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A TWO-STATE MODEL OF SIMPLE REACTION TIME

Yasuharu Okamoto

A TWO-STATE MODEL

OF

SIMPLE REACTION TIME

by

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of the requirements for the degree of
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TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

When a stimulus is presented, the subject responds to it with some delay. This delay is called a reaction time(abbreviated as RT). RTs are classified into two types, simple RTs and choice RTs. When the subject responds to one of possible stimuli in one of more than two ways according to the stimulus presented, the RTs are called choice RTs. If there is only one stimulus and only one type of response is required, the RTs are called simple RTs. The interval from the start of the trial to the presentation of the stimulus is called foreperiod(abbreviated as FP).

In this article, a new model of simple reaction time is proposed. To appreciate the necessity of a new model, it is useful to review models not only for simple RT, but also for choice RT. First, let us review literatures on models for choice RT.

MODELS FOR CHOICE REACTION TIME

A. Choice Reaction Time and The Number of Stimuli.

The following empirical relations between choice RT and the number of stimuli are well known(cf.,Welford(1960,1980)),

$$\overline{RT} = K \cdot \log(n+1) \qquad (1\text{-}1)$$

and

$$\overline{RT} = a + b \cdot \log n \qquad (1\text{-}2)$$

where $\overline{RT}$ and n are the mean choice reaction time and the number of stimuli, respectively. Welford(1960,1980) explained that eqs.(1-1) and (1-2) were proposed by Hick(Hick(1952), cited in Welford(1960,1980)) and Hyman(1953), respectively. If the event that no signal is presented is conceived of as one of possible signals, eq.(1-1) means that mean RT is proportional to the uncertainty of choice situation. As to eq.(1-2), when we set $n = 1$, $\overline{RT} = a + b \cdot \log n = a$. That is, a is the mean simple reaction time. $b \cdot \log n$ represents the increase over the simple RT due to the need for identification and choice. x bits of uncertainty means that we can identify the specific event by x steps of dichotomization process. Welford(1960) explained that Hick(1952) examined a serial dichotomous classification model.

According to Smith(1977,1980), low stimulus intensities should give a better fit against $\log n$ (eq.(1-2)), while high intensities should be better fitted against $\log(n+1)$ (eq.(1-1)) (cf. the next section).

B. Stimulus-Response Compatibility.

Smith(1977,1980) proposed the model which incorporated stimulus-response compatibility.

The onset of the stimulus, j, induces the following excitations.

$$e(j) = q + \frac{u}{N}$$

$$e(i) = \frac{u}{N} \qquad i \neq j.$$

These stimulus-excitations, e(i)'s, are transformed into response excitations, $\rho(i)$. At cycle s of this transformation, the increment in $\rho(i)$ is $\frac{e(i)}{N}$, and the time required for this cycle is $\frac{\sum \alpha(i) \cdot e(i)}{s}$. $\alpha(i)$ is the parameter which represents the stimulus-response compatibility for stimulus, i. Let $\delta(m)$ be the response m's criterion, and x be the cycle time at which $\rho(m)$ reaches $\delta(m)$, then,

$$\rho(m) = \int_1^x \frac{e(j)}{N} ds = \frac{e(j)}{N}(x-1)$$

Therefore

$$x = \frac{\delta(m)\cdot N}{e(j)} + 1 \qquad (1\text{-}3)$$

The mean reaction time of the response m to the stimulus j,

RT(j), is the sum of the integral of the x cycle duration,

$\int_1^x \frac{\sum\alpha(i)\cdot e(i)}{s}ds$, and any non-processing delays, a.

That is,

$$\begin{aligned} RT(j) &= a + \int_1^x \frac{\sum\alpha(i)\cdot e(i)}{s}ds \\ &= a + (\sum\alpha(i)\cdot e(i))\cdot \log x \\ &= a + (\sum\alpha(i)\cdot e(i))\cdot \log\left(\frac{\delta(m)\cdot N}{e(j)} + 1\right) \qquad \text{(by eq.(1-3))} \\ &= A + B\cdot \log\left(N + \frac{e(j)}{\delta(m)}\right) \qquad (1\text{-}4) \end{aligned}$$

where

$$A = a + (\sum\alpha(i)\cdot e(i))\cdot \log\frac{\delta(m)}{e(j)}$$

and

$$B = \sum\alpha(i)\cdot e(i)$$

Eq.(1-4) includes eqs.(1-1) and (1-2) as special versions

for $\frac{e(j)}{\delta(m)} = 1$ or 0, respectively.

C. Laming(1966)'s Interpretation.

Laming(1966) used the following approximation

$$\log(n+1) \doteqdot \sum_{r=1}^{n+1} \frac{1}{r}$$

and generalized eq.(1-1) as follows,

$$RT = a + b\cdot\sum_{r=1}^{n} \frac{1}{r+k} \qquad (1\text{-}5)$$

Laming(1966) proposed two models, which predicted that the mean RT follows eq.(1-5).

The first model is extended version of the model proposed by Christie and Luce(Christie and Luce(1956), cited in Laming(1966)).

According to this type of model, the reaction time, t_n, to one of n equiprobable signals is determined by the longest of n elementary decision processes. Let F(t) be the distribution function of this elementary decision latency, then

$$RT = E(t_n) = \int_0^{\infty} t\cdot d(F(t)^n) \qquad (1\text{-}6)$$

Laming(1966) solved eq.(1-6) with respect to F(t) in order that RT satisfies eq.(1-5). Let $F(t) = y$ and $t = \phi(y)$, then the solution is given by the following equation;

$$\phi(y) = \int \frac{b\cdot y^k}{1-y}\cdot dy + C$$

For $k = 0$,

$$F(t) = 1 - e^{-\lambda\cdot(t-a)}$$

This is Christie and Luce(1956)'s version.

The second model proposed by Laming(1966) is an analogy to an epidemic model. With the assumption that the rate of interactions involving a given individual is constant λ, and independent of the size of the group, i.e., the number of equiprobable stimuli, he derived the following equation;

$$RT = \frac{2\cdot(n-1)}{n\lambda}\cdot\sum_{r=1}^{n-1}\frac{1}{r}$$

D. Fast Guess Model.

In the fast guess model(Ollman(1966), Yellott(1967,1971)), there are two types of responses, guess responses and stimulus controlled responses. On any trial, the subject makes either a guess response with probability 1-q, or a stimulus controlled response with probability q. When the subject guesses, he makes response A_i $(i=1,2)$ with bias probability b_i regardless of which stimulus (S_1 or S_2) was presented. When the subject makes a stimulus controlled response, the response is correct with probability $a > .5$.

From these assumptions, Yellott(1971) derived the following equation;

$$\frac{p_c \cdot M_c - p_e \cdot M_e}{p_c - p_e} \simeq \text{constant.} \qquad (1\text{-}7)$$

where p_c and p_e are the probabilities of correct and error responses, respectively, and M_c and M_e are the mean reaction times of correct and error responses, respectively. Eq.(1-7) was supported by the experimental results reported in Ollman(1966) and Yellott(1967,1971).

Yellott(1971) proposed a deadline model, which does not always predict the constancy of the left side of eq.(1-7). The deadline model assumes that on every trial, information about the identity of the choice stimulus takes the form of a single quantum which arrives $\underline{S}$ msec after stimulus onset. $\underline{S}$ has the distribution function $S(t)$ and density function $s(t)$. If the subject waits until the arrival of the information quantum, and then responds, his response is correct with probability one. On each trial, however, the subject presets a deadline $\underline{D}$. If the information quantum has not arrived $\underline{D}$ msec after stimulus onset, the subject guesses with some bias probabilities b_1 and b_2 for responses r_1 and r_2. $\underline{D}$ has the distribution function $D(t)$

and density function d(t).

From these assumptions, Yellott(1971) derived the following equation;

$$\frac{p_c \cdot M_c - p_e \cdot M_e}{p_c - p_e} = \frac{\int_0^\infty t \cdot s(t) \cdot (1 - D(t)) \cdot dt}{\int_0^\infty s(t) \cdot (1 - D(t)) \cdot dt} \qquad (1\text{-}8)$$

The right side of eq.(1-8) is not in general invariant under arbitrary transformations of D(x). But, a special version of the deadline model yields the identical prediction of the fast guess model with $a=1$. That is, the deadline model can explain the constancy of the left side of eq.(1-7), too.

As to the speed-accuracy tradeoff, the fast guess model asserts that the error rate should be constant in order that the experimenter can controll the subject's strategy. In the fast guess model, the speed-accuracy tradeoff is controlled by the probability of guessing. Equality of the error rates between the experimental conditions means equality of the guessing probabilities between them. However, according to Ollman(1977)'s adjustable timing model, invariance of the error rate does not assure invariance of the strategy.

In the adjustable timing model, the joint density of the type and latency of the responses, $f(r,t)$, is expressed as the product of two probabilities;

$$f(r,t) = A(r|t) \cdot f(t)$$

where $A(r|t)$ is the conditional probability that the response is the specified type($r =$ correct response or error), given the particular value of RT($RT = t$), and $f(t)$ is the marginal probability of the RT. Ollman(1977) insists that $A(r|t)$ is specified only by the task and $f(t)$ is dependent only on the subject's strategy. Hence, in order to assure the invariance of the speed-accuracy tradeoff, the experimenter should control the reaction time, rather than the error rate.

E. Accumulation Model.

Random walk models(Stone(1960), Laming(1962,1968), Link and Heath(1975), Link(1975,1978), Thomas(1975), Swensson and Green(1977)) assumes that the subject accumulates information from periodic samples of the sensory input and responds when this accumulation reaches one of decision boundaries. Link and Heath(1975) derived the following equation;

$$E_A - E_B = \frac{D}{\mu} \cdot \left(\frac{c-1}{c}\right) \tag{1-9}$$

In eq.(1-9), E_A and E_B are the expected numbers of steps to the boundaries for responses, A and B. D is the absolute value of the boundary positions. μ and c are determined by the distribution function of sample values. If the distribution function of sample values is normal or trinomial, $c = 1$. In this case, $E_A = E_B$ from eq.(1-9). This means that the mean latency of the correct response is equal to the one of the error. But, if the distribution function of sample values is a Laplace distribution, i.e., difference between two exponential distributions, $c \neq 1$ in general. In this case, $E_A \neq E_B$, which means that the mean latency of the correct response is not equal to the mean latency of the error.

Kintsch(1963)'s model adopts a stochastic mechanism of random walk, although it is not an accumulation model. His model is described by the following equation;

$$Q = \begin{array}{c} \\ S \\ oA \\ oB \\ A \\ B \end{array} \begin{array}{c} \begin{array}{ccccc} S & oA & oB & A & B \end{array} \\ \left[\begin{array}{ccccc} 0 & 1-a & a & 0 & 0 \\ 0 & 0 & 1-b & b & 0 \\ 0 & 1-c & 0 & 0 & c \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{array}\right] \end{array} \qquad (1\text{-}10)$$

On each trial the subject begins in the starting state, S, goes to one or the other orienting state(oA or oB), and from there, he either goes on to make the recorded response(A or B) or shifts to the other orienting state(oB or oA). Furthermore, Kintsch(1963) assumes that the time required to complete each transition step is the discrete random variable which follows the geometric distribution, eq.(1-11);

$$P(k) = p^{k-1} \cdot (1 - p) \qquad (1\text{-}11)$$

From eqs.(1-10) and (1-11), the mean latency of responses for the case $b = c$ can be derived;

$$\text{The mean latency} = \frac{(1+b) \cdot p}{b \cdot (1 - p)}$$

In the recruitment theory proposed by LaBerge(1962), the accumulation process is determined by sampling by replacement. This model assumes that there are three types of elements, C_1, C_2

and C_0. C_1 and C_2 elements are connected to responses A_1 and A_2, respectively. C_0 elements are connected to no response alternatives. The subject chooses response A_1, when he draws r_1 elements of type C_1 while the number of drawings of type C_2 elements, x, is less than r_2, where r_1 and r_2 are criterions for responses A_1 and A_2. With these assumptions, LaBerge(1962) derived the following equation;

The average number of total draws(the mean latency)

$$= \frac{r_1 \cdot I_{p_1/(p_1+p_2)}(r_1+1, r_2)}{p_1 \cdot I_{p_1/(p_1+p_2)}(r_1, r_2)}$$

where p_1 and p_2 are the proportions of elements of types C_1 and C_2, and

$$I_s(t,u) = \sum_{k=0}^{u-1} \frac{(t+k-1)!}{(t-1)! \cdot k!} \cdot s^t \cdot (1-s)^k$$

The variable criterion theory proposed by Grice et al. (Grice, Nullmeyer and Spiker(1977), Grice, Spiker and Nullmeyer (1979), Grice and Spiker(1979), also cf.,Link(1979)) assumes that the accumulation process is deterministic, but the decision criterion is random. The probabilistic character of the decision process is attributed to the random fluctuation of the decision criterion. According to the variable criterion theory, the excitatory strengths of the correct response and the error at time t, $f_c(t)$ and $f_e(t)$, can be described as follows;

$$f_c(t) = V(t) + A(t)$$

$$f_e(t) = E_c(t) - I(t) - A_D(t)$$

$$= (V(t) - I(t)) + (A(t) - A_D(t)) \qquad (1\text{-}12)$$

where V(t) is the value of the sensory detection component, A(t) is associative strength of the correct stimulus, I(t) is associative inhibition, and $A_D(t)$ is associative discrimination. If $f_c(t)$ (or $f_e(t)$) reaches the criterion C before $f_e(t)$ (or $f_c(t)$) reaches its criterion, the correct response (or the error) occurs. Eq.(1-12) means that the sensory and associative components, V(t) and A(t), are suppressed by the associative inhibition I(t) and the associative discrimination $A_D(t)$, respectively.

F. Timing and Counting Models.

Green and Luce(1974) examined timing and counting models for two-choice reaction time data. According to these models, the decision is made on the base of the estimation of the rate of neural pulses. For the estimation, the timing model uses the inter-arrival-intervals of pulses and the counting model uses the number of pulses during a fixed time interval. For these models, Green and Luce(1974) derived the following equations for the mean two-choice reaction times for auditory stimuli;

For the timing model,

$$MRT_1 = \left(\frac{M_1}{M_2}\right)\cdot MRT_2 - \bar{r}\cdot\left(\frac{M_1}{M_2} - 1\right) \qquad (1\text{-}13)$$

$$p_c\cdot MRT_c - p_e\cdot MRT_e$$
$$= \bar{r}\cdot(p_c - p_e) + h(J,k,\sigma)\cdot\left\{M_1\cdot\left[P(1|1)-\tfrac{1}{2}\right] + M_2\cdot\left[P(2|2)-\tfrac{1}{2}\right]\right\} \qquad (1\text{-}14)$$

For the counting model,

$$MRT_1 = MRT_2 = \bar{r} + \sigma \qquad (1\text{-}15)$$

$$p_c\cdot MRT_c - p_e\cdot MRT_e = (\bar{r} + \delta)(p_c - p_e) \qquad (1\text{-}16)$$

In the above equations, MRT_1 and MRT_2 are the mean reaction times for the two stimuli, S_1 and S_2, MRT_c and MRT_e are the mean reaction times of the correct responses and errors, and p_c and p_e are the probabilities of the correct responses and errors. Eq.(1-13) means that MRT_1 is a linear function of MRT_2. Eq.(1-14) means that $p_c\ MRT_c - p_e\ MRT_e$ is an approximately linear function of $p_c - p_e$ when intense stimuli are used, but the former is an accelerated function of the latter when weak signals are used. The meaning of eq.(1-15) is obvious. According to eq.(1-16), $p_c \cdot MRT_c - p_e \cdot MRT_c$ is an accelerated function of $p_c - p_e$, because $p_c - p_e$ increase with δ. Green and Luce(1974) concluded that the timing model is generally more plausible except in situations when it is distinctly to the subject's advantage to employ the counting mechanism.

G. Preparation Model.

Falmagne(1965)(also cf.,Falmagne(1968), Theios and Smith (1972), Lupker and Theios(1977)) proposed a two-state model. According to this two-state model, the subject is either prepared or unprepared for each possible stimulus on any trial. If the subject is prepared (or unprepared) for the stimulus to be presented, his latency is shorter (or longer). The probability of the preparation for a particular stimulus depends on the events on the previous trial. From these assumptions, Falmagne(1965) derived many equations, which describe the sequential effects or the effects of the probabilities of the possible stimuli.

For example;

$$E(X_{i,n+1}) = (1 - c)\cdot E(X_{i,n}) + c\cdot E(X_k) \qquad \text{if } E_{i,n} = 1 \tag{1-17}$$

and

$$E(X_i) = \frac{\pi_i \cdot c \cdot E(X_k) + (1-\pi_i)\cdot c' \cdot E(X_{\bar{k}})}{\pi_i \cdot c + (1-\pi_i)\cdot c'} \tag{1-18}$$

Eq.(1-17) describes the relation between the mean reaction times on trials n and n+1, $E(X_{i,n})$ and $E(X_{i,n+1})$, if stimulus i is presented on trial n ($E_{i,n} = 1$). Eq.(1-18) describes the relation between the mean reaction time for stimulus i, $E(X_i)$, and the probability of presentation of stimulus i, π_i.

In some article (Falmagne and Theios(1969), Theios(1973), Falmagne, Cohen and Dwivedi(1975), Lupker and Theios(1975)), the preparedness of the subject is interpreted in terms of the process of memory scan. According to these interpretations, the preparedness for a particular stimulus means that the prototype of this stimulus is in short term memory, so is easily processed. Since the capacity of this short term memory is limited, prototypes of some stimuli cannot be in this short term memory and the processing of these stimuli needs more time.

* * * * * * *

Many models have been proposed, each of which emphasizes a different aspect of choice reaction time. To the author, Falmagne(1965)'s two-state model is most interesting because of the following two reasons;

1). It has very simple structure, i.e., it assumes only two states. Comparing two-state, three-state and four-state models, Lupker and Theios(1975) concluded that the two-state model could be accepted, but the three-state and four-state models could be rejected. That is, the model with the smallest number of states was the best.

2). The two-state model is a discrete one. The question whether psychological states are discrete or continuous is one of fundamental problems. But, to determine experimentally whether the state is discrete or not is difficult, because the prediction made by a particular model is also dependent on the assumptions other than the one to test. The author is interested in the question how well models with discrete states can do.

Now, let us review literatures on models for simple reaction times.

MODELS FOR SIMPLE REACTION TIMES

A. Time Uncertainty and Simple Reaction Times.

Klemmer(1957) obtained the following equation for the pooled data;

$$RT \doteq .018 \cdot \log_{10} \sigma_T + .235 \qquad (1\text{-}19)$$

where RT is the mean simple reaction time and σ_T is the measure of total time uncertainty, i.e., the standard deviation derived from adding variances from foreperiod and time-prediction distributions. According to Klemmer(1957), eq.(1-19) means that the averaged speed of information processing in simple reaction task is 18 msec per bit.

B. Thomas(1967)'s Anticipation Model.

Thomas(1967) proposed the model in which the state of readiness plays a central role. He assumed that, if T is the subject's estimate of t at which the signal will be presented, the subject's state of readiness, SR, would rise to a local maximum proportional to p_t (the conditional probability that the signal would arrive at t given that it has not arrived before t) at T, and then decline. The following equation was proposed as an approximation,

$$SR(z) = \ell \cdot p_t - m \cdot |z - T| \tag{1-20}$$

where ℓ and m are positive constants.

