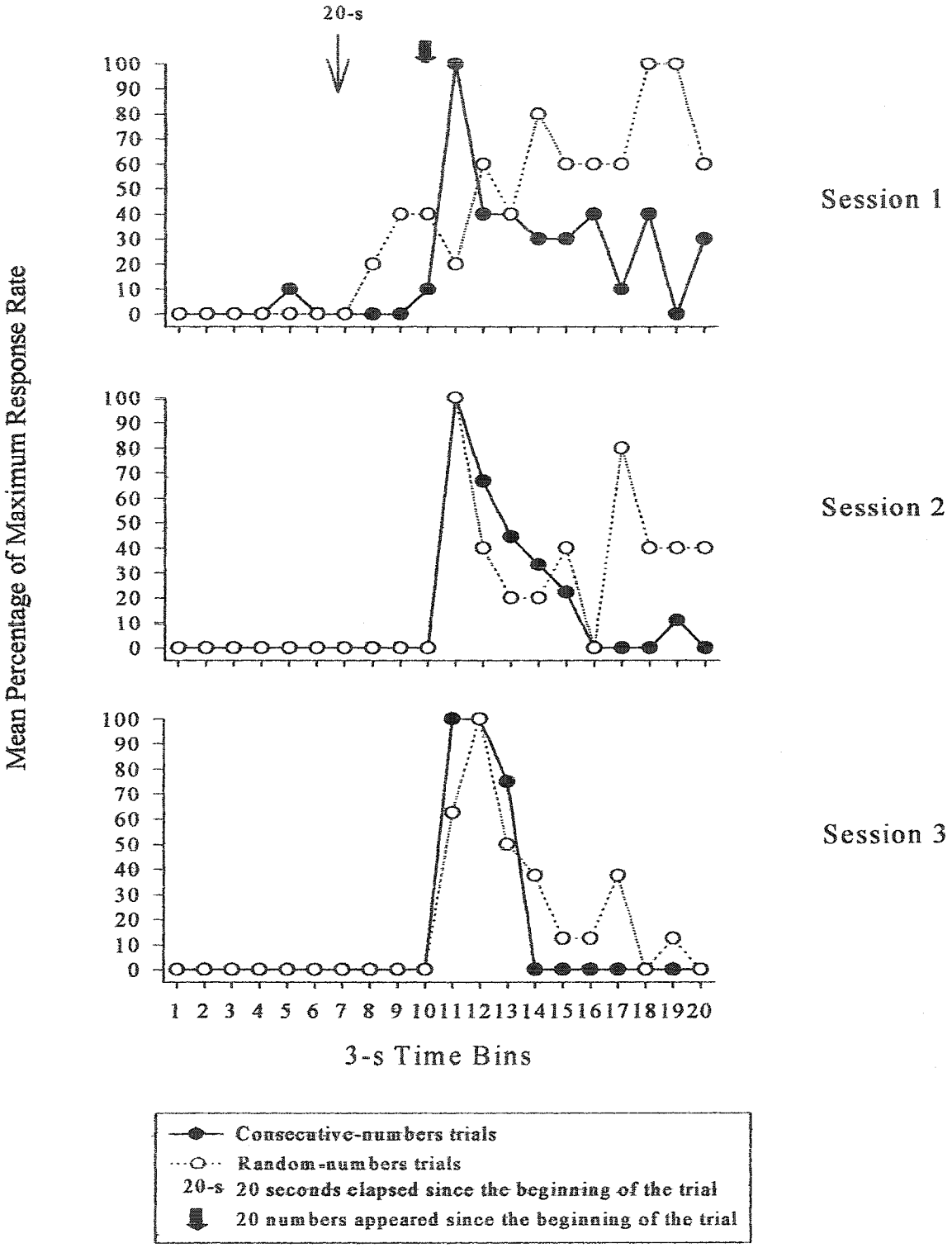


Figure 2. Mean percentage of maximum response rates during ten 60-s probe trials in each condition within 3-s time bins for Participant 2, Experiment 1.

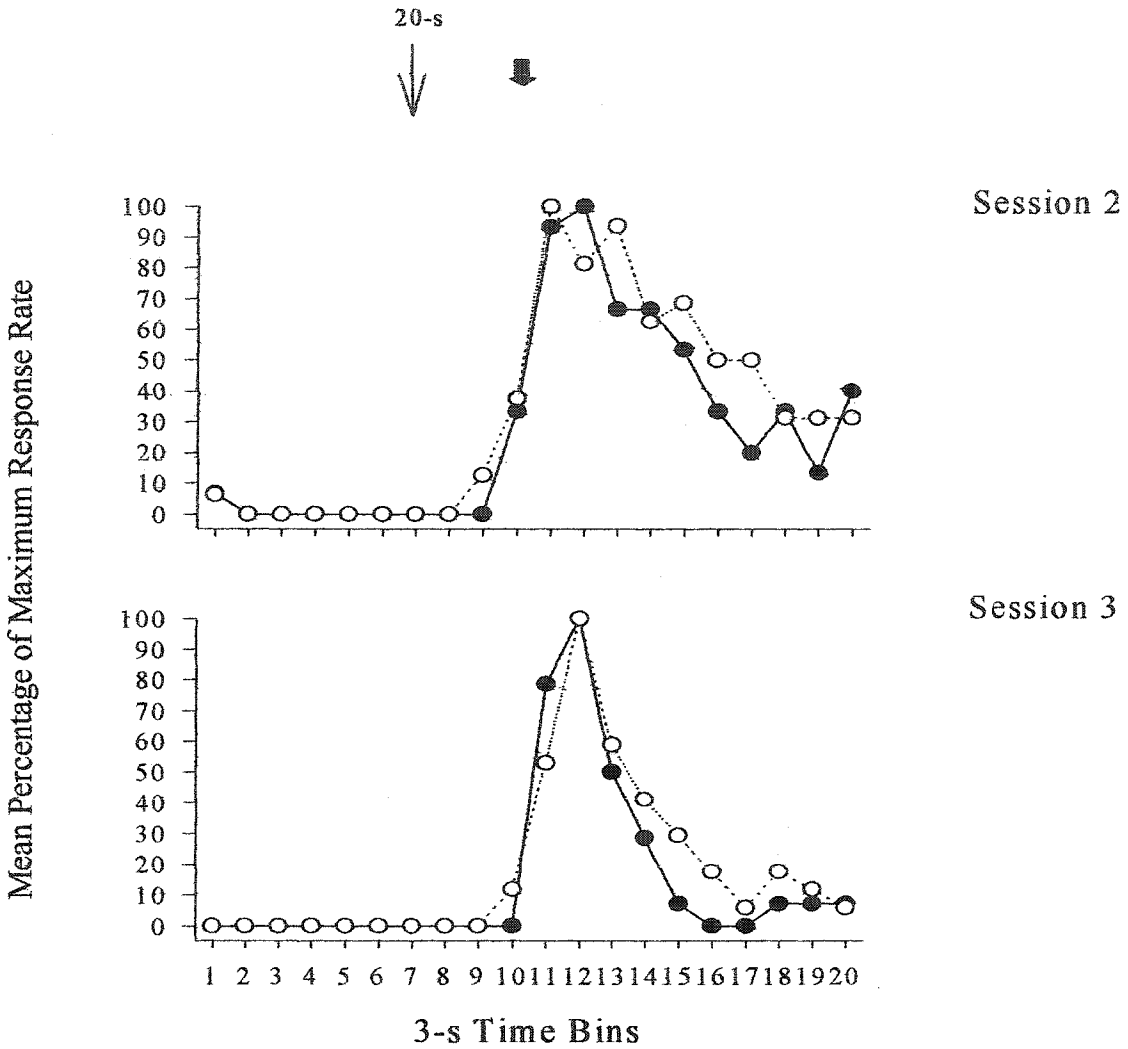


Figure 3. Mean percentage of maximum response rates during ten 60-s probe trials in each condition within 3-s time bins for Participant 3, Experiment 1.

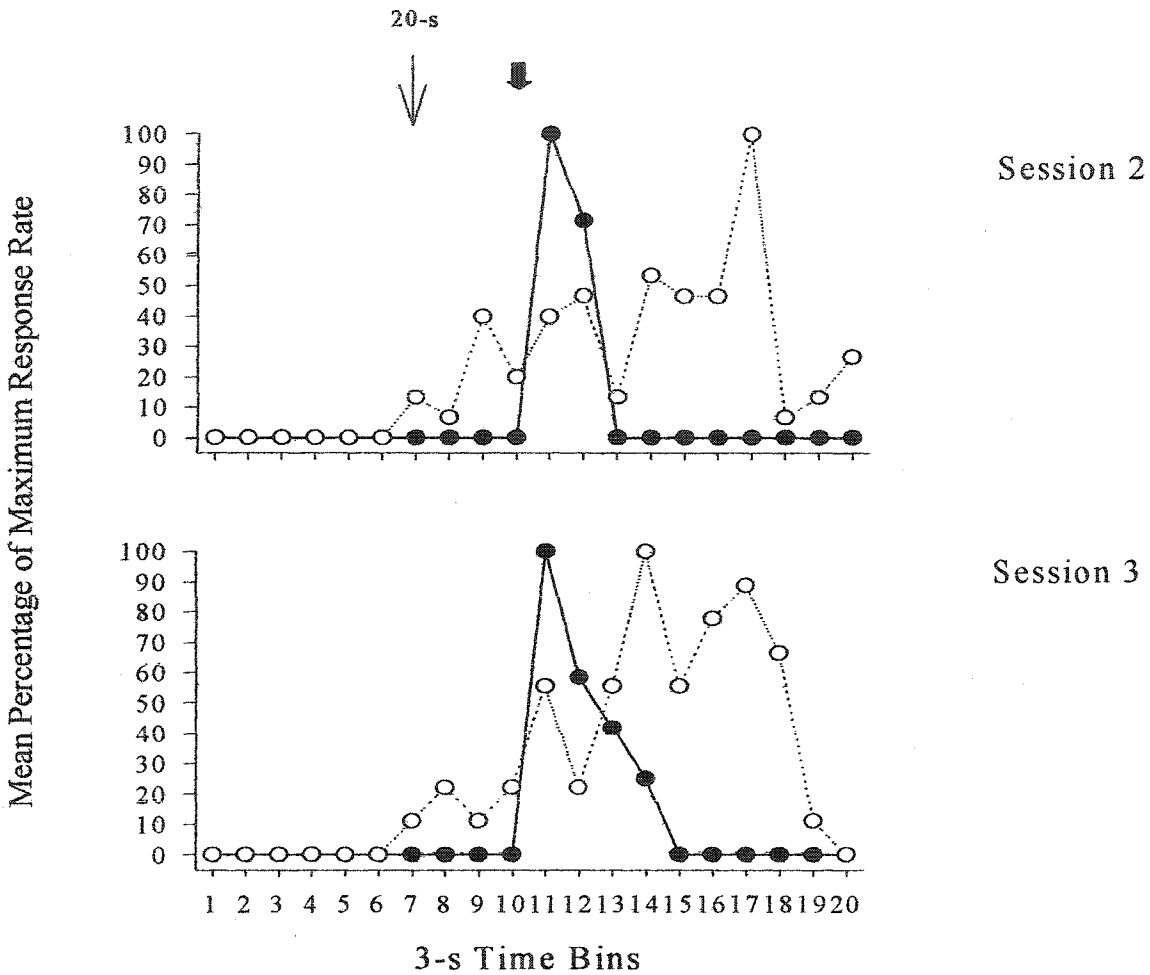


Figure 4. Mean percentage of maximum response rates during ten 60-s probe trials in each condition within 3-s time bins for Participant 4, Experiment 1.

