

*Thursday afternoon*

ANALYSIS OF THE SUBJECT-MACHINE RELATIONSHIP

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## Overview

An apparent phenomenon which defies the theory of probability occurs when Subject 2 plays this experimental game. He significantly exceeds his probability of success, .25, by scoring over .29. The question that this report addresses is: Is there a statistical or logical reason why he did so well? The methodology used to attack this problem and the resulting conclusions are summarized below. This summary can also serve as an outline to this detailed report.

### I. Statistical Analysis of the Machine Experimental Data

Pre-experiment data analysis discovered a non-random characteristic through the examination of forward-backward state transitions (i.e., Red-Blue, Blue-Red). However, the coefficient of correlation between the forward and backward states of .58 for the experimental data, .49 for Machine 1 data and .48 for Machine 2 data were considered low enough that this approach was dropped. Pre-experiment state transitions had a coefficient of correlation of .93.

The experimental data randomness analysis consisted of examining the distribution of color totals and the distribution of each color taken over various combinations and permutations of the data. No evidence of non-randomness was discovered.

### II. Analysis of the Subjects' Data Responses

The subject's responses were analyzed with the emphasis on the discovery of his strategy or the unveiling of a trend which would give him a statistical advantage. The possibilities investigated produces no solid reason how he was able to be so successful. However, in one case there is a strong indication why he was able to succeed. It appears that he was learning the states of Machine 2. The details of this are in

the remainder of the report.

### Miscellaneous

The report contains a section entitled "Miscellaneous" for the purpose of displaying detailed data which wasn't directly required by the above more general analysis. Details such as how many successful choices in the color red during the 50th trial were there, or what was the relationship of the number of passes to the number of successes.

The terminology used is as follows: the term "trial" refers to the string of machine states and corresponding choices from the time the subject begins until he makes 25 non-passing choices. A sample is a machine state and/or subject choice (including passes). There are  $(25 + \# \text{ passes/trial})$  samples in each trial.

I. Statistical Analysis of the Machine Experimental Data

SG11

Forward-backward State Transition Analysis

In a previous memorandum (Memo ORD 2240-75, 12 June 1975 to ) the question of randomness with the emphasis on state transitions as an indication of non-randomness was addressed. The data used in the investigation consisted of pre-experiment trials. The purpose of this section is to do a similar investigation using the actual data which occurred during S2's experiment.

Table 1 presents all possible transition frequencies. All transitions should have equal probability.

	YELLOW	GREEN	BLUE	RED
YELLOW	204	199	199	216
GREEN	192	218	222	207
BLUE	211	206	228	222
RED	209	206	223	221

Restructuring into a two-by-six table as in Ref 1 produces:

	Y/G	Y/B	Y/R	G/B	G/R	B/R
FORWARD	199	199	216	222	207	222
BACKWARD	192	211	209	206	206	223

The conclusion based on pre-experimental data was that these state-pairs show a very strong relationship between forward and backward transition frequencies (coefficient of correlation = .93). However, computing the coefficient of correlation,  $p_{S2}$  actual data = .58, it becomes apparent that the degree of dependence is slightly reduced. Therefore the dependence of forward to backward states can no longer be considered as a strong indicator of non-randomness.

The data used in the above discussion consisted of trials from both machine 1 and machine 2. Since non-randomness, made apparent by the state transitions, clearly existed for pre-experimental data, the investigation of the experimental data continued to include a search for this trend in the individual machines. The transitions (including identity) are as follows:

Machine 1

	YELLOW	GREEN	BLUE	RED
YELLOW	96	79	88	92
GREEN	85	87	86	88
BLUE	85	82	90	87
RED	91	91	83	92

Machine 2

	YELLOW	GREEN	BLUE	RED
YELLOW	108	120	111	124
GREEN	107	131	136	119
BLUE	126	124	138	135
RED	118	115	140	129

Computing the two coefficients of correlation,

$$\rho_{\text{machine 1}}^{\text{s2 data}} = .4934$$

and

$$\rho_{\text{machine 2}}^{\text{s2 data}} = .4838$$

it is obvious that the forward and backward transitions are even less dependent than in the combined case. Thus ended the search for non-randomness through state transition.



As a by-product the following table is produced for general information.

	BOTH MACHINES		MACHINE 1		MACHINE 2	
	MEAN	SD	MEAN	SD	MEAN	SD
FORWARD	210.8	10.7	86.6	4.27	124	9.74
BACKWARD	207.8	9.00	86.2	3.92	121	11.25
TOTAL DATA POINTS	3483		1446		2037	
COEFF OF COV	.5843		.4934		.4838	

3191  
2702  
3650

Experimental Data Randomness Analysis

The machine data used during the S2 experiment has been combined, summarized and/or permuted in an attempt to establish evidence of randomness or non-randomness. If an obvious indication of non-randomness would have evolved this task would be simplified because it would have become a closed form problem (i.e., the solution would be - the data has non-random characteristics). However, what has resulted is that various forms of the data have been examined with all indicating that the data is random.

*needed investigation*

Tables, plots and commentary are presented in this section to demonstrate randomness and in some cases just to provide general information concerning the machines data.

The distribution of the colors collectively and for each machine is as follows:

	Yellow	Green	Blue	Red	Total	Mean
Machine 1	365	353	356	372	1446	361.5
Machine 2	475	505	538	519	2037	509.25
TOTAL	840	858	891	891	3483	870.75

Machine 1 was not used in as many trials as machine 2 (44 trials to 56 for machine 2), thus the difference in totals. The standard deviation of binomial distribution with  $n=3483$  and  $p=1/4$  is 25.56 which would imply that each separate number is reasonably close to the mean.

Accepting the distribution of the totals consider the distribution of the colors throughout the experiment. The populations used for this investigation consisted of the first 25 samples of each trial (100 trials total). This population is acceptable since the distribution of its totals was reasonable and since the performance of S2 was approximately the same (success-29.61%) for this subset.

The following three approaches comprise the strategy used to attack the question of color distribution.

1. Each trial (abbreviated to 25 samples) as analyzed separate interval. Obviously this will indicate any bias within each trial.
2. The data (2500 samples) is divided into intervals of five samples each. This will indicate unusual repetitions either within the interval or interval-by-interval.
3. The data is reformatted into 25 intervals of 100 samples, where the nth interval consists of the nth sample in each trial.

The results of approach 1 is shown in Figures 1.1.a, 1.1.b, 1.1.c, and 1.1.d.

The binomial distribution for this strategy ( $n=25$   $p=1/4$ ) is mean 6.25 and the variance 4.69. The plots indicate randomness throughout the 100 trials.

The results of approach 2 are similar to approach 1 and are shown in the four tables in Figure 1.2. The plots indicated randomness but are not shown because of monotony. The binomial distribution mean is 1.25 and the variance .94.

The binomial distribution mean and variance for approach 3 is 25 and 18.75 respectively (Figure 1.3). A plot of the data (Figure 1.4) for the "RED" case because of the concern for the higher variance and ranges. The 13th sample seems to have an unusually high frequency of "RED" (44%). However in general this investigation has not produced a significant non-random characteristic.

sample size	100
maximum	12
minimum	3
range	9
mean	6.23
variance	4.239494949
standard deviation	2.059003387
mean deviation	1.6314
median	6
mode	6

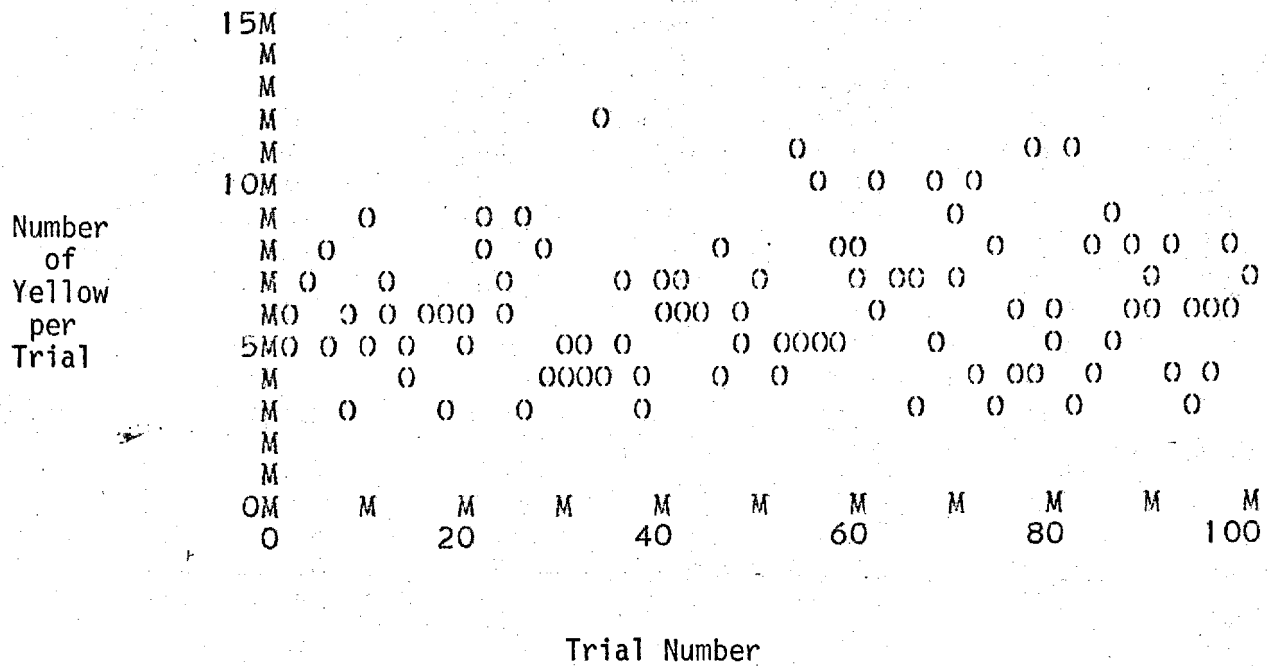


Figure 1.1.a Distribution of Machine Yellows Over Trials

sample size 100  
 maximum 12  
 minimum 0  
 range 12  
 mean 6.13  
 variance 5.851616162  
 standard deviation 2.419011402  
 mean deviation 1.9404  
 median 6  
 mode 5 7

