

# Compound Performance: The Role of Free and Controlled Operant Components\*

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Precision Teaching methodology promotes fluency building in component behaviors in order to impact on the performance of compound behaviors. A review of the literature suggests that component behaviors must attain a certain frequency of performance before they can easily coalesce into a behavioral compound. The purpose of this experiment was to examine performance on the compound behavior when one component was taught to a preset fluency aim range under free operant conditions and a second component was taught under controlled operant conditions, through pacing. Results indicate that compound performance was improved when tested with one component at the fluency aim range and the second component at the paced controlled operant criteria.

DESCRIPTORS: Component, compound, free operant, controlled operant, momentum

Precision Teaching methodology has a long history of building component skills to fluency in order to impact upon the acquisition and performance of compound behaviors (Binder, 1993; 1996). Research has shown that building component skills to high frequencies can sufficiently impact upon a subsequent compound skill to increase its' performance to a fluent level without ever delivering instruction on that skill (McDowell, 2001). Generally fluency, in the form of increased performance frequencies, is required to facilitate the easy combining of component behaviors into a behavioral compound. Data published by Barrett (1979, cited in Johnson & Layng, 1992) shows how normal functioning adults can perform the compound skill of writing the number 4 at an average rate of 100 per minute. This is roughly half the rate of performance on the component skill of writing the number 1, which was performed at the average rate of 210 per minute. However it remains unclear if all components of a compound skill must be fluent before they can combine to produce a compound behavior.

Lindsley (1997) suggests that fluency may be related to the area of behavioral momentum. Behavioral momentum is the frequency of performance "that is established and maintained by the contingencies of reinforcement, and its resistance to change when responding is challenged in some way" (Nevin, 1988, p. 123). Behavioral Momentum is comprised of two main elements, behavioral "velocity" and "behavioral mass." These two elements provide the links to the Precision Teaching framework. Behavioral velocity refers to rate or frequency of response. Behavioral mass refers to an established frequency's resistance to change when responding is challenged. The fluency products of "Retention", "Endurance" and "Application" also refer to resistance to change when responding is challenged. Retention refers to

resistance to change when performance is challenged by a period of non-practice. Endurance refers to resistance to change when performance is challenged by longer performance periods. And finally Application refers to resistance to change when performance is challenged by more complex requirements.

The links between Precision Teaching and the Behavioral Momentum framework provide the basis for an examination of the role of free-operant fluent components and controlled non-fluent components on the acquisition and performance of a related compound behavior. Higher rates of performance are associated with Application, Retention and Endurance, however research within the Precision Teaching framework has found that the highest rates of performance are not necessarily associated with subsequent progression on skills (Evans & Evans, 1985). Rather an optimal rate of performance may exist that allows a greater resistance to change. This rate may be deemed a Fluency rate. Conversely, within the Behavioral Momentum framework, Nevin (2001) states that lower performance rates are more resistant to change than higher performance rates, when reinforcement rates are equal. The purpose of this experiment was to examine compound behavior when 2 component skills are taught under differing conditions, one free operant and one controlled operant in the form of paced responding. A compound task was examined to establish if component skills performed at different rates relative to their Fluency Aim Range can coalesce into a compound behavior, and if so does that compound behavior display resistance to change in terms of Retention and Endurance.

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## METHOD

### *Participants and Setting*

Five school children, two girls and three boys, were participants in this experiment. Ashley, Bronagh, Gary, Shane and Tony were all seven years old at the beginning of the experiment. All five participants were students at a primary school in Northern Ireland. The students were selected for participation in the experiment on the basis of teacher assessment. Their teacher identified each of the students as experiencing some level of difficulty with reading tasks. The sessions were conducted in a vacant classroom of the primary school.

### *Tasks*

Each learner completed practice on two component reading skills and one compound reading skill; Component skill 1: practice see/say consonant-vowel blends. Component skill 2: practice see/say consonant-consonant blends. Compound skill: practice see/say words that contained consonant-vowel-consonant-consonant blends.