The reaction time, RT_t, was assumed to obey the following equation,

$$RT_t = \begin{cases} f(SR(t)) & (0 < p_t \leqslant p_x) \\ RT_m & (p_t \geqslant p_x) \end{cases} \tag{1-21}$$

where

$$f(x) = a + \frac{b}{x}$$

and p_x is a some constant.

If the foreperiod distribution was uniform on the integers 1 to n, then,

$$\begin{aligned} p_t &= \frac{\frac{1}{n}}{1-(t-1)\cdot\frac{1}{n}} \\ &= (n-t+1)^{-1}, \quad t = 1, 2, \cdots, n \end{aligned} \tag{1-22}$$

Suppose that the signal arrives at time $i \cdot d$; then the subject has to predict each of the time-point $t \cdot d$, $t = 1, 2, \ldots, i$. It is assumed that the subject predicts one-point starting from the previous one, so that for each prediction the subject predicts an interval of length d and does so with an error ε. It is also assumed that ε is $N(0, \sigma^2)$. Then the error, ε_i, in predicting the interval of length $i \cdot d$ is $N(0, i\sigma^2)$. Then, from eqs.(1-20),(1-21) and (1-22),

$$RT_i = a + b \cdot E\left(\frac{1}{p_i - m \cdot |\varepsilon_i|}\right)$$

$$\fallingdotseq a + b \cdot (n - i + 1) + b \cdot g \cdot (n - i + 1)^2 \cdot \sqrt{i}$$

where $g = m \cdot \sigma \cdot \sqrt{\frac{2}{\pi}}$, and RT_i is the mean reaction time for foreperiod $= i \cdot d$.

C. Deadline Model.

A deadline model(Ollman and Billington(1972), Kornblum(1973)) assumes that in a simple reaction task the two processes, the signal detection and time estimation processes, race and a faster one determines a reaction time. Let T_c and T_d be the random variables which represent the time of the deadline and the time at which the signal detection may occur. Then, the measured overt response time, T, is given by

$$T = \min(T_c, T_d)$$

Hence,

$$(1 - F(t)) = (1 - F_c(t)) \cdot (1 - F_d(t))$$

where $F(t) = P(T \leq t)$ and so on.

From the above equation,

$$F_d(t) = \frac{F(t) - F_c(t)}{1 - F_c(t)} \qquad (1\text{-}23)$$

$F(t)$ is the cumulative distribution of the observed response times, and $F_c(t)$ is given by the response times on the trials where no signal occurred. By eq.(1-23), we can estimate the true reaction time distribution, $F_d(t)$, using $F(t)$ and $F_c(t)$.

D. Recruitment Model.

Recruitment model(LaBerge(1962)) assumes that there are two types of elements, C_1 and C_0. The elements of type C_1 are connected to the response, but the elements of type C_0 are connected to no responses. The evocation of the response involves the sampling of r elements of type C_1 plus w neutral elements. That is, r is the decision boundary for the response. If m elements must be drawn to obtain the rth conditional element, then the latency is given as,

$$\text{latency} = \lambda \cdot m + t_0 \qquad (1\text{-}24)$$

where λ is the time required for sampling one element, and t_0 is the residual latency. If $m = r + w$, and the proportions of the elements of types C_0 and C_1 are p_0 and p_1, respectively, then,

$$P(r+w) = \frac{(r+w-1)!}{(r-1)!\cdot w!} \cdot p_1^r \cdot p_0^w \qquad (1\text{-}25)$$

Hence, from eqs.(1-24) and (1-25),

$$\text{the mean latency} = \lambda \cdot E(r+w) + t_0$$

$$= \lambda \cdot \left(\frac{r}{p_1}\right) + t_0 \qquad (1\text{-}26)$$

Eq.(1-26) means that, if p_1 is an increasing function of the stimulus intensity, then the mean latency is a decreasing function of the stimulus intensity.

E. Variable Criterion Model.

Variable criterion model(Grice(1968,1972), Grice,Nullmeyer and Spiker(1977)) assumes that the accumulation process is deterministic, but the criterion is randomly varying. The basic formula is given as

$$f(t) = H(t) + V(t)$$

where f(t), H(t) and V(t) are the excitatory strength, the associative strength and the sensory component at time t. The response occurs when the excitatory strength f(t) reaches the criterion T. The criterion T is assumed to be normally distributed. Grice(1977) determined the forms of the functions H(t) and V(t) from the experimental data. The H(t)s were fitted with Gompertz growth functions, $H(t) = a \cdot b^{c^t}$ and the V(t)s were fitted with exponential growth functions, $V(t) = a - b \cdot e^{-c \cdot t}$.

F. Temporal Integration Model.

Hildreth(1973) proposed a temporal integration model of simple reaction time to brief visual stimuli. This model assumes that detection time, T_d, is the time required for the time integral of a nonnegative function, $v(t;d,\ell)$, called the visual response function, to reach some fixed criterion, c. The parameters, d and ℓ, represent the duration and luminance of the presented stimulus. The form of $v(t;d,\ell)$ for a square-wave flash is assumed to be given as,

$$v(t;d,\ell) = \begin{cases} 0 & \text{for } t \leq e_\ell \\ \lambda_\ell & \text{for } e_\ell < t \leq d \\ \lambda_\ell \cdot e^{-\gamma_\ell \cdot (t-d)} & \text{for } d \leq t \end{cases} \quad (1\text{-}27)$$

That is, the visual response function $v(t;d,\ell)$ corresponding to a square-wave flash with intensity ℓ and duration d begins as a square-wave with amplitude λ_ℓ at $t = e_\ell$, is maintained until time d, and then decays exponentially following offset of the flash.

Then,

$$V(t;d,\ell) = \int_0^t v(t) \cdot dt$$

$$= \begin{cases} 0 & t \leq e_\ell \\ \lambda_\ell \cdot (t - e_\ell) & e_\ell < t \leq d \\ \lambda_\ell \cdot (d - e_\ell) + \frac{\lambda_\ell}{\gamma_\ell} \cdot (1 - e^{-\gamma_\ell \cdot (t-d)}) & d < t \end{cases} \quad (1\text{-}28)$$

and

$$V(T_d;d,\ell) = c \quad (1\text{-}29)$$

From eqs.(1-27),(1-28) and (1-29), we get the detection time, T_d, as the function of d,

$$T_d = \begin{cases} \infty \text{ (no detection)} & d \leq \delta_\ell \\ d - \frac{1}{\gamma_\ell} \cdot \log(\gamma_\ell (d - \delta_\ell)) & \delta_\ell < d < \tau_\ell = \delta_\ell + \frac{1}{\gamma_\ell} \\ \delta_\ell + \frac{1}{\gamma_\ell} = \tau_\ell & \tau_\ell \leq d \end{cases}$$

where δ_ℓ and τ_ℓ satisfy the following equations,

$$V(\infty ; \delta_\ell , \ell) = c$$

and

$$V(\tau_\ell ; \tau_\ell , \ell) = c.$$

That is, δ_ℓ is the shortest duration for which a flash with intensity ℓ is above threshold, and τ_ℓ is the shortest duration for which $V(d;d,\ell) > c$.

G. Timing and Counting Models.

According to the timing model(Luce and Green(1972), Green and Luce(1974)), inter-arrival-intervals,IAIs, of the pulses of sensory information is monitored, and the subject responds when the IAI is shorter than the criterion, β, which suggests that the reaction signal has been presented. The train of the pulses is assumed to obey a Poisson process. The following equation is one of the equations derived by Luce and Green(1972) with the assumption that the mean magnitude estimation,ME, is proportional to μ, the parameter of the Poisson process when the signal is presented, i.e., $ME = D\mu$;

$$\text{the mean RT} \doteqdot \bar{r} + \begin{cases} \frac{2D}{ME} & \text{for } \mu \text{ large} \\ \frac{D}{ME} + \frac{D^2}{ME^2 \cdot \beta} & \text{for } \mu \text{ small} \end{cases}$$

The poisson counting model proposed by Hildreth(1979) is a stochastic version of the temporal integration model proposed by Hildreth(1973). According to this counting model, the onset of the stimulus with intensity ℓ activates N_ℓ parallel Poisson processes with intensity parameter r_ℓ. After the offset of the stimulus with duration d, each of the N_ℓ Poisson processes is left with exactly one more pulse to deliver to the detection center. The subject responds when the Kth pulse arrives at the detection center. Hildreth(1979) derived the following equation;

$$\begin{aligned} &E(W_{K,\ell} \mid \text{detection}) \\ &= P(W_{K,\ell} \leqslant d) \cdot E(W_{K,\ell} \mid W_{K,\ell} \leqslant d) \\ &\quad + P(d < W_{K,\ell} < \infty) \cdot E(W_{K,\ell} \mid d < W_{K,\ell} < \infty) \end{aligned} \qquad (1\text{-}30)$$

where $W_{K,\ell}$ is the random variable for the waiting time required for the Kth pulse to arrive at the detection center, i.e., the detection time.

Hildreth(1979) did not give the explicit form of eq.(1-30), but the distribution function of $W_{K,\ell}$, $f_{K,\ell}(t)$, is given as

$$f_{K,\ell}(t) = \frac{1}{(K-1)!} \cdot N_\ell \cdot r_\ell \cdot (N_\ell \cdot r_\ell \cdot t)^{K-1} \cdot e^{-N_\ell \cdot r_\ell \cdot t} \qquad (t > 0)$$

H. Spark Discharge Model.

Ida(1980) proposed a spark discharge model, which is modeled after the phenomena of the occurrence of spark discharge when voltage is applied between electrodes. This model assumes that the decay of neural information from the onset of a stimulus obeys the exponential distribution,

$$f(t) = \lambda \cdot e^{-\lambda \cdot t} \qquad (1\text{-}31)$$

where λ is a linear function of the stimulus intensity which is further assumed to be a linear function of time, i.e., $\lambda = c \cdot t$.

Hence, eq.(1-31) can be rewritten as follows;

$$f(t) = c \cdot t \cdot e^{-c \cdot t^2}$$

Let $F(t) = \int_0^t f(t) \cdot dt$, then he derived the following equation;

$$F(t) = 1 - e^{-\frac{c}{2} \cdot t^2} \qquad (1\text{-}32)$$

That is, the distribution of the latencies obeys a Weibull distribution, eq.(1-32).

* * * * * * *

There are many models for the simple reaction time, too.

The role of expectancy in the simple reaction time has been emphasized by Näätänen and his collaborators(Näätänen(1970,1971), Näätänen and Merisalo(1977), Niemi and Näätänen(1981)). Only one of the models reviewed here gives a central role to the expectancy processes, the anticipation model(Thomas(1967)). But, this model ignores the sequential effects. The reaction time is affected by the foreperiod in the preceding trial(cf., the results of experiment III in this article, or the review by Niemi and Näätänen(1981)). In this dissertation, the author will propose a new model with the following characteristics;

1). The role of anticipation is emphasized.

2). The sequential effects are incorporated.

3). The model is described in terms of discrete states, i.e., the prepared and not-prepared states.

As to the third point, the author was encouraged by the following conclusion by Lupker and Theios(1977);

" The two-state model should serve as a useful tool in answering some of the basic questions regarding the temporal properties of human choice behavior."

Although their conclusion was concerned with choice reaction times, the author is interested in the question whether a two-state model is useful in the domain of simple reaction time, or not.

CHAPTER II

EXPERIMENTS

In the previous chapter, we saw that we need a new model, which incorporates the process of expectation (or preparedness) and predicts sequential effects. In order to construct a model, we must collect the data relevant to the model. For our purpose, at least two types of data are necessary. One type of data is concerned to the existancy of the process of expectation and the other to the sequential effects. Inspecting available evidences reported in published papers, we find some difficulties.

1) Näätänen(1970,1971) made the experiments, where the probability of the presentation of the stimulus at each moment was constant. He expected that under these conditions, the expectancy by the subject would disappear and the FP-RT relation could not be observed. However, we should not confuse objective probabilities with subjective ones, that is, under the conditions where the mathematical probability of the presentation of the stimulus is constant, the subject may expect the stimulus in some moment.

Another approach to effects of the expectancy by the subject on RT is the attempt by Baumeister and Joubert(1969). They varied the relative frequency of the various FPs to manipulate the expectancy. But, the FPs used by them were 2,4,8,16 sec. These FPs are highly discriminable so that we suspect that the subject might be unduly forced to develop the expectancy during the experiment.

2) In some experiments reviewed by Niemi and Näätänen(1981), FPs were very short, i.e., shorter than 1 sec, and in others, they were very long, i.e., longer than 10 sec. For too short FPs, the subject may not be able to prepare his motor system before the presentation of the stimulus when no warning signal is used. When too long FPs are used, we suspect that multiple preparation may be invoked, i.e., the process of simple reaction for longer FPs may not be the same as that for other FPs.

3) Analyzing the data from trained and unexperienced subjects separately, Näätänen and Merisalo(1977) found differences between the two kinds of subjects in the sensitivity of the RT to manipulations of experimental conditions. In general, as to the kind of the subjects, experimenters used trained subjects or

untrained ones, or did not specify the kind of the subjects.

Considering the three difficulties above, the author felt the need to carry out the series of experiments, which satisfy the following conditions;

1) Discriminability between the FPs is not so high.

2) Lengths of the FPs are not too long and not too short.

3) Kind of the subjects is controlled. In the experiemnts which will be reported here, all subjects are untrained at least with respect to reaction time experiments.

4) Ranges of the FPs used in the experiments are as equal to each other as possible.

In this dissertation, four of the experiments which were made will be reported. Experiments I and II are concerned to the phenomena which can be interpreted as effects of change in expectation. Experiments III and IV are concerned to the sequential effects.

EXPERIMENT I

Two ranges of FPs were used. If expectancy plays a role in a simple reaction task, we can observe shift of the optimum FP, for which the RT is the shortest, when the range of FPs is shifted. Very short FPs entails the problem of refractoriness of responses. Very long FPs entails the problem of boredom. The following two ranges were used, from 1.00 to 3.69 sec, and from 2.84 to 7.01 sec.

Apparatus

The subject was seated in front of a desk, on which a box, 6cm x 20cm x 30cm, was laid. On the upper surface, 20cm x 30cm, of the box, nine microswitches and one red 7-segment LED(Light-Emitting Diode) were laid(Figure 1). One microswitch was at the center of the box and the other eight microswitches were arranged horizontally to fit the arrangement of the eight fingers and they were about 3cm above the switch in the center. The LED was about 5cm above the microswitch in the center. This 7-segment LED displayed the number 0 as the imperative stimulus

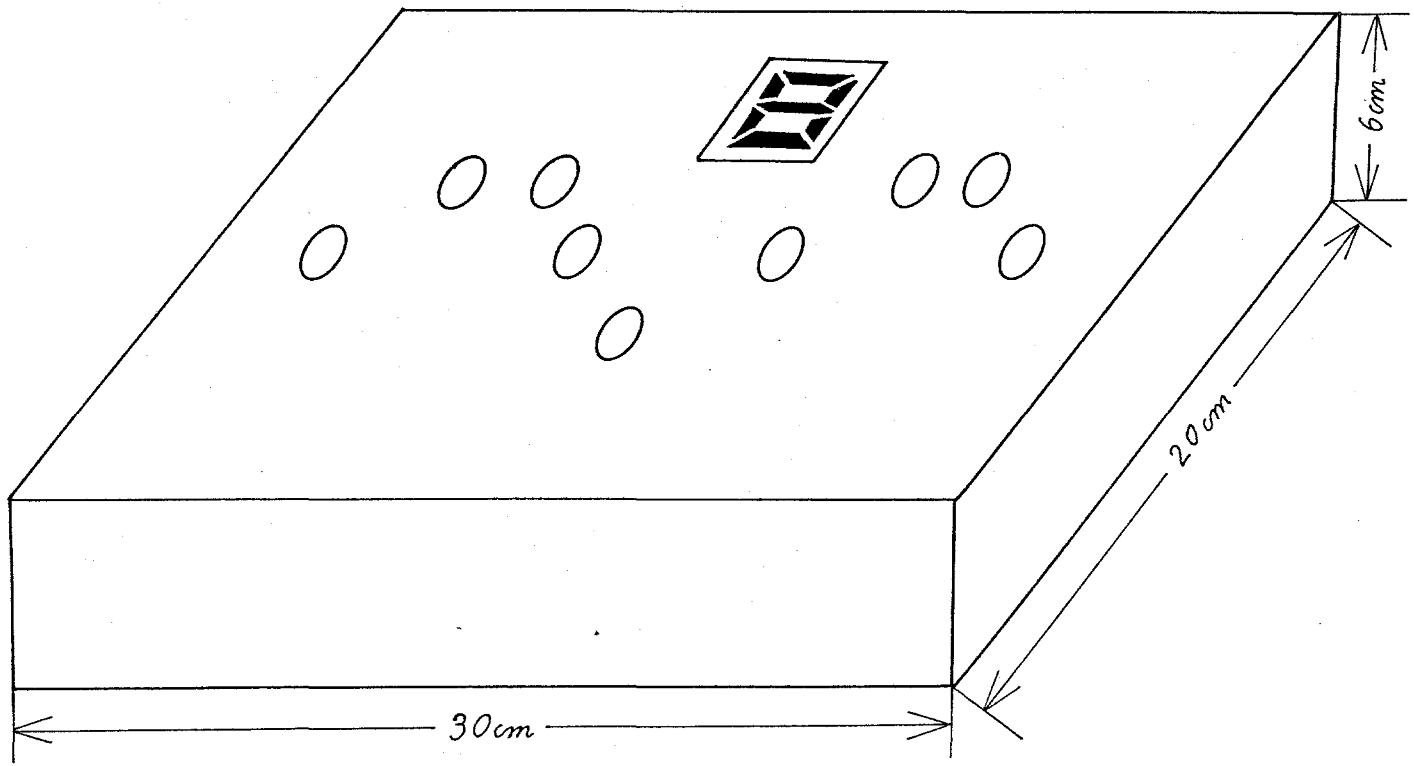

Figure 1. Arrangement of the microswitches and the LED on the box used in experiments I and II.

and only the microswitch at the center was used as the response switch. AIDACS-3000 microcomputer system(Ai Electronics Corp.) controlled presentation of the stimulus and recorded RTs.

Subjects

Six male students participated in experiment I. They were all untrained with respect to this type of experiment and unpaid.

Procedure

The experiment consisted of 16 blocks, each of which had 51 trials. Each block started by experimenter's key pressing of a CRT display. A trial started with an imperative stimulus which went out when the subject pushed down the microswitch. He was instructed to press the microswitch as fast as possible after the LED lit up. The next trial began after a prescribed time(foreperiod(FP)) elapsed from the subject's response. If the subject responded before the LED lit up, that trial was discarded and the next FP was timed from the preceding false-alarm response. After one block of 51 trials finished, the subject was given as much rest time as he desired to refresh himself. Total times of experiment I were between 40 and 80 minutes.

Two sets of FPs, set S and set L, were prepared. Each set was used in one of two experimental conditions, namely, Short FPs and Long FPs conditions. In the Short FPs condition, the FPs were 1.00, 1.30, 1.69, 2.19, 2.84 and 3.69 sec (set S). In the Long FPs condition, the FPs were 2.84, 3.40, 4.07, 4.88, 5.85 and 7.01 sec (set L). Three subjects (subjects 1,2 and 3) were tested under the Short FPs condition, and the other three (subjects 4,5 and 6) in the Long FPs condition. In a block, 50 FPs were used. The first two FPs were 2.00 sec in the Short FPs condition, and 5.00 sec in the Long FPs condition. The other 48 FPs were randomized sequence of eight set Ss in the Short FPs condition and of eight set Ls in the Long FPs condition.