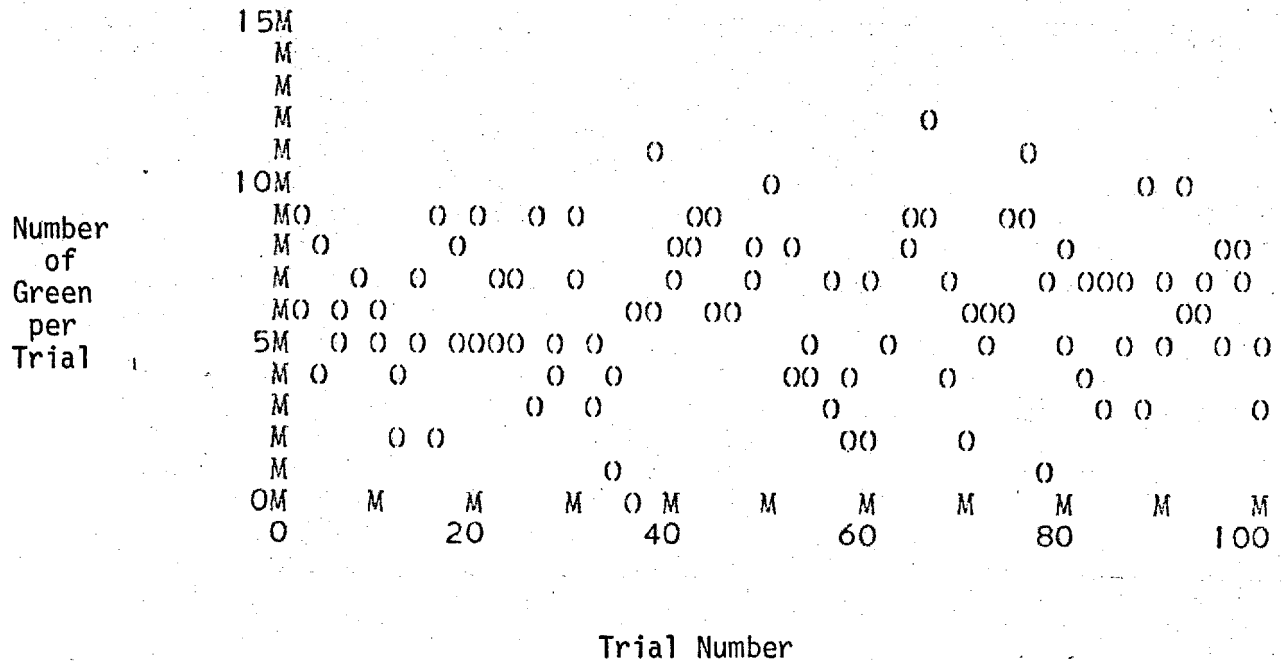
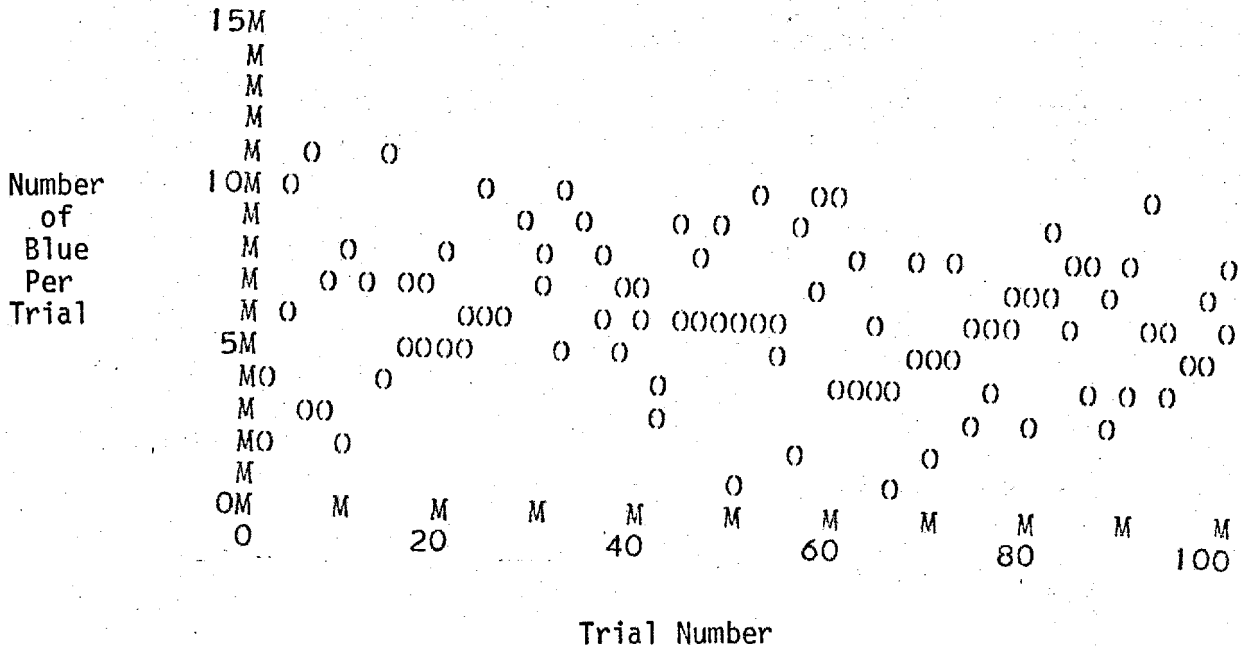
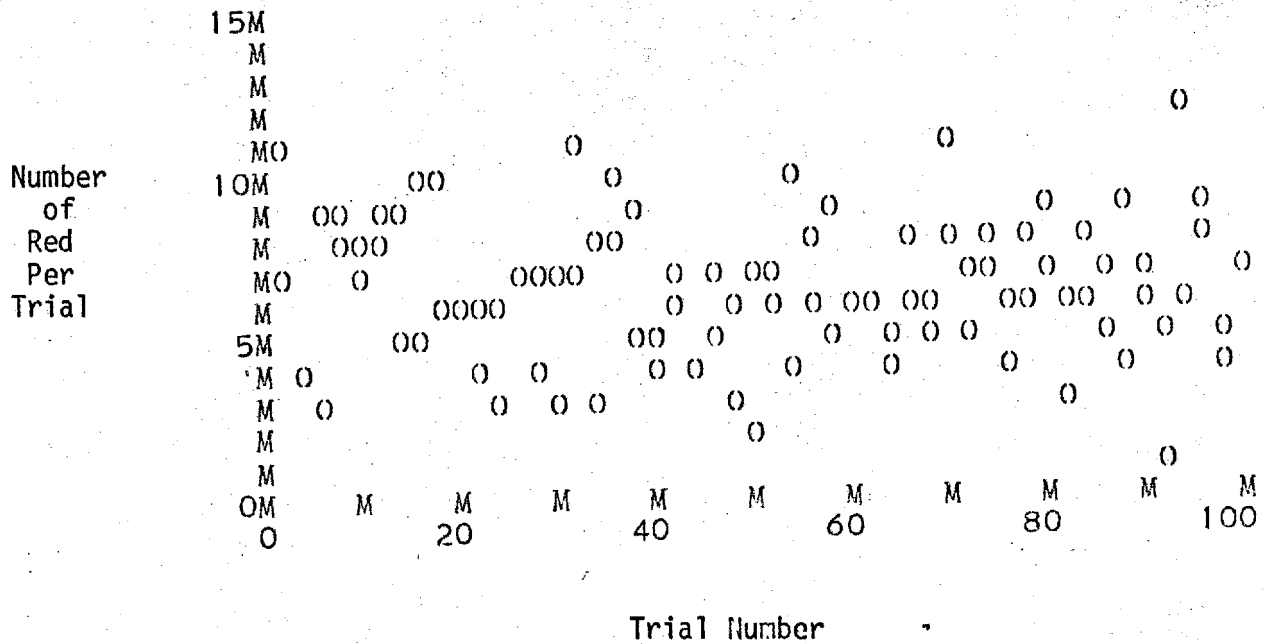


Figure 1.1.b Distribution of Machine Greens Over Trials  
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sample size 100  
 maximum 11  
 minimum 1  
 range 10  
 mean 6.21  
 variance 5.218080808  
 standard deviation 2.284311889  
 mean deviation 1.8194  
 median 6  
 mode 6



sample size	100
maximum	12
minimum	1
range	11
mean	6.43
variance	4.631414141
standard deviation	2.152072058
mean deviation	1.7158
median	6
mode	6



sample size 500  
maximum 5  
minimum 0  
range 5  
mean 1.246  
variance 0.9594028056  
standard deviation 0.9794910952  
mean deviation 0.784848  
median 1  
mode 1

Distribution of Green  
sample size 500  
maximum 5  
minimum 0  
range 5  
mean 1.226  
variance 0.9969178357  
standard deviation 0.9984577285  
mean deviation 0.804512  
median 1  
mode 1

Distribution of Blue  
dstat grp:<3\*  
sample size 500  
maximum 4  
minimum 0  
range 4  
mean 1.242  
variance 0.9513507014  
standard deviation 0.9784429985  
mean deviation 0.792192  
median 1  
mode 1

Distribution of Red  
sample size 500  
maximum 5  
minimum 0  
range 5  
mean 1.286  
variance 1.026256513  
standard deviation 1.013043194  
mean deviation 0.823216  
median 1  
mode 1



Yellow Distribution  
sample size 25  
maximum 31  
minimum 19  
range 12  
mean 24.92  
variance 10.57666667  
standard deviation 3.252178757  
mean deviation 2.6304  
median 24  
mode 24

Green Distribution  
sample size 25  
maximum 35  
minimum 15  
range 20  
mean 24.52  
variance 24.59333333  
standard deviation 4.959166597  
mean deviation 3.9392  
median 25  
mode 22 25

Blue Distribution  
sample size 25  
maximum 34  
minimum 19  
range 15  
mean 24.84  
variance 14.47333333  
standard deviation 3.804383437  
mean deviation 2.9664  
median 25  
mode 26

Red Distribution  
sample size 25  
maximum 44  
minimum 16  
range 28  
mean 25.72  
variance 26.71  
standard deviation 5.168171824  
mean deviation 3.3664  
median 25  
mode 25

Figure 1.3 Distribution of Machine Colors When Samples are Taken 100 at a Time

(One From Each Trial)

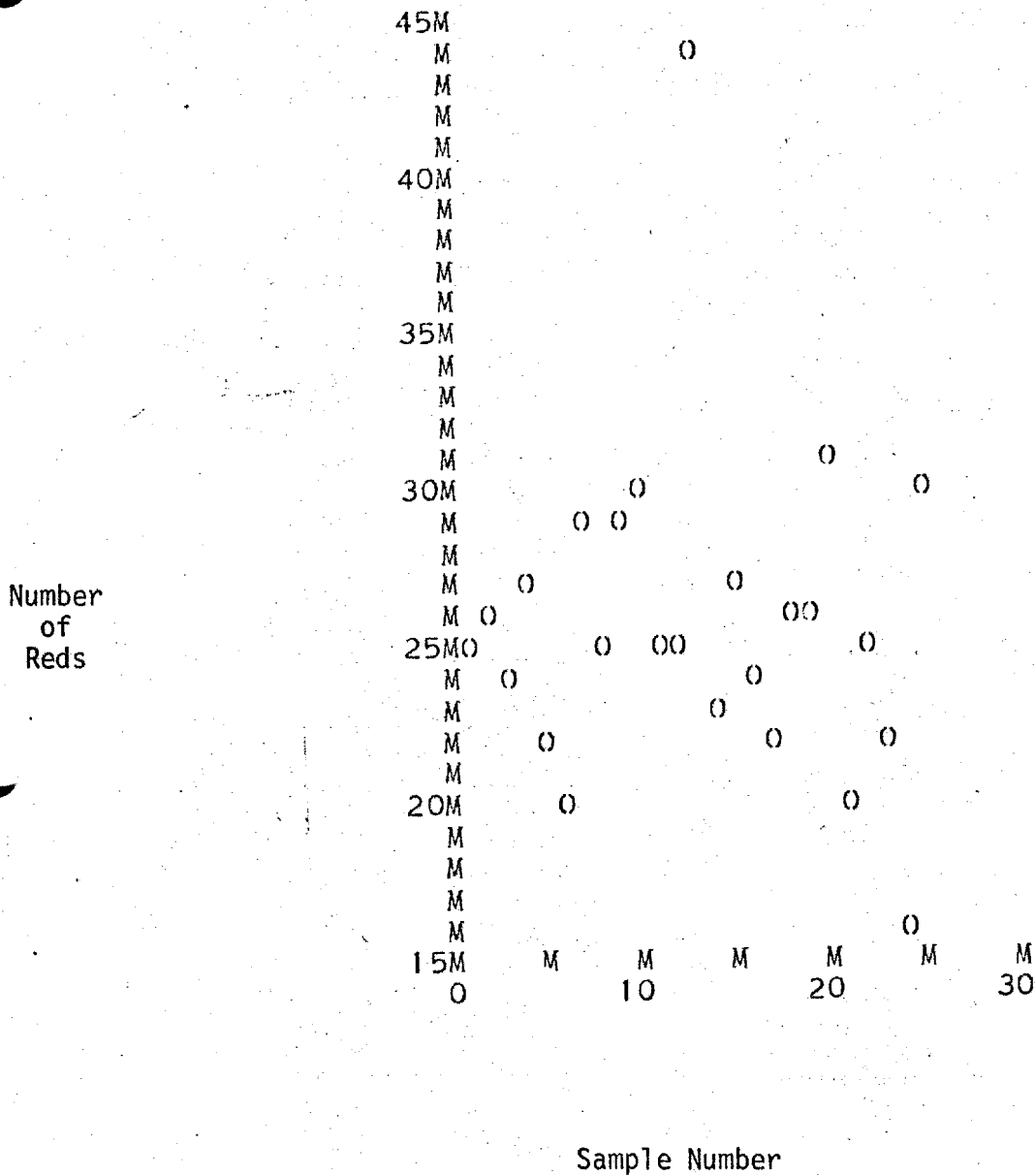


Figure 1.4 Distribution of Machine "Reds" when the Samples are taken 100 at a time (one from each trial)