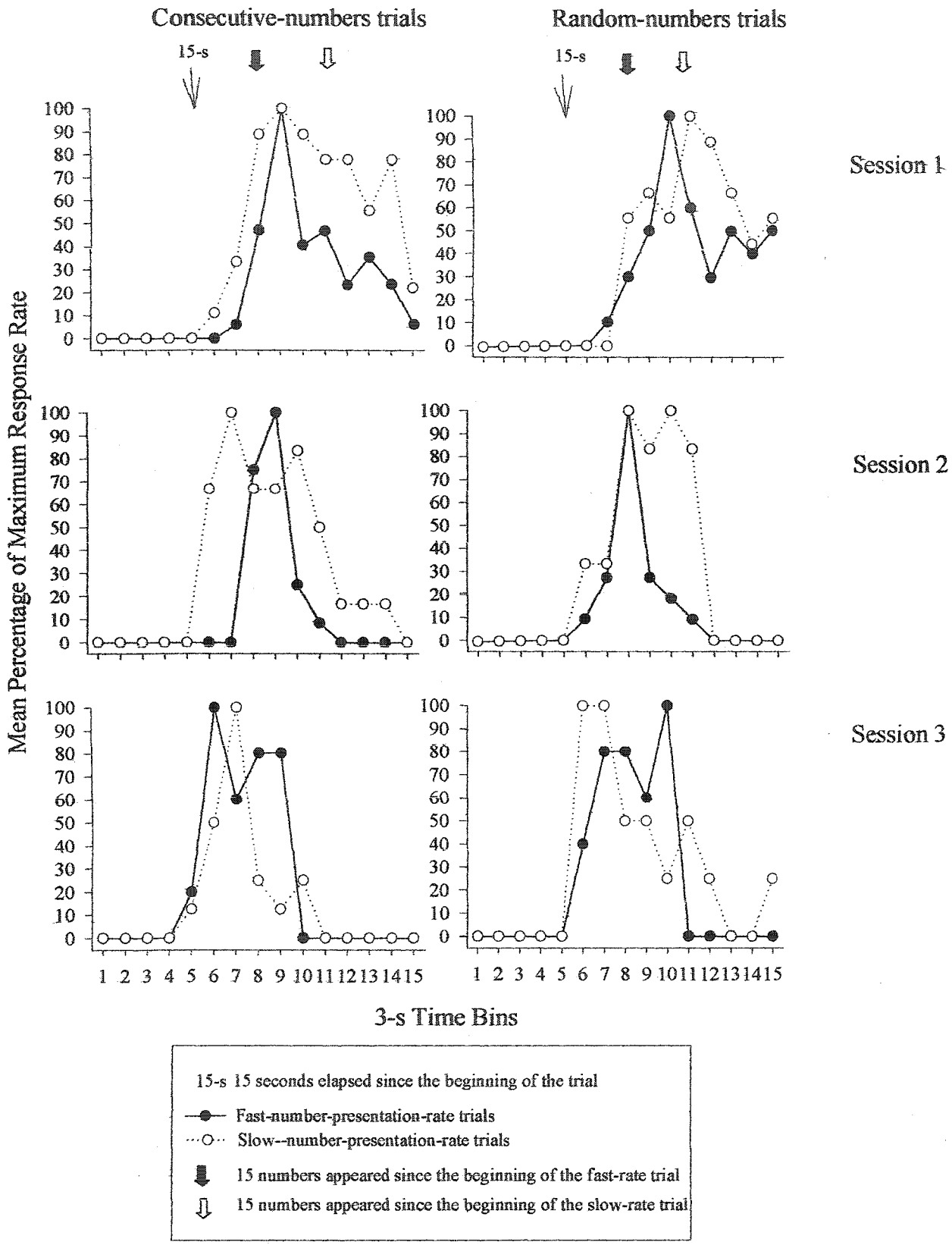


Figure 5. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 1, Experiment 2.

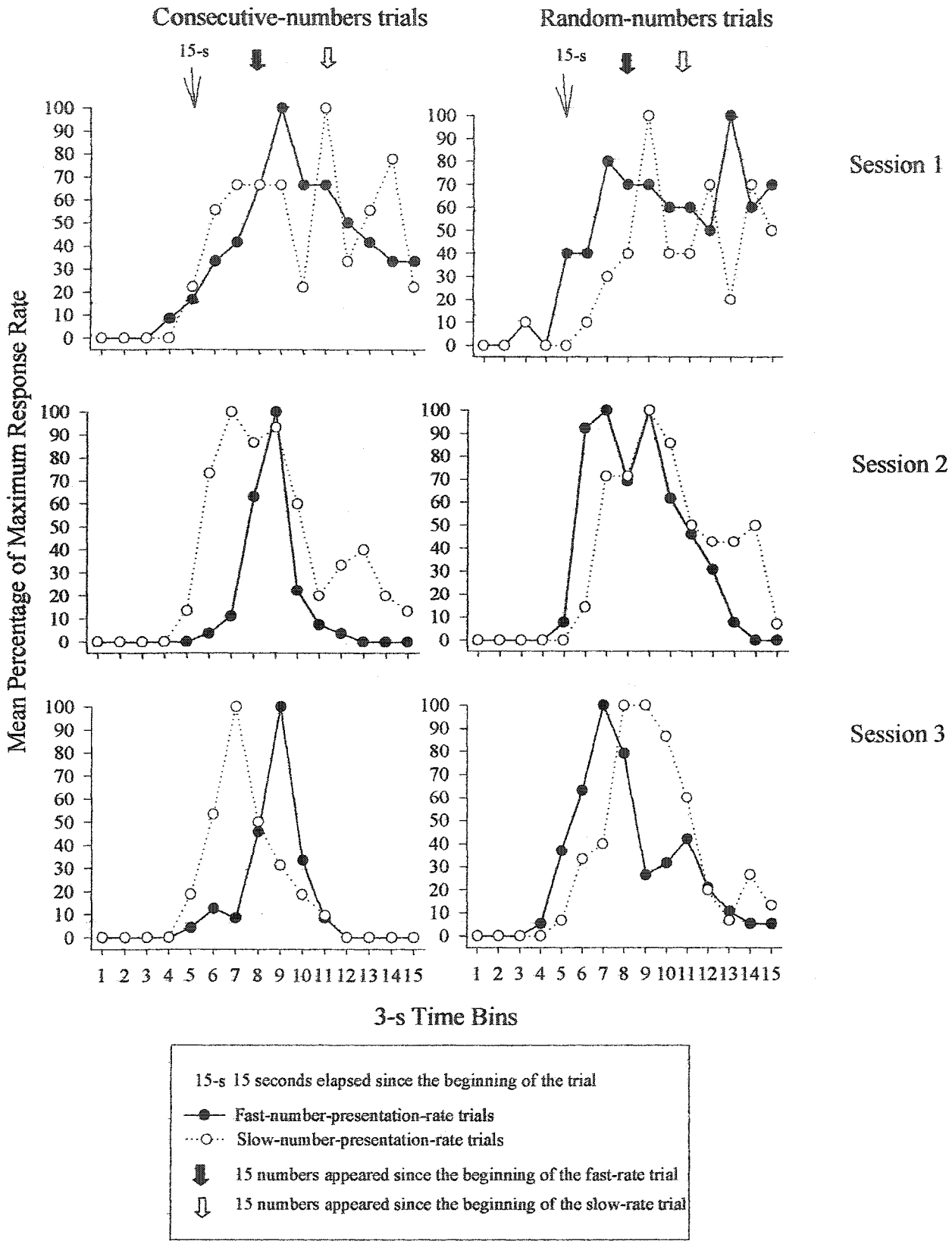


Figure 6. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 2, Experiment 2.

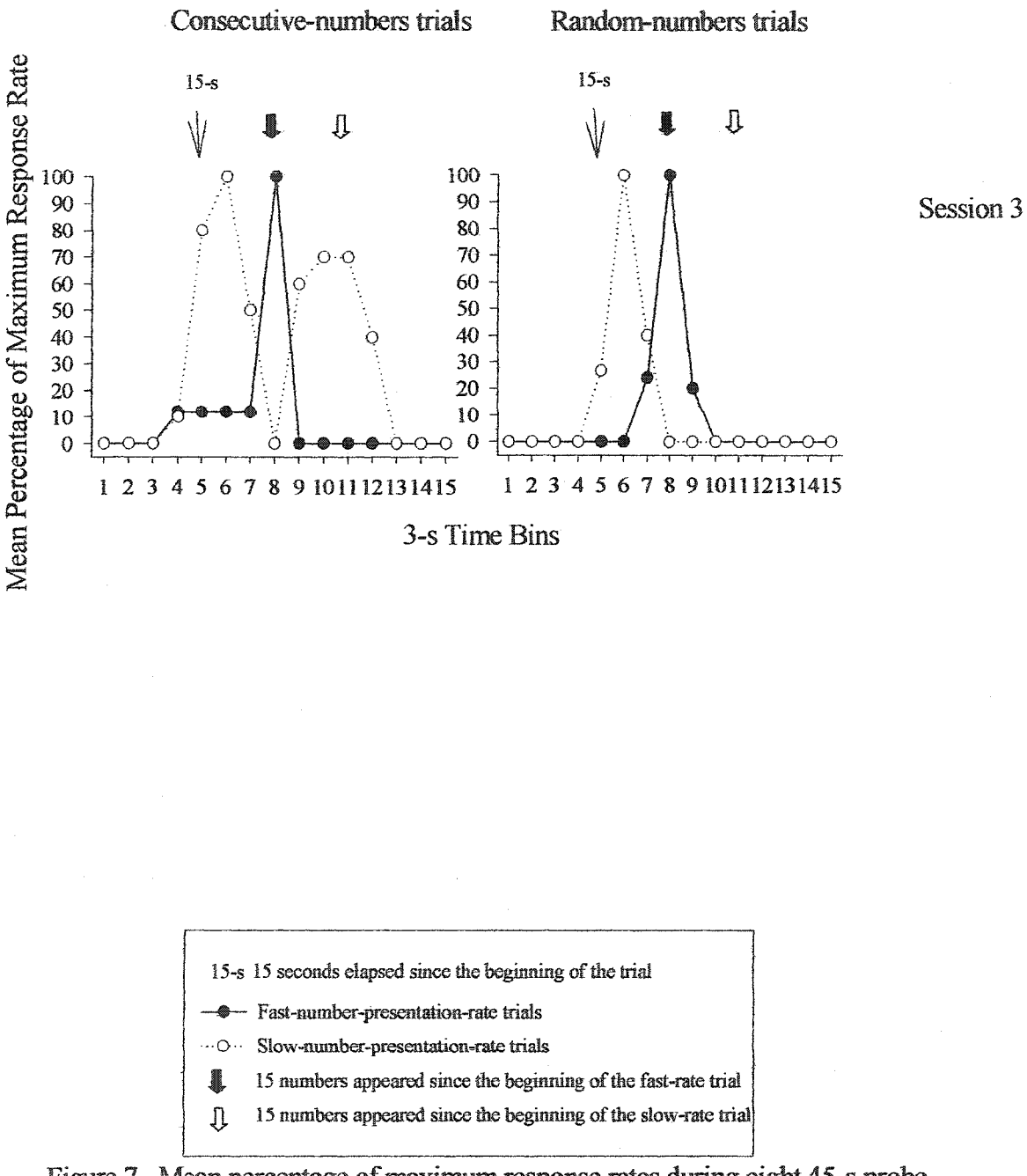


Figure 7. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 3, Experiment 2.