### *Phases and Conditions*

There were five different phases during the experiment: Phase 1 involved the collection of baseline data on the two component skills and the compound skill. Phase 2 comprised of two separate conditions, Condition 1 was a paced condition. In order to respond to the visual stimulus the student had to wait until an auditory stimulus was heard. Responding to the next visual stimulus was contingent upon hearing the next auditory stimulus. Condition 2 was a free-operant condition where the all the visual stimuli were presented together. The student was free to respond to the material at his or her own pace, no auditory stimulus was present. In this Phase students received instruction on both component skills. During practice one component skill was practiced under free-operant conditions, the second component skill was practiced under paced responding conditions. The components practiced under free and paced conditions were randomly alternated between students. During this phase performance was reinforced through the use of a token economy, where 10 tokens could be exchanged for a choice of 1 item from a selection of small toys, novelty stationary items and edibles. Reinforcement was contingent upon attaining a preset aim. In Phase 3 the compound skill was tested under baseline conditions, and checked for retention and endurance. In Phase 4 the student practiced the previously paced component skill

under free operant conditions. During this phase performance was reinforced in the same manner as in Phase 2. In Phase 5 the compound skill was tested under baseline conditions, and checked for retention and endurance.

### *Timings*

Three timing periods were used throughout the practice sessions, 30 seconds, 1 minute and 3 minutes. 30-second timings were used only when data indicated that a student had difficulty performing a task for 1 minute. A 1-minute timing period was used as a standard performance period throughout the practice sessions. 3-minute timing periods were used to check for endurance of performance on the compound task.

## PROCEDURE

### *Sessions*

Baseline data collection and intervention sessions (Phases 1-5) were conducted on a number of days each week that suited the schools timetable. Sessions were occasionally cancelled due to school activities.

*Phase 1: Baseline.* In this phase, stimuli were presented under free operant conditions. Stimuli were presented on cards that were placed in random order on the tabletop. For see/say consonant-vowel combinations a total of 26 different combinations were presented. The 26 combinations were repeated 2 times in random order (52 cards in total). For see/say consonant-consonant combinations 14 different combinations were presented, repeated 3 times randomly (a total of 42 cards). For see/say words 31 different words were presented, repeated 2 times randomly (a total of 62 cards). Before the timing began the student was given the following instructions; "I am going to point to a card, this card is your starting point. When you are ready I want you to say what you see on the card, and move on to the next one and so on. If you come to the end of the cards I want you to return to the start and continue saying what you see on the cards." Starting points were chosen at random. The timing began once the student responded to the first card. All baseline timings were of a 1-minute duration. Students received only one timing opportunity during a baseline session. The number of correct and incorrect responses were counted, the student received no feedback or instruction at this point. Baseline data collection ended when the students' rate of responding showed little or no change.

*Phase 2: Paced and Free Operant Responding.*  
*Condition 1 - Paced Responding:* In this condition stimuli were again presented on cards placed

in random order on the tabletop. The same number of cards were presented, and repeated, as in Phase 1. Before a timing began the student was given the following instructions; "I am going to point to a card, this card is your starting point. When you hear the beep I want you to say what you see on the card, do not move on to the next card until you hear the next beep and so on. If you come to the end of the cards I want you to return to the start and continue saying what you see on the cards, as you hear the beep."

Starting points were chosen at random. The timing began once the student responded to the first card. In this condition all timings were of a 1-minute duration. Students received repeated timing opportunities during a paced responding session. The number of correct and incorrect responses were counted. At the end of the timing the student received feedback and instruction. The paced responding condition ended when the student had responded at a preset Paced Aim Range (P.A.R.) for three days (P.A.R was set at 40-45, half of the component skills F.A.R., or Fluency Aim Range of 80-100).

*Condition 2 - Free Operant Responding:* As in Phase 1, stimuli were presented on cards placed in random order on the desktop. The same number of cards were presented, and repeated. Before the timing began the student was given the following instructions; "I am going to point to a card, this card is your starting point. When you are ready I want you to say what you see on the card, and move on to the next one and so on. If you come to the end of the cards I want you to return to the start and continue saying what you see on the cards. I want you to try to get through as many cards as you can."

Again starting points were chosen at random. Timings in this condition were either 30-seconds or 1-minute in duration, depending on the performance of the student. Students received repeated timing opportunities during a free operant session. At the end of the timing the number of correct and incorrect responses were counted and the student received feedback and instruction. Free operant conditions ended when the student had responded at a preset Fluency Aim Range for three days (F.A.R. was set at 80-100 for both component skills and compound task).

*Phase 3: Testing, Retention and Endurance.* Performance, retention and endurance on the compound skill were tested under baseline conditions. Stimuli were arranged in the same manner and similar instructions were delivered. Testing of performance on the compound skill ended when the student's performance showed little or no change for three days. At this point the

student received no practice opportunities on the task for at least 1 week in order to check for retention. However due to the applied nature of the experiment some no practice periods were longer than 1-week. During the endurance check instructions varied slightly from those delivered during baseline, the performance test and the retention check. At this point students were informed that the performance period would be 3-minutes. As in all conditions, the number of correct and incorrect responses were counted at the end of all timings. The student received no feedback or instruction at this time.