The programs which were used in experiment I are given in appendix A.

RESULTS

The data from blocks 2 to 16 were used. Trials in which the subject responded before the LED lit up were discarded. Too slow

RTs were also discarded, because these were produced by the subject's distraction and so on. Proportions of these discarded trials were between 0 and 1 % when calculated individually.

Figures 2a and 2b depicts the mean RTs graphically for separate subjects. ANOVA(Analysis of Variance) shows that differences in RTs between FPs are significant at 5 % level, except for subject 6. The differences for subject 6 can be observed at 10 % level.

In summary, we can conclude that optimum FP in the Short FPs condition is between 2.19 and 2.84 sec, and, in the Long FPs condition, between 4.88 and 5.85 sec. That is, optimum FP depends on the range from which the FPs are sampled.

EXPERIMENT II

In experiment II, the range of FPs is fixed, but the relative frequencies of FPs are varied. If the subject anticipates the time point at which the stimulus appears, he may be induced to expect the FP which is subjectively most often used. Two sets

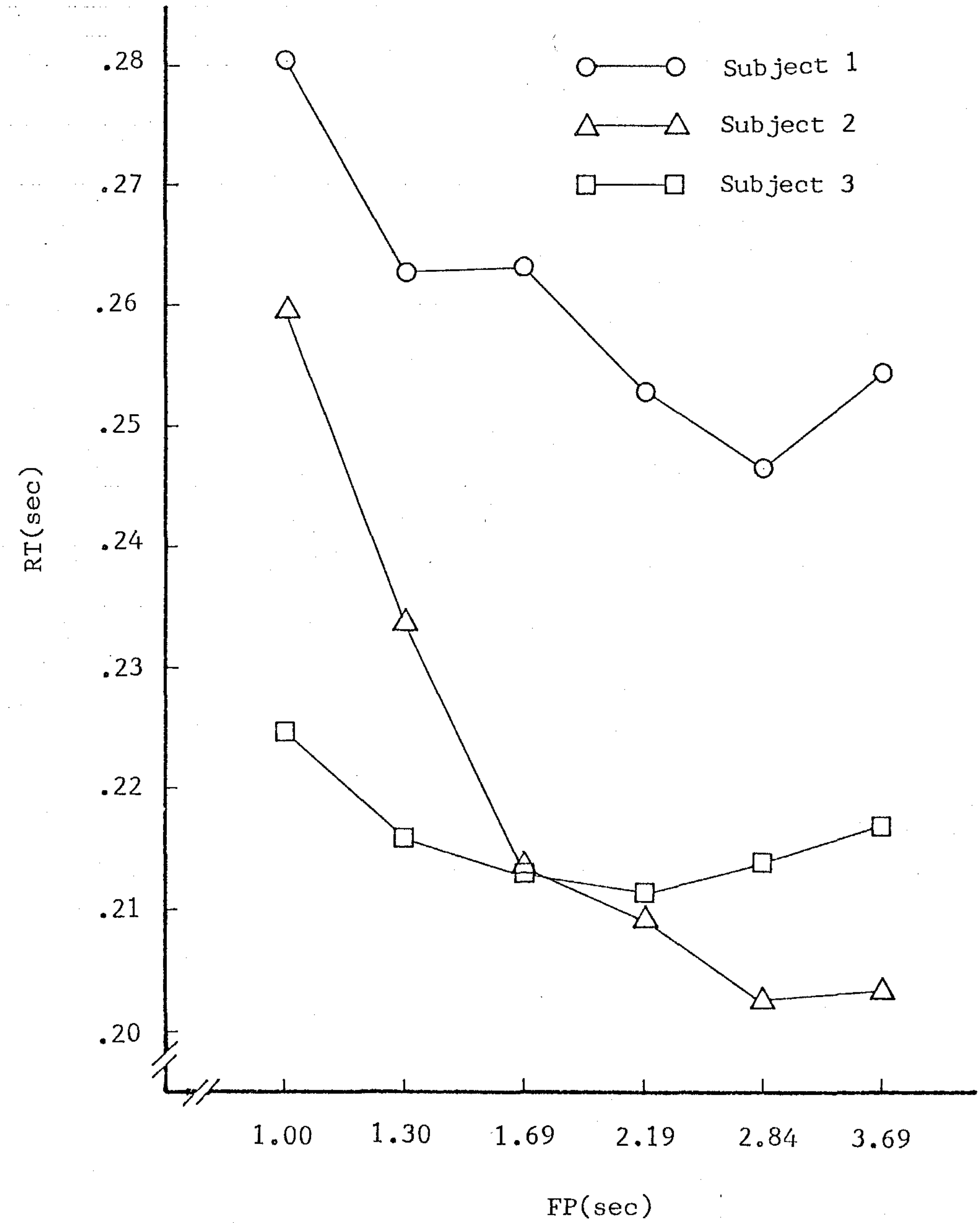

Figure 2a. Mean RTs as a function of FP for separate subjects.

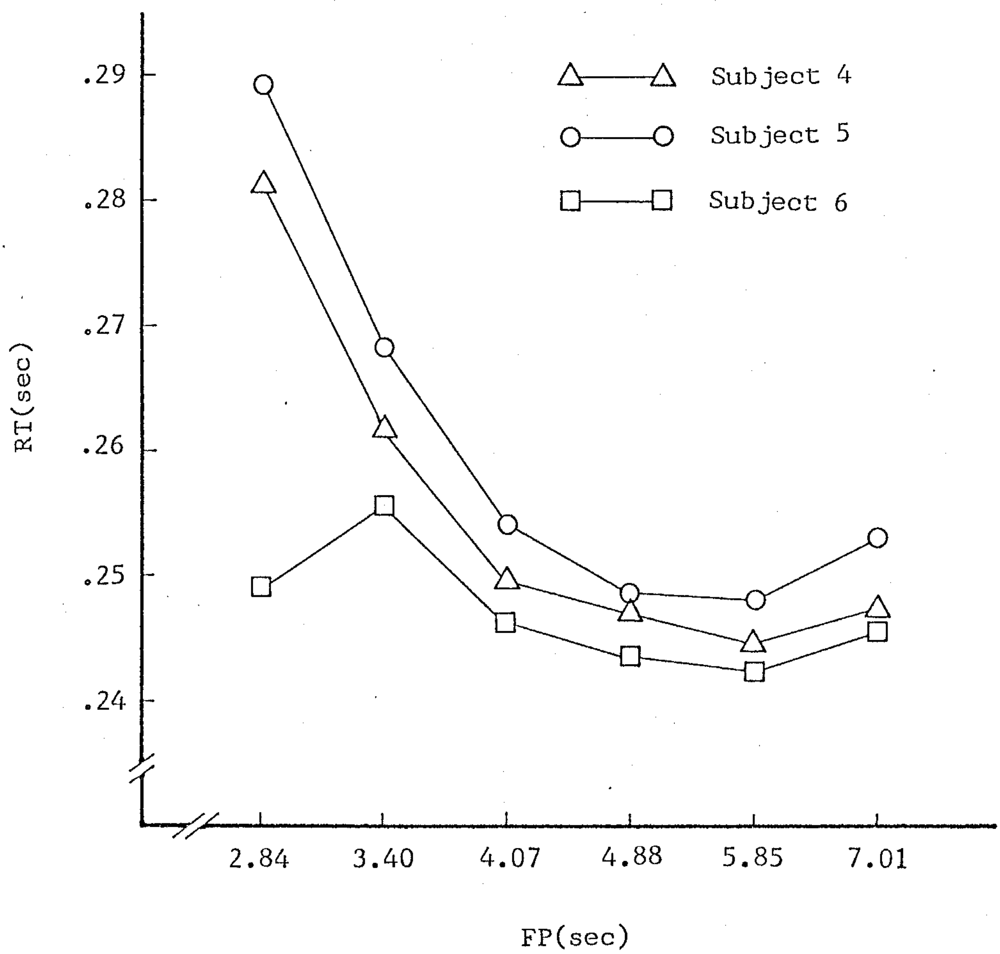

Figure 2b. Mean RTs as a function of FP for separate subjects.

of frequencies are used. In set Sw of FPs, shorter FPs are more often used than longer ones. In set Lw, longer FPs are more often used than shorter ones. It is predicted that the optimum FP is shorter for set Sw than for set Lw.

Apparatus

The apparatus used in experiment II was the same as in experiment I.

Subjects

Six male subjects participated in experiment II. They were all untrained with respect to this type of experiment and unpaid. No one subject participated in both experiment I and II.

Procedure

The procedure was the same as in experiment I except for the following points;

Experiment II consisted of 24 blocks, each block with 103 trials. Twenty-four blocks were divided into two sessions of 12 blocks each. Two sets of FPs were prepared, set Sw and set Lw. In group Sw, there were three 1.00, one 1.30, three 1.69, one 2.19, one 2.84 and one 3.69 sec FPs. In set Lw, one 1.00, one 1.30, one 1.69, three 2.19, one 2.84 and three 3.69 sec FPs. That is, in set Sw, shorter FPs were weighted and, in set Lw, longer FPs weighted. In a block, 102 FPs were used. The first two FPs were 2.00 sec. The other 100 FPs were consisted of a randomized sequence of ten set Sw's or ten set Lw's. In order to investigate contextual effects on RT under a within-subject design, the following two conditions were prepared. In the S-L condition, FPs used in the first session belonged to set Sw, and FPs in the second session to set Lw. In the L-S condition, FPs used in session 1 belonged to set Lw and FPs in session 2 to set Sw. Three subjects (subject 7,8 and 9) were tested under the S-L condition, and the other three (subjects 10,11 and 12) under the L-S condition. Total times of experiment II were between 120 and 140 minutes.

The programs which were used in experiment II are given in appendix B.

RESULTS

The data from blocks 2 to 12 of sessions 1 and 2 were used. Trials in which the subject responded before the LED lit up were discarded. Too slow RTs were also discarded because these RTs were caused by the subject's distraction and so on. Proportions of these discarded trials from blocks 2 to 12 of sessions 1 or 2 were below 2 % when calculated individually.

For each subject, ANOVA was applied to FP(1.30 vs. 2.84 sec) x context from which the FPs were picked out(shorter vs. longer FPs weighted, i.e.,session 1 vs. 2). Table I summarizes the results. The interaction effect was significant at 5 % level for subjects 7,8 and 10. Figures 3a,3b and 3d show mean RTs of subjects 7,8 and 10 for various FPs. As to subject 11, the median test showed that medians of RTs for 1.00, 1.30 and 1.69 sec FPs were significantly different at 5 % level when longer FPs were weighted, and not significantly different when shorter ones were weighted. From this difference we can conclude that, for subject 11, the optimum FP, when longer FPs were being weighted, was shifted toward a longer FP than when shorter ones were weighted. As to subjects 9 and 12, no statistically

Table I

Significant effects in ANOVA of experiment II

	Subject 7	subject8	subject 9	subject 10	subject 11	subject 12
main effect of context	non.	sig.	sig.	sig.	sig.	sig.
main effect of FP	non.	non.	non.	non.	non.	sig.
Interaction effect	sig.	sig.	non.	sig.	non.	non.

Note: sig.: significant at 5% level; non.: nonsignificant at 5% level.

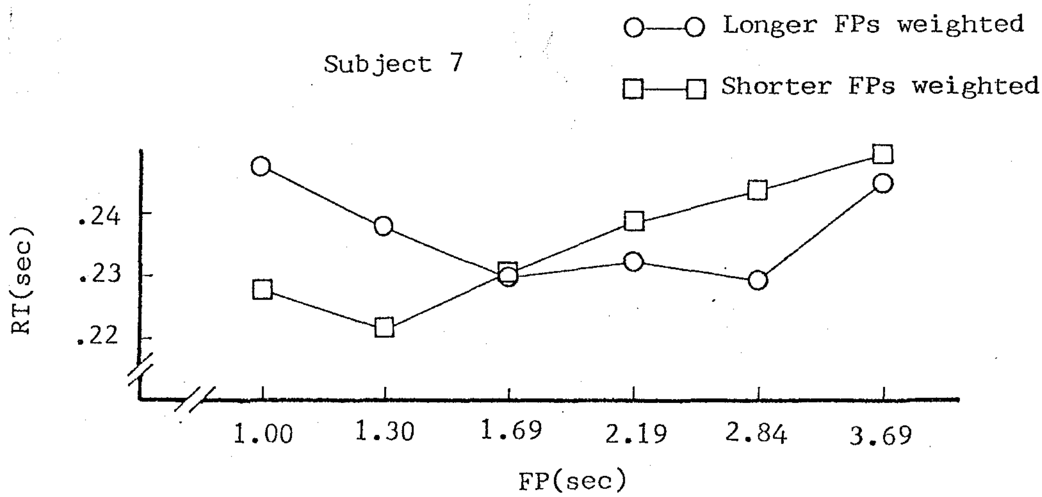

Figure 3a. Mean RTs as a function of FP for subject 7.

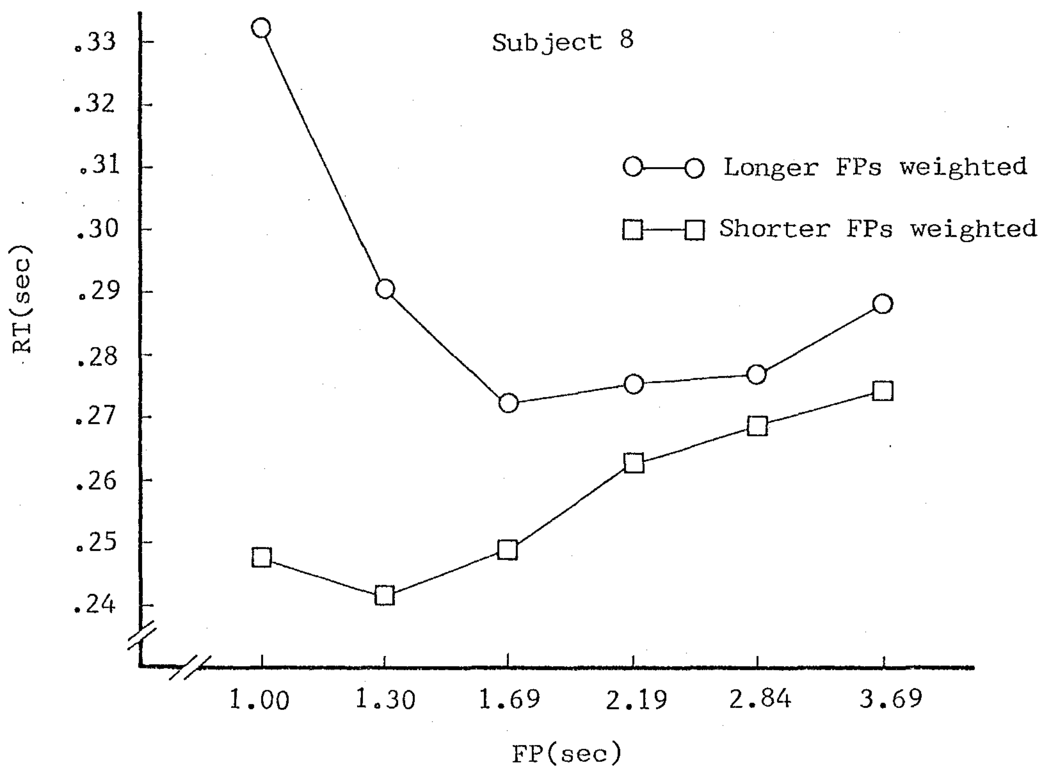

Figure 3b. Mean RTs as a function of FP for subject 8.

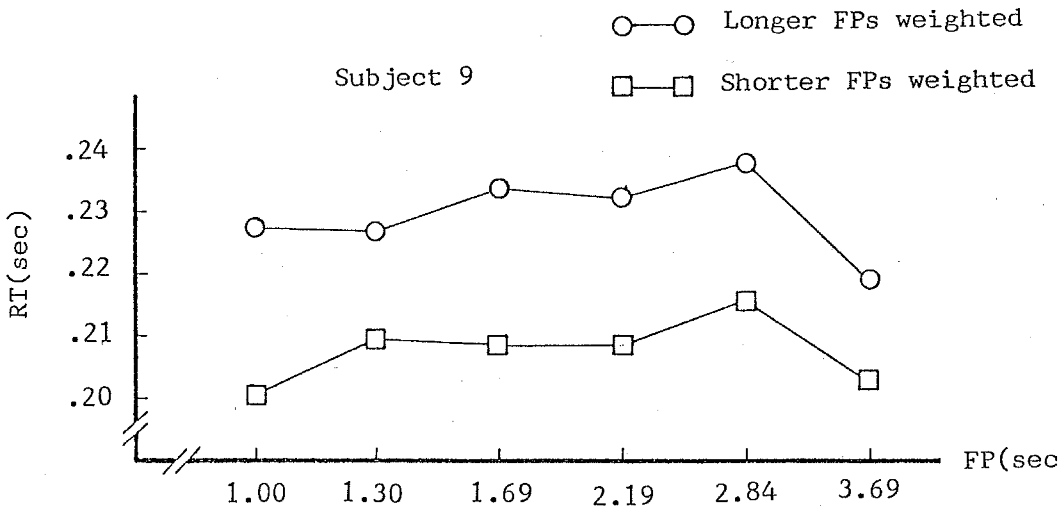

Figure 3c. Mean RTs as a function of FP for subject 9.

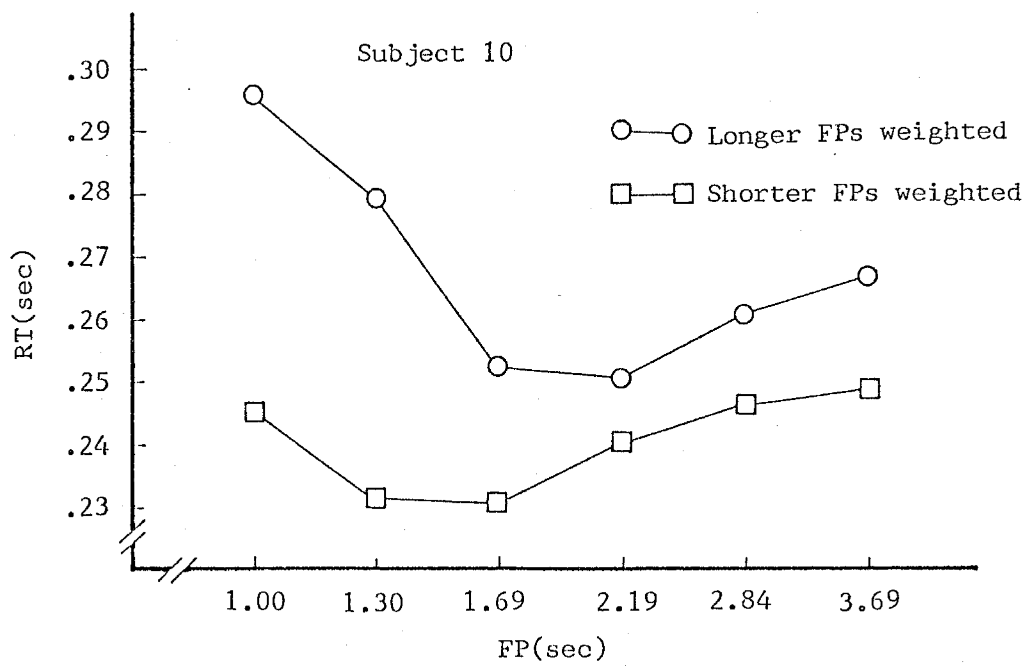

Figure 3d. Mean RTs as a function of FP for subject 10.