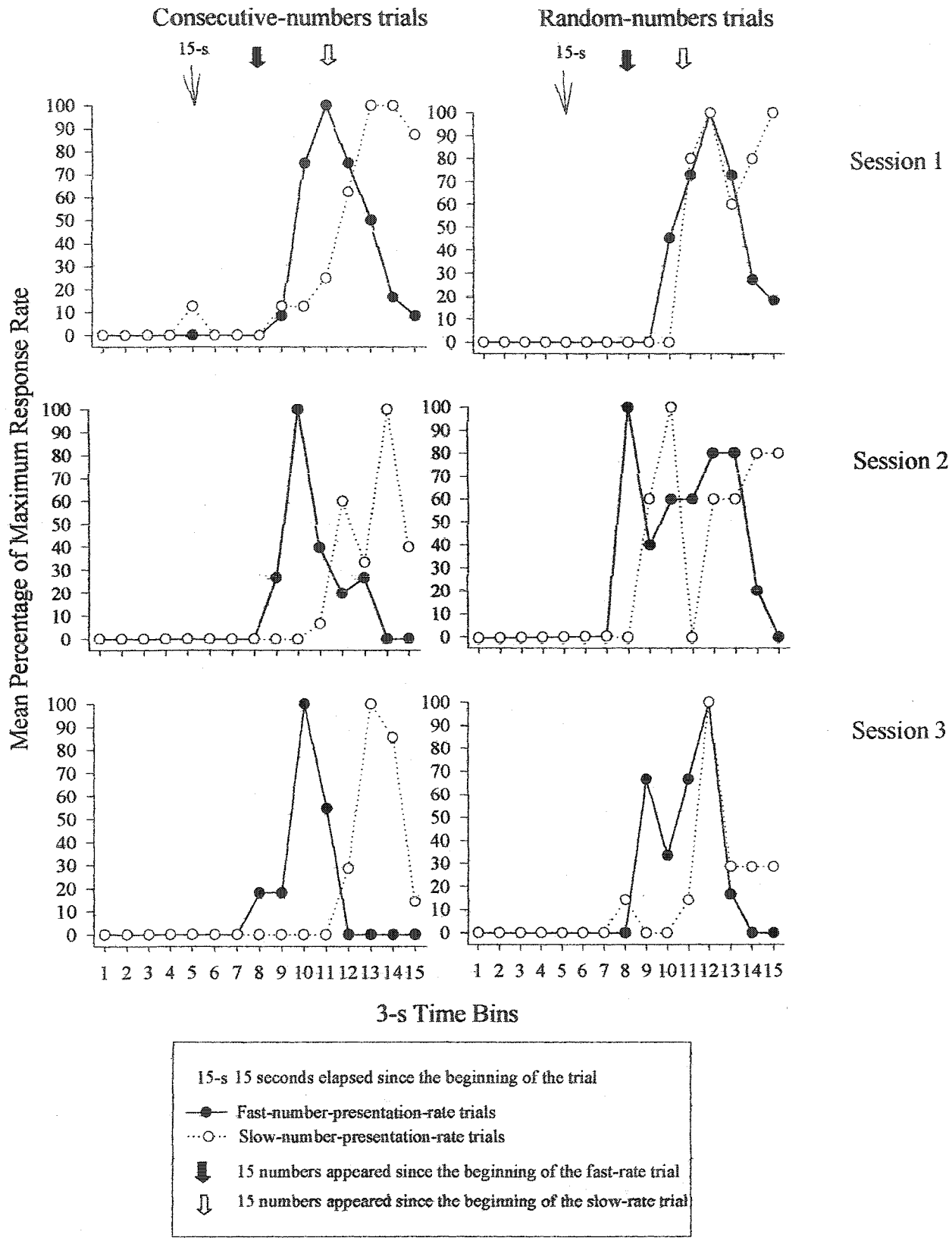
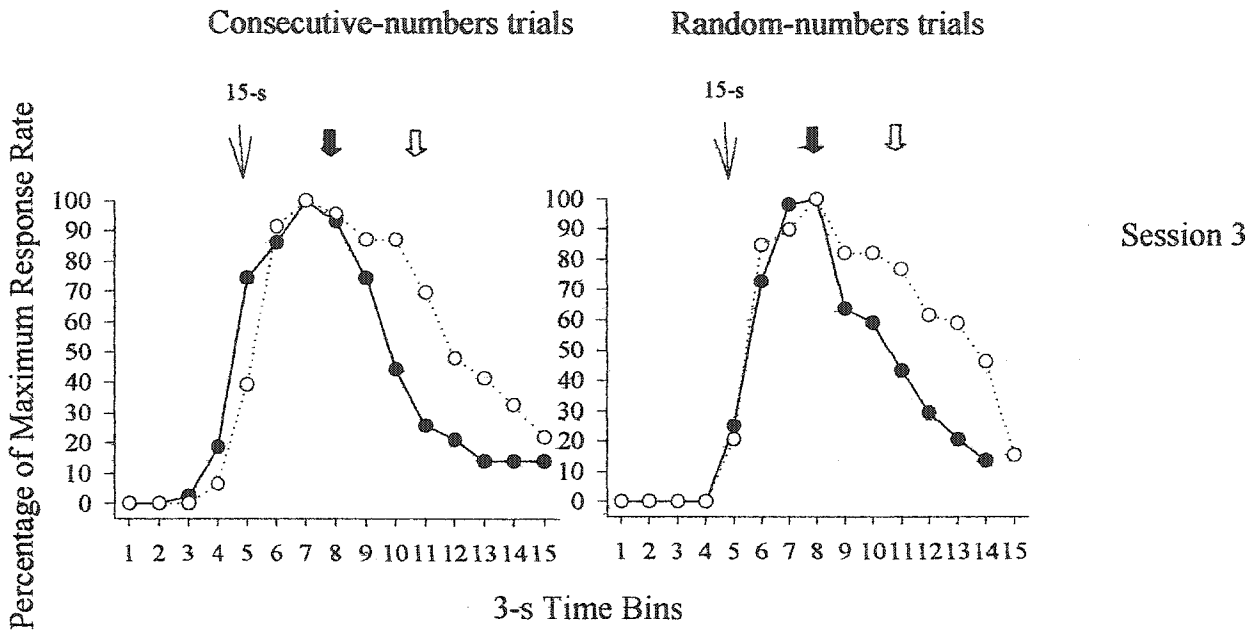


Figure 8. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 5, Experiment 2.



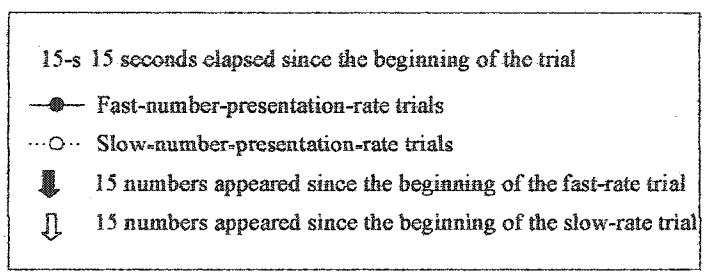


Figure 9. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 7, Experiment 2.

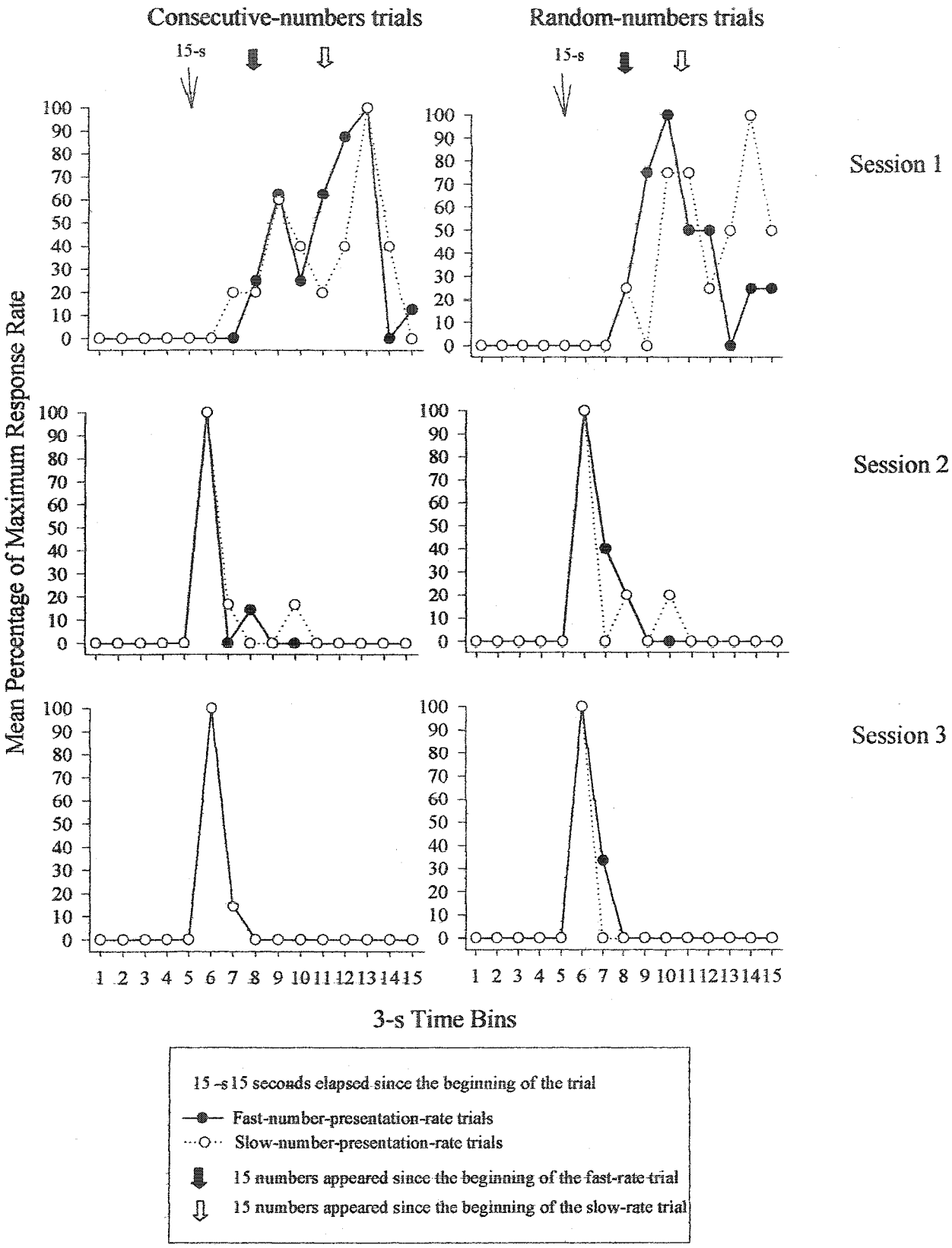


Figure 10. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 8, Experiment 2.

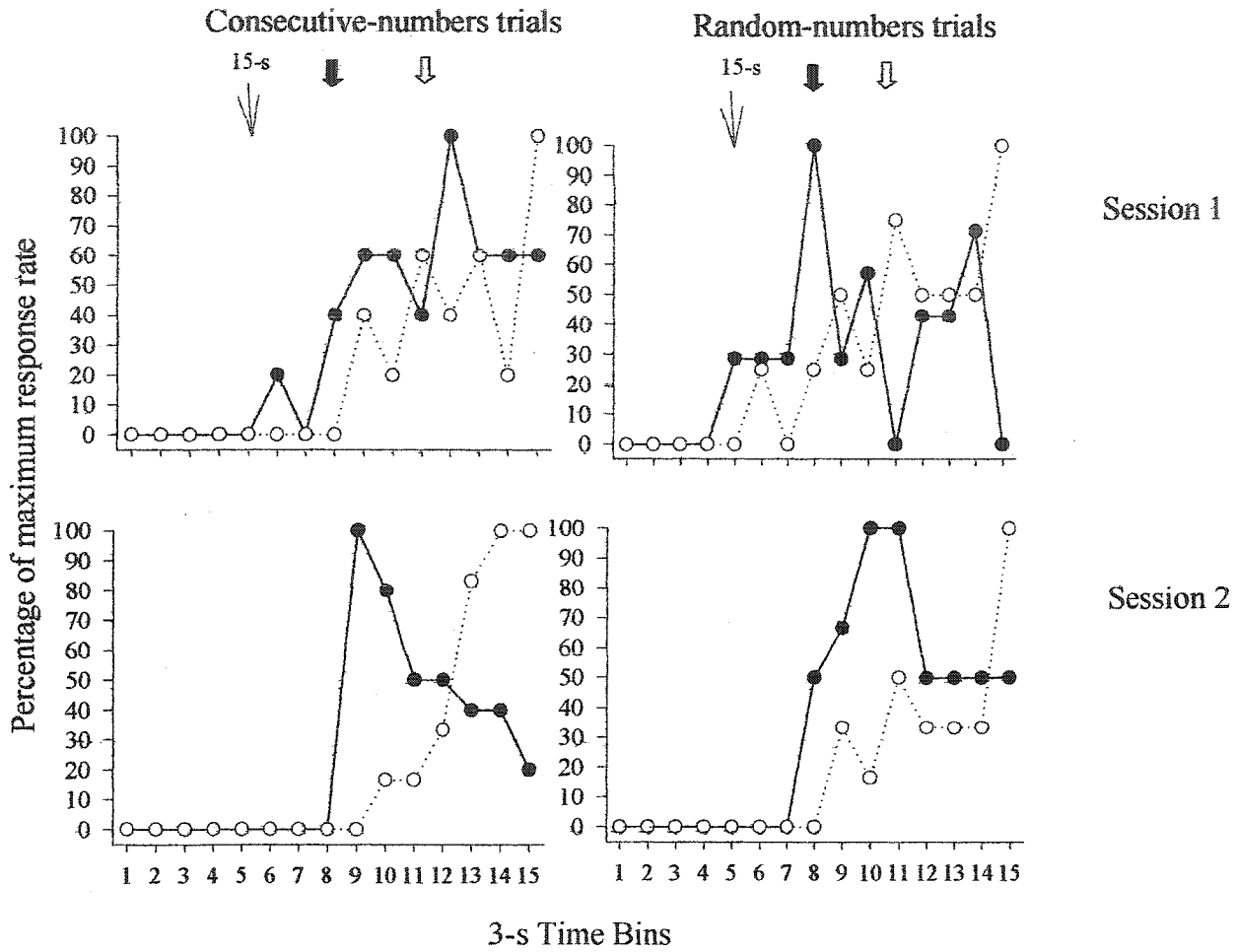


Figure 11. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 9, Experiment 2.