*Phase 4: Free Operant Practice on Previously Controlled Component.* In this phase the procedure followed the same format as in Phase 2, Condition 2.

*Phase 5: Testing, Retention and Endurance.* In this phase the procedure followed the same format as in Phase 3.

## RESULTS

Table 4 displays the Phase 1 rate of responding for each learner during a 1-minute timing on the component skills see/say consonant - vowel blends and see/say consonant - consonant blends and the compound task see/say words. Skills were practiced under baseline conditions during this phase.

It can be seen from table 1 that responding for all learners was well below the Fluency Aim Range on all skills, with a variable degree of error occurring. Baseline rates of responding for each learner are shown in Phase 1 on Figures 1 to 5.

Table 2 displays the Phase 2 rates of responding for each learner on the component skills see/say consonant - vowel blends and see/say consonant - consonant blends. In this phase the learners practiced both skills. However for each learner one skill was practiced under free conditions and the other under paced conditions.

It can be seen from table 2 that all learners reached both the Fluency Aim Range and the Paced Aim Range for both component skills depending on the conditions under which they were practicing. Each learner's rate of responding on both component skills can be seen in Phase 2, Figures 1 to 5.

Table 3 displays the Phase 3 rate of responding for each learner on the compound task see/say words under baseline conditions. In this phase the compound task was assessed during a 1 minute timing, and checked for Retention and Endurance.

It can be seen from table 3 that the rate of responding for all learners had improved from

Table 1

Phase 1 baseline performance ranges on component skills and compound task during a 1 minute timing

<i>Learner</i>	See/Say consonant-vowel blends			See/Say consonant-consonant blends			See/Say words		
	<i>Correct</i>	<i>Incorrect</i>	<i>Sessions to stability</i>	<i>Correct</i>	<i>Incorrect</i>	<i>Sessions to stability</i>	<i>Correct</i>	<i>Incorrect</i>	<i>Sessions to stability</i>
Ashley	8-21	13-1	5	11-13	11-14	4	5-14	5-15	6
Bronagh	15-23	5-9	6	8-10	8-12	4	19-28	3-10	4
Gary	9-18	4-12	6	4-8	9-18	6	19-22	5-10	5
Shane	26-31	2-3	4	18-22	1-6	4	9-13	4-8	4
Tony	14-17	5-9	4	14-17	5-10	4	4-10	5-8	4

Table 2

Phase 2 performance ranges on component skills see/say consonant – vowel blends and see/say consonant – consonant blends

<i>Learner</i>	See/Say consonant-vowel blends							See/Say consonant-consonant blends						
	<i>Condition</i>	<i>Aim</i>	<i>Timing Durations Used</i>	<i>Correct Score Range</i>	<i>Incorrect Score Range</i>	<i>Sessions to Aim</i>	<i>Initial Correct Celeration</i>	<i>Condition</i>	<i>Aim</i>	<i>Timing Durations Used</i>	<i>Correct Score Range</i>	<i>Incorrect Score Range</i>	<i>Sessions to Aim</i>	<i>Initial Correct Celeration</i>
Ashley	Free	80 - 100	30 seconds 1 Minute	47-93	0-4	12	X3	Paced	40 - 45	1 Minute	41-45	0-2	12	—
Bronagh	Free	80 - 100	1 Minute	52-96	0-10	6	X4	Paced	40 - 45	1 Minute	34-45	0-10	6	—
Gary	Free	80 - 100	1 Minute	66-83	0-3	4	X3	Paced	40 - 45	1 Minute	40-44	0-5	6	—
Shane	Paced	40 - 45	1 Minute	40-42	0-1	4	—	Free	80 - 100	1 Minute	54-87	0-1	5	X 1.4
Tony	Paced	40 - 45	1 Minute	42-45	0	3	—	Free	80 - 100	1 Minute	51-84	0-3	5	X 2