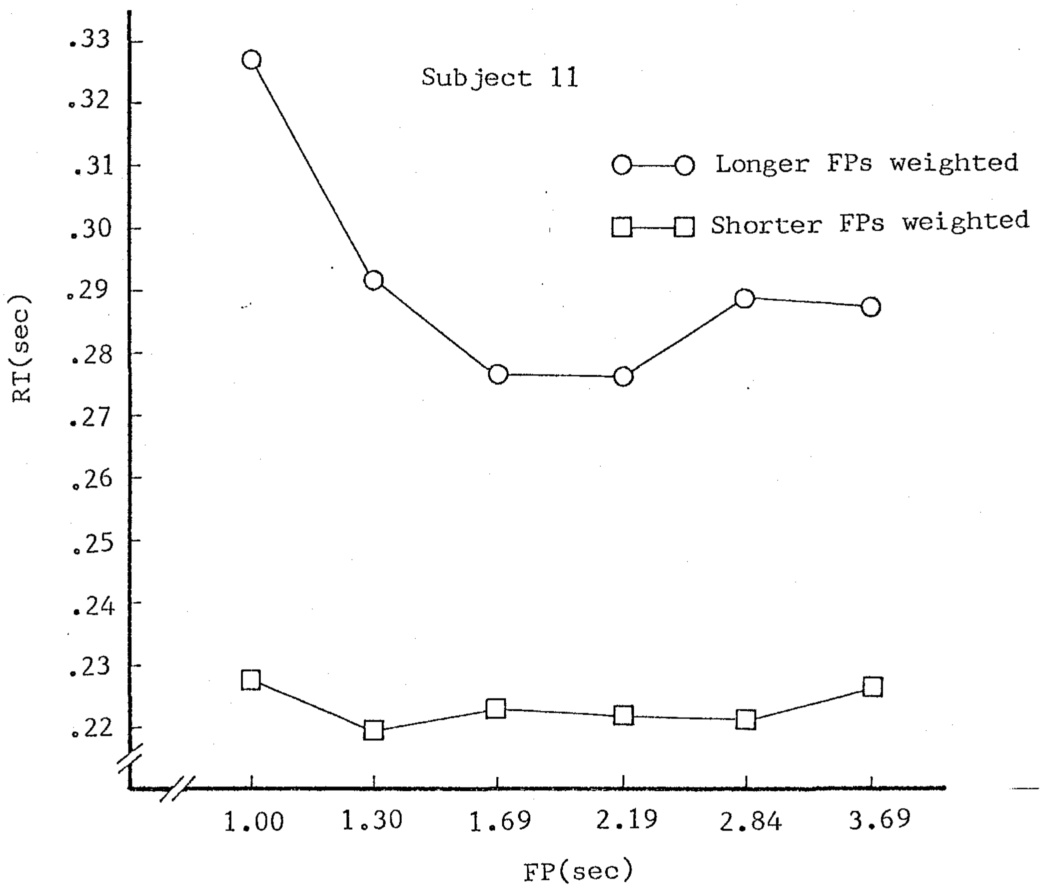

Figure 3e. Mean RTs as a function of FP for subject 11.

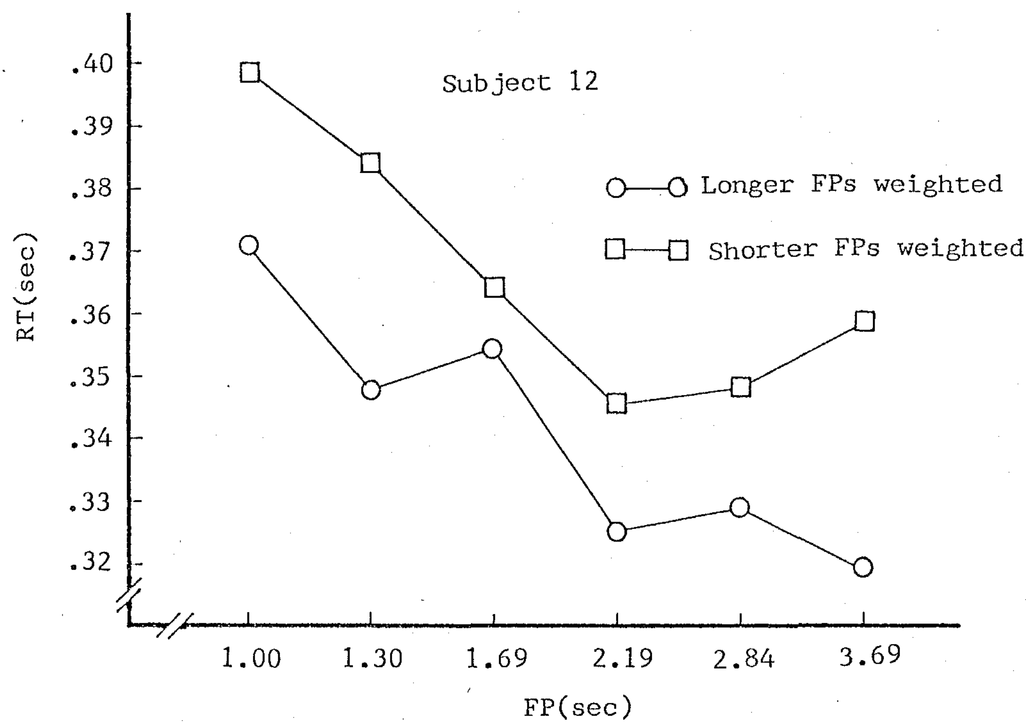

Figure 3f. Mean RTs as a function of FP for subject 12.

significant results which might show an effect of change in weight on optimum FP could be found. But as to subject 12, the pattern of the graph shows the optimum FP is shorter for the shorter FPs weighted condition than for the longer FPs weighted condition, although no significant statistical evidence could be found.

Considering the general pattern of the results obtained from experiment II, we can conclude that change in weight on FPs can bring about shift of optimum FP.

EXPERIMENT III

When the subject anticipates the time point at which the next stimulus will be presented, his anticipation may be affected by the preceding context of the experimental situation. Reaction times for a particular FP may depend on the FP at the preceding trial.

In experiment III, this dependency of RT on the FP at the preceding trial were investigated.

Apparatus

The subject was seated in front of a desk, on which a box, 5cm x 14cm x 24cm, was laid. On the upper surface, 14cm x 24cm, of the box, two microswitches and one 7-segment LED(green) were laid(Figure 4). These microswitches were arranged horizontally, separated 12cm apart, 4cm above the nearest edge of the box to the subject. The LED was mounted between and 6cm above the microswitches. When the LED, which was the imperative stimulus to respond to, lit up, it always displayed number 0. An AIDACS-3000 microcomputer system(Ai Electrics Corp.) controlled these apparatus and recorded responses of the subject.

Subjects

Three students from the undergraduate course of the faculty of letters of Kyoto University participated. They were all untrained with respect to this type of experiment.

Procedure

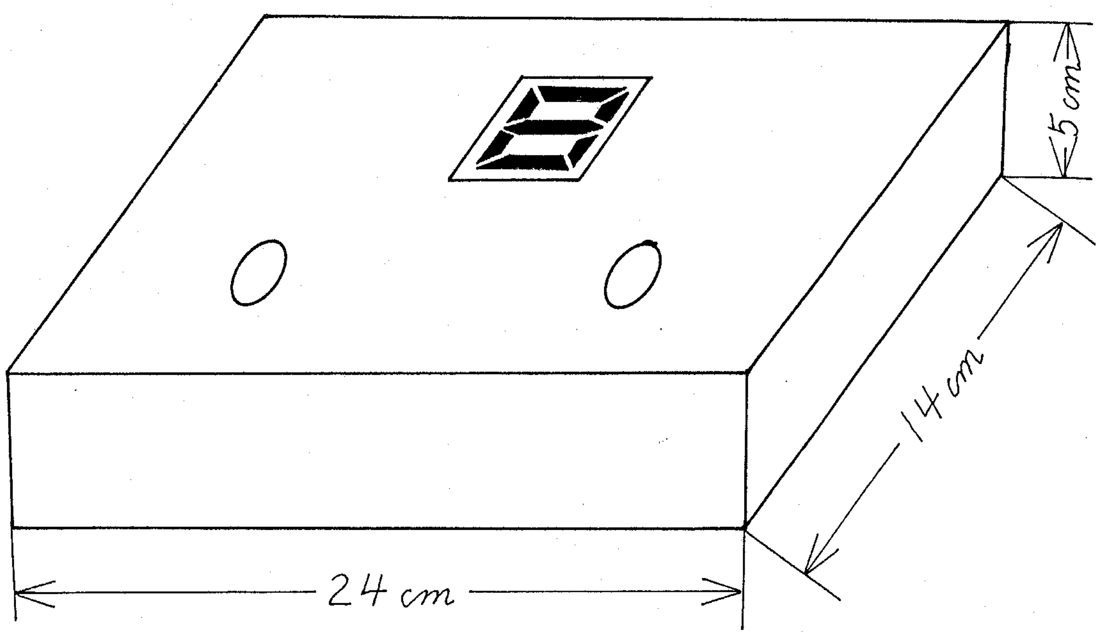

Figure 4. Arrangement of the microswitches and the LED on the box used in experiments III and IV.

The experiment consisted of 7 blocks, each of which had 103 trials. Each block started when the subject pressed down the left microswitch. When 0.5 sec had passed after this response, the LED lit up. The subject was instructed to press down the right microswitch as fast as possible when the LED lit up. The LED went out immediately when the subject responded. After some time (FP) had passed, the next trial began, that is, the LED lit up and the subject responded. An FP-LED-response cycle was repeated until the end of the block.

In a block, 102 FPs were used. The first two FPs were 2 sec. The other 100 FPs were in a randomized sequence of 20 sets of FPs. Each set consisted of 1.00, 1.30, 1.69, 2.19 and 2.84 sec FPs. It was randomized with the following restriction; 1.00, 1.69 and 2.84 sec FPs were preceded by each of the members of the set, which included itself, at least two times, respectively.

The subject was allowed to rest between blocks as long as he would like to.

The program for experiment III is given in appendix C.

RESULTS

Total times of experiment III were between 27 and 54 minutes. The data from blocks 2 through 7 were used, although the first 3 RTs and RTs for immediate FPs of 1.30 and 2.19 sec were discarded. Blocks 2 and 3 (blocks 4 and 5, blocks 6 and 7, respectively) were pooled as session 1 (session 2, session 3, respectively). The medians of RTs to 1.00, 1.69 and 2.84 sec FPs, which were classified according to the FPs in the preceding trials, were calculated. To calculate mean RTs for each combination of the immediate FPs and the preceding FPs of individual subjects, these medians were averaged over the three sessions. These mean RTs were analyzed by ANOVA with the design, immediate FP(1.00, 1.69 and 2.84 sec) x preceding FP(1.00, 1.30, 1.69, 2.19 and 2.84 sec). Main effect of immediate FP and the interaction effect of immediate FP x preceding FP were significant at 5 % level. This results indicates that mean RT is dependent on immediate FP and the preceding FP (Figure 5).

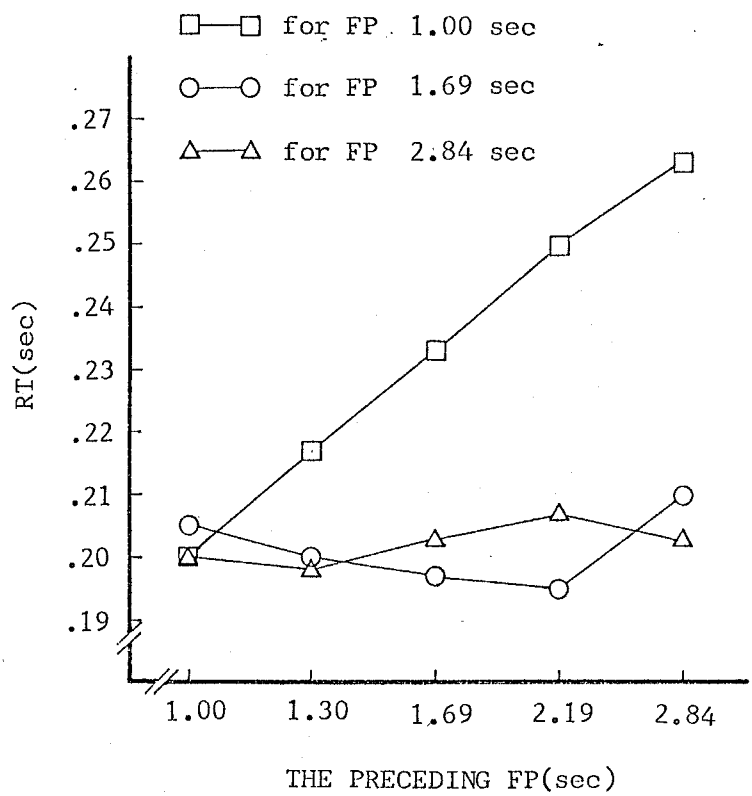

Figure 5. The mean RTs for immediate FP 1.00, 1.69 and 2.84 sec as a function of the FP in the preceding trial.

EXPERIMENT IV

In experiment I, II and III, the subject's response terminated the trial and started the next trial. That is, foreperiod(FP) was timed from the subject's response to the stimulus.

But, FP can be timed from another event, e.g., a warning signal. In this case, the sequence of the events in a trial is as follows; the warning signal - FP - the stimulus - the response. That is, there is a time lag between the response and the start of the next FP. This time lag may have some effect on the sequential effects found in experiment III.

In experiment IV, to investigate this possibility, an interval was inserted between the response and the start of the next FP.

Apparatus

The apparatus used in experiment IV was the same as in experiment III, except that, in experiment IV, an electric buzzer was used as a feedback signal.

Subjects

Eight subjects from the undergraduate course of the faculty of letters of Kyoto University participated in experiment IV. They were all untrained with respect to this type of experiment.

Procedure

The procedure was the same as in experiment III, except for the following points;

Experiment IV consisted of 10 blocks, which were divided into 2 groups, sessions 1 and 2. In one of the two sessions, the experimental condition was the same as in experiment III (the continuous condition). In the other session (the discrete condition), each trial began after the buzzer sounded for 0.2 sec. In the first trial, the buzzer sounded when the experimenter pushed down the start key on the CRT display. After trial 2, the buzzer sounded after 0.5 sec had passed on from the subject's response, pressing down the right switch, to the LED in the preceding trial. After the buzzer sounded, the subject was allowed to press the left switch. FPs were timed after this left switch pressing. If he pressed down the left switch before 0.5 sec had passed after the preceding response or during the sounding of the buzzer, the buzzer continued to sound for 5 sec after the release of the left switch. By this prolonged sounding, the subject was informed that he pressed down the left switch too early.

Four subjects served in the continuous (or discrete) condition in session 1 (or 2, respectively), and the other four the discrete (or continuous) condition in session 1 (or 2, respectively).

The programs which were used in experiment IV are given in appendix D.

RESULTS

Total times of experiment IV were between 48 and 71 minutes. The data from blocks 2 to 5 and from blocks 7 to 10 were used, although the first 3 (or 2) RTs of each block in the continuous (or discrete, respectively) condition and RTs for the immediate FPs of 1.30 and 2.19 sec were discarded.

Table II. The mean RT(sec) for immediate FPs of 1.00, 1.69 and 2.84sec as a function of the FP in the preceding trial.

		FP in the preceding trial(sec)				
		1.00	1.30	1.69	2.19	2.84
FP in the immediate trial(sec)	1.00	.205	.217	.221	.232	.243
	1.69	.198	.199	.205	.207	.216
	2.84	.201	.199	.201	.202	.203

Medians of RTs for each combination of 3 immediate FPs, 1.00, 1.69 and 2.84 sec, and the preceding FPs, 1.00, 1.30, 1.69, 2.19 and 2.84 sec, were calculated for sessions 1 and 2. These medians were analyzed by ANOVA with the design, FP (1.00, 1.69 and 2.84 sec) x the preceding FP (1.00, 1.30, 1.69, 2.19 and 2.84 sec) x conditions of sessions (continuous vs. discrete) x order of conditions (from the continuous(in session 1) to the discrete condition(in session 2) vs. from the discrete(in session 1) to the continuous condition(in session 2)).

Main effects of immediate FPs and of the preceding FPs, and interaction effect of immediate FP x the preceding FP were significant at 5 % level. The use of the warning signal had no statistically significant effects. Medians of RTs, which were averaged over non significant factors, were summarized in Table II.

DISCUSSION

The results of experiments I and II suggest that expectation plays some role in simple reaction task and the results of experiments III and IV indicate that this expectation in part depends on the FP in the preceding trial. These conclusions are compatible with the review by Niemi and Näätänen(1981).

Of course, expectation or anticipation of the occurrence of the stimulus in simple reaction task depends on the perception of time. Hence, we must review studies on the time perception, before we construct a new model, which is based on the process of anticipation.

CHAPTER III

TIME PERCEPTION

A. The Power Law.

Many authors adopted power functions as psychophysical functions, which relate subjective time to physical one. Ekman(1958) proposed the model, which determined the exponent by the method of fractionation. In the method of fractionation, the subject is instructed to adjust a variable stimulus so that it appears subjectively equal to a certain fraction of the standard, usually half the standard. Ekman(1958) set the power function as eq.(3-1),

$$R = C(S-S_0)^n \qquad (3\text{-}1)$$

where R (or S) is a subjective (or physical) scale of time, C is a constant related to the unit of measurement of R, S_0 is a kind of absolute threshold, and n is the exponent determining the curvature of the function.

When the subject adjusts the variable stimulus to a value, S_p, which, subjectively, is p times that of the subjective value of the standard, S,

$$pR = C(S_p-S_0)^n \qquad (3\text{-}2)$$

Combining eqs.(3-1) and (3-2) and solving for S_p,

$$S_p = S_0(1-k) + kS \tag{3-3}$$

where $k = p^{1/n}$.

Eq.(3-3) describes a relation between S, a standard stimulus, and S_p, a variable stimulus. Applying eq.(3-3) to the data, we can get the value of k, the slope of eq.(3-3), and $S_0(1-k)$, the intercept when $S=0$.

From the values of k and $S_0(1-k)$, we can get

$$n = \frac{\log p}{\log k}$$

and

$$S_0 = \frac{S_0(1-k)}{1-k}$$

With these values of n and S_0, we can specify eq.(3-1) except the unit parameter, C.