Approach 1 has been repeated for Machine 1 and Machine 2 separately to check for abnormalities. The binomial distribution mean and variance are as follows:

	Trials	Mean	Variance
Machine 1	44	11	8.25
Machine 2	56	14	10.5

Machine 1		Yellow	Machine 2	
sample size	25		sample size	25
maximum	16		maximum	19
minimum	7		minimum	7
range	9		range	12
mean	11.4		mean	13.52
variance	7.75		variance	7.51
standard deviation	2.783882181		standard deviation	2.740437921
mean deviation	2.224		mean deviation	2.176
median	12		median	14
mode	12		mode	15
		Green		
sample size	25		sample size	25
maximum	17		maximum	24
minimum	4		minimum	8
range	13		range	16
mean	10.68		mean	13.84
variance	9.726666667		variance	12.723333333
standard deviation	3.118760438		standard deviation	3.56697818
mean deviation	2.3584		mean deviation	2.7808
median	11		median	13
mode	11		mode	13
		Blue		
sample size	25		sample size	25
maximum	15		maximum	25
minimum	3		minimum	10
range	12		range	15
mean	10.32		mean	14.12
variance	7.726666667		variance	8.943333333
standard deviation	2.779688232		standard deviation	2.990540642
mean deviation	2.3072		mean deviation	1.984
median	11		median	14
mode	8 12		mode	15
		Red		
sample size	25		sample size	25
maximum	19		maximum	21
minimum	4		minimum	11
range	15		range	10
mean	11.6		mean	14.52
variance	10.5		variance	10.01
standard deviation	3.240370349		standard deviation	3.163853404
mean deviation	2.4		mean deviation	2.6624
median	12		median	13
mode	12		mode	11 13

Best Strategy

Based on the above analysis what is the best strategy to pursue? No good strategy is available based on the randomness of the data. The best possible strategy based on the above transition matrices is:

1. If the subject can't distinguish between machine then press blue when blue appears, else pass.
2. If the subject can distinguish them on Machine 1, press yellow when yellow occurs, and on Machine 2 press blue when red occurs.

For all its worth, of the existing data the following success would result - 26%, 26%, and 27%.

### Analysis of S2 Data Responses

The attempt here is to discover a reason for S2's success at responding. The investigation was unable to give a definitive reason for his success. Although no strategies were uncovered there was in one case a indication that the subject was learning.

Two major approaches have been taken in this investigation. They are as follows:

1. Strategy of S2 - Was there any trends in the way he guessed? Did he respond based on the previous state of the machine?
2. Hit analysis - Did the subjects' hits (correct choices) increase within a run; did it increase from run to run (i.e., was he learning?)

*These are two questions*

### Strategy of S2

For general information and future reference the first figure (Figure 2.1) presented is the actual choices. One item of curiosity from this is that when he passes, he tends to do it in strings. This characteristic of course wasn't pursued because of its insignificance to this report; however, observations like that are pointed out throughout the report as possible importance to those in the field.

### Total Color Choices

The distribution of S2's color choice totals are shown below.

0210232010213003020300330  
0203121303030330000102332  
3003103030312032103222123  
0233310020320130300020313  
3030030010303031313030103  
3303031303030003202103103  
0323030303020301032030330  
0320303030302103030301303  
0303032022303010313021020  
3010103103013303013023013  
0313023313303102013103231  
0210310310310332031030230  
3030203103030130130303023  
3030323013030203010330303  
3030030302303130313031300  
3023130302102313010130203  
30307030730010307230770731377030773  
320301303077307070130303723770373  
03023010737097737301730307177707207370  
021303077730702302303070723730703  
03701037777321033700371307077301031  
0777377730777317077377037233103273073030373  
373031377773073277307707307707073007077773203  
307370307302130313313777073023777377770  
0303170012012031302772323103  
0131320203120310773071730777772031  
30373030377730301307307770330377777773070  
31217033030130037777771300012003  
002730770377277777310777377777377777773132133013070  
317377777777777717071077777730137777073703132777777030777737013  
37777077770177777770307373177777303031031031020  
377172707777013071737177773777777777702030317013201  
03777777777377010377777707770777777773013131303230320  
0023071301307777777777713013023201303  
077777701010203010230703730270730777777713  
30713777037077703777773231077777777777777031307777777777777773703703771  
302077771303703130313021037013777777777777770  
31037321013013102310370107731  
31313023130132013023730177703  
13037373730130132077777377777777707313021071  
13731037373173021772731771317777777703733170  
13237013077072313103127773713173777373  
313777777777777377703313102137177777717077731727120713  
01237073773177731737201720307072170130  
073373113701310701077201377032770070  
321317032331303203723032123  
137370710303107720311307100323773  
10307710237371307307230233203730  
2030330231313302212121331  
23077701273212000303333130300

Figure 2.1 Subject 2 Color Choices for First Fifty Trials (0-yellow, 1-green, 2-blue, 3-red, 7-pass)

323031301202137077123217233030  
0311373071731020377777777770377373017333070  
20703123070231703030330133703  
30170102031730730300330313713  
01007777373707303777173777273377310770777130777373773  
2070737073177737007703737000273177770707777707377777377773  
01730330320370330327013703013  
303717033207303073773013023737203  
0373737303373032173233377173733707371  
23707377313033333703773773707173777377373270  
13107303737730103333370737313707700  
33373707730730373333130373370707770733  
033037737703337337777077777327777301027337333  
030303720000377373377707737733030332  
33032133270323233130121330  
10701101301101313030230123  
300703300723730030371777137777033002  
0313373737030003200030001003  
302332131000001371303703037770  
77201771007703072370313731013777377177777303  
337171017711371300217333733030733  
30717373717077130117303707301373370071  
03303203020071027107377121270703  
03231327320373023770331110077700  
33173707371071317331331730117207073  
271313107327033277731177130323303  
3000373300033003710303071330  
301270013333013077737077373303377770770  
0303703037073732311370710732001773  
37733070072000770300373130003002  
132002000300303770300731723370  
30707207020773307033030303777377737377073  
07077730703700377777707731707330307307077770737373  
0070773737700307373077777770737777737773770300077773333  
1301037132010717301002720073723  
3101310317001300001730073020  
03777720070773100770707373007200730700700  
30300007100000232113002002  
3031301301320130231033003  
2301203130120310311303120  
3013023103173713073032300131  
3013013013201302101302303  
130231032303713273031030130  
3010310310773230313073021331  
310313031737701373001330033777713  
31301030310330307377070037717003  
023130332013700137230201330  
0217373103101303700073027777310373  
137073107103702373132710331073703  
331300301707301070700371073700713

Figure 2.1 (Continued) S2 Color Choices for Last 50 Trials



	Yellow	Green	Blue	Red
Total Times Chosen	881	411	237	971
% of Total	35%	16.5%	9.5%	39%

The first inclination is to try and determine how his strategy of choosing so many yellows and reds benefitted him. Examine the following table:

	Yellow	Green	Blue	Red
Total Number of Hits	255	127	<del>50</del> <sup>60</sup>	292
% of Total Hits	35%	17%	8%	40%
% of Success in Color	29%	31%	25%	30%

(Hits - Correct Choices)

As can be seen his results with blue are significantly lower than the others. However, assuming the probability of success to be .25 and using the binomial distribution the expected value = 69 and the standard deviation = 7. The inference from this is that the 60 Blue hits are not a statistical abnormality. However, it is curious that he did so much worse on his lowest preference.

State Transition Color Choice

This investigation consists of examining the states of the machine verses the choice on the next sample of the subject (i.e., if the machine shows "red" does the subject consistently choose one color on the next turn). Consider the following table:

SUBJECT	MACH \ SUBS	Machine				Pass	% Pass
		Yellow	Green	Blue	Red		
SUBJECT	Yellow	106	119	69	314	210	26%
	Green	177	25	69	316	252	30%
	Blue	241	99	27	198	302	35%
	Red	322	157	65	97	218	25%

r = .30

The subject obviously avoids repeats (i.e., he assumes the machine won't repeat a color) which, based on the machine data analysis, isn't a strategy which would give him a statistical advantage. Previous analysis showed that identity transitions are approximately equally probable as nonidentity. Notice also that he passes 35% of the time after seeing a blue.

The same state transitions are shown below separated by machine.

		Yellow	Green	Blue	Red	Pass
M A C H I N E 1	Yellow	48	49	25	150	83
	Green	62	13	35	153	83
	Blue	105	36	10	78	115
	Red	133	72	30	58	64
			$\psi = .94$	↑		
M A C H I N E 2	Yellow	58	70	44	164	127
	Green	115	12	34	163	169
	Blue	136	63	17	120	187
	Red	189	85	35	39	154

The negative state transition (i.e., relationship of the subject color choice to the machine state on the next sample) is considered too bizarre of a concept to be presented in this section. Results of that investigation is found in the section entitled "miscellaneous"

Hit Analysis

This section is significantly more important than the randomization analysis of the machine data. The reason is that if he is not learning from the machine or he is not taking advantage of biases then the discovery of such non-randomness is of little value to the overall analysis.

Learning from Trial to Trial

The question of whether the subject learned from trial to trial can best be answered by examining the following three plots. The first is the number of hits vs. the trial number, the second is a frequency distribution of the number of trials vs. number of hits, the third is the accumulated probability vs. the trial number.