Table 3

Phase 3 performance ranges on the compound task see/say words

Learner	Condition	Phase 1 Correct Score High	Phase 3 Performance Assessment				Phase 3 Performance Retention Check			Phase 3 Performance Endurance Check	
			Timing Durations Used	Correct Score High	Incorrect Score Range	Sessions to Stability	Initial Correct Celeration	Timing Durations Used	Correct Score per Minute	Timing Durations Used	Correct Score per Minute
Ashley	Baseline	14	1 Minute	41	1-3	5	X 2	1 Minute	40	3 Minutes	39
Bronagh	Baseline	28	1 Minute	62	2-3	5	X 1.3	1 Minute	72	3 Minutes	71
Gary	Baseline	22	1 Minute	62	1-5	3	X 1.1	1 Minute	51	3 Minutes	51
Shane	Baseline	13	1 Minute	44	2-5	5	X 1.8	1 Minute	36	3 Minutes	45
Tony	Baseline	10	1 Minute	43	2-7	6	X 8	1 Minute	52	3 Minutes	42

Phase 1. It can also be seen from Table 3 that all learners displayed a good degree of retention and endurance relative to the 1-minute assessment. Each learner's rate of responding on the compound task can be seen in Figures 1 to 5, Phase 3.

Table 4 displays the Phase 4 rate of responding for each learner on a previously paced component skill, now practiced under free conditions.

It can be seen from table 4 that all learners achieved F.A.R. rate of responding. Each learner's rate of responding on a previously controlled component skill is seen in Figures 1 to 5, Phase 4.

Table 5 displays the Phase 5 rate of responding for each learner on the compound task see/say words under baseline conditions. In this phase the compound task was assessed during a 1 minute timing, and checked for Retention and Endurance.

It can be seen from table 5 that the rate of responding for all learners had improved from Phase 3. It can also be seen from Table 5 that all learners displayed a good degree of retention and endurance relative to the 1-minute assessment. Each learner's rate of responding on the compound skill can be seen in Figures 1 to 5, Phase 5.

Table 4

Phase 4 performances ranges on previously paced component

<i>Learner</i>	<i>Component Skill</i>	<i>Phase 2 Condition</i>	<i>Phase 2 Aim</i>	<i>Phase 4 Condition</i>	<i>Phase 4 Aim</i>	<i>Timing Durations Used</i>	<i>Sessions to Aim</i>	<i>Initial Correct Celeration</i>
Ashley	Consonant - Consonant Blends	Paced	40-45	Free	80-100	1 Minute	5	X 2
Bronagh	Consonant - Consonant Blends	Paced	40-45	Free	80-100	1 Minute	5	X 4
Gary	Consonant - Consonant Blends	Paced	40-45	Free	80-100	30 seconds 1 Minute	9	/ 3
Shane	Consonant - Vowel Blends	Paced	40-45	Free	80-100	1 Minute	6	X 1.3
Tony	Consonant - Vowel Blends	Paced	40-45	Free	80-100	1 Minute	5	X 3

Table 5

Phase 5 performance ranges on the compound task see/say words

		Phase 5 Performance Range					Phase 5 Performance Retention Check			Phase 5 Performance Endurance Check	
Learner	Condition	Phase 3 Correct Score High	Timing Durations Used	Correct Score High	Incorrect Score Range	Sessions to Stability	Initial Correct Celeration	Timing Durations Used	Correct Score per Minute	Timing Durations Used	Correct Score per Minute
Ashley	Baseline	41	1 Minute	50	2-3	3	X 1.3	1 Minute	46	3 Minutes	45
Bronagh	Baseline	62	1 Minute	91	1-3	3	X 1	1 Minute	89	3 Minutes	94
Gary	Baseline	62	1 Minute	80	0-1	3	X 1.2	1 Minute	87	3 Minutes	75
Shane	Baseline	44	1 Minute	56	0-7	3	X 1.6	1 Minute	54	3 Minutes	50
Tony	Baseline	43	1 Minute	61	0-2	3	X 1	1 Minute	64	3 Minutes	60

## DISCUSSION

The purpose of this experiment was to examine the acquisition and performance of a compound task when components were taught under different conditions, free-operant and controlled-operant (paced). The results show that performance on the compound skill was improved for all participants, relative to previous performance, when 1 component skill was performed at the free operant Fluency Aim Range (F.A.R.) and the second component was performed at the controlled operant Paced Aim Range (P.A.R.). However results also demonstrate that compound performance was further facilitated when both components were performed at the F.A.R.

The average correct performance high for all students during baseline, when both components were not fluent, was 87 responses per minute. When 1 component was performed at the F.A.R. and the other at the P.A.R. average correct

performance for all learners was 251 responses per minute. This represents an average increase of x2.9 between compound performance at Phase 1 and Phase 3. In addition to this all students, with the exception of Shane, retained this rate of performance after a period of non-practice. Endurance checks showed that the compound task could be performed for longer periods of time with only 1 component at the F.A.R. However, no student reached the F.A.R. on the compound task with only 1 component fluent.