The model proposed by Björkman and Holmkvist(1960) incorporated the effect of time-order. Their model is based on the power law, $R = C(S-S_0)^n$, and the empirical relation (eqs.(3-4) and (3-5)) between the standard stimulus, S, and the variable stimulus, S_L and $S_{1/2}$, where S_L and $S_{1/2}$ are the adjusted stimulus as equal to or as half of the standard stimulus S.

$$S_L = bS + a \tag{3-4}$$

$$S_{1/2} = b_1 S + a_1 \tag{3-5}$$

Let $P_r(t)$ be the proportion retained after t time passed from the end of S. For a suitable pair of standard stimuli, S_1 and S_2, $S_L = S_{1/2}$. For this pair of S_L and $S_{1/2}$ ($=t$),

$$\frac{(S_L - S_0')^n}{(S_1 - S_0)^n} = P_r(t) = \frac{2(S_{1/2} - S_0')^n}{(S_2 - S_0)^n}$$

where S_0 and S_0' are the absolute thresholds for the standard and variable stimuli.

Substituting for S_1 and S_2 the values obtained from eqs. (3-4) and (3-5),

$$\frac{b^n (S_L - S_0')^n}{(S_L - a - bS_0)^n} = P_r(t) = \frac{2b_1^n (S_{1/2} - S_0')^n}{(S_{1/2} - a_1 - b_1 S_0)^n}$$

Substituting t for S_L and $S_{1/2}$,

$$b^n \left[\frac{t - S_0'}{t - a - bS_0}\right]^n = 2b_1^n \left[\frac{t - S_0'}{t - a_1 - b_1 S_0}\right]^n$$

hence

$$\frac{b}{t-(a+bS_0)} = \frac{2^{\frac{1}{n}} b_1}{t-(a_1+b_1S_0)}$$

This should hold for all positive values of t.

Thus,

$$n = \frac{\log \frac{1}{2}}{\log(\frac{b_1}{b})}$$

and

$$S_0 = \frac{a_1 - a}{b - b_1}$$

Eisler(1975) derived the power law from the empirical linearity described as eqs.(3-4) or (3-5), which is formulated again as eq.(3-6),

$$\Phi_V = a\,\Phi + b \qquad (3\text{-}6)$$

where Φ denotes the physical value of the standard duration, and Φ_V the variable duration (these notational changes are in accord to Eisler's notation.).

Let f and g be the psychophysical functions which relate subjective values, ψ and ψ_V, to physical values, Φ and Φ_V, as follows,

$$\psi = f(\Phi) \qquad (3\text{-}7)$$

$$\psi_V = g(\Phi_V) \qquad (3\text{-}8)$$

If the subject carried out an r setting, we have

$$\psi_T = r\psi \tag{3-9}$$

Eqs.(3-6) to (3-9) yield

$$r f(\Phi) = g(a\Phi + b) \tag{3-10}$$

Taking the derivative of eq.(3-10) with respect to r yields

$$f(\Phi) = (a'\Phi + b')\cdot g'(a\Phi + b) \tag{3-11}$$

and with respect to Φ yields

$$r f'(\Phi) = a\, g'(a\Phi + b) \tag{3-12}$$

Dividing eq.(3-12) by eq.(3-11) yields

$$\frac{r f'(\Phi)}{f(\Phi)} = \frac{a}{a'\Phi + b'} \tag{3-13}$$

and integrating eq.(3-13) with respect to Φ yields

$$r \log f(\Phi) = \frac{a}{a'} \log|a'\Phi + b'| + C_1(r)$$

or

$$f(\Phi) = C(r)\cdot(a'\Phi + b')^{\frac{a}{a'r}}$$

Because $f(\Phi)$ is independent of r, $f(\Phi)$ is rewritten in the following way,

$$\psi = f(\Phi) = \alpha(\Phi - \Phi_0)^{\beta}, \qquad \Phi > \Phi_0$$

Eisler(1976) reviewed 111 studies from 1868 to 1975 and concluded that a value of .9 seemed to come closest to the exponent of subjective duration. From table 1 in the review by Eisler(1976), we can see the exponents ranging from .31 to 1.36.

Blankenship and Anderson(1976) tested their simple weighted sum model, eq.(3-14), for time perception.

$$R_{ij} = A(w_1 d_i + w_2 d_j) + B \tag{3-14}$$

They had the subject to rate the total duration, R_{ij}, of two time intervals, d_i and d_j, which were presented successively.

Analyzing their data by ANOVA, they concluded that eq.(3-14) was confirmed

Cuttis and Rule(1977) proposed a more general model, eq.(3-15), than eq.(3-14),

$$J_{ij} = a[w\phi_i^k + (1-w)\phi_j^k]^m + b \tag{3-15}$$

where J_{ij} denotes the judgement by the subject, ϕ_i and ϕ_j denote the two stimuli, w denotes the weight, and a and b are coefficients of the linear equation.

Curtis and Rule(1977) got the values of parameters in eq. (3-15) as follows,

$$J_{ij} = .95(.51\phi_i^{1.94} + .49\phi_j^{1.94})^{.49} + .94 \tag{3-16}$$

for judgment of total magnitude of simultaneously presented temporal intervals,

and

$$J_{ij} = .53(.46\phi_i^{1.09} + .54\phi_j^{1.09})^{1.08} + 1.25 \qquad (3\text{-}17)$$

for judgments of average duration of successively presented stimuli.

With the assumption that subjective duration is related to measured duration by a linear function, both equations can be rewritten as follows,

For eq.(3-17),

$$\psi_{ij} = \psi_i + \psi_j \qquad (3\text{-}18)$$

For eq.(3-16),

$$\psi_{ij} = (\psi_i^2 + \psi_j^2)^{\frac{1}{2}} \qquad (3\text{-}19)$$

That is, they concluded that (1) when the information to be integrated was presented sequentially, the judgment was made in the way which was consistant with a linear composition rule, eq.(3-18), and (2) when the information was presented simultaneously, judgments were based on the vector summation rule, eq.(3-19).

B. Logarithmic Psychophysical Law.

In his model of the "internal clock", Treisman(1963) adopted a logarithmic function to represent the magnitude of the time interval stored in the short term memory.

Treisman(1964) criticized the psychophysical power law. He argued; "... a model sufficient to account for the result of any direct scaling experiment can be based on either a power function or a log function law. This is true of each scaling procedure, not just of fractionation, when the model is adapted appropriately.".

For example;

Let the weight W_c was chosen as being subjectively half as great as the given weight W_s. If the power law was adopted,

$$2\, W_c^n = W_s^n$$

hence,

$$n \log W_s - n \log W_c = \log 2$$

That is, if we write,

$$S = n \log W + C$$

then

$$S_s - S_c = \log 2 \qquad (3\text{-}20)$$

Eq.(3-20) means, according to Treisman(1964), that the log function can also describe the data from the ratio (1/2) setting experiment, as well as the power function does.

C. Weber's Law Models.

Getty(1975) compared Weber's law models with counter models. He generalized Weber's law as follows,

$$\mathrm{Var}(T) = k_W^2 \cdot T^2 + V_R \qquad (3\text{-}21)$$

where Var(T) is the total variance, V_R is sum of the all magnitude-independent variances and $k_W^2 \cdot T^2$ is sum of the all magnitude-dependent variances.

Square-root of $k_W^2 \cdot T^2$ is $\sqrt{k_W^2 \cdot T^2} = k_W \cdot T$, so k_W is the Weber fraction.

According to the counter model, which was proposed by Creelman (1962), the total variance can be divided as follows,

$$\mathrm{Var}(T) = k \cdot T + V_R \qquad (3\text{-}22)$$

That is, the sum of the all magnitude-dependent variances is proportional to stimulus magnitude (time interval) T.

In general, Poisson counter models produce the variance and the mean, both of which are proportional to the time interval T, in which the counting was made.

Distribution of number of counts in an interval T approaches to normal distributions with a mean $\lambda \cdot T$ and a variance $\lambda \cdot T$, as T becomes larger. So, Kinchla(1972), in his data analysis, used a Gaussian random variables.

Getty(1975) tested eq.(3-21) and eq.(3-22) against his data from his forced-choice experiment and concluded that Weber's law model is better.

Getty(1976) also compared Weber's law models with proportional variance models, using the silent counting task, and reached to the same conclusion as in Getty(1975).

D. Constant Variance Models.

In the model proposed by Allan, Kristofferson and Wiens (1971), variances associated with time perception are constant irrespectively of length of time intervals. They conceptualized the mechanism of time perception as follows;

Suppose that at some time after the onset of a d_i-msec stimulus, an interval timing process is activated by the stimulus onset. This delay is called the psychological onset time.

Similarly, the offset of the stimulus terminates the internal timing process after a time delay called the psychological offset time. The psychological onset and offset times were assumed to have uniform distributions, $f_1(u)$ and $f_2(u)$, respectively.

$$f_1(u)= \begin{cases} 1/q & \text{if } 0<u<q \\ 0 & \text{otherwise} \end{cases}$$

and

$$f_2(u)= \begin{cases} 1/q & \text{if } d_i< u<d_i+q \\ 0 & \text{otherwise} \end{cases}$$

where q is constant irrespective of d_i.

Then, the distribution of durations of the internal timing process, denoted as $g(u')$, is

$$g(u') = \int f_2(u)\cdot f_1(u-u')\cdot du$$

$$= \begin{cases} \dfrac{q+d_i-u'}{q^2} & \text{if } d_i<u'<d_i+q \\ \dfrac{q-d_i\mp u'}{q^2} & \text{if } d_i-q<u'<d_i \\ 0 & \text{otherwise} \end{cases}$$

That is, the graph of $g(u')$ is an isosceles triangle with a base of 2q msec.

The real-time criterion model by Kristofferson(1977) also made the distribution of the time at which a criterion occurs an isosceles triangle.

E. Nontemporal Factors.

Hornstein and Rotter(1969) found effects of sex and methods on temporal perception. They employed three methods, the method of verbal estimation (MVE) in which a subject makes a verbal judgment of the length of a physical interval, the method of production (MP) in which a subject must translate a verbalized interval into a physical one, and the method of reproduction (MR) in which a subject must reproduce physically an interval of a given duration first presented physically by an experimenter. Their data showed that (1) as to male subjects, in MR, they reproduced shorter intervals than presented, but, in MVE and MP, their responses were accurate, and (2) as to female subjects, in MVE, their verbal estimations were larger than physical ones, but, in MP and MR, they produced or reproduced shorter intervals.

Cahoon and Edmonds(1980) investigated an effect of expectancy on time estimation. They instructed the experimental subjects as follows: "There will be a delay in starting the experiment.

I will return for you when we are ready. Would you mind calling me in the other room when the water starts boiling? Thanks.". In the instruction to the control subjects, reference to the water was omitted. After giving the instruction, the experimenter left the room for 240 sec. At the end of that interval, the experimenter returned and asked the subject to estimate the elapsed time. The experimental group tended to overestimate the time relative to the control group.

Thomas and Weaver(1975, also cf. Thomas and Cantor(1975)) proposed the following model:

A visual stimulus is analized by a timer called f processor and by visual information processors called g processors. The output, f(t,I), of the f processor is a temporal encoding which is directly related to t and the amount of attention allocated to the timer. The output, g(I,t), of the g processors contains encodings of the nontemporal stimulus features and an encoding, g*(I,t), of the time spent processing I. It is assumed that perceived duration, τ , is a weighted average,

$$\tau = a \cdot f(t,I) + (1 - a) \cdot g^*(I,t)$$

Massaro and Idson(1978) investigated perception of duration of the tones which were followed by masking tones. They proposed the following model,

$$JD = PD + K \cdot t_m \qquad (3\text{-}23)$$

and

$$PD = X + Y \qquad (3\text{-}24)$$

where

$$X = \alpha \cdot [1 - e^{-(\theta_D \cdot t_D)}]$$

and

$$Y = (\alpha - X) \cdot [1 - e^{-(\theta_I \cdot t_I)}]$$

PD is the perceived duration of the target tone and JD is the judged duration of the target. Eq.(3-23) means that JD is PD plus a constant proportion, K, of mask duration, t_m. Eq.(3-24) means PD consists of two components, X and Y. X is the perceived duration obtained during the actual duration of the target. The value of α is the asymptotic value of perceived duration, θ_D represents the rate of growth of PD during the time of target presentation, t_D. Y is the component which is added during the silent interval, t_I, following target offset. θ_I represents the growing rate during this silent interval.

Pöppel(1978) proposed a taxonomy of time experiences into five elementary ones (experience of duration, simultaneity/successiveness, sequence, present, and anticipation). His basic assumption is that time perception has to be related to the occurrence of events as they are perceived and actions taken by the subject. Duration estimation of longer intervals is determined by the amount of information processed (and/or stored) or by the mental content. As to experiences of simultaneity/successiveness, he pointed out two aspects of temporal resolving power, that is, fusion and order thresholds. Fusion threshold is dependent on sensory modalities, but, order threshold is independent on them. Experience of sequence is concerned to the order in which events occurred. As to the experience of present, he insisted that temporal intervals up to a few seconds are experienced in a way qualitatively different from longer temporal intervals. Time interval of approximately 2 sec is experienced as a unit, that is, as a present. Anticipation is concerned to temporal organization, that is, to the programming of future behavior sequences.

*   *   *   *   *   *   *

Most prevailing psychophysical functions are power functions. But, in Eisler(1976)'s review of 111 studies, the exponents range from .31 to 1.36. This wide range of exponents of the power functions which relate physical stimuli to psychological scales let the author doubt of the validity of power functions as psychophysical functions. Treisman(1964) criticized the power law from theoretical point of view, which was briefly reviewed in section B of this chapter.

Apart from the discussion which of the power law or the logarithmic law is proper one, Allan et. al(1971) proposed a constant variance model. According to their model, perception of time is essentially a linear function of physical time. But, Getty(1975) generalized Weber's law and his model succeeded in describing his data.

At present, there are two types of psychophysical functions, power or log functions, and two types of variance models, constant variance models and Weber's law.

Reviewed in section E, time perception is also affected by nontemporal factors. Pöppel(1978) insisted that intervals longer than 2 sec are perceived in a way qualitatively different from shorter ones.

With all these varieties of theories of time perception in mind, we cannot adopt the specific model of time perception, on which a model of simple reaction time would be based. Foreperiods in a simple reaction task may include both shorter and longer than 2 sec intervals.

CHAPTER IV

A TWO-STATE MODEL

In chapter I, we saw that, for choice reaction time, the two-state (prepared and unprepared states) model by Falmagne (1965) is simple with respect to its structure and successful in describing data. For simple reaction time, we found one model, which incorporates a process of expectation/anticipation. But, this model does not predict the sequential effects, the effects of the preceding FPs.

In chapter II, the author reported experiments, which confirmed importance of expectation in simple reaction task and the effects of the preceding FP. In this chapter, the author proposed a model, which has the following three characteristics;

1) The model is based on the process of expectation (cf. the results of experiments I, II, III and IV).

2) The sequential effects are incorporated (cf. the results of experiments III and IV).

3) The model is described in terms of discrete states, i.e., the prepared and not-prepared states. As to the term preparedness, there are other terms, which have close relationships to it, i.e., expectation, anticipation and refractoriness. Refractoriness

frequently refers to the physiological state of being not able to respond immediately after some event. The term 'adaptation level' is used in reference to sensory processes. Expectation or anticipation refers to a process at higher level. The term 'preparedness' may be used in reference to mental or motor system. As to our two-state model, it is not important to determine to which kind of processes the term 'state' refers, physiological, sensory or conscious ones. These processes may occur simultaneously. What we should make clear is that there are two states in one of which the subject can be at a given time. But, if these states have some names, it would be better. According to Falmagne(1965)'s terminology, the term 'prepared' will be used.

As to the type of the new model, it should be qualitative. In order to make the model quantitative, we must adopt a specific psychophysical scale of time, because the anticipation is based on the perception of time. But, as reviewed in chapter III, there is no scale of time which is accepted by most investigators.

A MODEL

When we fixed a set of FPs to use, we observe that mean RTs for the various FPs differ (cf. the results of experiment I). It seems that the subject was prepared to respond for FPs with about relatively middle length. Having this in mind, the following three assumptions were proposed.

Assumption 1.

A subject is in one of two states, the prepared state (abbreviated as Sp) and the not-prepared state (abbreviated as Snp).

Assumption 2.

When the subject is in Sp (or in Snp, resp.), the distribution function of reaction time is Fp(x) (or Fnp(x), resp.).

Assumption 3.

At the start of a trial, the subject is in Snp. After some time has passed, the subject enters into Sp. The distribution function of the time at which the subject enters into Sp is D(x).

As to the exact form of Fp(x) or Fnp(x), the general-gamma distribution, eq.(4-1), was proposed by McGill and Gibbon(1965) and the Weibull distribution, eq.(4-2), by Ida(1980).

$$F(x) = 1 - \sum_{i=0}^{i=k} C_i \cdot e^{-\lambda_i \cdot x} \tag{4-1}$$

$$F(x) = 1 - e^{-\lambda \cdot (t-L)^m} \tag{4-2}$$

The general-gamma distribution is obtained when exponential distributions are summed. The gamma distribution is the special case of the general-gamma distribution in which the values of parameters of the exponential distributions are equal to each other (cf. McGill(1963)). The Weibull distribution is obtained when the conditional probability at time x that a subject who has not yet responded will come to respond, r(x), obeys the following equation;

$$r(x) = \lambda \cdot m \cdot (x - L)^{m-1}$$

In this article, the aspects of the two-state model which do not depend on the exact forms of Fp(x) and Fnp(x) are discussed. Only the relation that the mean of Fp(x) is shorter than the one of Fnp(x) is assumed.

Assumption 4 was introduced to account for the effect of the preceding FP.

Assumption 4.

$T_0 = f(T_B, w_B, T_{pr}, w_{pr})$

where Tpr is the FP in the preceding trial and T_B is determined by the background context. w_{pr} and w_B are weights for Tpr and T_B. That is, T_0 depends on gloval (T_B) and local (Tpr) contexts. T_0 is defined as one of parameters of D(x), that is, D(x) should be written as $D(x,T_0)$.

It seems evident that a subject cannot maintain his preparedness indefinitely.

Assumption 5.

After entering into Sp, the subject remains in it for a while. The distribution function of this distribution is R(x).

Now, because the model proposed here is a qualitative approximation, let us make the functions, D(x), R(x) and $f(T_B, w_B, T_{pr}, w_{pr})$, simple ones.

Assumption 3-1.

$$D(x,T_0) = \begin{cases} 0 & x \leqslant T_0 \\ (x - T_0)/\delta_0 & T_0 \leqslant x \leqslant T_0 + \delta_0 \\ 1 & T_0 + \delta_0 < x \end{cases}$$

where $\delta_0 = \delta \cdot T_0$

At this point, $D(x,T_0)$ should be written as $D(x,T_0,\delta_0)$.

See Figure 6.

Assumption 4-1.

$$T_0 = f(T_B,\ w_B,\ T_{pr},\ w_{pr})$$

$$= (w_B \cdot T_B + w_{pr} \cdot T_{pr})/(w_B + w_{pr})$$

Assumption 5-1.

$$R(x) = \begin{cases} 0 & x \leqslant \rho \\ (x - \rho)/\lambda & \rho < x \leqslant \rho + \lambda \\ 1 & \rho + \lambda < x \end{cases}$$

At this point, $R(x)$ should be written as $R(x,\rho,\lambda)$.

See Figure 7.