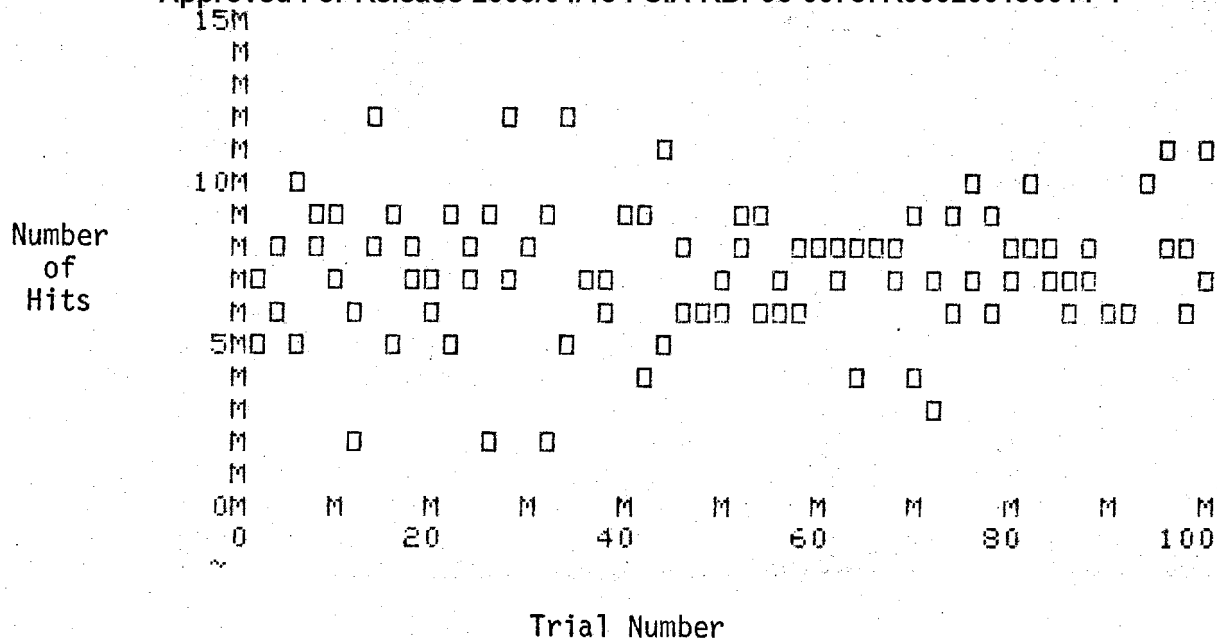


Figure 2.2 Plot of number of hits/trial

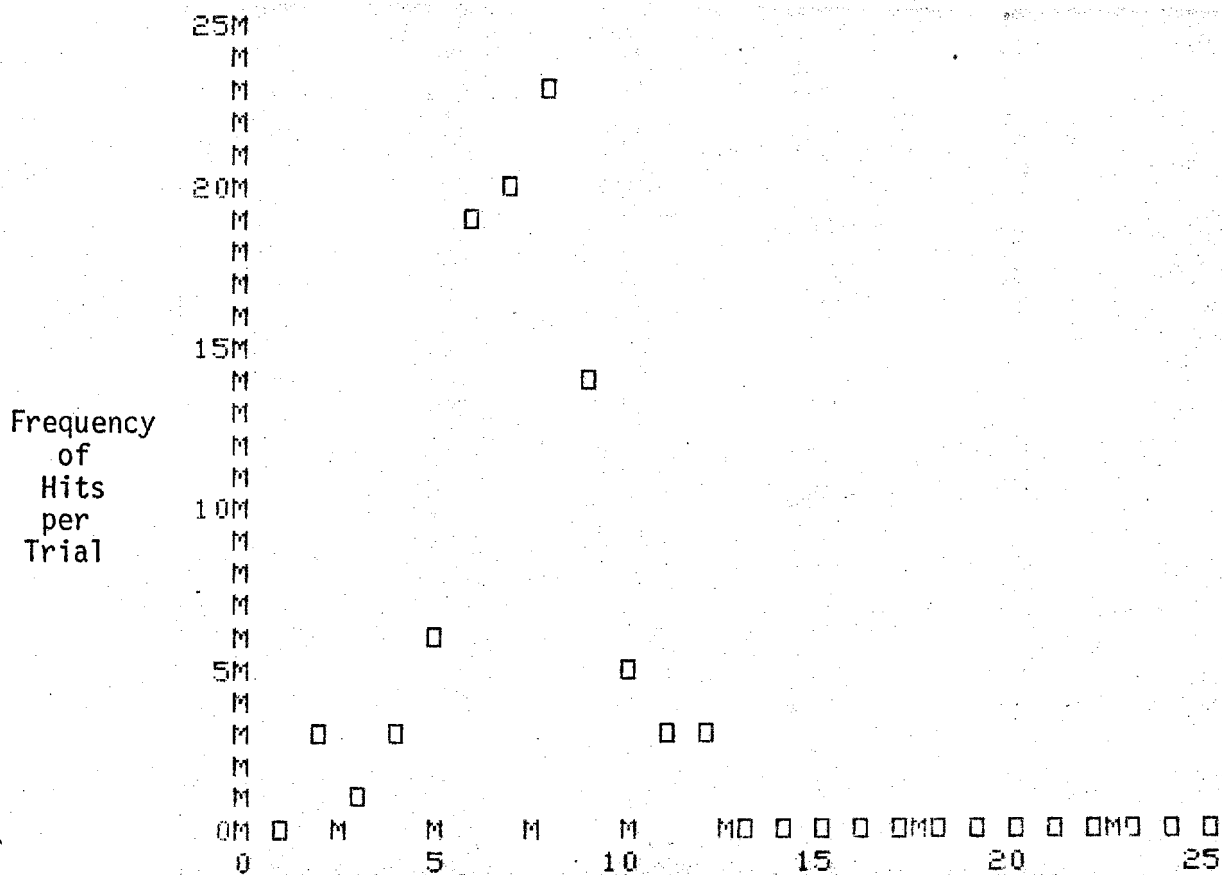


Figure 2.3 Frequency plot of Number of Hits

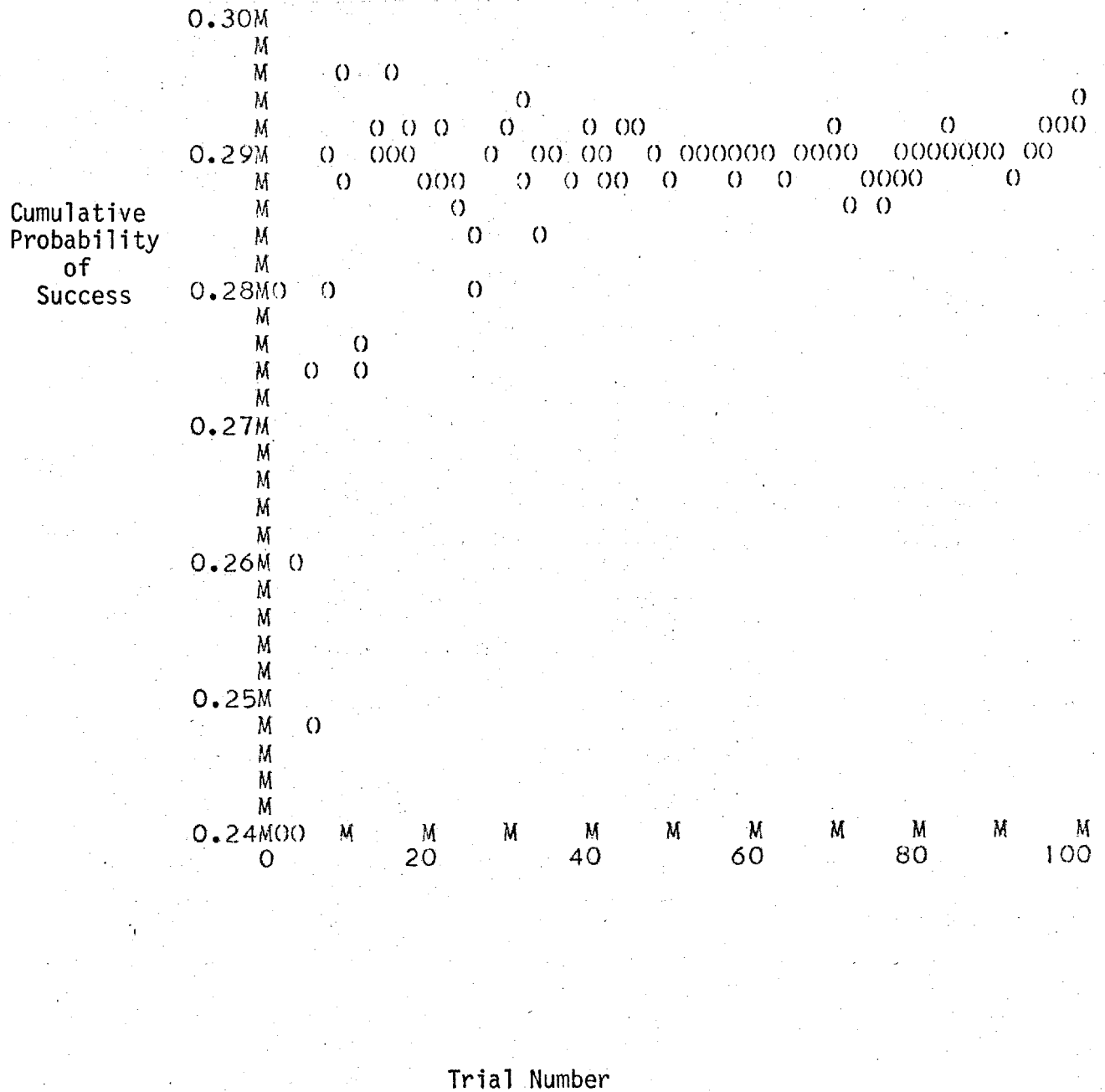


Figure 2.4 Cumulative Success Ratio of Subject (both machines used)

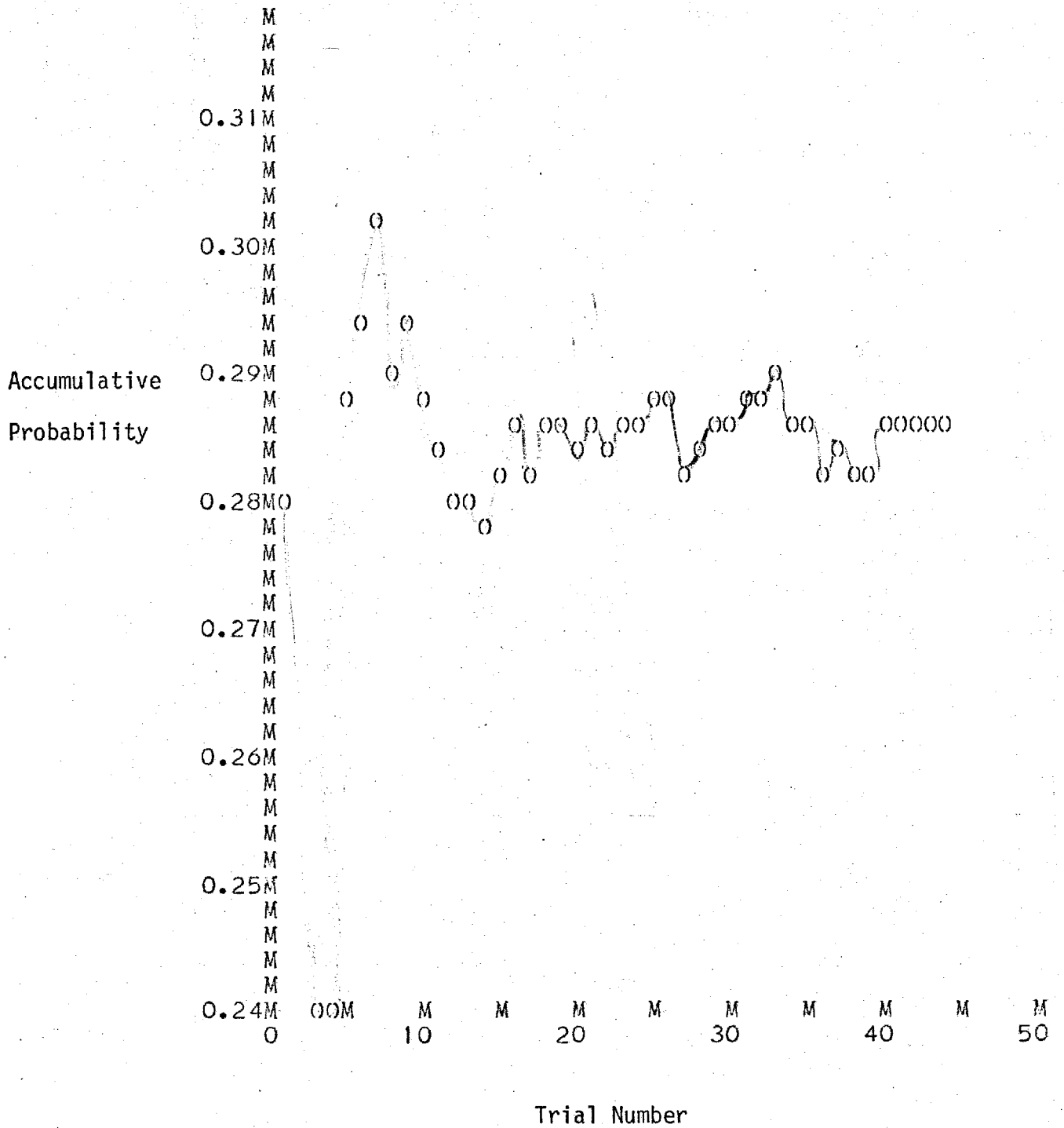
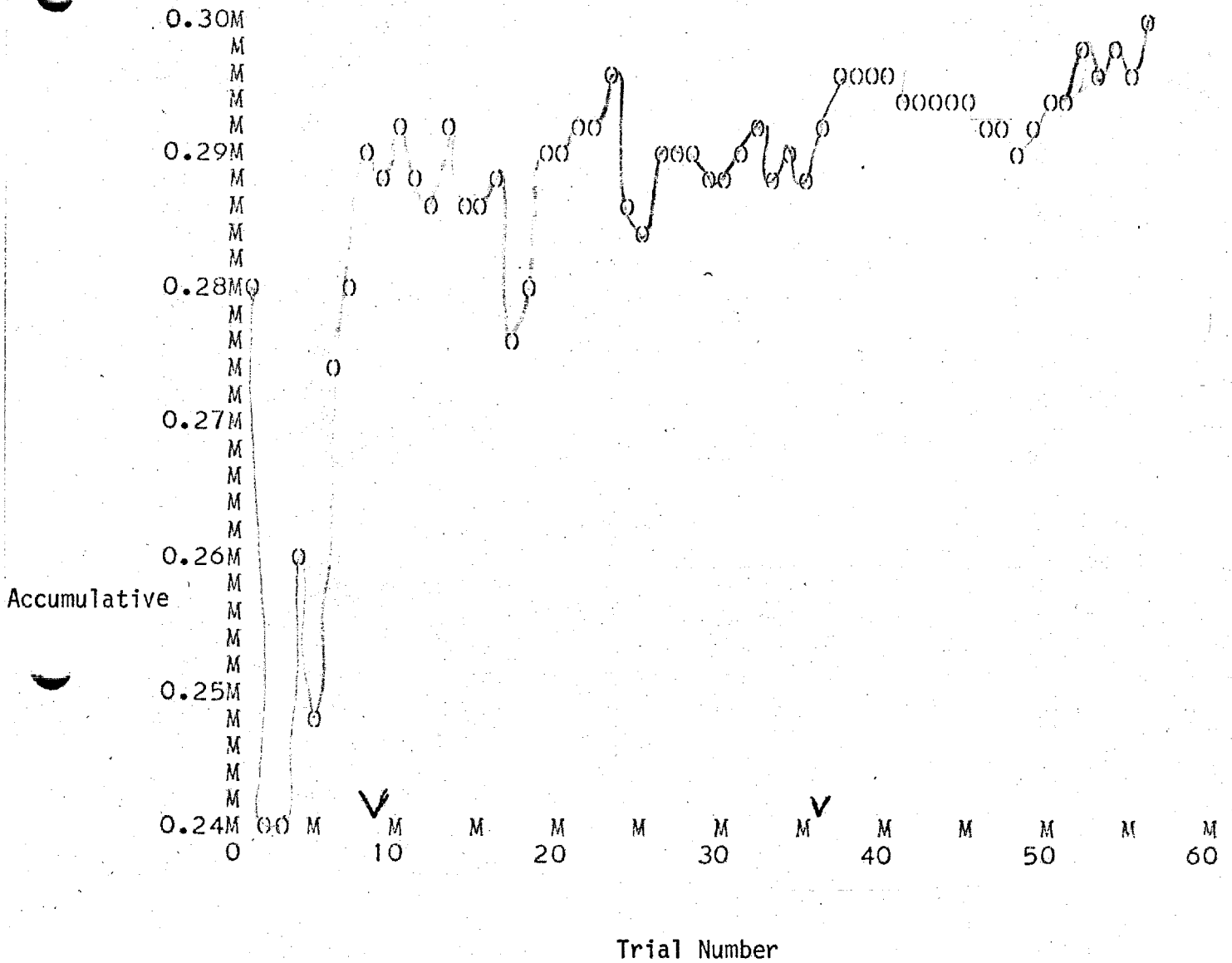