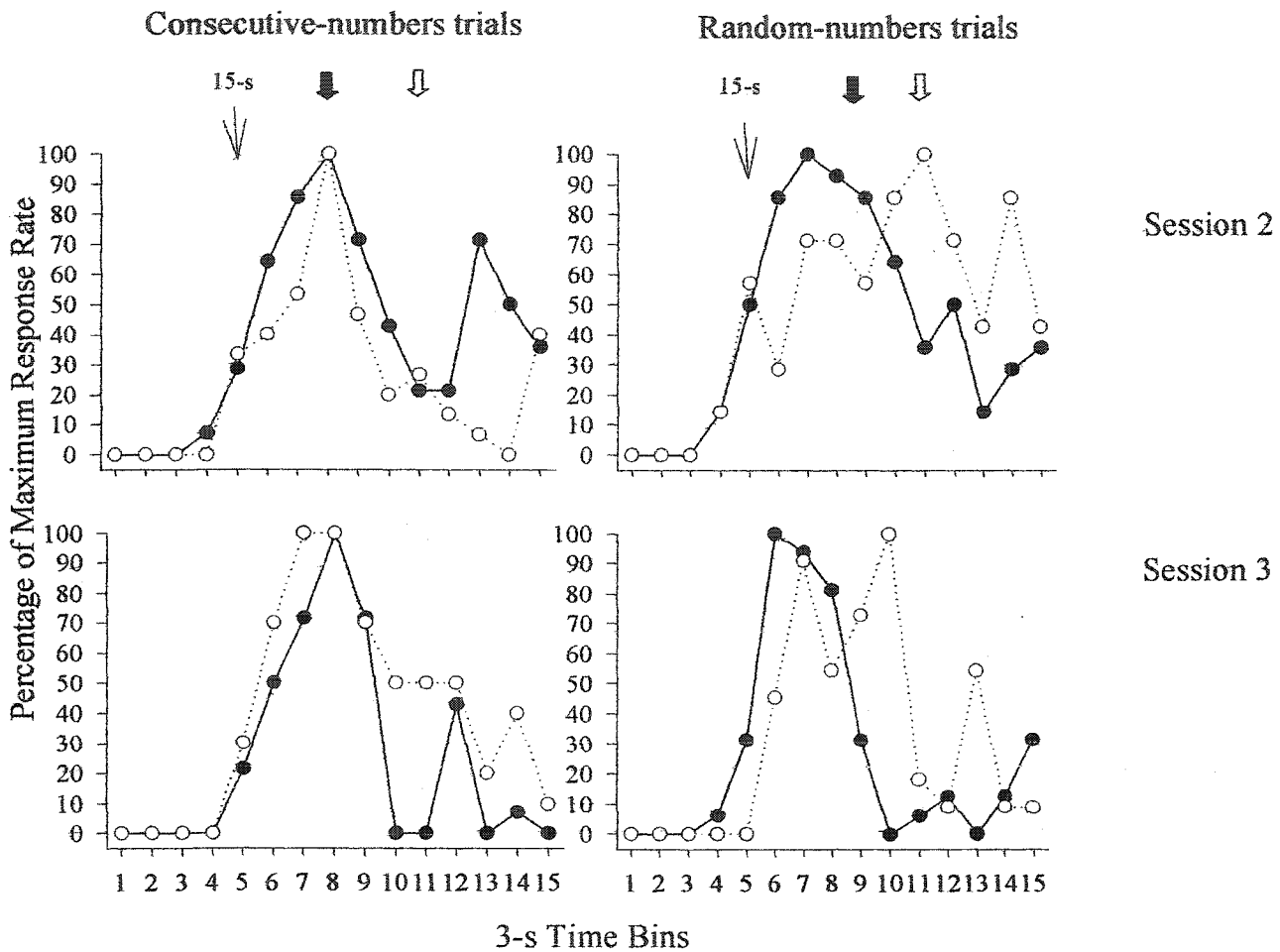


Figure 12. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 11, Experiment 2.

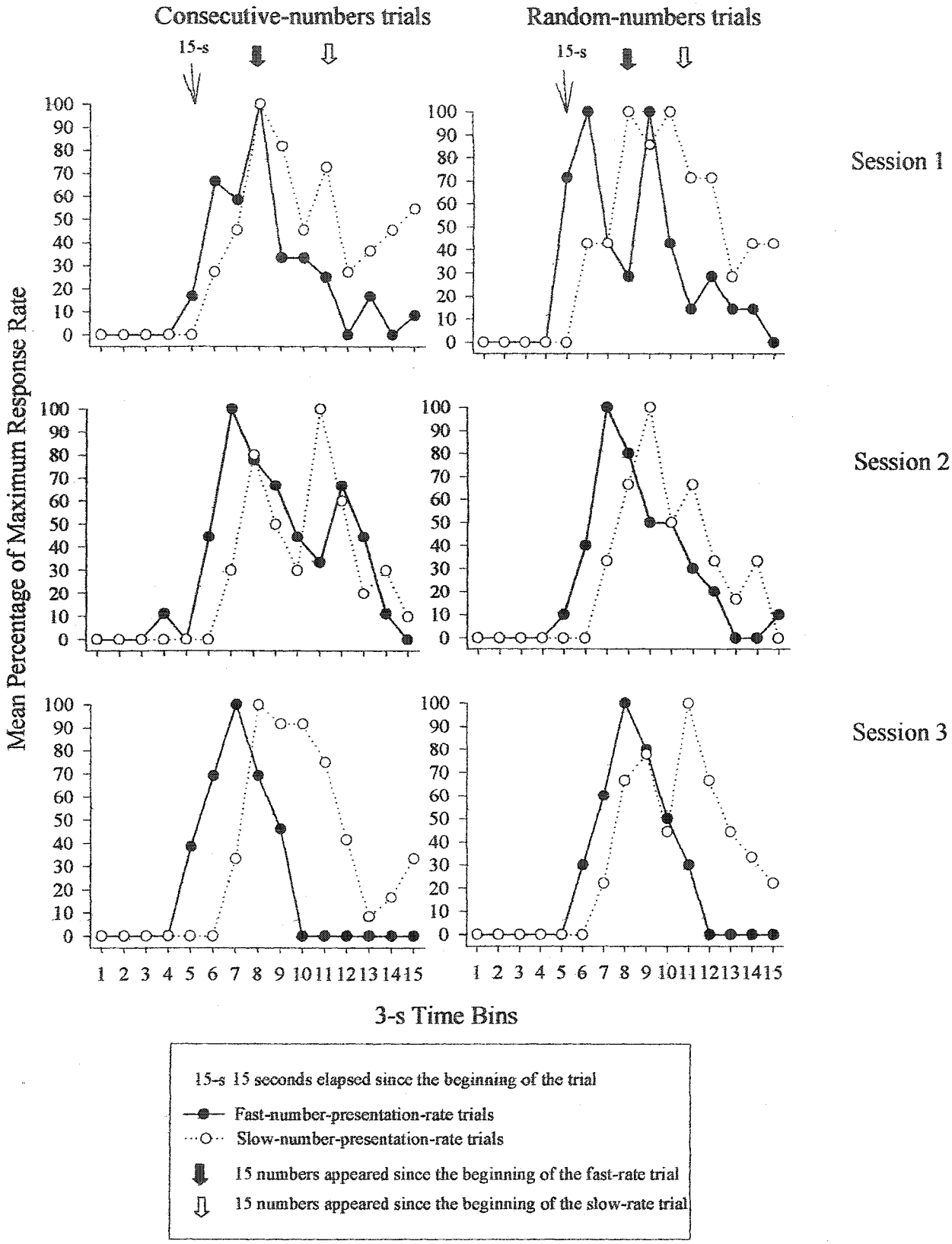
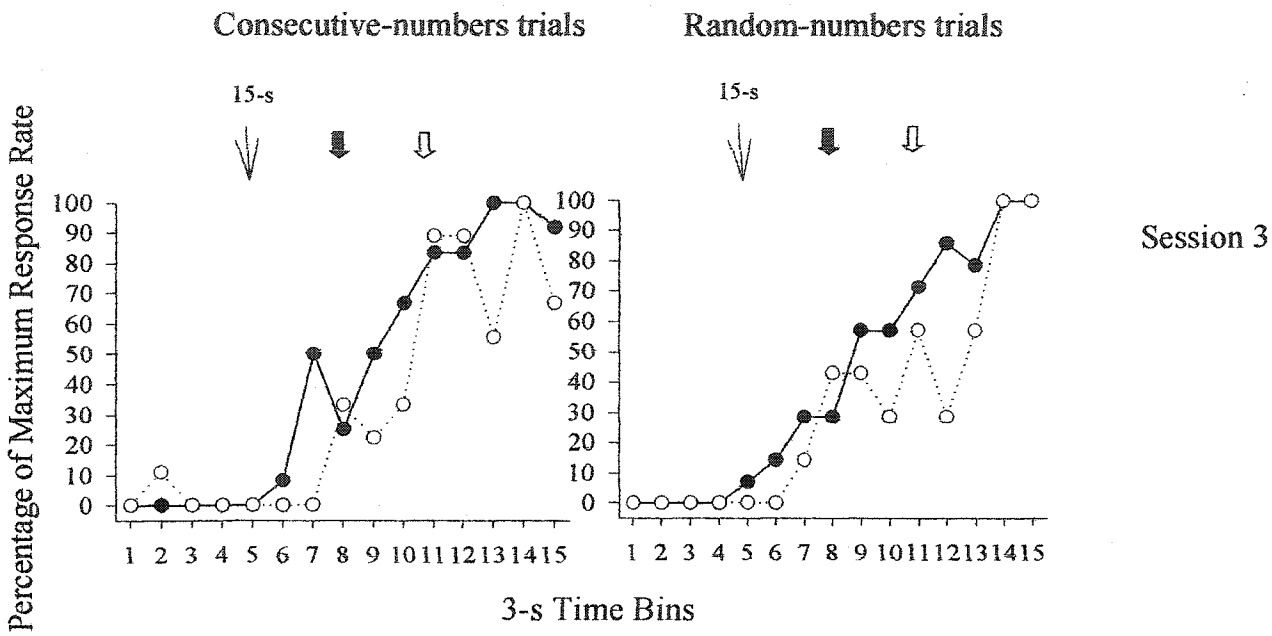


Figure 13. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 12, Experiment 2.



15-s 15 seconds elapsed since the beginning of the trial
Fast-number-presentation-rate trials
Slow-number-presentation-rate trials
15 numbers appeared since the beginning of the fast-rate trial
15 numbers appeared since the beginning of the slow-rate trial

Figure 14. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 13, Experiment 2.

Appendix A

Motivational system script

Every point you earn during the session will be exchangeable for one lottery ticket. At the end of the session, the tickets you earned will be put into a bag with the other lottery tickets. When the study is finished, after all of the participants have been run, one ticket will be pulled out of the bag. The winner will receive a prize, such as movie tickets, a book, or a cool mousepad. The more tickets you receive the higher the likelihood that you will win.