With these assumptions, we can derive a distribution function of simple RT at time t, which is measured from the start of the trial. To simplify notations, some of the

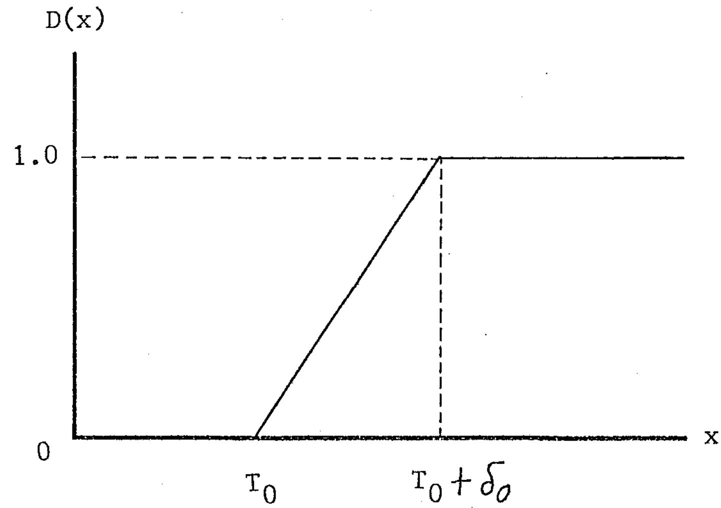

Figure 6. The distribution function, D(x), of the time at which the subject enters into S_p from S_{np}.

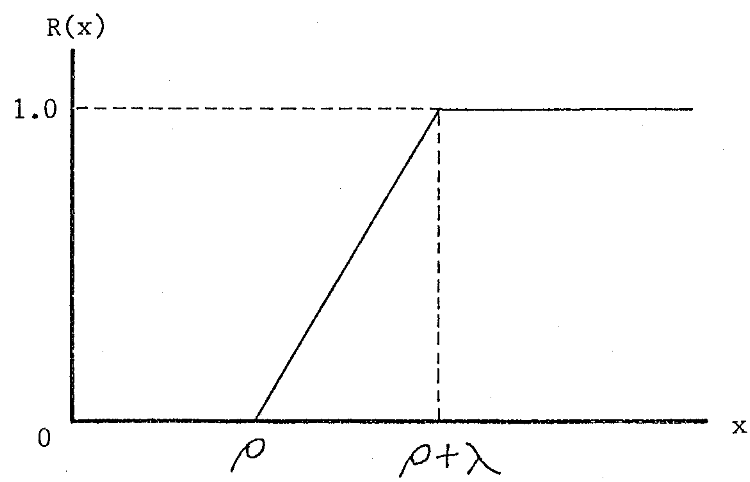

Figure 7. The distribution function, R(x), of the duration for which the subject remains in S_p.

parameters of the distribution functions are suppressed, but the reader should not be confused by this notational simplification.

Let $\tilde{R}(x) = 1 - R(x)$. That is, $\tilde{R}(x)$ is the probability that the subject remains in Sp during more than x time units. Then, $\tilde{R}(t-x) \cdot dD(x)$ is the probability that the subject enters into Sp at time x and be still in Sp at time t. The probability that the subject is in Sp at time t, $P(t,T_0)$, can be expressed as follows,

$$P(t,T_0) = \int_0^t \tilde{R}(t-x) \cdot dD(x) \qquad (4\text{-}3)$$

Now, let $RT(x,t,T_0)$ be the distribution function of simple RT when the stimulus is presented after time t has elapsed from the start of the trial.

Then,

$$RT(x,t,T_0) = P(t,T_0) \cdot Fp(x) + (1 - P(t,T_0)) \cdot Fnp(x)$$

Hence, mean RT at time t, $\overline{RT}(t,T_0)$, is

$$\begin{aligned} \overline{RT}(t,T_0) &= \int_0^\infty x \cdot dRT(x,t,T_0) \\ &= P(t,T_0) \cdot \int_0^\infty x \cdot dFp(x) + (1 - P(t,T_0)) \cdot \int_0^\infty x \cdot dFnp(x) \\ &= P(t,T_0) \cdot \overline{RT}p + (1 - P(t,T_0)) \cdot \overline{RT}np \qquad (4\text{-}4) \end{aligned}$$

where $\overline{RT}p$ and $\overline{RT}np$ are the mean RTs when the subject is in Sp or in Snp, respectively.

Figure 8 shows the graph of the theoretical $\overline{RT}(t,T_0)$ for immediate FPs of 1.00, 2.00 and 3.00 as a function of Tpr value (Tpr = 1.00, 1.50, 2.00, 2.50 and 3.00) when we set

$\rho = \lambda = 2.00$, $\delta = 1.5$, $W_B = 2.0$, $W_{pr} = 1.0$, $T_B = 0.0$, $\overline{RT}_p = 0.2$ and $\overline{RT}_{np} = 0.3$.

The program which was used to calculate the values in Figure 8 is given in appendix E.

Figure 9 shows the graph of the theoretical mean RTs, $\overline{RT}(t) =$ averaged $\overline{RT}(t,T_0)$ over T_0 values.

Inspecting the qualitative trends in Figures 8 and 9, we can conclude that the model proposed here fits qualitatively to the fact that 1) there is the optimum FP (Figure 9, also compare Figure 9 with Figures 2a and 2b), and 2) mean RTs depend on the FP in the preceding trial (Figure 8, also compare Figure 8 with Figure 5.).

MATHEMATICAL ANALYSIS

If we want to calculate the integration of eq.(4-3), we

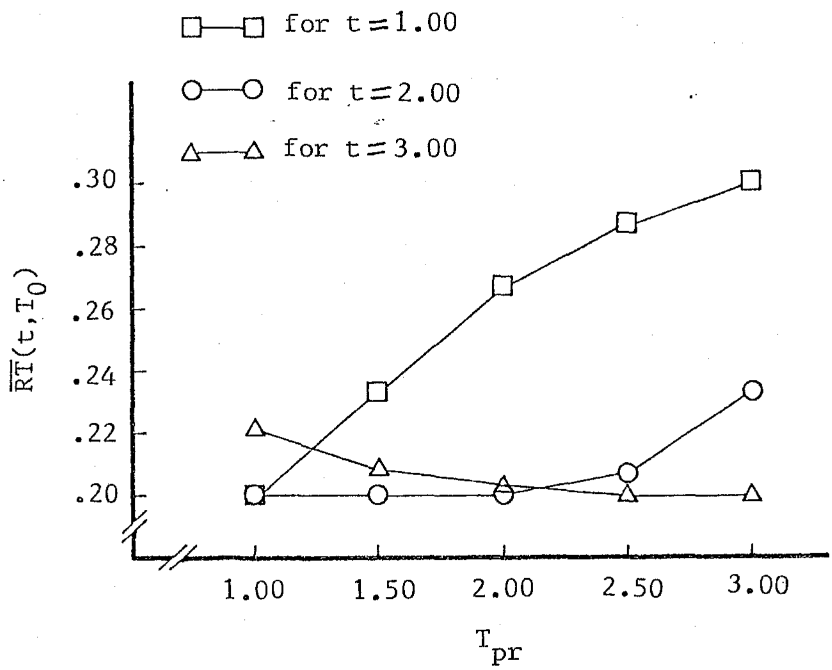

Figure 8. The theoretical mean RT for immediate FP 1.00, 2.00 and 3.00 in the psychological unit as a function of the preceding FP. The parameters were set as follows: $\rho = 2.00$, $\lambda = 2.00$, $\delta = 1.5$, $T_B = 0.0$, $W_B = 2.00$, $W_{pr} = 1.00$, $\overline{RT} = 0.20$ and $\overline{RT}_{np} = 0.30$.

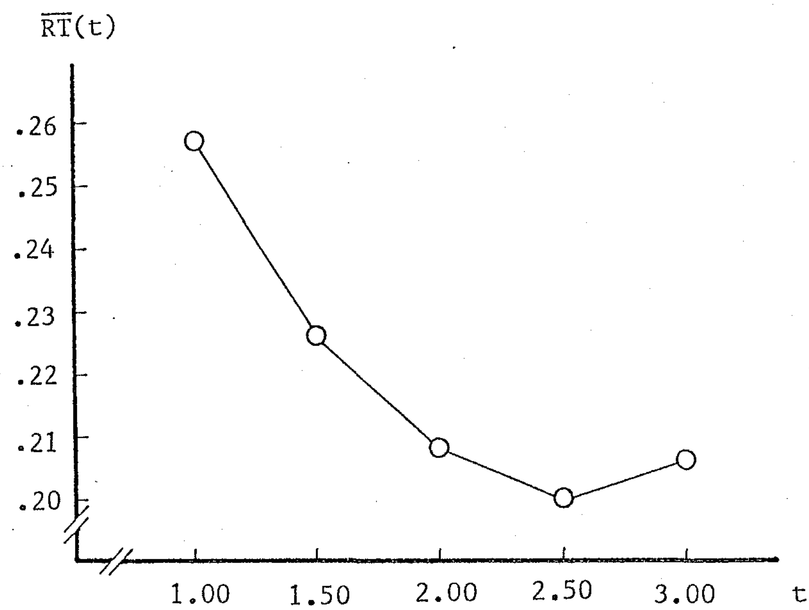

Figure 9. The theoretical mean RT as a function of immediate FP. The values of the parameters were the same as in Figure 8.

meet rather complex situation, where we must investigate many situations, each of which corresponds to each combination of the ranges of values of the parameters, T_0, δ_0, ρ and λ, of the functions, D(x) and R(x). The forms of D(x) and R(x) are natural approximations to the real ones. Densities of D(x) and R(x) are concentrated on rather restricted ranges, which are some distant from the origin 0. The forms of D(x) and R(x) are very simple, so the programming and calculation by computer of these functions is very easy.

But, computer calculations leave some dissatisfaction. We can see only the narrow range of the behaviors of the model which were simulated. The other part of the range of the behaviors which have not yet simulated is unknown until it is calculated.

In the following part of this chapter, in order to analyze the model mathematically, we make the forms of D(x) and R(x) mathematically analyzable ones.

Assumption 3-2.

$$D(x, \delta) = 1 - e^{-\delta \cdot x}$$

where δ is a decreasing function, $g(T_0)$, of T_0.

Assumption 5-2.

$$R(x) = 1 - e^{-\rho \cdot x}$$

The assumption that δ is a decreasing function of T_0 is due to the fact that $\int_0^\infty x \cdot dD(x, \delta) = \frac{1}{\delta}$

δ is a monotonic function of T_0 and can be written as $\delta = g(f(T_B, w_B, T_{pr}, w_{pr}))$ by assumption 4. In assumption 3-2, $D(x, \delta)$ has δ instead of T_0 as one of the explicit parameters. So, in the following analysis, we use δ as the parameter which depends on the FP in the preceding trial.

With assumptions 3-2 and 5-2, eq.(4-1) can be calculated as follows;

$$\begin{aligned} P(t, \delta) &= \int_0^t \tilde{R}(t - x) \cdot dD(x) \\ &= \int_0^t e^{-\rho \cdot (t-x)} \cdot \delta \cdot e^{-\delta \cdot x} \cdot dx \\ &= \delta \cdot e^{-\rho \cdot t} \cdot \int_0^t e^{(\rho - \delta) \cdot x} \cdot dx \\ &= \delta \cdot e^{-\rho \cdot t} \cdot \left[\frac{1}{(\rho - \delta)} \cdot e^{(\rho - \delta) \cdot x} \right]_0^t \\ &= \delta \cdot e^{-\rho t} \cdot \left\{ \frac{1}{(\rho - \delta)} \cdot e^{(\rho - \delta) \cdot t} - \frac{1}{(\rho - \delta)} \right\} = \frac{\delta}{\rho - \delta} \left(e^{-\delta \cdot t} - e^{-\rho \cdot t} \right) \end{aligned}$$

Hence, eq.(4-4) is given as

$$\overline{RT}(t,\delta) = P(t,\delta)\cdot\overline{RT}p + (1 - P(t,\delta))\cdot\overline{RT}np$$

$$= \overline{RT}np + (\overline{RT}p - \overline{RT}np)\cdot\frac{\delta}{\rho-\delta}\cdot(e^{-\delta\cdot t} - e^{-\rho\cdot t})$$

$$\frac{\partial\overline{RT}(t,\delta)}{\partial t} = (\overline{RT}p - \overline{RT}np)\cdot\frac{\delta}{\rho-\delta}\cdot(-\delta\cdot e^{-\delta\cdot t} + \rho\cdot e^{-\rho\cdot t})$$

$$= (\overline{RT}p - \overline{RT}np)\cdot\frac{\rho\delta}{\rho-\delta}\cdot e^{-\rho\cdot t}\cdot\left(1 - \frac{\delta}{\rho}\cdot e^{(\rho-\delta)\cdot t}\right)$$

Let $\frac{\partial\overline{RT}(t,\delta)}{\partial t} = 0$

Then

$$1 - \frac{\delta}{\rho}\cdot e^{(\rho-\delta)\cdot t} = 0$$

$$e^{(\rho-\delta)\cdot t} = \frac{\rho}{\delta}$$

$$t = \frac{1}{\rho-\delta}\log\frac{\rho}{\delta}$$

Let $h(\delta) = \frac{1}{\rho-\delta}\cdot\log\frac{\rho}{\delta}$

Then

$$\frac{dh}{d\delta} = \frac{1}{(\rho-\delta)^2}\cdot\log\frac{\rho}{\delta} + \frac{1}{\rho-\delta}\cdot\frac{-1}{\delta}$$

$$= \frac{1}{(\rho-\delta)^2}\cdot\left(\log\frac{\rho}{\delta} + (\rho-\delta)\cdot\frac{-1}{\delta}\right)$$

$$= \frac{1}{(\rho-\delta)^2}\cdot\left(\log\frac{\rho}{\delta} - \frac{\rho}{\delta} + 1\right)$$

$$\leqslant 0$$

Hence, the point, $t = h(\delta)$, at which $P(t,\delta)$ becomes minimal is a decreasing function of δ (i.e., a increasing function of T_0). This means that, when the FP in the preceding trial is larger one, then the value of T_0 is also larger (which is implicitly assumed in assumption 4.), δ becomes smaller, and the optimum FP becomes longer. This is the sequential effect (cf. the results of experiment III).

Now, let U(x) be the distribution function of δ.

Then,

$$\overline{RT}(t) = \int_0^{\infty} \overline{RT}(t, \delta) \cdot dU(\delta) \qquad (4\text{-}5)$$

If U(x) is a discrete distribution, eq.(4-5) can be written as,

$$\overline{RT}(t) = \sum_{i=1}^{n} p_i \cdot \overline{RT}(t, \delta) \qquad (4\text{-}6)$$

where $p_i \geqslant 0, \quad \sum_{i=1}^{n} p_i = 1.$

When the distribution of FPs is discrete, the distributions of T_0 and δ are also discrete by assumption.

In experiment II, six FPs were used. Consider two distributions, $\{p_i^1\}_{i=1}^{6}$ and $\{p_i^2\}_{i=1}^{6}$,

and let

$$p_1^1 = p_2^1 = p_3^1 = \frac{2}{9}, \quad p_4^1 = p_5^1 = p_6^1 = \frac{1}{9},$$

and

$$p_1^2 = p_2^2 = p_3^2 = \frac{1}{9}, \quad p_4^2 = p_5^2 = p_6^2 = \frac{2}{9}.$$

Denote $\overline{RT}(t)$'s corresponding to $\{p_i^1\}$ and $\{p_i^2\}$ as $\overline{RT}^1(t)$ and $\overline{RT}^2(t)$, respectively.

Then, by eq.(4-6),

$$\overline{RT}^1(t) = \frac{2}{9}\overline{RT}^a(t) + \frac{1}{9}\overline{RT}^b(t)$$

and

$$\overline{RT}^2(t) = \frac{1}{9}\overline{RT}^a(t) + \frac{2}{9}\overline{RT}^b(t)$$

where

$$\overline{RT}^a(t) = \overline{RT}(t, \delta_1) + \overline{RT}(t, \delta_2) + \overline{RT}(t, \delta_3)$$

and

$$\overline{RT}^b(t) = \overline{RT}(t, \delta_4) + \overline{RT}(t, \delta_5) + \overline{RT}(t, \delta_6)$$

So,

$$\overline{RT}^1(t) - \overline{RT}^2(t) = \frac{1}{9}\cdot(\overline{RT}^a(t) - \overline{RT}^b(t)) \qquad (4\text{-}7)$$

When $\delta_i > \delta_j$ for $i < j$

then the value of t at which $\overline{RT}^a(t)$ becomes minimal is smaller than the one at which $\overline{RT}^b(t)$ becomes minimal, because $h(\delta_i) < h(\delta_j)$ for $i < j$.

Hence, eq.(4-7) means that the value of t at which $\overline{RT}^1(t)$ becomes minimal is smaller than the one at which $\overline{RT}^2(t)$ becomes minimal. This means that the optimum FP depends on the relative frequencies of FPs, the results of experiment II.

CHAPTER V

SUMMARY

A new model of simple reaction time was proposed in this dissertation. In order to recognize the need to propose a new model, literatures on models of choice reaction time were reviewed in the first part of chapter I and literatures on models of simple reaction time were reviewed in the following part. We found that the two-state model of choice reaction time proposed by Falmagne(1965) was simple and successful in predictions. As to models of simple reaction time, there are many models. But, only one of the models reviewed in chapter I incorporated a process of expectancy/anticipation, although the role of expectancy in simple reaction time has been emphasized by Näätänen and his collaborators (Näätänen(1970,1971), Näätänen and Merisalo(1977), Niemi and Näätänen(1981)). However, this anticipation model ignores the sequential effects.

In chapter II, the author reported four experiments, which gave the data needed to construct a new model. In experiments I and II, factors, which seemed to affect the expectancy, were manipulated. Shift of the range of FPs caused shift of the optimum FP. The optimum FP in the case where shorter FPs were more often used was shorter than in the case where longer FPs were more often used. In experiements III and IV, the sequential effects were investigated. When the FP in the preceding trial is longer, the reaction time for short FP is longer.

To incorporate a expectation process into a quantitative model, we must adopt a specific model of time perception. Literatures on models of time perception were reviewed in chapter III, but we could not find the model which is accepted by most investigators. We must be content to construct a qualitative model.

In chapter IV, the author proposed the new model of simple reaction time which has the following characteristics;

1) The model is based on the process of expectation.

2) The sequential effects are incorporated.

3) The model is a two-state one.

In computer simulation, the proposed model produced the data which are similar to the data of experiments I and III. Mathematical analysis showed that the proposed model can predict the effects of the FP in the preceding trial and of the relative frequencies of FPs.

APPENDICES

APPENDIX A

The programs for experiment I.

The program for the Short FPs condition.