The rate of correct responding on the compound task improved yet again for all students when performance on the second component was brought to the F.A.R. The average correct performance high for all students on the compound task, with both components at the F.A.R., was 334 responses per minute. This represents an average increase of x 1.3 between

compound performance at Phase 3 and Phase 5. Retention checks showed that all students retained this rate of performance after a period of non-practice. Checks for endurance showed that compound performance could endure for longer periods when both components are performed at the F.A.R. Two students reached the F.A.R. without any intervention when both components were performed at the F.A.R.. Bronagh's performance on the compound task reached 91 correct responses per minute. Gary's performance on the compound task reached 87 correct responses per minute. Of interest is the fact that in Phase 2 of the experiment the performance of both of these students was controlled on the see/say consonant-consonant blends component. Of the students whose performance was controlled on the component see/say consonant-vowel blends in Phase 2 of the experiment, none reached the F.A.R. on the compound task in Phase 5.

The results of this experiment confirms the findings of McDowell (2001) who found that building component skills to fluency can increase rate of performance on a compound skill to a fluent level without having to deliver instruction on that skill. In addition to this the results support the methodological practice of increasing frequencies in component skills in order to enhance performance on compound skills. Of interest is the fact that when only one component was performed at the F.A.R., with the second being performed at the P.A.R., almost all students performed the compound task at roughly half the rate of the F.A.R. This is similar to the finding of Barrett (1979, cited in Johnson & Layng, 1992) where compound skills are performed at roughly half the rate of the fluent component skill. Based on this similarity in findings it would appear that bringing 1 component (from a choice of 2) to a F.A.R. can facilitate compound skill acquisition and performance. This may be due to a momentum effect in the component at the F.A.R. that compensates for a non-fluent component and therefore facilitates compound performance. In addition to this it appears that performance on a compound task in which all components are not fluent can still display resistance to change in terms of retention and endurance.

The results of this experiment raise questions as to whether all components of a compound skill need to be taught to fluency or if perhaps certain components play a greater role in compound acquisition and performance. Research is needed to establish if these effects hold when a compound task is constructed from more than 2 components. The findings of the experiment also have important implications in the planning and

implementation of curriculums. This is particularly so for students who are lagging behind their peers in the educational process and are playing a game of "catch-up." If certain components are more important in the acquisition of compound skills, the challenge to all educators is to identify which ones.