In addition to the lottery tickets, you may exchange points earned for the following during breaks or after the entire session today. You can choose only money, only snacks, or a combination; it's your choice:

Money - For every 5 points you can receive 10 cents

Snacks - for every 10 points you can have a small chocolate bar, for every 15 points you can have a small salty snack, and for every 20 points, you can have a small bag of assorted dried fruit or assorted nuts.

These are only samples; I have a lot more of each of these.

Appendix B

Instructions read by participants on computer monitor and posted near the computer

1 - You will start a trial by pressing the space bar.

2 - To get points you have to type "win" after 20 seconds from the beginning of the trial.

3 - As soon as you earn a point, you will get a message and a cheer.

4 - On some trials you will not be able to earn points.

5 - You only have to type "win" one time as long as it is after 20 seconds.

6 - It is OK to type "win" whenever you want, and as many times as you want.

7 - There is a second task to do. When you see numbers on the computer monitor, you must read them out loud with place names, for example the number 135 would be read one hundred and thirty five. Your voice will be recorded.

8 - Read every number that appears. It is OK to type "win" as you are reading numbers.

9 - If you do not type "win" accurately during the trial and/or do not pronounce numbers to the best of your ability, your participation will be terminated before the scheduled end of the session and you will not receive credit for participation.

Appendix C

Questions asked by the experimenter prior to each practice trial

1 - How do you start a trial?

2 - How do you get a point?

3 - How do you know you got a point?

4 - How many times do you have to type "win" to get a point?

5 - How many times are you allowed to type "win"?

6 - What do you do when you see numbers on the screen?

7 - How would you read this number? [show 769 on a piece of paper]

8 - What should you do when numbers appear and you want to type "win?"

Appendix D

Debriefing questions asked by the experimenter following the experiment

1- Before we finish up, will you please tell me again what you had to do to earn points?

2- Was there any particular strategy that you used to help you to type "win" after 20 seconds?

3- Did you use any other strategies?

4- Did you notice any differences in the way the numbers that you read out loud were presented at different points in the experiment?

5- Did it make any difference to you whether the numbers were presented in order or out-of-order?

6- When the numbers were presented in order, did you use them to keep track of when it was time to type "win"?

7- Did you try to count seconds when the numbers were out of order?

8- Were you able to do so?

9- Did you use any different strategies when the numbers were in order or out-of-order?

10- Did you try to count numbers when numbers were out of order?

11- May I ask your age?

12- Is English your first language [If it was not -] How long have you been speaking English?

Appendix E

Data for which the Discrimination Index was under 2 during one condition or more

Figure Captions

Figure 1. Mean percentage of maximum response rates during ten 60-s probe trials in each condition within 3-s time bins for Participant 3, Experiment 1.

Figure 2. Mean percentage of maximum response rates during ten 60-s probe trials in each condition within 3-s time bins for Participant 4, Experiment 1.

Figure 3. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 6, Experiment 2.

Figure 4. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 7, Experiment 2.

Figure 5. Mean percentage of maximum response rates during eight 45-s probe in each condition during 3-s time bins for Participant 10, Experiment 2.

Figure 6. Mean percentage of maximum response rates during eight 45-s probe trials in each condition during 3-s time bins for Participant 11, Experiment 2.

Figure 7. Mean percentage of maximum response rates during eight 45-s probe trials during each condition within 3-s time bins for Participant 13, Experiment 2.

Figure 8. Mean percentage of maximum response rates during eight 45-s probe trials during each condition within 3-s time bins for Participant 14, Experiment 2.

Figure 9. Mean percentage of maximum response rates during eight 45-s probe trials within each condition within 3-s time bins for Participant 13, Experiment 2.

Figure 10. Mean percentage of maximum response rates during eight 45-s probe trials within each condition within 3-s time bins for Participant 14, Experiment 2.

Figure 11. Mean percentage of maximum response rates during 45-s probe trials within each condition within 3-s time bins for Participant 15, Experiment 2.

Figure 12. Mean percentage of maximum response rates during 45-s probe trials within each condition within 3-s time bins for Participant 16, Experiment 2.

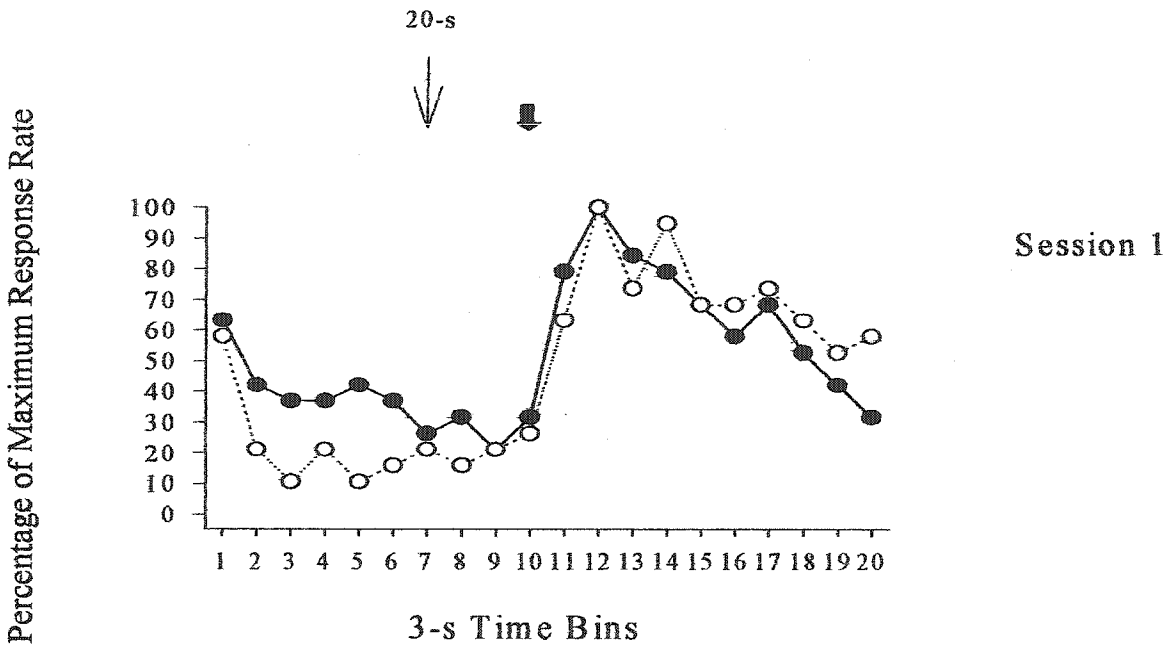


Figure 1. Mean percentage of maximum response rates during ten 60-s probe trials in each condition within 3-s time bins for Participant 3, Experiment 1.

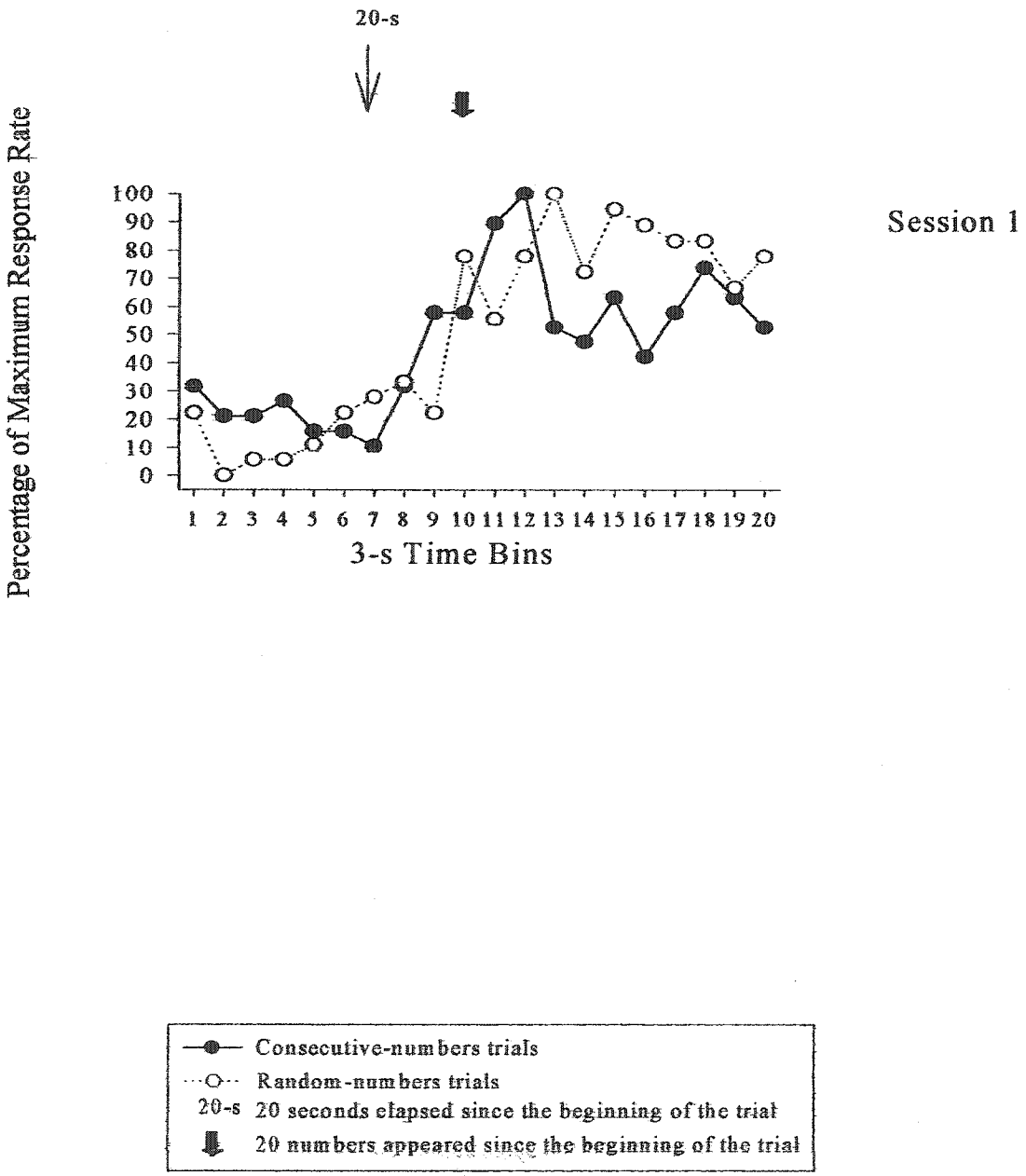


Figure 2. Mean percentage of maximum response rates during ten 60-s probe trials in each condition within 3-s time bins for Participant 4, Experiment 1.