EXP.A2 1

```
      DIMENSION CMNT(10),STTM(10),SBJNM(10),XENDTM(10),
     *          RTT(48),INTVLT(192),ISBT1(48),ISBT2(48),
     *          ISBT3(48),ISBT4(48),RTSTK1(24),RTSTK2(24)
      EQUIVALENCE (INTVLT(1),ISBT1(1)),(INTVLT(49),ISBT2(1)),
     *            (INTVLT(97),ISBT3(1)),(INTVLT(145),ISBT4(1))
      DATA ISBT1/
     *    4,1,2,1,4,5,2,3,0,5,3,0,
     *    0,5,1,1,2,3,2,4,3,5,4,0,
     *    0,3,2,3,1,0,5,4,2,4,1,5,
     *    0,3,5,0,1,5,1,4,2,3,2,4/
      DATA ISBT2/
     *    5,2,4,4,3,1,5,3,1,0,0,2,
     *    3,5,4,5,1,3,2,0,4,1,0,2,
     *    1,0,3,3,5,4,5,4,0,2,2,1,
     *    3,4,1,1,0,2,5,4,3,2,5,0/
      DATA ISBT3/
     *    0,2,5,5,3,3,0,4,1,4,2,1,
     *    5,0,2,1,2,4,5,0,3,1,3,4,
     *    4,0,3,4,1,5,2,3,2,5,0,1,
     *    5,4,4,5,2,2,0,3,1,1,3,0/
      DATA ISBT4/
     *    1,4,3,1,4,2,0,2,5,3,0,5,
     *    1,4,1,5,3,4,0,0,3,5,2,2,
     *    2,2,4,3,5,1,1,5,3,4,0,0,
     *    5,5,1,3,4,3,0,2,2,4,0,1/
C
C
      WRITE(2,1010)
 1010 FORMAT(25(/),'COMMENT')
      READ(1,1011)CMNT
 1011 FORMAT(10A4)
      WRITE(2,1000)
 1000 FORMAT(//'START TIME')
      READ(1,1001)STTM
 1001 FORMAT(10A4)
      WRITE(2,1002)
 1002 FORMAT(//'SUBJ. NAME')
      READ(1,1003)SBJNM
 1003 FORMAT(10A4)
      REWIND 8
      DO 100 NSSN1=1,4
      DO 101 NSSN2=1,4
      ISSN=(NSSN1-1)*4+NSSN2
      WRITE(2,2010)ISSN
 2010 FORMAT('SESSION',I3,1X,'READY?')
      READ(1,2000)A
 2000 FORMAT(A4)
      CALL OUT40(1)
C
C  ******* PRE-TRIAL *******
C
 200  CALL INP40(IRES)
      IF(IRES.EQ.0)GO TO 200
```

EXP.A2   1

```
        CALL INTLTM
        CALL OUT40(0)
 230    CALL TMR(I10MS,ISEC)
        IF(I10MS.LT.50)GO TO 230
        DO 210 I1=1,2
 202    CALL TMR(I10MS,ISEC)
        CALL INP40(IRES)
        IF(IRES.NE.0)GO TO 201
        IF(I10MS.LT.200)GO TO 202
        CALL OUT40(1)
        CALL INTLTM
 203    CALL INP40(IRES)
        IF(IRES.EQ.0)GO TO 203
        CALL OUT40(0)
 201    CALL INTLTM
 220    CALL TMR(I10MS,ISEC)
        IF(I10MS.LT.50)GO TO 220
 210    CONTINUE
 C
 C   ********  MAIN TRIALS  **********
 C
        ISTRL=1
 305    ITRL=(NSSN2-1)*48+ISTRL
        IRSI=100
        NCNTR=INTVLT(ITRL)
 311    IF(NCNTR.EQ.0)GO TO 310
        IRSI=IFIX(FLOAT(IRSI)*1.3)
        NCNTR=NCNTR-1
        GO TO 311
 310    CONTINUE
 301    CALL INP40(IRES)
        CALL TMR(I10MS,ISEC)
        IF(IRES.NE.0)GO TO 300
        IF(I10MS.LT.IRSI)GO TO  301
        GO TO 322
 300    RTT(ISTRL)=FLOAT(I10MS+1000)*0.01
        GO TO 303
 322    CALL OUT40(1)
        CALL INTLTM
 304    CALL INP40(IRES)
        CALL TMR(I10MS,ISEC)
        IF(IRES.EQ.0)GO TO 304
        RTT(ISTRL)=FLOAT(I10MS)*0.01
 303    CALL OUT40(0)
        CALL INTLTM
 500    CALL TMR(I10MS,ISEC)
        IF(I10MS.LT.50)GO TO 500
        ISTRL=ISTRL+1
        IF(ISTRL.LE.48)GO TO 305
        WRITE(2,3300)ISSN
 3300   FORMAT('SESSION',I3,1X,'ENDS.')
 C
 C   ********    DATA STACK ROUTINE   **********
```

EXP.A2 1

```
C
      DO 400 II1=1,24
      II2=II1+24
      RTSTK1(II1)=RTT(II1)
      RTSTK2(II1)=RTT(II2)
400   CONTINUE
      WRITE(8,3000)RTSTK1
3000  FORMAT(24F6.2)
      WRITE(8,3000)RTSTK2
101   CONTINUE
100   CONTINUE
      CALL OWARI
      WRITE(2,4000)
4000  FORMAT(////,'ALL SESSIONS FINISHED'////
     *       'END TIME ?')
      READ(1,4001)XENDTM
4001  FORMAT(10A4)
      WRITE(6,4002)CMNT,SBJNM,STTM,XENDTM
4002  FORMAT(1H1///////5X,10A4//5X,'NAME OF THE SBJ.',10X,10A4//
     *       5X,'START TIME'/10X,10A4//
     *       5X,'END TIME'/10X,10A4)
C
C   ********   PRINT OUT ROUTINE   *********
C
      REWIND 8
      DO 600 NSSN1=1,4
      DO 601 NSSN2=1,4
      ISSN=(NSSN1-1)*4+NSSN2
      WRITE(6,5000)ISSN
5000  FORMAT(1H1,5X,'SESSION NO. IS',I3//5X,'FOREPERIOD',
     *       5X,'REACTION TIME'//)
      READ(8,3000)RTSTK1
      READ(8,3000)RTSTK2
      DO 602 II1=1,24
      II2=II1+24
      RTT(II1)=RTSTK1(II1)
      RTT(II2)=RTSTK2(II1)
602   CONTINUE
      DO 603 ISTRL=1,48
      ISTRL1=(NSSN2-1)*48+ISTRL
      IRSI=100
      NCNTR=INTVLT(ISTRL1)
605   IF(NCNTR.EQ.0)GO TO 604
      IRSI=IFIX(FLOAT(IRSI)*1.3)
      NCNTR=NCNTR-1
      GO TO 605
604   XIRSI=FLOAT(IRSI)*0.01
      WRITE(6,5001)XIRSI,RTT(ISTRL)
5001  FORMAT(4X,F5.2,' SEC.',7X,F7.2,' SEC.')
603   CONTINUE
601   CONTINUE
600   CONTINUE
      WRITE(6,5050)
```

EXP.A2 1

```
160: 5050 FORMAT(1H1////////////)
161:      STOP
162:      END
```

The program for the Long FPs condition.

EXP.A3 1

```
      DIMENSION CMNT(1Ø),STTM(1Ø),SBJNM(1Ø),XENDTM(1Ø),
     *          RTT(48),INTVLT(192),ISBT1(48),ISBT2(48),
     *          ISBT3(48),ISBT4(48),RTSTK1(24),RTSTK2(24)
      EQUIVALENCE (INTVLT(1),ISBT1(1)),(INTVLT(49),ISBT2(1)),
     *            (INTVLT(97),ISBT3(1)),(INTVLT(145),ISBT4(1))
      DATA  ISBT1/
     *      4,1,2,1,4,5,2,3,Ø,5,3,Ø,
     *      Ø,5,1,1,2,3,2,4,3,5,4,Ø,
     *      Ø,3,2,3,1,Ø,5,4,2,4,1,5,
     *      Ø,3,5,Ø,1,5,1,4,2,3,2,4/
      DATA  ISBT2/
     *      5,2,4,4,3,1,5,3,1,Ø,Ø,2,
     *      3,5,4,5,1,3,2,Ø,4,1,Ø,2,
     *      1,Ø,3,3,5,4,5,4,Ø,2,2,1,
     *      3,4,1,1,Ø,2,5,4,3,2,5,Ø/
      DATA  ISBT3/
     *      Ø,2,5,5,3,3,Ø,4,1,4,2,1,
     *      5,Ø,2,1,2,4,5,Ø,3,1,3,4,
     *      4,Ø,3,4,1,5,2,3,2,5,Ø,1,
     *      5,4,4,5,2,2,Ø,3,1,1,3,Ø/
      DATA  ISBT4/
     *      1,4,3,1,4,2,Ø,2,5,3,Ø,5,
     *      1,4,1,5,3,4,Ø,Ø,3,5,2,2,
     *      2,2,4,3,5,1,1,5,3,4,Ø,Ø,
     *      5,5,1,3,4,3,Ø,2,2,4,Ø,1/
C
C
      CALL DFFILE
      WRITE(2,1Ø1Ø)
 1Ø1Ø FORMAT(25(/),'COMMENT')
      READ(1,1Ø11)CMNT
 1Ø11 FORMAT(1ØA4)
      WRITE(2,1ØØØ)
 1ØØØ FORMAT(//'START TIME')
      READ(1,1ØØ1)STTM
 1ØØ1 FORMAT(1ØA4)
      WRITE(2,1ØØ2)
 1ØØ2 FORMAT(//'SUBJ. NAME')
      READ(1,1ØØ3)SBJNM
 1ØØ3 FORMAT(1ØA4)
      REWIND 8
      DO 1ØØ NSSN1=1,4
      DO 1Ø1 NSSN2=1,4
      ISSN=(NSSN1-1)*4+NSSN2
      WRITE(2,2Ø1Ø)ISSN
 2Ø1Ø FORMAT('SESSION',I3,1X,'READY?')
      READ(1,2ØØØ)A
 2ØØØ FORMAT(A4)
      CALL OUT4Ø(1)
C
C  ******* PRE-TRIAL *******
C
 2ØØ  CALL INP4Ø(IRES)
```

EXP.A3   1

```
      IF(IRES.EQ.0)GO TO 200
      CALL INTLTM
      CALL OUT40(0)
 230  CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.50)GO TO 230
      DO 210 I1=1,2
 202  CALL TMR(I10MS,ISEC)
      CALL INP40(IRES)
      IF(IRES.NE.0)GO TO 201
      IF(I10MS.LT.500)GO TO 202
      CALL OUT40(1)
      CALL INTLTM
 203  CALL INP40(IRES)
      IF(IRES.EQ.0)GO TO 203
      CALL OUT40(0)
 201  CALL INTLTM
 220  CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.50)GO TO 220
 210  CONTINUE
C
C   ********  MAIN TRIALS  **********
C
      ISTRL=1
 305  ITRL=(NSSN2-1)*48+ISTRL
      IRSI=284
      NCNTR=INTVLT(ITRL)
 311  IF(NCNTR.EQ.0)GO TO 310
      IRSI=IFIX(FLOAT(IRSI)*1.2)
      NCNTR=NCNTR-1
      GO TO 311
 310  CONTINUE
 301  CALL INP40(IRES)
      CALL TMR(I10MS,ISEC)
      IF(IRES.NE.0)GO TO 300
      IF(I10MS.LT.IRSI)GO TO  301
      GO TO 302
 300  RTT(ISTRL)=FLOAT(I10MS+1000)*0.01
      GO TO 303
 302  CALL OUT40(1)
      CALL INTLTM
 304  CALL INP40(IRES)
      CALL TMR(I10MS,ISEC)
      IF(IRES.EQ.0)GO TO 304
      RTT(ISTRL)=FLOAT(I10MS)*0.01
 303  CALL OUT40(0)
      CALL INTLTM
 500  CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.50)GO TO 500
      ISTRL=ISTRL+1
      IF(ISTRL.LE.48)GO TO 305
      WRITE(2,3300)ISSN
 3300 FORMAT('SESSION',I3,1X,'ENDS.')
C
```

EXP·A3   1

```
C   ********     DATA STACK ROUTINE    **********
C
        DO 400 II1=1,24
        II2=II1+24
        RTSTK1(II1)=RTT(II1)
        RTSTK2(II1)=RTT(II2)
  400   CONTINUE
        WRITE(8,3000)RTSTK1
 3000   FORMAT(24F6.2)
        WRITE(8,3000)RTSTK2
  101   CONTINUE
  100   CONTINUE
        CALL OWARI
        WRITE(2,4000)
 4000   FORMAT(////,'ALL SESSIONS FINISHED'////
       *          'END TIME ?')
        READ(1,4001)XENDTM
 4001   FORMAT(10A4)
        WRITE(6,4002)CMNT,SBJNM,STTM,XENDTM
 4002   FORMAT(1H1///////5X,10A4//5X,'NAME OF THE SBJ.',10X,10A4//
       *          5X,'START TIME'/10X,10A4//
       *          5X,'END TIME'/10X,10A4)
C
C   ********    PRINT OUT ROUTINE    *********
C
        REWIND 8
        DO 600 NSSN1=1,4
        DO 601 NSSN2=1,4
        ISSN=(NSSN1-1)*4+NSSN2
        WRITE(6,5000)ISSN
 5000   FORMAT(1H1,5X,'SESSION NO. IS',I3//5X,'FOREPERIOD',
       *          5X,'REACTION TIME'//)
        READ(8,3000)RTSTK1
        READ(8,3000)RTSTK2
        DO 602 II1=1,24
        II2=II1+24
        RTT(II1)=RTSTK1(II1)
        RTT(II2)=RTSTK2(II1)
  602   CONTINUE
        DO 603 ISTRL=1,48
        ISTRL1=(NSSN2-1)*48+ISTRL
        IRSI=284
        NCNTR=INTVLT(ISTRL1)
  605   IF(NCNTR.EQ.0)GO TO 604
        IRSI=IFIX(FLOAT(IRSI)*1.2)
        NCNTR=NCNTR-1
        GO TO 605
  604   XIRSI=FLOAT(IRSI)*0.01
        WRITE(6,5001)XIRSI,RTT(ISTRL)
 5001   FORMAT(4X,F5.2,' SEC.',7X,F7.2,' SEC.')
  603   CONTINUE
  601   CONTINUE
  600   CONTINUE
```

```
EXP.A3      1

              WRITE(6,5050)
        5050  FORMAT(1H1////////////)
              STOP
              END
```

APPENDIX B

The programs for experiment II.

The program for S-L condition.

EXP.B1   1

```
C
C       *******   MAIN PROGRAM    *********
C
        DIMENSION   INTVLT(400),
       *            ISBT1(100),ISBT2(100),ISBT3(100),ISBT4(100)
        EQUIVALENCE   (INTVLT(1),ISBT1(1)),(INTVLT(101),ISBT2(1)),
       *              (INTVLT(201),ISBT3(1)),(INTVLT(301),ISBT4(1))
        DATA  ISBT1/
       *      1,2,9,9,3,8,7,6,6,3,4,0,5,4,0,7,2,5,8,1,
       *      3,4,7,5,2,1,7,9,0,2,6,8,5,3,9,4,8,6,1,0,
       *      2,2,9,6,7,4,1,5,9,5,6,8,4,3,3,1,8,0,7,0,
       *      9,3,2,5,7,8,5,2,0,3,7,0,8,1,6,9,6,1,4,4,
       *      8,1,2,0,4,6,7,9,1,3,5,7,4,6,0,3,9,2,5,8/
        DATA  ISBT2/
       *      4,8,5,6,0,5,9,7,0,3,9,7,3,1,2,4,2,1,8,6,
       *      8,2,0,9,3,5,7,1,9,1,0,8,2,5,4,3,4,7,6,6,
       *      4,7,5,2,9,6,0,4,1,8,3,5,9,6,8,0,3,7,2,1,
       *      7,8,0,4,0,2,6,7,1,6,5,1,5,3,8,9,3,4,2,9,
       *      4,8,0,5,9,1,3,6,7,1,0,6,2,8,7,5,3,4,9,2/
        DATA  ISBT3/
       *      1,7,7,9,4,6,3,5,3,0,2,9,1,2,5,6,4,0,8,8,
       *      9,6,8,6,7,5,0,0,8,5,4,3,1,7,4,2,1,3,2,9,
       *      7,6,9,3,5,2,6,9,4,1,0,8,5,1,4,7,3,2,0,8,
       *      1,4,0,0,6,8,3,3,5,8,7,1,2,9,2,7,4,5,6,9,
       *      3,0,2,0,1,6,6,8,7,1,9,4,4,9,5,3,2,5,8,7/
        DATA  ISBT4/
       *      4,5,9,3,2,1,0,6,3,2,1,4,5,7,8,9,6,0,8,7,
       *      1,6,4,2,3,2,3,5,0,6,5,4,0,9,7,8,1,9,7,8,
       *      6,4,6,4,7,8,0,5,2,3,1,1,0,9,7,9,5,8,2,3,
       *      1,5,7,2,8,4,7,3,6,8,0,2,9,3,1,4,5,6,0,9,
       *      9,0,4,0,9,2,6,7,1,3,2,4,8,6,7,3,5,5,1,8/
C
C
        CALL DFFILE
        CALL SUB1(INTVLT)
        CALL SUB2(INTVLT)
        STOP
        END
C
C
C       ********  EXPERIMENT  ******
C
        SUBROUTINE SUB1(INTVLT)
C
        DIMENSION INTVLT(400),CMNT(10),STTM(10),SBJNM(10),XENDTM(10
       *          RTT(100)
        WRITE(2,1010)
 1010   FORMAT(25(/),'COMMENT')
        READ(1,1011)CMNT
 1011   FORMAT(10A4)
        WRITE(2,1000)
 1000   FORMAT(//'START TIME')
        READ(1,1001)STTM
```

EXP.B1   1

```
1001  FORMAT(10A4)
      WRITE(2,1002)
1002  FORMAT(//'SUBJ. NAME')
      READ(1,1003)SBJNM
1003  FORMAT(10A4)
      REWIND 8
      DO 190 NSSN0=1,2
      DO 100 NSSN1=1,3
      DO 101 NSSN2=1,4
      ISSN=(NSSN0-1)*12+(NSSN1-1)*4+NSSN2
      WRITE(2,2010)ISSN
2010  FORMAT('SESSION',I3,1X,'READY?')
      READ(1,2000)A
2000  FORMAT(A4)
      CALL OUT40(1)
C
C  ******* PRE-TRIAL *******
C
200   CALL INP40(IRES)
      IF(IRES.EQ.0)GO TO 200
      CALL INTLTM
      CALL OUT40(0)
230   CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.50)GO TO 230
      DO 210 I1=1,2
202   CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.50)GO TO 202
      CALL INP40(IRES)
      IF(IRES.NE.0)GO TO 201
      IF(I10MS.LT.200)GO TO 202
      CALL OUT40(1)
203   CALL INP40(IRES)
      IF(IRES.EQ.0)GO TO 203
      CALL OUT40(0)
201   CALL INTLTM
210   CONTINUE
C
C   ********  MAIN TRIALS  **********
C
      ISTRL=1
305   ITRL=(NSSN2-1)*100+ISTRL
      NCNTR=INTVLT(ITRL)
      IF(NSSN0.EQ.1)CALL STINT1(NCNTR,IRSI)
      IF(NSSN0.EQ.2)CALL STINT2(NCNTR,IRSI)
310   CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.50)GO TO 310
301   CALL INP40(IRES)
      CALL TMR(I10MS,ISEC)
      IF(IRES.NE.0)GO TO 300
      IF(I10MS.LT.IRSI)GO TO  301
      GO TO 302
300   RTT(ISTRL)=FLOAT(I10MS+1000)*0.01
      GO TO 303
```