Figure 2.5 Accumulative Probability of Success on Machine 1



Note: V - Points at which he switches machines

Figure 2.6 Accumulative Probability of Success on Machine 2

The first plot (Figure 2.2) demonstrates the randomness of the number of hits while the second plot (Figure 2.3) demonstrates the frequency distribution takes on a "normal" appearance. The accumulative probability plots, at first glance, indicates that the subject was in a learning mode for the first five trials. A closer examination of the data indicates that this can occur naturally as part of the statistical distribution.

The first three number of hits points are 7, 5, and 6 considering the first 75 points as the population with probability of success = .2936 (the final probability) then the expected value is 22 (using binomial distribution) and the variance is 15.55 (S.D=3.9). As a normal deviation from the mean (i.e., using normal distribution approximation  $P(x < 18) = .13$ ).

Although the observed learning can be rationalized as a natural statistical deviation it warranted further investigation. The plots of the accumulative probability of success for machine 1 and machine 2 are presented in Figure 2.5 and Figure 2.6. The plot for machine 1 (Figure 2.5) is a typical sinesoidal decreasing amplitude convergent curve. The plot for machine 2 however, is very suspicious in terms of learning. The major peaks of the curve (at approximately trial 10, 23, 40 and 56) are increasing which implies his probability of success is continuing to increase instead of converging on one point. Another interesting point is that the points at which he switches onto machine 2 are 1, 9, and 36.

Also of concern is the sharp upward turn during the last 8 samples. The hits totals for this period, starting at sample 49 is 10, 10, 8, 11, 6, 8, 7, and 11 for a total of 71 hits out of a possible 200 for a probability of success of .36. Once again using the binomial distribution and using the probability of success of .29 (the cumulative probability up to the 49th point) the expected mean is 58 and the standard deviation 6.42. Using the





normal approximation the probability  $P(X \geq 71) = .02$  of such an occurrence is quite low.

Although there are only 56 data points in this population and the apparent abnormalities are statistically possible (with low probability) this investigation concludes that the subject's learning for this case must be flagged as a real possibility. Figure 2.7 (Number of hits on Machine 1) has been added to provide clarity. It appears that the subject just didn't have "low hit" days toward the end.

#### Learning within a Trial

The question of learning within a trial or run has been investigated by summing the number of hits of the  $i$ th sample for the run. The results are somewhat distorted because of the inequitable distribution of passes.

The lower numbered samples have significantly more hits because of this.

A plot of the number of hits per sample vs. sample number is shown in Figure 2-7.

Notice that the first sample has a value of 34 hits. This means that everytime he ists down for a new 25 sample trial he hits 34% of the time on his first try. With this in mind along with the rest of the data points, it is obvious that the subject doesn't learn throughout the trial.

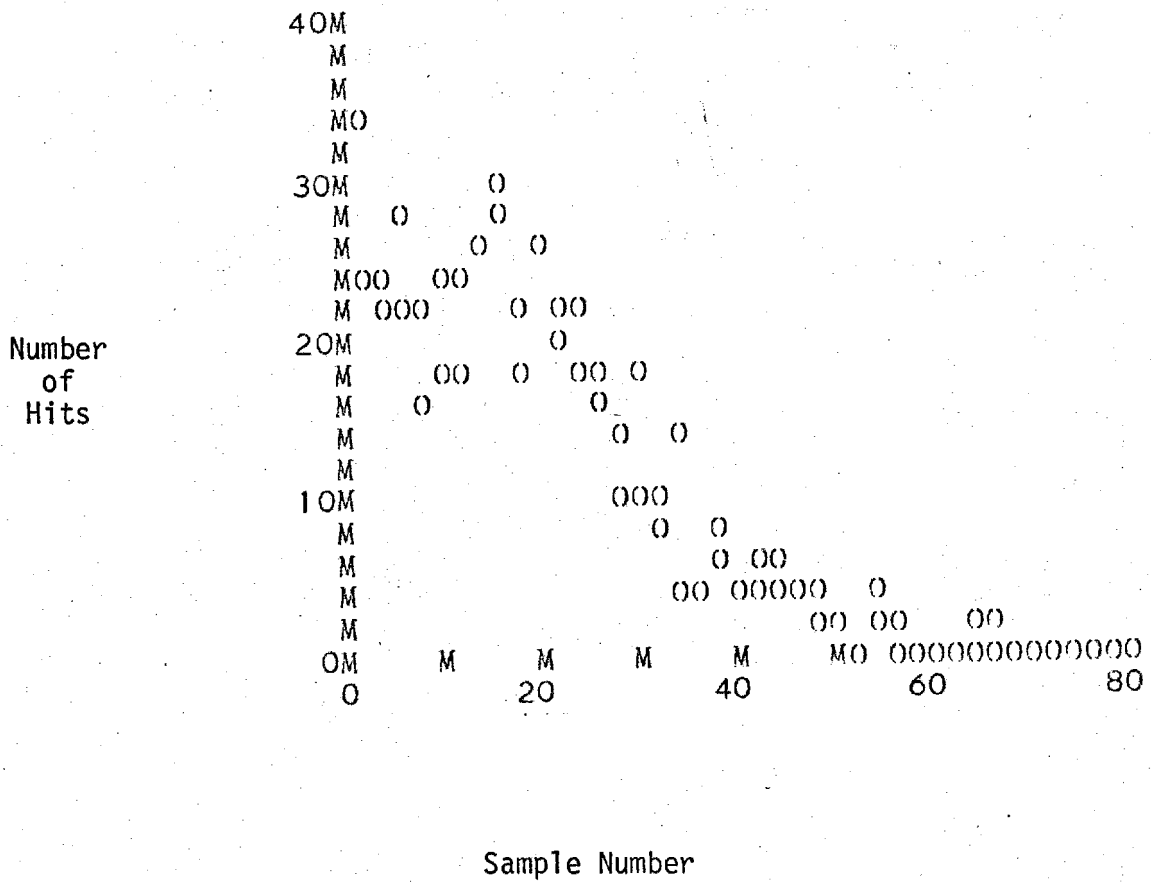


Figure 2.8 Total Number of Hits Within a Trial

Miscellaneous

Numerous arrays of data have been examined for the purpose of obtaining some insight into the data. Some of the data is being printed herein so that the data can be examined more closely if desired.

This first table is presented for use as a quick reference.

Day	Last Trial	Number of Tracks	Machine Used
1	8	8	2
2	16	8	1
3	24	8	2
4	36	12	2
5	44	8	2
6	52	8	1
7	56	4	1
8	64	8	1
9	68	4	1
10	72	4	1
11	76	4	1
12	80	4	1
13	84	4	2
14	88	4	2
15	100	12	2

The following displays are presented below with little commentary.