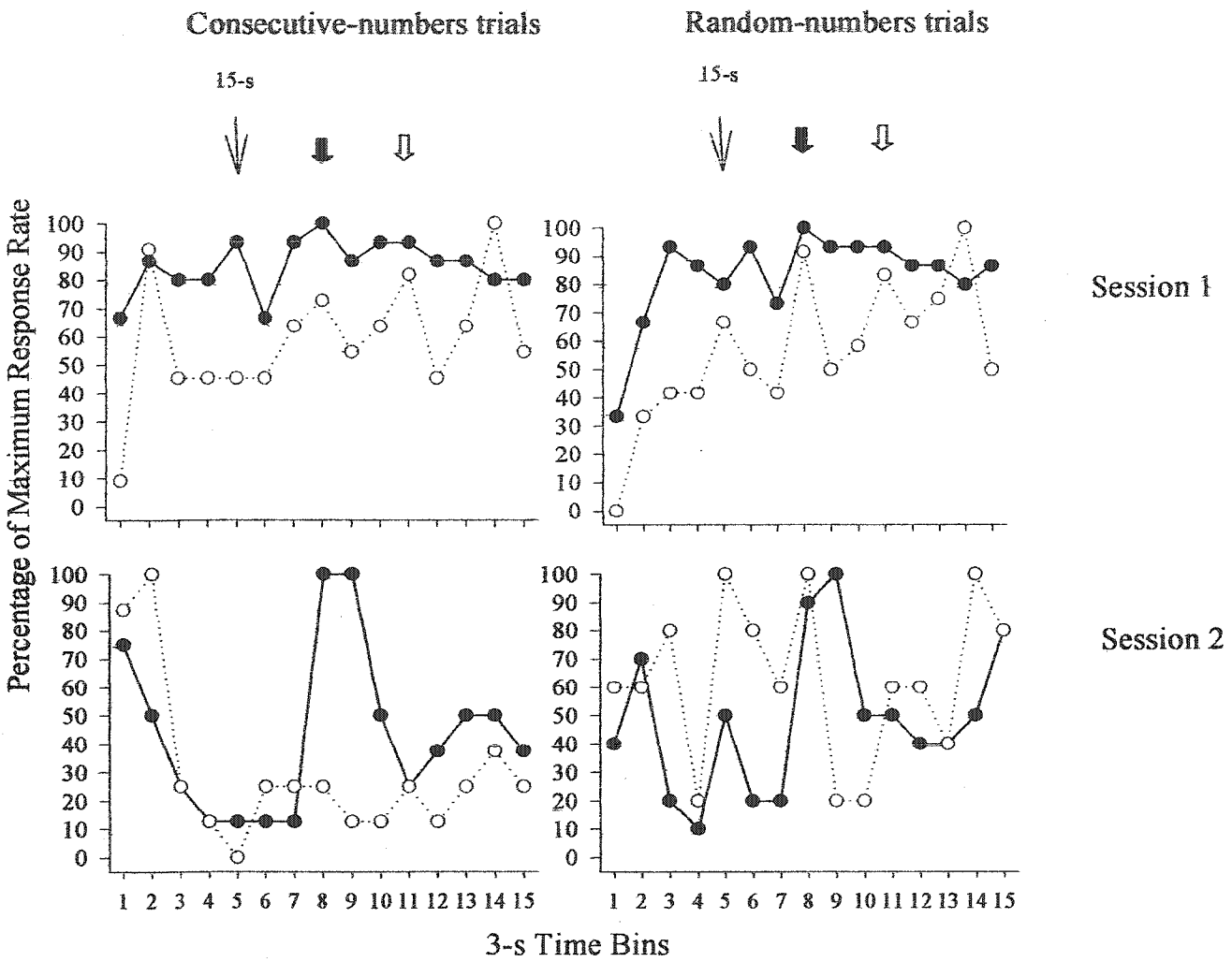


Figure 3. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 3, Experiment 2.

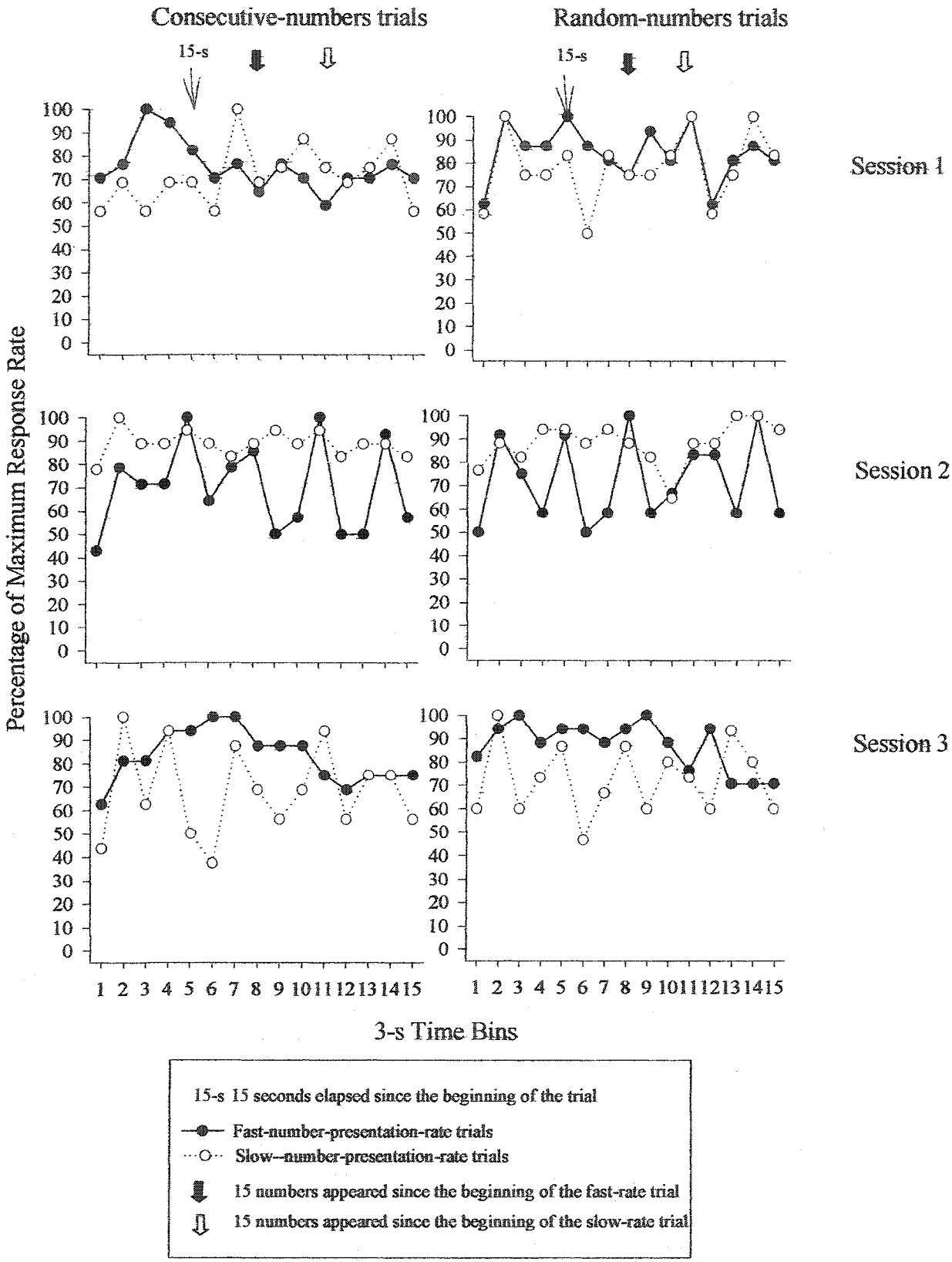


Figure 4. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 4, Experiment 2.

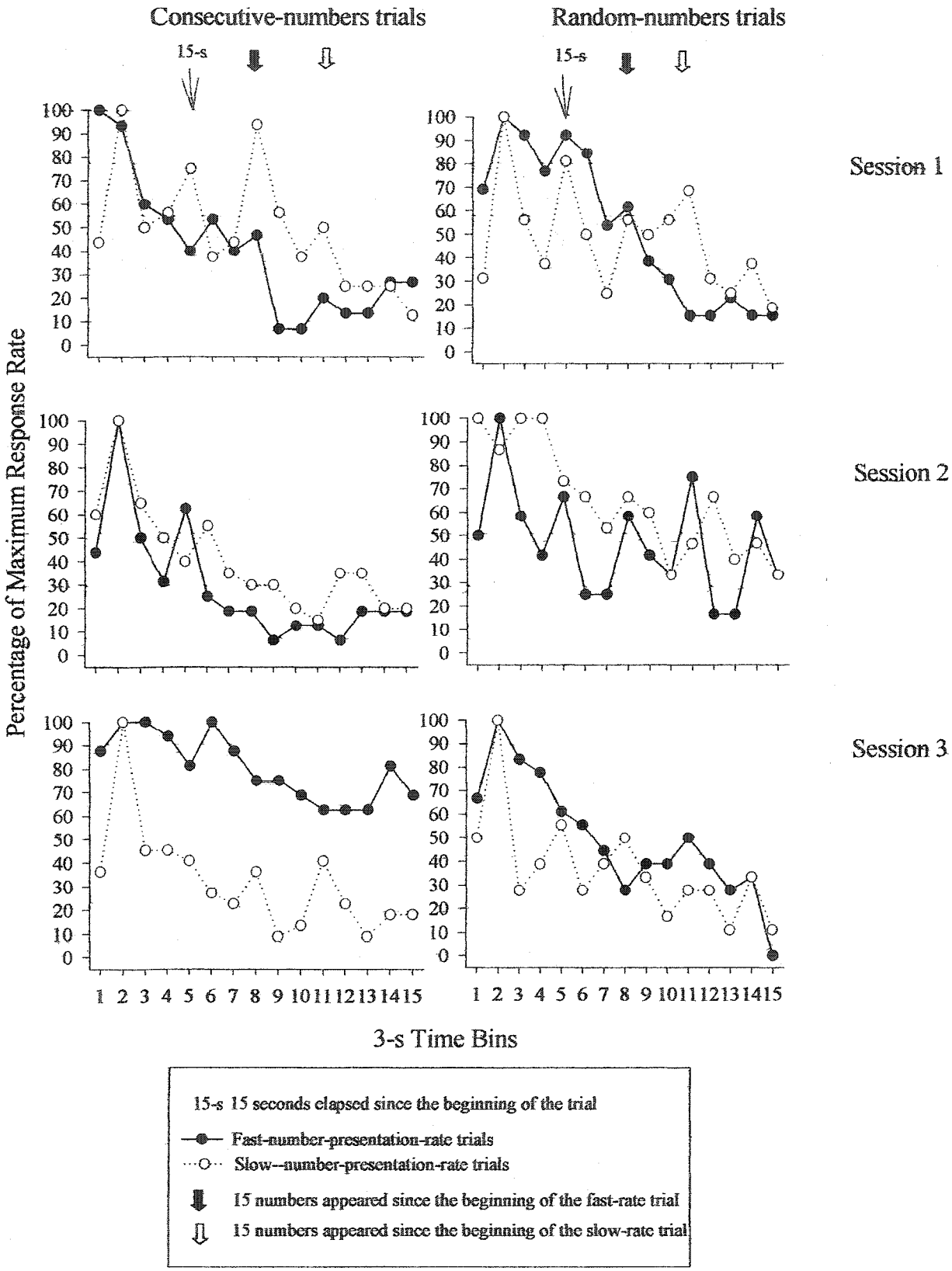


Figure 5. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 6, Experiment 2.