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Figure 1

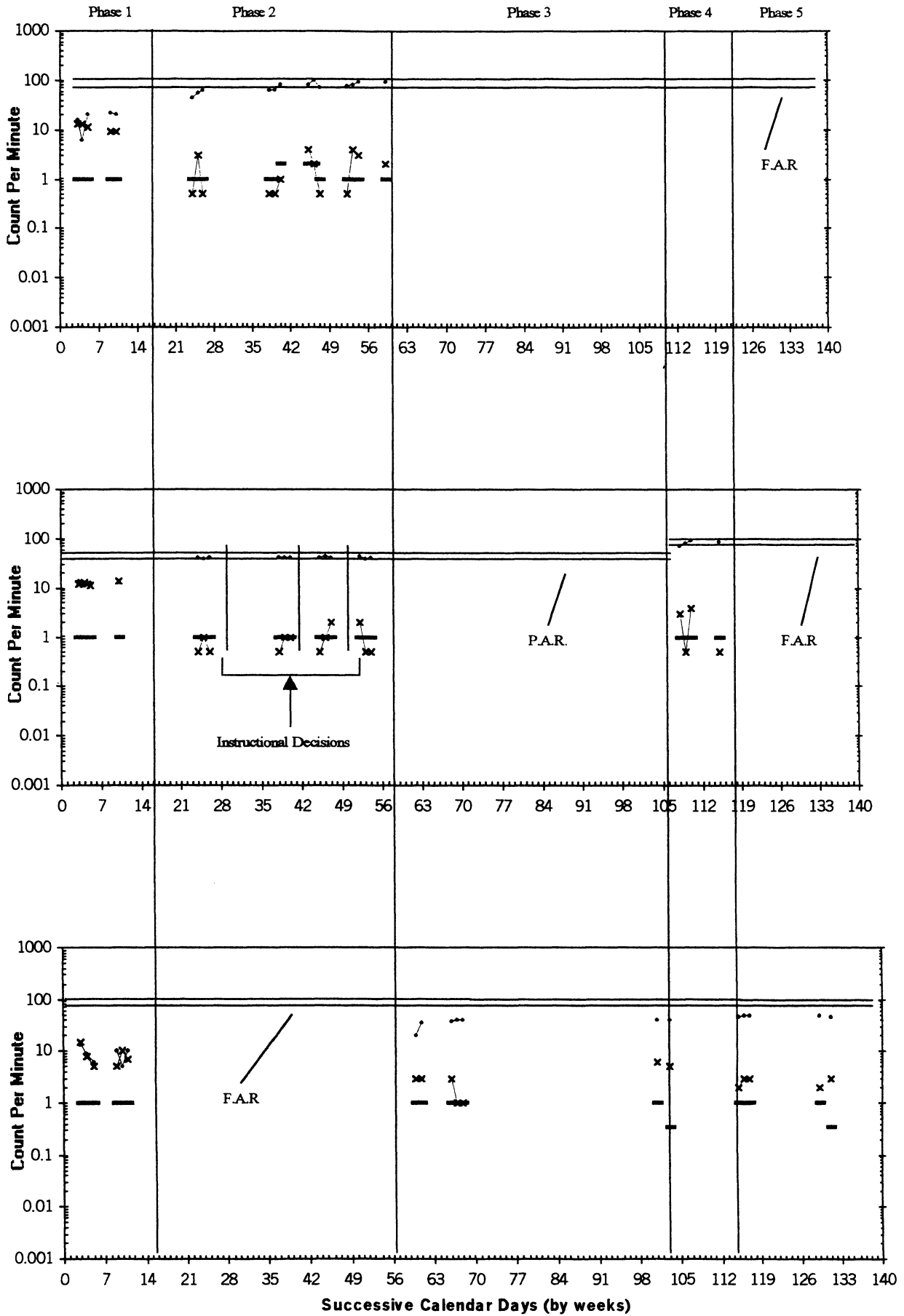