- I. General trial summary (Figure 3.1). Each trial (25 choices) is listed with the following information.
  - A. Machine used (1 or 2)
  - B. Total number of machine states in each color (i.e., 6 yellow, 6 green ....) for each trial.
  - C. Total number of subject choices for each color for each trial.
  - D. Total number of hits for each trial.
  - E. Total number of passes for each trial.
  - F. Breakdown of hits by color.
- II. Machine data for machine 1 and machine 2 separately (Figures 3.2, 3.3)  
Just by examining these displays it may be possible to glean meaningful information. For example, machine 1 was used for the first 8 trials during which the first state of each trial was a yellow or red. If the first sample of each trial is most memorable, perhaps this is responsible for the subject's obvious preference of yellow and red (see Section 2 - Analysis of S2 Data Responses).
- III. Plots of the number of passes made.
  - A. Number of passes vs. trial number (i.e., trial is 25 or more samples) (Figure 3.4)
  - B. Number of passes vs. sample number (Figure 3.5)

trial	mach	mach yell	mach gren	mach blue	mach red	sub yel	sub grn	sub blu	sub red	numb hits	num pas	hit yel	hit grn	hit blu	hit red
1	2	6	6	2	11	11	3	5	6	7	0	3	0	0	4
2	2	5	9	4	7	10	3	4	8	5	0	2	1	0	2
3	2	7	8	6	4	7	4	6	8	6	0	2	2	1	1
4	2	7	4	10	4	10	3	4	8	8	0	4	1	2	1
5	2	5	6	11	3	11	4	0	10	5	0	2	1	0	2
6	2	8	5	3	9	10	3	2	10	10	0	3	1	0	6
7	2	3	7	7	8	11	1	3	10	8	0	2	0	2	4
8	2	6	7	3	9	11	2	2	10	9	0	4	1	0	4
9	1	9	6	2	8	10	3	5	7	7	0	4	0	0	3
10	1	5	5	8	7	9	6	1	9	9	0	3	3	0	3
11	1	6	4	7	8	6	6	3	10	2	0	0	0	0	2
12	1	7	2	7	9	9	5	3	8	6	0	4	0	0	2
13	1	5	7	4	9	10	3	2	10	12	0	3	2	1	6
14	1	4	5	11	5	10	2	2	11	8	0	2	1	2	3
15	1	6	9	5	5	10	3	1	11	9	0	3	2	0	4
16	1	6	2	7	10	8	5	4	8	5	0	2	0	0	3
17	2	10	12	7	7	12	2	1	10	7	11	4	0	0	3
18	2	4	9	9	11	10	2	2	11	8	8	1	1	1	5
19	2	8	9	10	11	11	3	2	9	6	13	3	0	1	2
20	2	7	13	5	8	11	1	4	9	7	8	3	1	1	2
21	2	9	8	9	9	10	5	1	9	9	10	3	2	0	4
22	2	13	12	9	9	8	2	2	13	5	18	0	0	1	4
23	2	9	9	15	12	11	1	2	11	7	20	2	0	1	4
24	2	10	9	11	9	8	3	2	12	8	14	3	2	0	3
25	2	3	11	7	8	8	5	5	7	2	4	1	0	1	0
26	2	10	4	10	10	8	6	4	7	9	9	4	0	2	3
27	2	11	6	15	9	11	1	0	13	12	16	6	1	0	5
28	2	5	6	10	11	10	5	2	8	7	7	2	1	1	3
29	2	7	16	16	14	8	4	3	10	8	28	1	2	1	4
30	2	16	19	18	12	8	6	1	10	8	40	3	3	0	2
31	2	10	10	9	19	10	5	1	9	9	23	2	1	1	5
32	2	12	9	19	12	8	7	3	7	2	27	2	0	0	0
33	2	11	14	20	10	9	4	2	10	5	30	2	1	1	1
34	2	16	4	10	8	9	5	3	8	12	13	5	2	1	4
35	2	9	7	11	15	12	4	3	6	7	17	3	0	2	2
36	2	14	17	19	22	9	4	1	11	7	47	2	1	0	4
37	2	5	16	13	11	9	5	2	9	6	20	0	4	0	2
38	2	5	7	8	9	7	8	2	8	7	4	1	3	0	3
39	2	7	7	9	6	6	6	3	10	9	4	1	3	1	4
40	2	11	13	10	10	7	6	2	10	9	19	2	4	0	3
41	2	10	14	9	12	4	8	2	11	4	20	1	1	0	2
42	2	11	11	7	9	4	7	3	11	9	13	2	3	0	4
43	2	15	13	14	11	4	9	3	9	5	28	0	4	0	1
44	2	10	9	11	8	8	6	4	7	11	13	4	1	4	2
45	1	12	9	7	8	10	6	2	7	8	11	5	1	1	1
46	1	5	6	9	7	4	4	6	11	6	2	0	0	2	4
47	1	9	10	10	4	8	6	2	9	6	8	3	2	0	1
48	1	9	10	7	6	8	3	4	10	6	7	2	1	1	2
49	1	7	10	6	2	4	6	6	9	7	0	0	5	1	1
50	1	9	12	1	7	9	3	4	9	6	4	3	0	0	3

trial	mach	mach yell	mach grn	mach blue	mach red	sub yel	sub grn	sub blu	sub red	numb hits	num pas	hit yel	hit grn	hit blu	hit red
51	1	6	5	10	8	6	5	6	8	9	4	2	2	3	2
52	1	7	15	11	9	8	5	1	11	8	17	3	2	0	3
53	1	11	5	7	6	9	3	3	10	6	4	3	1	1	1
54	1	6	4	7	12	9	5	1	10	9	4	2	2	0	5
55	1	13	14	12	14	8	4	1	12	7	28	0	2	0	5
56	1	12	14	19	14	12	2	2	9	6	34	3	0	1	2
57	1	8	2	11	8	9	3	2	11	8	4	3	0	1	4
58	1	6	4	11	12	8	2	3	12	6	8	1	0	1	4
59	1	11	5	15	6	4	3	2	16	8	12	2	1	1	4
60	1	11	11	11	11	5	2	2	16	8	19	3	0	1	4
61	1	10	8	9	8	8	4	0	13	8	10	0	1	0	7
62	1	13	6	9	10	7	1	0	17	7	13	3	0	0	4
63	1	10	18	10	7	6	1	2	16	4	20	2	0	0	2
64	1	10	11	6	9	10	0	2	13	8	11	4	0	0	4
65	1	7	9	2	8	4	4	5	12	8	1	1	1	1	5
66	1	3	12	4	7	8	9	2	6	8	1	3	4	0	1
67	1	8	10	10	8	11	2	2	10	8	11	3	1	0	4
68	1	10	4	5	9	13	2	1	9	7	3	4	0	0	3
69	1	10	8	4	8	10	4	2	9	9	5	4	1	0	4
70	1	9	6	12	17	8	6	2	9	4	19	0	2	0	2
71	1	11	7	7	8	5	7	1	12	7	8	2	1	0	4
72	1	7	9	13	9	8	7	0	10	3	13	1	1	0	1
73	1	11	6	5	10	10	4	5	6	9	7	4	1	2	2
74	1	4	12	8	8	8	4	4	9	6	7	0	2	1	3
75	1	9	11	7	8	5	8	1	11	7	10	1	3	0	3
76	1	8	14	5	6	4	6	4	11	10	8	2	4	1	3
77	1	11	3	8	6	12	2	0	11	9	3	7	0	0	2
78	1	9	9	10	11	9	3	1	12	6	14	3	0	0	3
79	1	7	8	7	12	9	4	2	10	7	9	2	2	0	3
80	1	8	6	10	8	14	1	2	8	8	7	4	0	1	3
81	2	13	4	8	5	12	2	3	8	10	5	7	1	0	2
82	2	6	14	10	11	11	0	2	12	8	16	2	0	1	5
83	2	7	10	17	16	13	1	0	11	8	25	3	0	0	5
84	2	14	12	16	14	12	0	0	13	7	31	3	0	0	4
85	2	7	7	10	7	9	6	4	6	6	6	2	2	1	1
86	2	11	7	4	6	12	6	1	6	7	3	5	1	0	1
87	2	13	13	9	6	17	1	2	5	8	16	5	1	2	0
88	2	6	3	8	9	14	3	4	4	7	1	4	1	1	1
89	2	6	5	8	6	8	5	2	10	6	0	2	1	1	2
90	2	7	7	4	7	7	7	4	7	6	0	1	3	1	1
91	2	9	10	7	2	7	6	2	10	6	3	4	1	1	0
92	2	4	6	10	5	8	6	3	8	6	0	1	3	1	1
93	2	6	7	7	7	7	5	3	10	10	2	3	2	1	4
94	2	5	6	4	13	7	6	2	10	10	3	3	1	1	5
95	2	7	5	10	11	7	6	0	12	8	8	2	1	0	5
96	2	7	9	7	9	11	4	0	10	11	7	5	1	0	5
97	2	8	8	6	5	8	4	4	9	6	2	2	1	1	2
98	2	7	12	10	5	9	5	2	9	8	9	3	3	0	2
99	2	8	9	8	8	7	6	2	10	7	8	2	2	0	3
100	2	9	5	9	10	12	5	0	8	11	8	5	3	0	3

Figure 3.1 (Continued)

0031003121303211033331132  
0113100111033230023033300  
2232103103310123321302022  
2203311021022233333312000  
3030220232231003033033122  
3131202300133133132213001  
2221122313233202200312210  
1221131110300132213003120  
03221123202221101003203120123102330031  
001122313200131033002212023000130131  
130223130102313222122130302  
211120010202223111321220321100300  
23333030020021221111031210110120  
3221121001210212010100131  
11111330101033101300310231010  
01202123323202222312033013130  
103112123203303111022312321102211012313210  
13310102231200200000123003322  
32133133233120023230021303203  
211311110302330311003000003013331333122220122211132022  
32220232333331022012010231302232200233201313111112112200012  
30021020322232132003022203323  
122323003321332212001303302233232  
0222003302023212023123203010022221201  
22121100300031311303030212303222031112021323  
03221320000232112031322130301030211  
10110332022100001033330021020223232303  
033111022302000012112311223111211233110100121  
020311131021101301033122001233320103  
13133011310013013133020102  
10103132133321232111110113  
330201102012032131231212210032203113  
1230200002033210310031203333  
101130032201331300330301020121  
30132032333032330033012022323213303123021212  
112233022001200302031000123121033  
13221230023032101331321221230112202203  
10122031320033013313300100200233  
33120221103320211133311121122013  
31022132112201313120103131103032000  
231011112232011111031000311201303  
0000223302302002321000233112  
302310321323331121020131200010232130223  
3313011313201303310123210320033222

Figure 3.2 Color states of machine 1 during the experiment  
(0-yellow, 1 green, 2 blue, 3 red)



3030021330303023133311131  
3323130111011333133310131  
0303111222003203201112101  
0220233110022220313200212  
3230122322222001002111212  
0323130003013313030203112  
0121131322332323102110233  
300032323321002303221323  
111310320122303013031012200113012201  
022322300312323333132311110312211  
01323231132020102230201233321331131020  
321301110321331100202112310033111  
00232122130302000121301333121323021  
1101020113302031202031200203310013211132320  
22322222001010001322110322323112331333301203  
212131201330120310020213313002002222133  
2202313333232102111311012311  
2200211300320330002023133220232133  
10023020000130321222213220132222220313033  
33323012112033222122030123312303  
13033112201002231233321122113312311121302202132013322  
0021212120121200311131223222323000221331120310120113013032012300  
220133203233331331032310103310300121032031233123  
1233013220323210222202330110000232023231211202021323  
003213223101023312232233212111322102103202202120012120  
30212022020230003000222003011003301323  
330220332330223033222300033123113111213020  
230031110213332123232010333012233111313322001230203301100322113213222303  
331100231210122132011131113222211223203321331  
31211032332213300312123232100  
00203100132132212112233013202  
12201200130132103221031100101233110223033321  
210311120033110330112003302313112232211002313  
13121022332310310100311100323000201213  
20023011200113201121213130102210003223312203030133022  
22130202313302320310213012300212  
123000000103011020322022203203  
11221232201333322321010213310311121013103  
22122330301301101323312132023302212233221322132330  
33330202202003321001220123121120131212303301203201213302  
1303220101302331233021222201012  
0323332110010001012102301030  
11300023311100103001221112122201321302000  
20020333331232021123023032  
1102302323213122203102030  
2103010003333212110310132  
1011021230212001120111200203  
0232212112223203231310120  
033231031211110302023012232  
1130230333333230211113233300  
203213203111330213320330022222303  
31303012320132312113320110032012  
212203312300210001010131321  
0320102302131222201103111110312212  
111303223212300102300230301122113