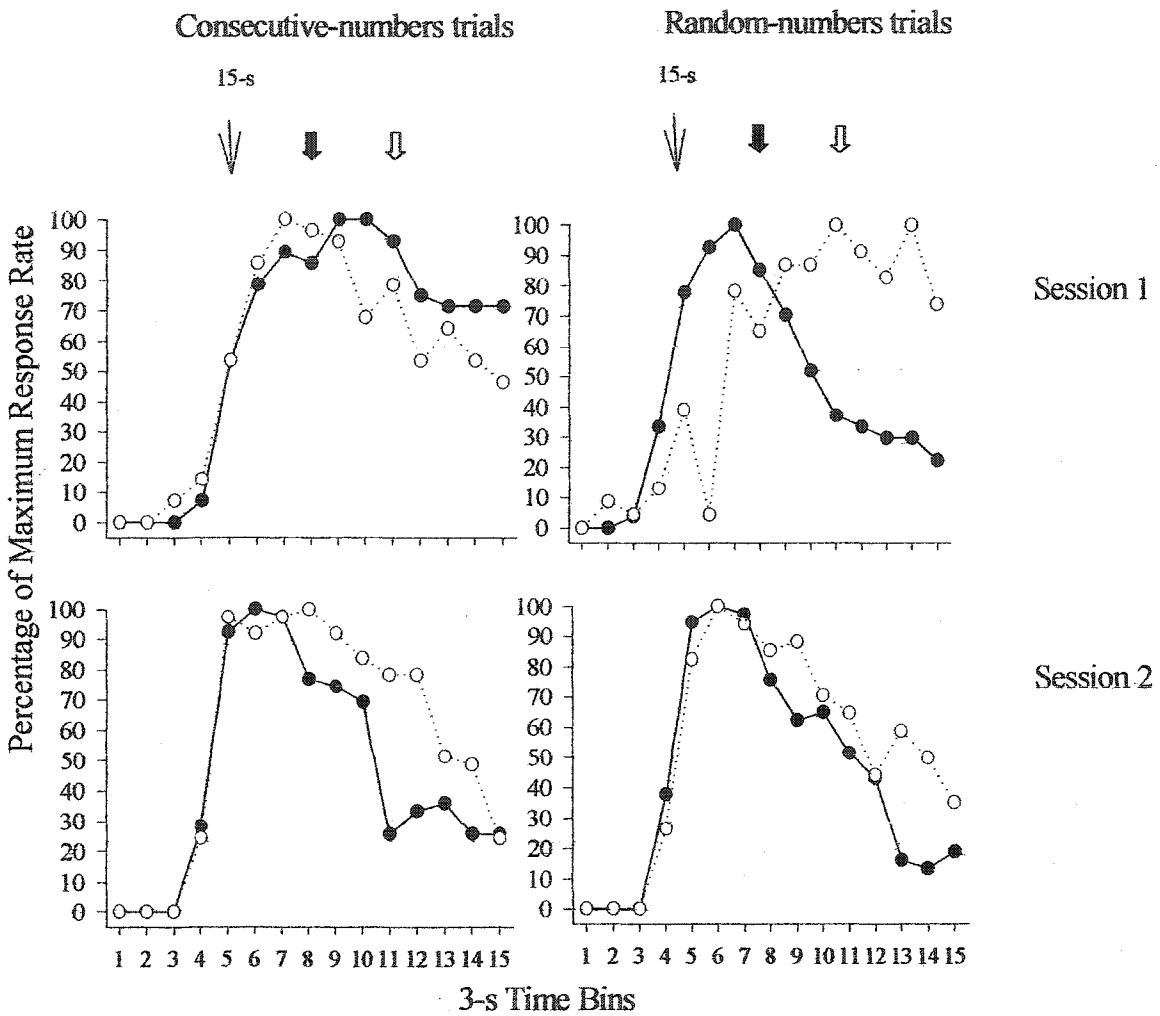


Figure 6. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 7, Experiment 2.

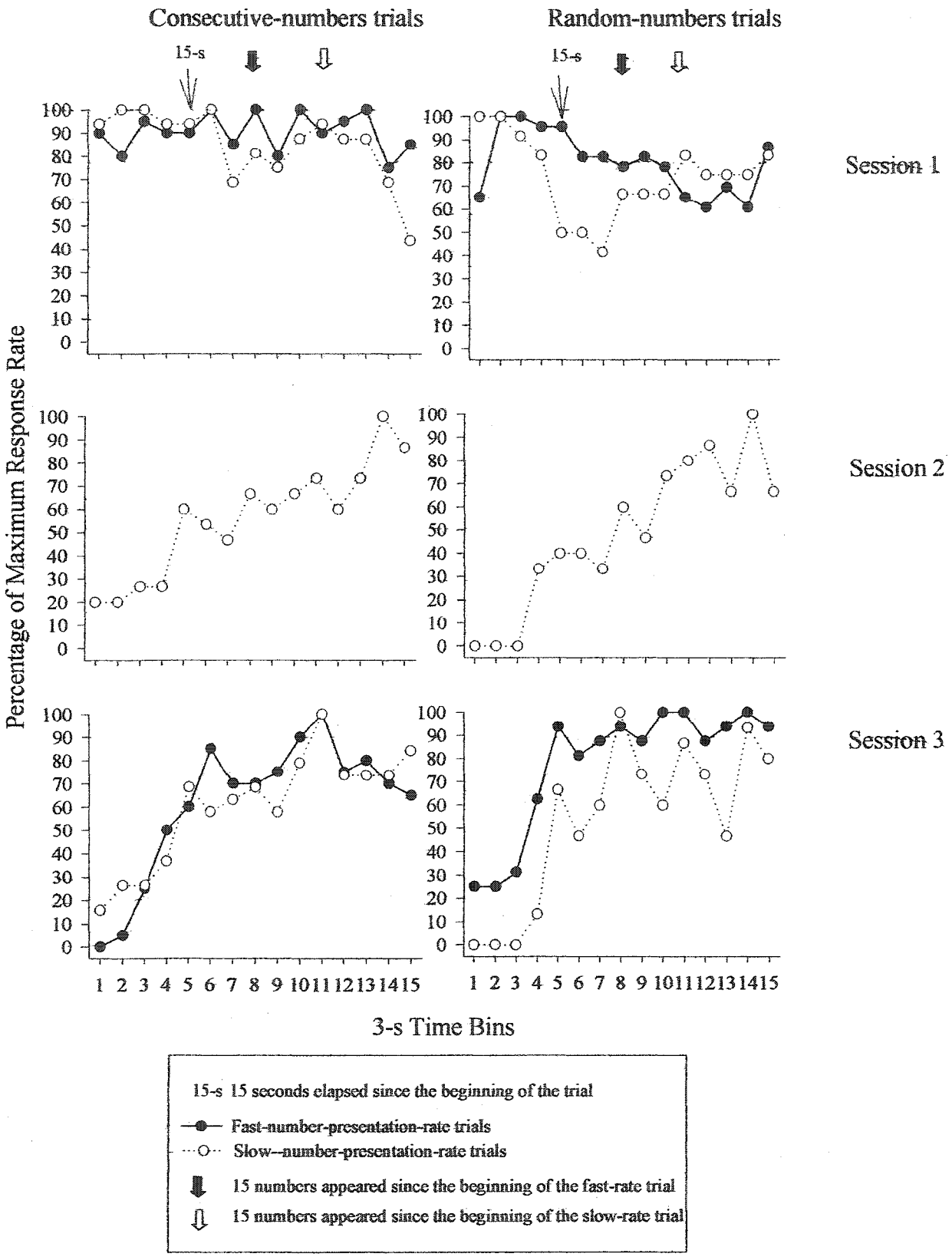
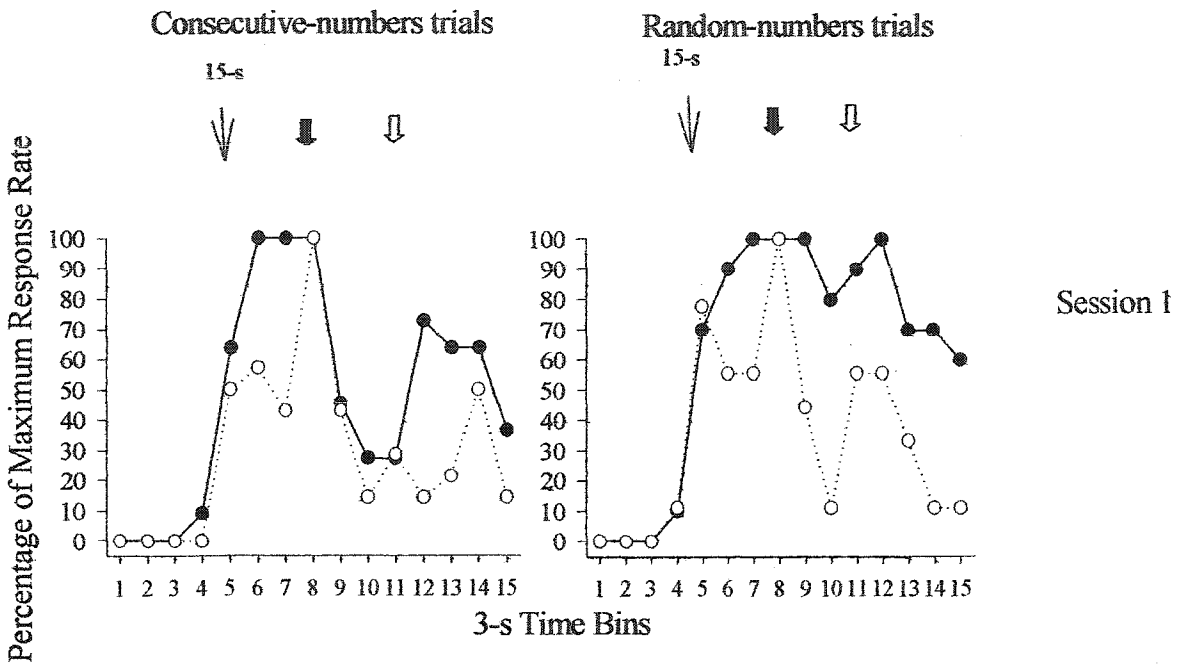


Figure 7. Mean percentage of maximum response rates during eight 45-s probe trials ~~in each condition within~~ 3-s ~~time~~ bins ~~for~~ Participant ~~10~~, ~~Experiment~~ 2.



15-s 15 seconds elapsed since the beginning of the trial
Fast-number-presentation-rate trials
Slow-number-presentation-rate trials
15 numbers appeared since the beginning of the fast-rate trial
15 numbers appeared since the beginning of the slow-rate trial

Figure 8. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 11, Experiment 2.

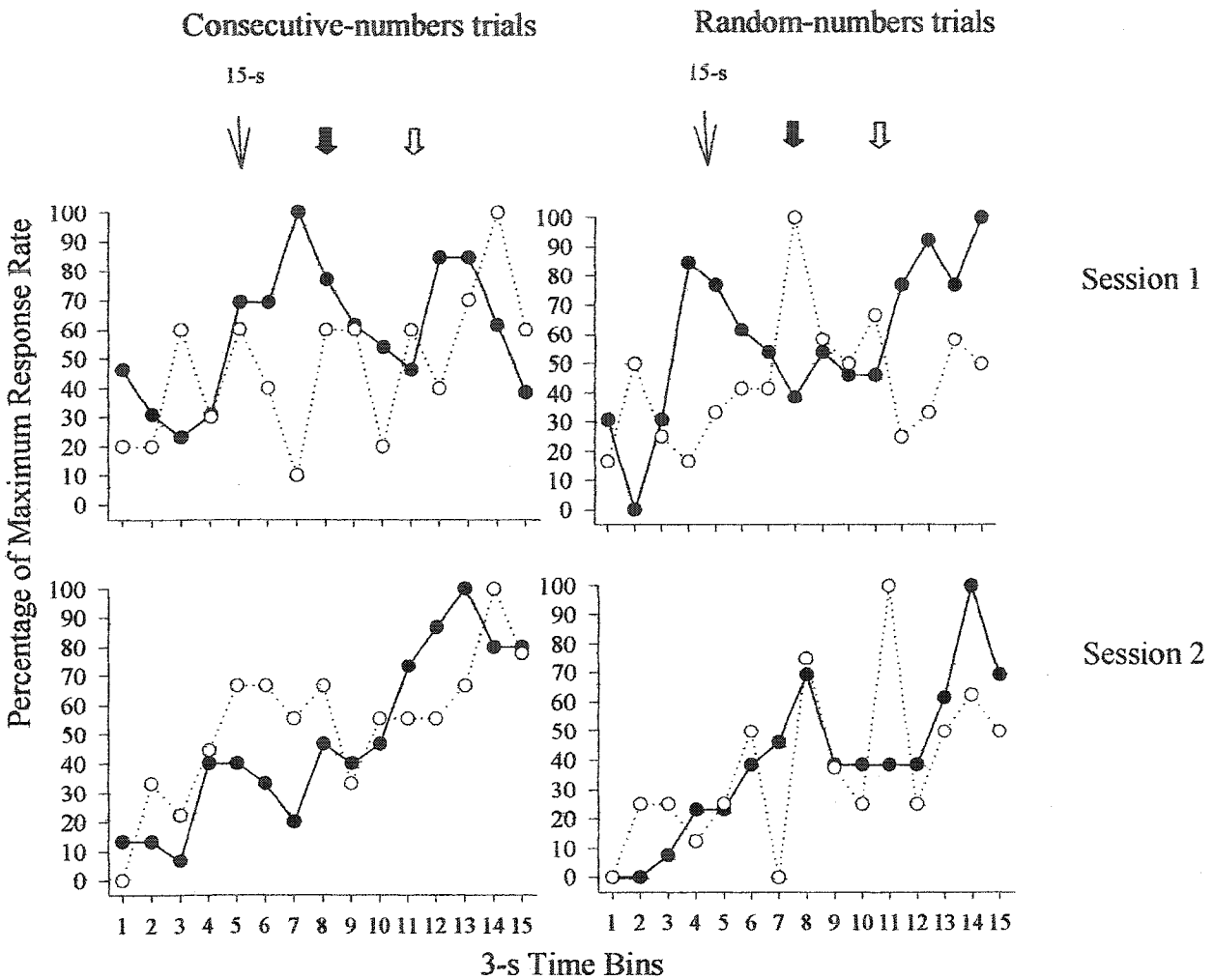


Figure 9. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 13, Experiment 2.