Figure 2

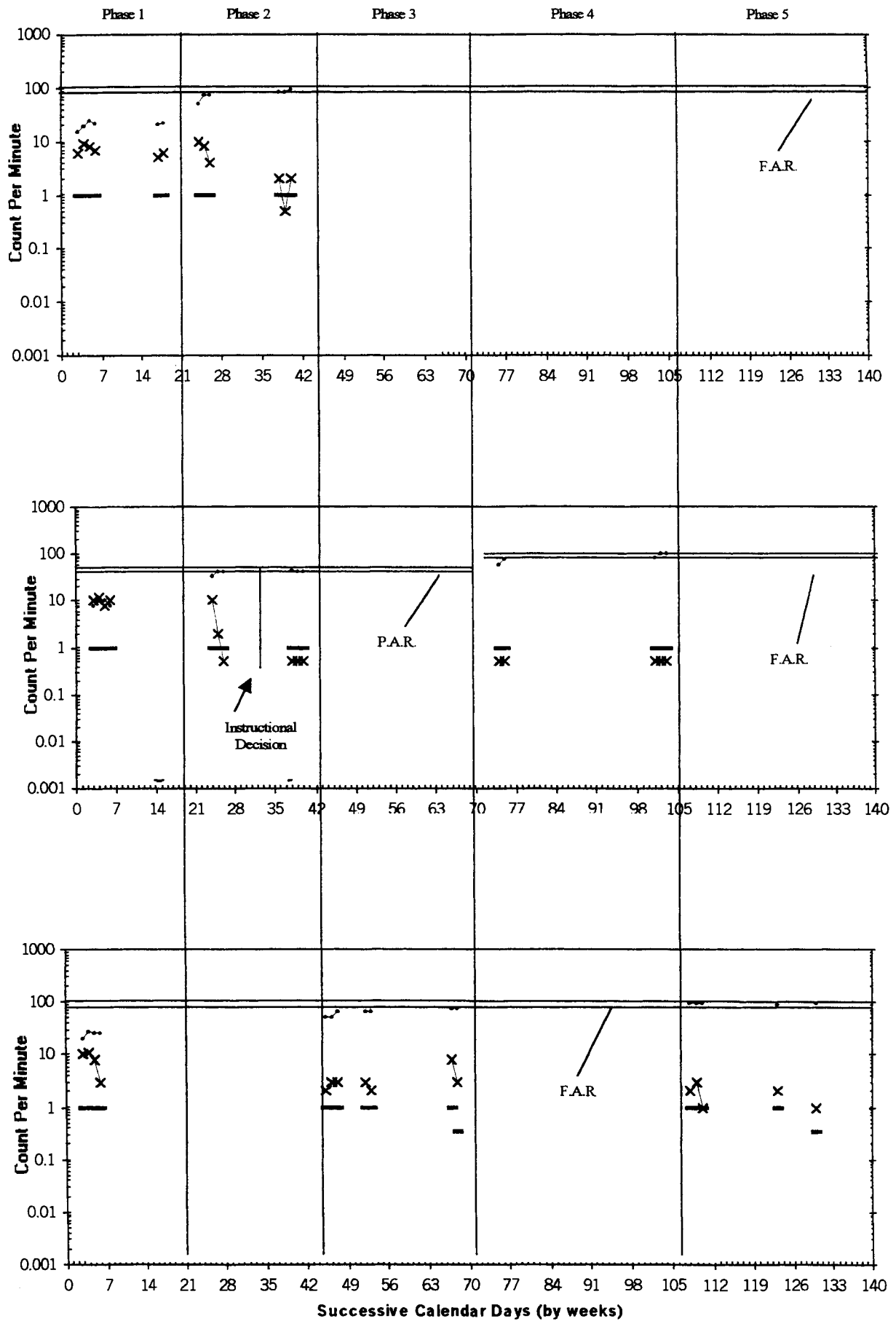


Figure 3