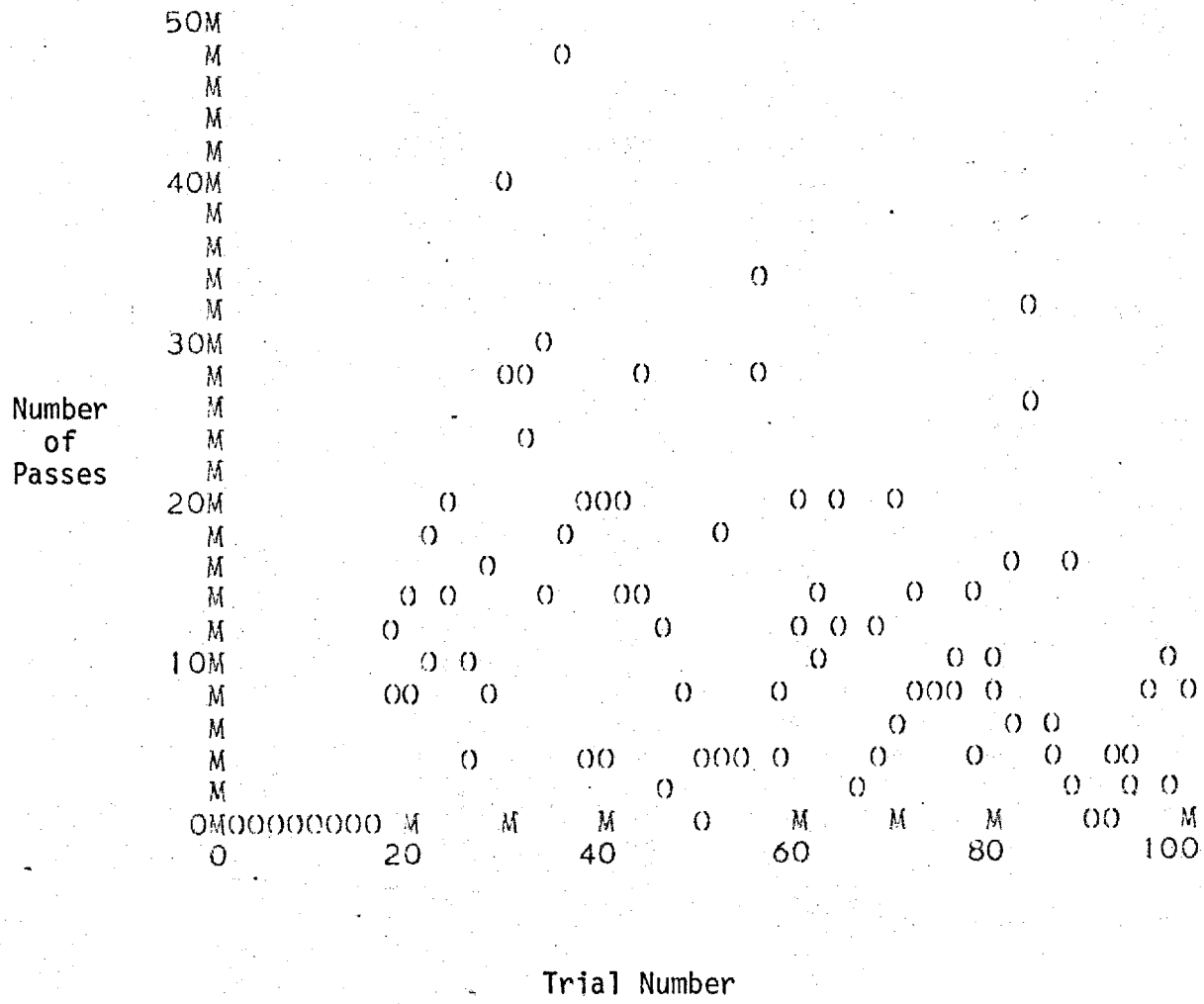


Figure 3.4 Total number of passes summed over a trial

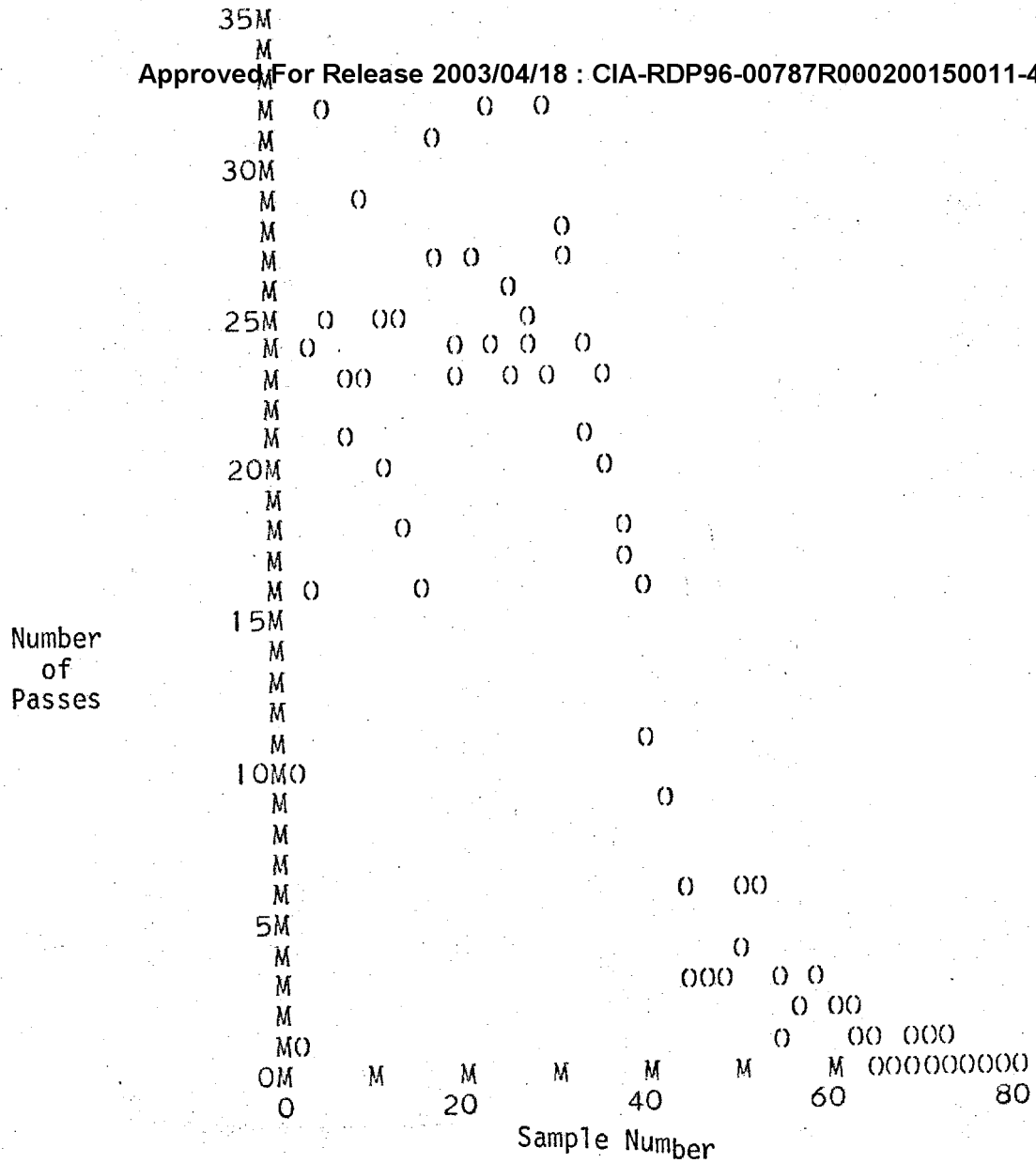


Figure 3.5 Total number of passes summed over sample number

- C. Number of passes and the number of hits vs. the trail number on one plot. Investigation of the hits/passes relationship was dropped when the coefficient of correlation between the two was computed at  $-.114$

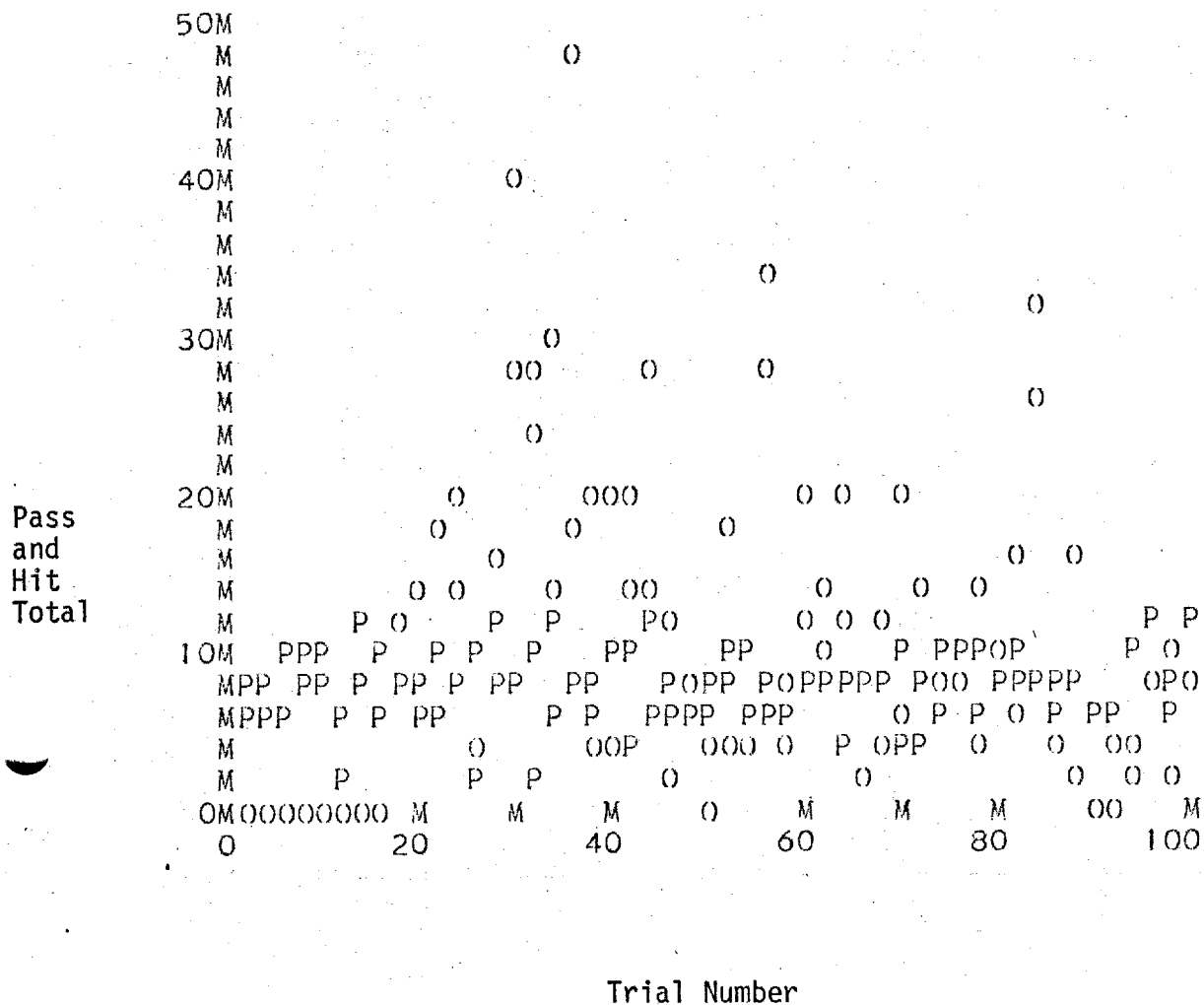


Figure 3.6 Plot of number of hits per trial and number of passes per trial

IV. Tables of state transitions which reflect the influence of the subject on the machine. For color choices of the subject the table shows the number of colors the machine has on the next sample. For example on the first table, when the subject picked yellow, on the next sample 197 times the machine state was yellow.

MACHINE STATES ON FOLLOWING SAMPLE					
	Yellow	Green	Blue	Red	
Yellow	88	77	87	95	
Green	38	46	39	47	Machine 1
Blue	27	28	24	24	
Red	120	105	99	112	
Pass	84	83	98	81	
Yellow	109	124	128	141	
Green	58	47	58	66	Machine 2
Blue	25	32	42	30	
Red	121	125	136	102	
Pass	146	162	161	168	
Yellow	197	201	215	236	
Green	96	93	97	113	Both Machines
Blue	52	60	66	54	
Red	241	230	235	214	
Pass	230	245	259	249	

Figure 3.7 State Transitions from Subject Choice to Future Machine State

V. Because of the possibility that the subject was learning the state of machine 2 the distribution of the colors are plotted in Figures 3.8, 3.9, 4.0, and 4.1. The only states used are those in which the subject didn't pass. Therefore there is a total of 25 for each trial.