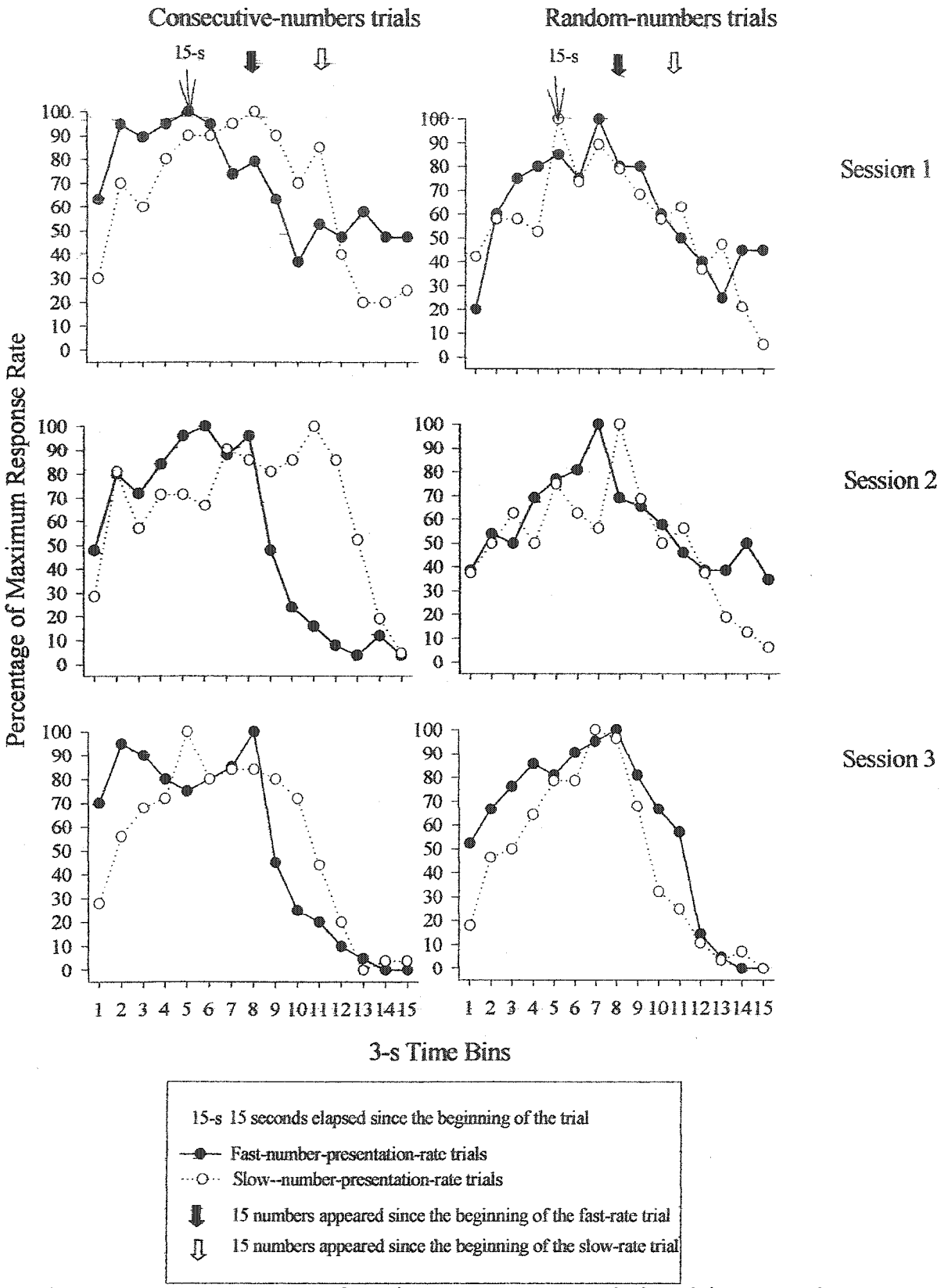


Figure 10. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 14, Experiment 2.

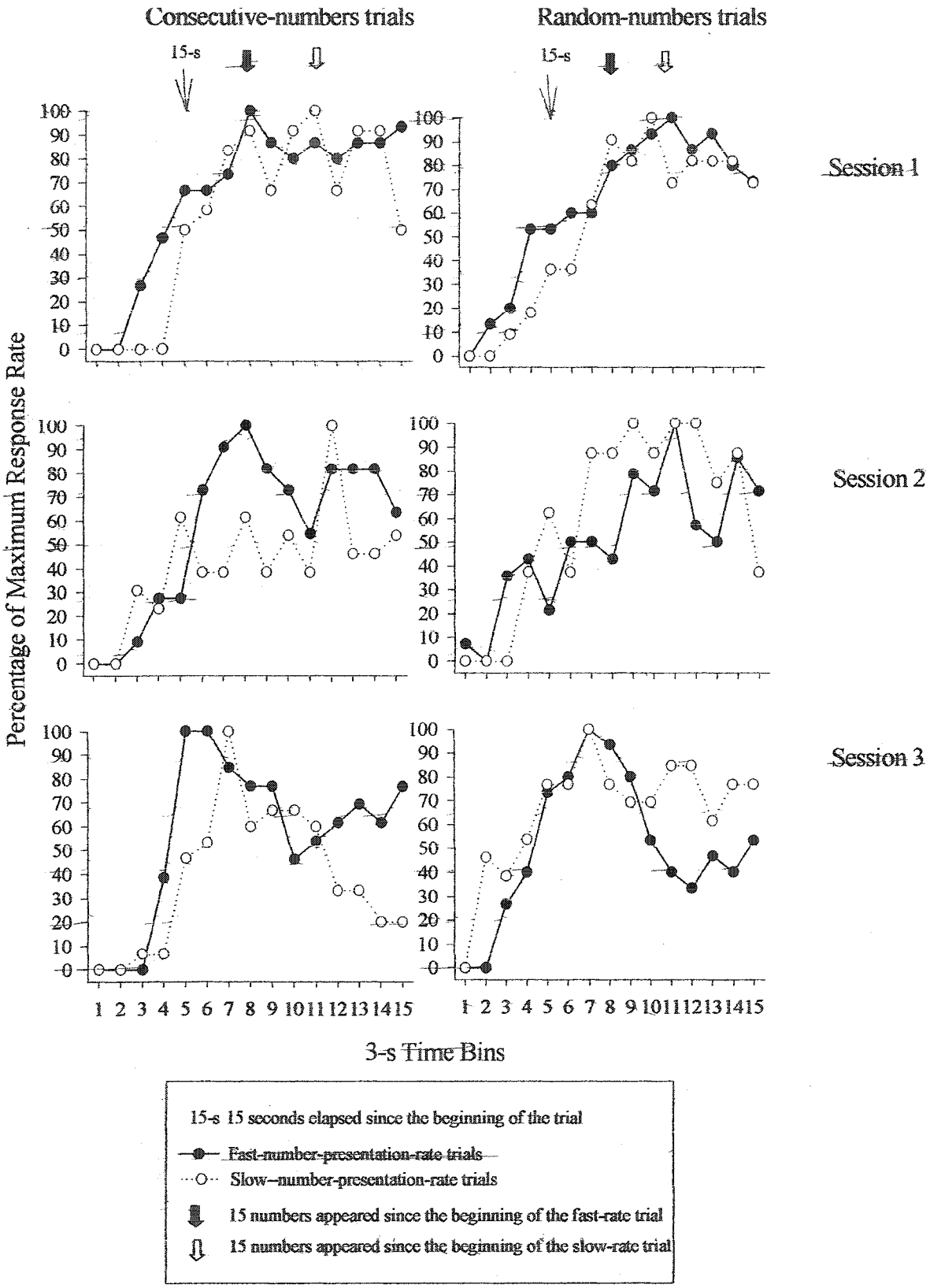


Figure 11. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 15, Experiment 2.

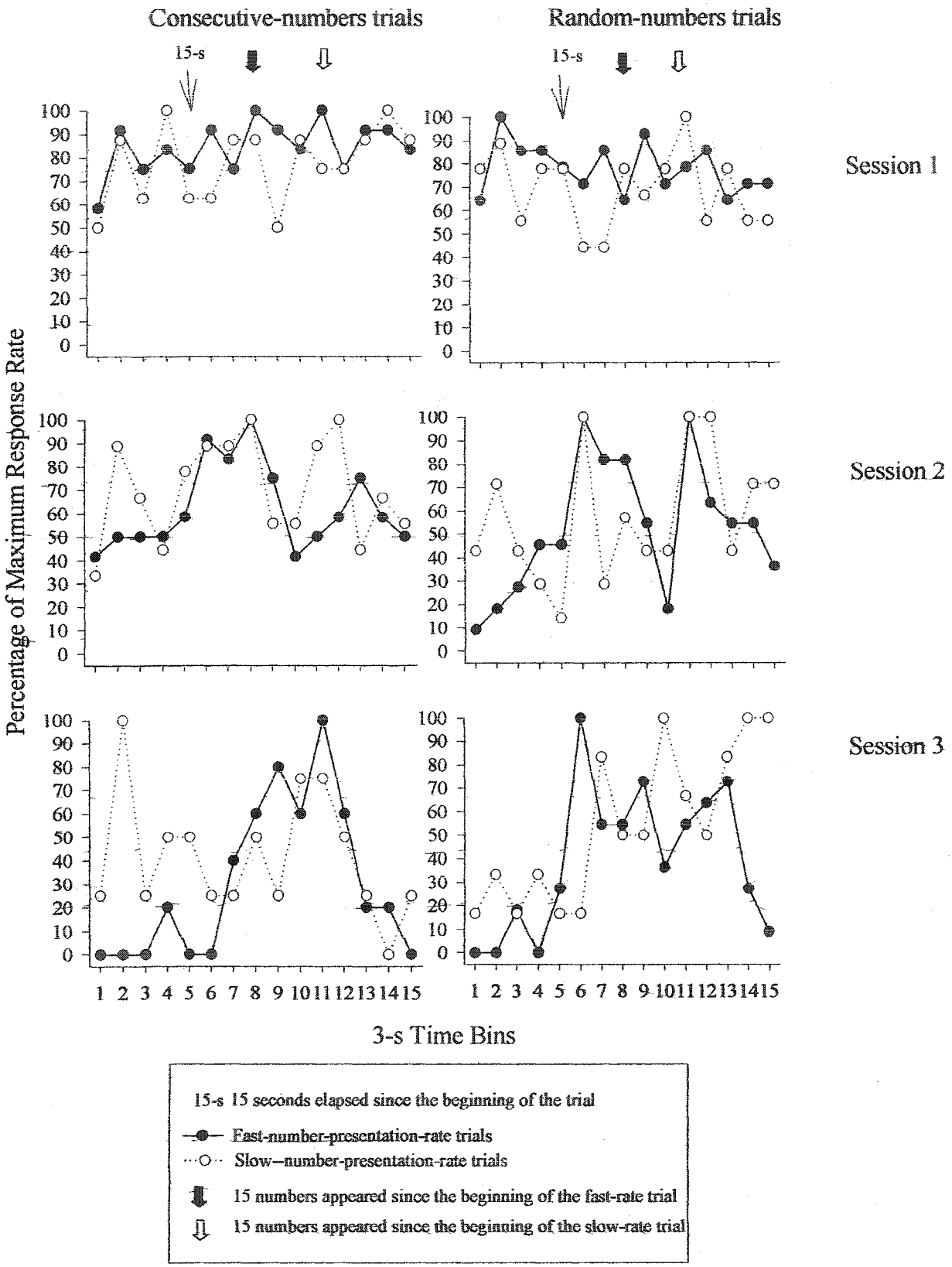


Figure 12. Mean percentage of maximum response rates during eight 45-s probe trials in each condition within 3-s time bins for Participant 16, Experiment 2.

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