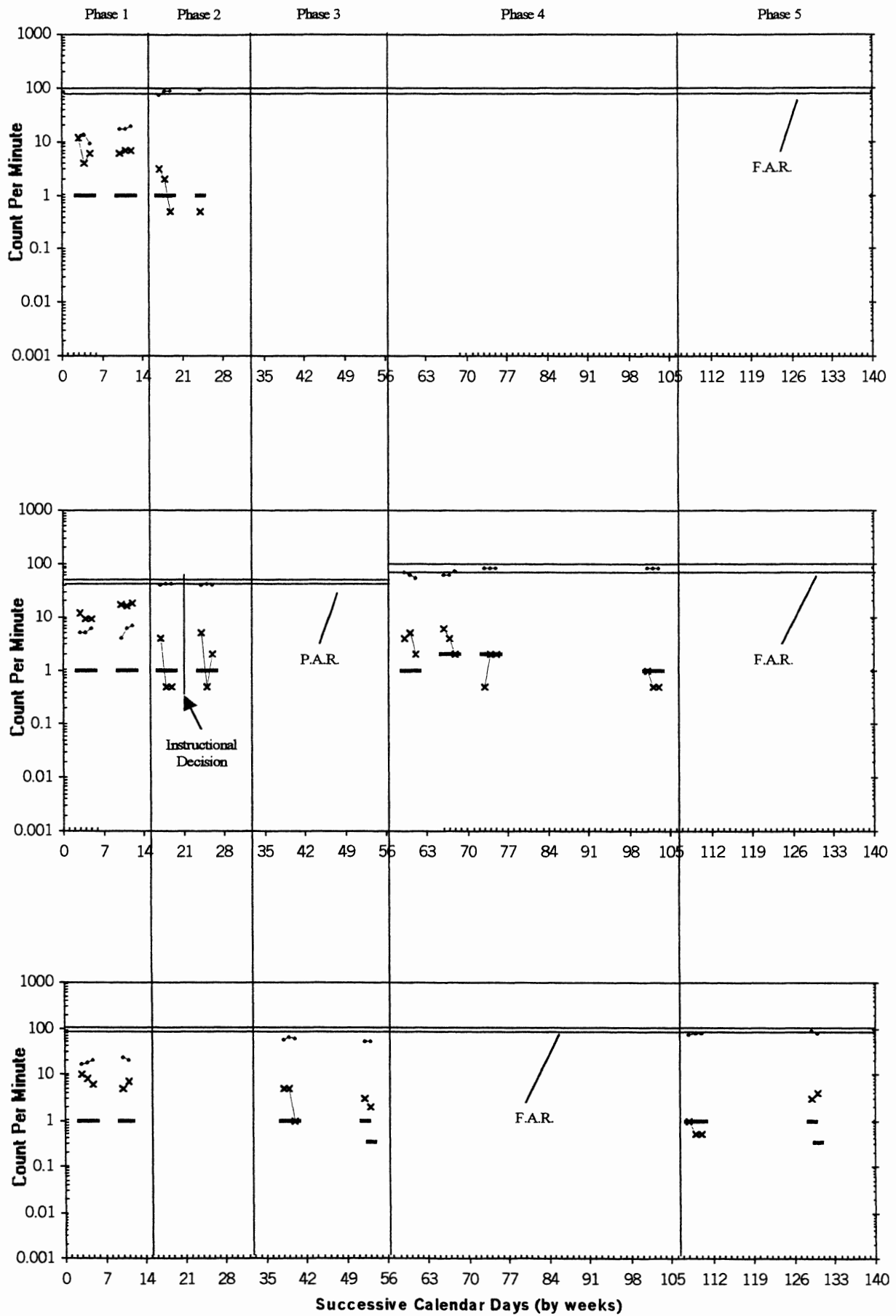


Figure 4

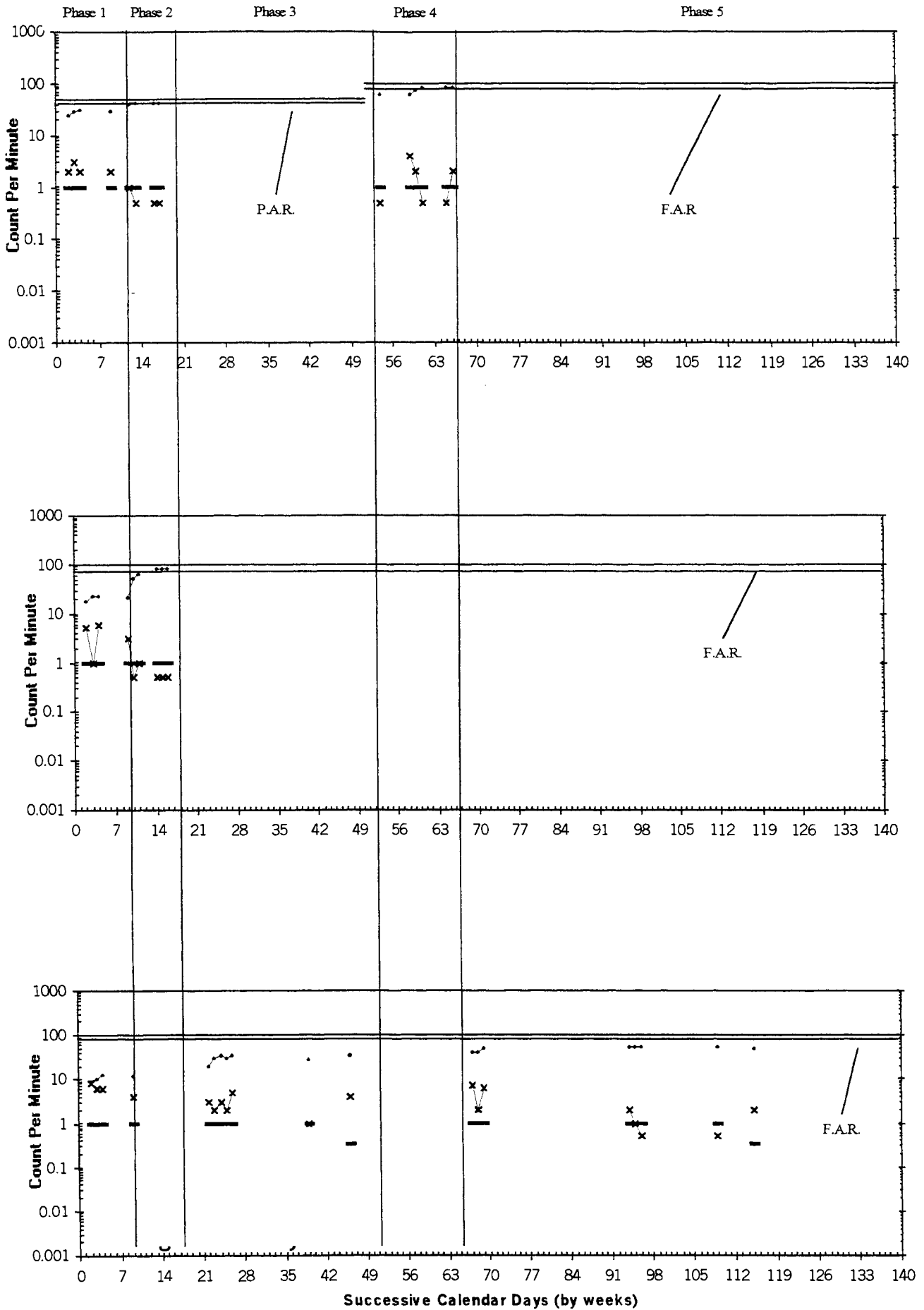


Figure 5