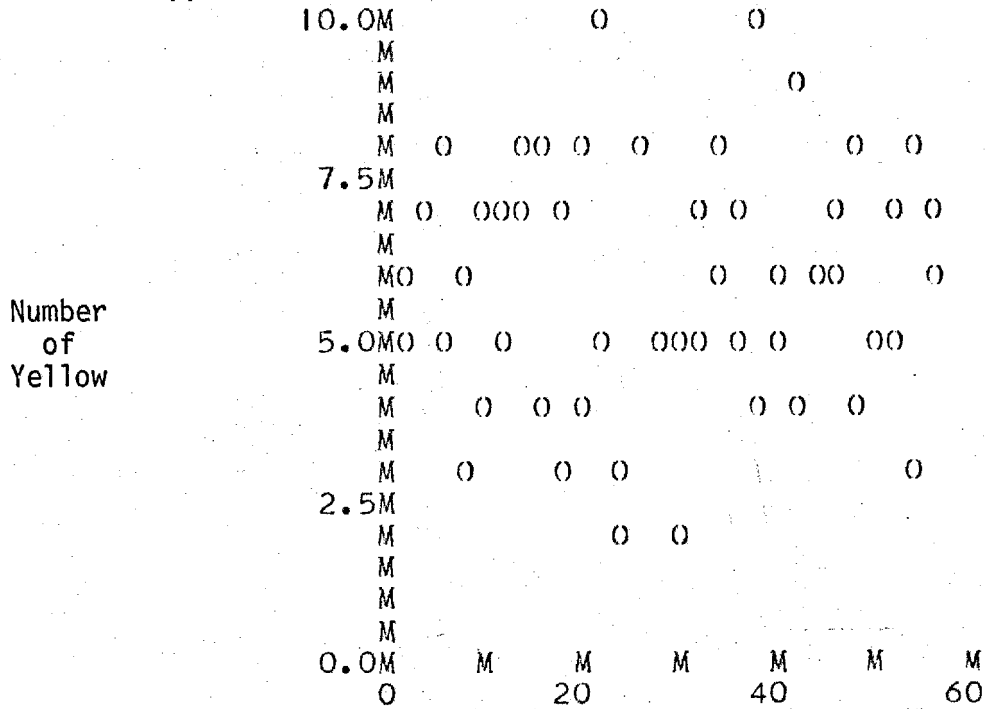
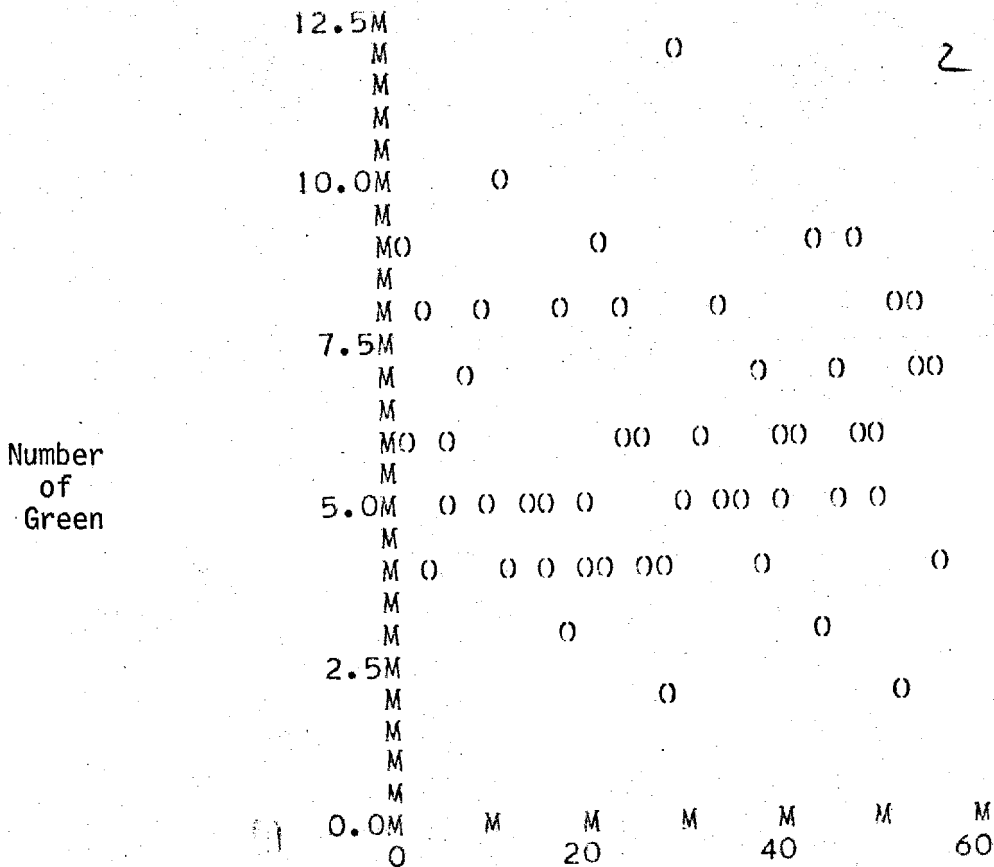


Figure 3.8 Distribution of Yellow for Machine 2





Number  
 of  
 Blue

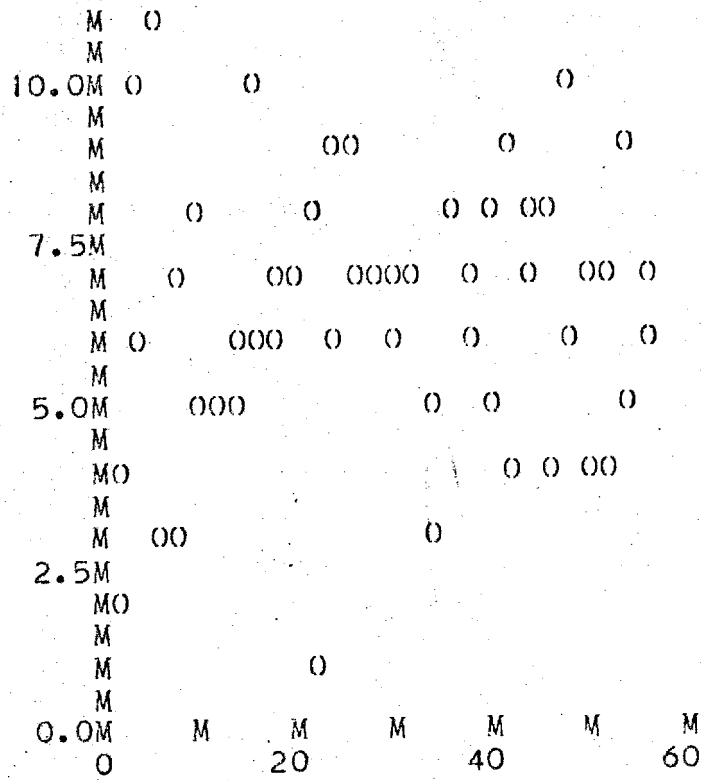
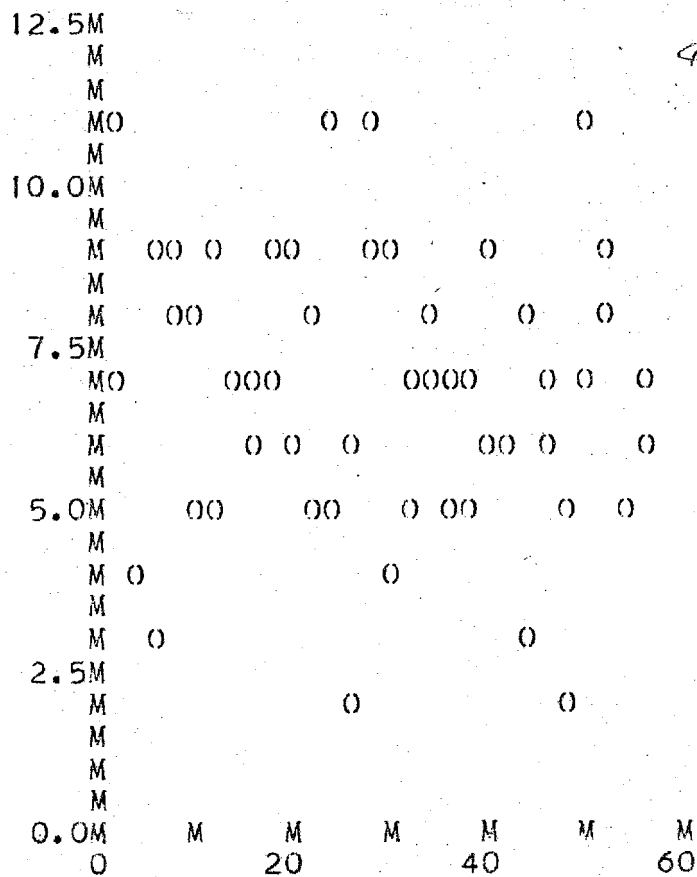


Figure 4.0 Distribution of Blue for Machine 2

Number  
 of  
 Red



Approved For Release 2003/04/18 : CIA-RDP96-00787R000200150014

Test	Description	Scoring					
		S1	S2	S3	S4	S5	S6
Halstead Category Test	Nonverbal test requiring abstraction of conceptual relationships. Score: Total errors.	7	14	33	26	6	28
Tactual Performance Test	Requires placement of 10 geometrically shaped blocks in their correct locations on a formboard while blindfolded. Separate RT, LT, and bimanual trials. Score: Total time (min.).	16.4	11.8	7.7	7.7	11.4	6.9
Speech Perception Test	Discrimination of non-word speech sounds. Score: Total errors.	4	2	0	2	5	3
Seashore Rhythm Test	Discrimination of nonverbal rhythms. Score: Number correct.	27	25	28	29	26	29
Finger Tapping Test	Measure of finger oscillation rate for 10-sec. period, both RT and LT hand trials. Score: No. taps/10 sec.	RT/LT 53/50	RT/LT 53/49	RT/LT 48/47	RT/LT 54/53	RT/LT 47/47	RT/LT 48/43
Trail Making Test (Part A)	Requires connecting numbered circles in order from 1 to 25. Paper and pencil task. Score: Total times (sec)	40	16	18	19	30	27
Trail Making Test (Part B)	Requires connecting alphabetic and numbered circles by alternating 1→A→2→B, etc. Score: Total time (sec)	56	50	55	50	54	53
Knox Cube Test	Measure of attention span and immediate visual memory. Score: Number correct.	13	14	13	16	17	17
Raven Progressive Matrices	Nonverbal intelligence test involving spatial matrices. Score: Number correct.	39	53	49	55	60	54
Verbal Concept Attainment Test	Requires abstraction of verbal conceptual relationships. Score: Number correct.	22	24	27	23	21	24
Buschke Memory Test	Requires learning a 20-word list in a maximum of 12 trials with repetition of words omitted after each trial. Score: Max. no. words correctly remembered; List: no. words consistently remembered	Total: 14/20 List: 8/20	17/20	18/20	19/20	20/20	20/20
Grooved Pegboard Test	Requires insertion of 25 pegs in their holes in a pegboard. Both RT and LT hand trials. Score: Total time (sec).	RT/LT 76/74	RT/LT 69/70	RT/LT 58/67	RT/LT 59/67	RT/LT <del>71/70</del> 71/70	RT/LT 48/50
Spatial Relations Subtest of the PMA	Requires mental rotation and identification of figures rotated in 2 dimensions. Score: no. correct - no. errors.	-	-	-	-	60	52
Gottschaldt Hidden Figures Test	Requires tracing outline of simple figure hidden within lines of more complex figure. Score: no. correct - no. errors.	-	-	-	-	v. good	outst. outst.

Approved For Release 2003/04/18 : CIA-RDP96-00787R000200150014