EXP.B1 1

```
302   CALL OUT40(1)
      CALL INTLTM
304   CALL INP40(IRES)
      CALL TMR(I10MS,ISEC)
      IF(IRES.EQ.0)GO TO 304
      RTT(ISTRL)=FLOAT(I10MS)*0.01
303   CALL OUT40(0)
      CALL INTLTM
      ISTRL=ISTRL+1
      IF(ISTRL.LE.100)GO TO 305
      WRITE(2,3300)ISSN
3300  FORMAT('SESSION',I3,1X,'ENDS.')
C
C    ********    DATA STACK ROUTINE    **********
C
      WRITE(8)RTT
101   CONTINUE
100   CONTINUE
190   CONTINUE
      CALL OWARI
      WRITE(2,4000)
4000  FORMAT(////,'ALL SESSIONS FINISHED'////
     *        'END TIME ?')
      READ(1,4001)XENDTM
4001  FORMAT(10A4)
      WRITE(6,4002)CMNT,SBJNM,STTM,XENDTM
4002  FORMAT(1H1///////5X,10A4//5X,'NAME OF THE SBJ.',10X,10A4//
     *        5X,'START TIME'/10X,10A4//
     *        5X,'END TIME'/10X,10A4)
C
C    ********    PRINT OUT ROUTINE    *********
C
      REWIND 8
      DO 690 NSSN0=1,2
      DO 600 NSSN1=1,3
      DO 601 NSSN2=1,4
      ISSN=(NSSN0-1)*12+(NSSN1-1)*4+NSSN2
      WRITE(6,5000)ISSN
5000  FORMAT(1H1,5X,'SESSION NO. IS',I3//5X,'FOREPERIOD',
     *        5X,'REACTION TIME'//)
      READ(8)RTT
      DO 603 ISTRL=1,100
      ISTRL1=(NSSN2-1)*100+ISTRL
      NCNTR=INTVLT(ISTRL1)
      IF(NSSN0.EQ.1)CALL STINT1(NCNTR,IRSI)
      IF(NSSN0.EQ.2)CALL STINT2(NCNTR,IRSI)
      XIRSI=FLOAT(IRSI)*0.01
      WRITE(6,5001)XIRSI,RTT(ISTRL)
5001  FORMAT(4X,F5.2,' SEC.',7X,F7.2,' SEC.')
603   CONTINUE
601   CONTINUE
600   CONTINUE
690   CONTINUE
```

```
      WRITE(6,5050)
 5050 FORMAT(1H1///////////)
      RETURN
      END
C
C
C      ****** SET INTERVAL ********
C
      SUBROUTINE STINT1(NCNTR,IRSI)
C
      IF(NCNTR*(NCNTR-1)*(NCNTR-2).EQ.0)IRSI=100
      IF(NCNTR.EQ.3)IRSI=130
      IF((NCNTR-4)*(NCNTR-5)*(NCNTR-6).EQ.0)IRSI=169
      IF(NCNTR.EQ.7)IRSI=219
      IF(NCNTR.EQ.8)IRSI=284
      IF(NCNTR.EQ.9)IRSI=369
      RETURN
      END
C
C
C       ******* SET INTERVAL *********
C
      SUBROUTINE STINT2(NCNTR,IRSI)
C
      IF(NCNTR.EQ.0)IRSI=100
      IF(NCNTR.EQ.1)IRSI=130
      IF(NCNTR.EQ.2)IRSI=169
      IF((NCNTR-3)*(NCNTR-4)*(NCNTR-5).EQ.0)IRSI=219
      IF(NCNTR.EQ.6)IRSI=284
      IF((NCNTR-7)*(NCNTR-8)*(NCNTR-9).EQ.0)IRSI=369
      RETURN
      END
C
C
C     **********   ARRANGE DATA   *************
C
      SUBROUTINE SUB2(INTVLT)
C
      DIMENSION  INTVLT(400),RTT(100),RRT0(10),RRT1(10),RRT2(10),
     *              RRT3(10),RRT4(10),RRT5(10),RRT6(10),
     *              RRT7(10),RRT8(10),RRT9(10)
C
      REWIND 8
      WRITE(6,1000)
 1000 FORMAT(1H1,5X,'DATA ARRANGED'///////)
      DO 102 ISTP0=1,2
      DO 100 ISTP1=1,3
      DO 101 ISTP2=1,4
      NSSN=(ISTP0-1)*12+(ISTP1-1)*4+ISTP2
      WRITE(6,2000)NSSN
 2000 FORMAT(10X,'SESSION NO. IS  ',I5///
     *        5X,'( 0 )',6X,'( 1 )',6X,'( 2 )',6X,'( 3 )',
     *        6X,'( 4 )',6X,'( 5 )'/
```

```
      *         8X,'( 6 )',6X,'( 7 )',6X,'( 8 )',6X,'( 9 )'//)
       READ(8)RTT
       NO0=0
       NO1=0
       NO2=0
       NO3=0
       NO4=0
       NO5=0
       NO6=0
       NO7=0
       NO8=0
       NO9=0
       DO 300 I1=1,100
       ITRL=(ISTP2-1)*100+I1
       NTRCK=INTVLT(ITRL)
       RT=RTT(I1)
       IF(NTRCK.EQ.9)GO TO 390
       IF(NTRCK.EQ.8)GO TO 380
       IF(NTRCK.EQ.7)GO TO 370
       IF(NTRCK.EQ.6)GO TO 366
       IF(NTRCK.EQ.5)GO TO 350
       IF(NTRCK.EQ.4)GO TO 340
       IF(NTRCK.EQ.3)GO TO 330
       IF(NTRCK.EQ.2)GO TO 320
       IF(NTRCK.EQ.1)GO TO 310
       NO0=NO0+1
       RRT0(NO0)=RT
       GO TO 360
  390  NO9=NO9+1
       RRT9(NO9)=RT
       GO TO 360
  380  NO8=NO8+1
       RRT8(NO8)=RT
       GO TO 360
  370  NO7=NO7+1
       RRT7(NO7)=RT
       GO TO 360
  366  NO6=NO6+1
       RRT6(NO6)=RT
       GO TO 360
  350  NO5=NO5+1
       RRT5(NO5)=RT
       GO TO 360
  340  NO4=NO4+1
       RRT4(NO4)=RT
       GO TO 360
  330  NO3=NO3+1
       RRT3(NO3)=RT
       GO TO 360
  320  NO2=NO2+1
       RRT2(NO2)=RT
       GO TO 360
  310  NO1=NO1+1
```

EXP.B1 1

```
             RRT1(NO1)=RT
      360    CONTINUE
      300    CONTINUE
             DO 400 I1=1,10
             WRITE(6,4000)RRT0(I1),RRT1(I1),RRT2(I1),RRT3(I1),
           *              RRT4(I1),RRT5(I1),RRT6(I1),RRT7(I1),
           *              RRT8(I1),RRT9(I1)
      4000   FORMAT(5X,F6.2,5(6X,F6.2)/2X,4(6X,F6.2))
      400    CONTINUE
             WRITE(6,4001)
      4001   FORMAT(/////////)
      101    CONTINUE
      100    CONTINUE
      102    CONTINUE
             WRITE(6,4400)
      4400   FORMAT(1H1////////////////////)
             RETURN
             END
```

The program for L-S condition.

EXP.E2   1

```
C
C       *******   MAIN PROGRAM    *********
C
        DIMENSION   INTVLT(400),
       *            ISBT1(100),ISBT2(100),ISET3(100),ISBT4(100)
        EQUIVALENCE   (INTVLT(1),ISBT1(1)),(INTVLT(101),ISBT2(1)),
       *              (INTVLT(201),ISET3(1)),(INTVLT(301),ISET4(1))
        DATA  ISBT1/
       *      1,2,9,9,3,8,7,6,6,3,4,0,5,4,0,7,2,5,8,1,
       *      3,4,7,5,2,1,7,9,0,2,6,8,5,3,9,4,8,6,1,0,
       *      2,2,9,6,7,4,1,5,9,5,6,8,4,3,3,1,8,0,7,0,
       *      9,3,2,5,7,8,5,2,0,3,7,0,8,1,6,9,6,1,4,4,
       *      8,1,2,0,4,6,7,9,1,3,5,7,4,6,0,3,9,2,5,8/
        DATA  ISBT2/
       *      4,8,5,6,0,5,9,7,0,3,9,7,3,1,2,4,2,1,8,6,
       *      8,2,0,9,3,5,7,1,9,1,0,8,2,5,4,3,4,7,6,6,
       *      4,7,5,2,9,6,0,4,1,8,3,5,9,6,8,0,3,7,2,1,
       *      7,8,0,4,0,2,6,7,1,6,5,1,5,3,8,9,3,4,2,9,
       *      4,8,0,5,9,1,3,6,7,1,0,6,2,8,7,5,3,4,9,2/
        DATA  ISET3/
       *      1,7,7,9,4,6,3,5,3,0,2,9,1,2,5,6,4,0,8,8,
       *      9,6,8,6,7,5,0,0,8,5,4,3,1,7,4,2,1,3,2,9,
       *      7,6,9,3,5,2,6,9,4,1,0,8,5,1,4,7,3,2,0,8,
       *      1,4,0,0,6,8,3,3,5,8,7,1,2,9,2,7,4,5,6,9,
       *      3,0,2,0,1,6,6,8,7,1,9,4,4,9,5,3,2,5,8,7/
        DATA  ISBT4/
       *      4,5,9,3,2,1,0,6,3,2,1,4,5,7,8,9,6,0,8,7,
       *      1,6,4,2,3,2,3,5,0,6,5,4,0,9,7,8,1,9,7,8,
       *      6,4,6,4,7,8,0,5,2,3,1,1,0,9,7,9,5,8,2,3,
       *      1,5,7,2,8,4,7,3,6,8,0,2,9,3,1,4,5,6,0,9,
       *      9,0,4,0,9,2,6,7,1,3,2,4,8,6,7,3,5,5,1,8/
C
C
        CALL DFFILE
        CALL SUB1(INTVLT)
        CALL SUB2(INTVLT)
        STOP
        END
C
C
C       ********  EXPERIMENT  ******
C
        SUBROUTINE SUB1(INTVLT)
C
        DIMENSION INTVLT(400),CMNT(10),STTM(10),SBJNM(10),XENDTM(10
       *          RTT(100)
        WRITE(2,1010)
  1010  FORMAT(25(/),'COMMENT')
        READ(1,1011)CMNT
  1011  FORMAT(10A4)
        WRITE(2,1000)
  1000  FORMAT(//'START TIME')
        READ(1,1001)STTM
```

EXP.B2   1

```
1001  FORMAT(10A4)
      WRITE(2,1002)
1002  FORMAT(//'SUBJ. NAME')
      READ(1,1003)SBJNM
1003  FORMAT(10A4)
      REWIND 8
      DO 190 NSSN0=1,2
      DO 100 NSSN1=1,3
      DO 101 NSSN2=1,4
      ISSN=(NSSN0-1)*12+(NSSN1-1)*4+NSSN2
      WRITE(2,2010)ISSN
2010  FORMAT('SESSION',I3,1X,'READY?')
      READ(1,2000)A
2000  FORMAT(A4)
      CALL OUT40(1)
C
C  ******* PRE-TRIAL *******
C
200   CALL INP40(IRES)
      IF(IRES.EQ.0)GO TO 200
      CALL INTLTM
      CALL OUT40(0)
230   CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.50)GO TO 230
      DO 210 I1=1,2
202   CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.50)GO TO 202
      CALL INP40(IRES)
      IF(IRES.NE.0)GO TO 201
      IF(I10MS.LT.200)GO TO 202
      CALL OUT40(1)
203   CALL INP40(IRES)
      IF(IRES.EQ.0)GO TO 203
      CALL OUT40(0)
201   CALL INTLTM
210   CONTINUE
C
C   ********  MAIN TRIALS  **********
C
      ISTRL=1
305   ITRL=(NSSN2-1)*100+ISTRL
      NCNTR=INTVLT(ITRL)
      IF(NSSN0.EQ.1)CALL STINT2(NCNTR,IRSI)
      IF(NSSN0.EQ.2)CALL STINT1(NCNTR,IRSI)
310   CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.50)GO TO 310
301   CALL INP40(IRES)
      CALL TMR(I10MS,ISEC)
      IF(IRES.NE.0)GO TO 300
      IF(I10MS.LT.IRSI)GO TO  301
      GO TO 302
300   RTT(ISTRL)=FLOAT(I10MS+1000)*0.01
      GO TO 303
```

EXP·B2   1

```
302     CALL OUT40(1)
        CALL INTLTM
304     CALL INP40(IRES)
        CALL TMR(I10MS,ISEC)
        IF(IRES.EQ.0)GO TO 304
        RTT(ISTRL)=FLOAT(I10MS)*0.01
303     CALL OUT40(0)
        CALL INTLTM
        ISTRL=ISTRL+1
        IF(ISTRL.LE.100)GO TO 305
        WRITE(2,3300)ISSN
3300    FORMAT('SESSION',I3,1X,'ENDS.')
C
C    ********    DATA STACK ROUTINE    **********
C
        WRITE(8)RTT
101     CONTINUE
100     CONTINUE
190     CONTINUE
        CALL OWARI
        WRITE(2,4000)
4000    FORMAT(////,'ALL SESSIONS FINISHED'////
      *          'END TIME ?')
        READ(1,4001)XENDTM
4001    FORMAT(10A4)
        WRITE(6,4002)CMNT,SBJNM,STTM,XENDTM
4002    FORMAT(1H1///////5X,10A4//5X,'NAME OF THE SBJ.',10X,10A4//
      *         5X,'START TIME'/10X,10A4//
      *         5X,'END TIME'/10X,10A4)
C
C    ********    PRINT OUT ROUTINE    *********
C
        REWIND 8
        DO 690 NSSN0=1,2
        DO 600 NSSN1=1,3
        DO 601 NSSN2=1,4
        ISSN=(NSSN0-1)*12+(NSSN1-1)*4+NSSN2
        WRITE(6,5000)ISSN
5000    FORMAT(1H1,5X,'SESSION NO. IS',I3//5X,'FOREPERIOD',
      *         5X,'REACTION TIME'//)
        READ(8)RTT
        DO 603 ISTRL=1,100
        ISTRL1=(NSSN0-1)*100+ISTRL
        NCNTR=INTVLT(ISTRL1)
        IF(NSSN0.EQ.1)CALL STINT2(NCNTR,IRSI)
        IF(NSSN0.EQ.2)CALL STINT1(NCNTR,IRSI)
        XIRSI=FLOAT(IRSI)*0.01
        WRITE(6,5001)XIRSI,RTT(ISTRL)
5001    FORMAT(4X,F5.2,' SEC.',7X,F7.2,' SEC.')
603     CONTINUE
601     CONTINUE
600     CONTINUE
690     CONTINUE
```

```
      WRITE(6,5050)
 5050 FORMAT(1H1///////////)
      RETURN
      END
C
C
C      ****** SET INTERVAL ********
C
      SUBROUTINE STINT1(NCNTR,IRSI)
C
      IF(NCNTR*(NCNTR-1)*(NCNTR-2).EQ.0)IRSI=100
      IF(NCNTR.EQ.3)IRSI=130
      IF((NCNTR-4)*(NCNTR-5)*(NCNTR-6).EQ.0)IRSI=169
      IF(NCNTR.EQ.7)IRSI=219
      IF(NCNTR.EQ.8)IRSI=284
      IF(NCNTR.EQ.9)IRSI=369
      RETURN
      END
C
C
C       ******* SET INTERVAL *********
C
      SUBROUTINE STINT2(NCNTR,IRSI)
C
      IF(NCNTR.EQ.0)IRSI=100
      IF(NCNTR.EQ.1)IRSI=130
      IF(NCNTR.EQ.2)IRSI=169
      IF((NCNTR-3)*(NCNTR-4)*(NCNTR-5).EQ.0)IRSI=219
      IF(NCNTR.EQ.6)IRSI=284
      IF((NCNTR-7)*(NCNTR-8)*(NCNTR-9).EQ.0)IRSI=369
      RETURN
      END
C
C
C     **********   ARRANGE DATA   *************
C
      SUBROUTINE SUB2(INTVLT)
C
      DIMENSION  INTVLT(400),RTT(100),RRT0(10),RRT1(10),RRT2(10),
     *            RRT3(10),RRT4(10),RRT5(10),RRT6(10),
     *            RRT7(10),RRT8(10),RRT9(10)
C
      REWIND 8
      WRITE(6,1000)
 1000 FORMAT(1H1,5X,'DATA ARRANGED'///////)
      DO 102 ISTP0=1,2
      DO 100 ISTP1=1,3
      DO 101 ISTP2=1,4
      NSSN=(ISTP0-1)*12+(ISTP1-1)*4+ISTP2
      WRITE(6,2000)NSSN
 2000 FORMAT(10X,'SESSION NO. IS  ',I5///
     *       5X,'( 0 )',6X,'( 1 )',6X,'( 2 )',6X,'( 3 )',
     *       6X,'( 4 )',6X,'( 5 )'/
```

```
     *        8X,'( 6 )',6X,'( 7 )',6X,'( 8 )',6X,'( 9 )'//)
      READ(8)RTT
      NOØ=Ø
      NO1=Ø
      NO2=Ø
      NO3=Ø
      NO4=Ø
      NO5=Ø
      NO6=Ø
      NO7=Ø
      NO8=Ø
      NO9=Ø
      DO 3ØØ I1=1,1ØØ
      ITRL=(ISTP2-1)*1ØØ+I1
      NTRCK=INTVLT(ITRL)
      RT=RTT(I1)
      IF(NTRCK.EQ.9)GO TO 39Ø
      IF(NTRCK.EQ.8)GO TO 38Ø
      IF(NTRCK.EQ.7)GO TO 37Ø
      IF(NTRCK.EQ.6)GO TO 366
      IF(NTRCK.EQ.5)GO TO 35Ø
      IF(NTRCK.EQ.4)GO TO 34Ø
      IF(NTRCK.EQ.3)GO TO 33Ø
      IF(NTRCK.EQ.2)GO TO 32Ø
      IF(NTRCK.EQ.1)GO TO 31Ø
      NOØ=NOØ+1
      RRTØ(NOØ)=RT
      GO TO 36Ø
39Ø   NO9=NO9+1
      RRT9(NO9)=RT
      GO TO 36Ø
38Ø   NO8=NO8+1
      RRT8(NO8)=RT
      GO TO 36Ø
37Ø   NO7=NO7+1
      RRT7(NO7)=RT
      GO TO 36Ø
366   NO6=NO6+1
      RRT6(NO6)=RT
      GO TO 36Ø
35Ø   NO5=NO5+1
      RRT5(NO5)=RT
      GO TO 36Ø
34Ø   NO4=NO4+1
      RRT4(NO4)=RT
      GO TO 36Ø
33Ø   NO3=NO3+1
      RRT3(NO3)=RT
      GO TO 36Ø
32Ø   NO2=NO2+1
      RRT2(NO2)=RT
      GO TO 36Ø
31Ø   NO1=NO1+1
```

EXP.B2 1

```
            RRT1(NO1)=RT
      360   CONTINUE
      300   CONTINUE
            DO 400 I1=1,10
            WRITE(6,4000)RRT0(I1),RRT1(I1),RRT2(I1),RRT3(I1),
     *                   RRT4(I1),RRT5(I1),RRT6(I1),RRT7(I1),
     *                   RRT8(I1),RRT9(I1)
      4000  FORMAT(5X,F6.2,5(6X,F6.2)/2X,4(6X,F6.2))
      400   CONTINUE
            WRITE(6,4001)
      4001  FORMAT(////////)
      101   CONTINUE
      100   CONTINUE
      102   CONTINUE
            WRITE(6,4400)
      4400  FORMAT(1H1////////////////////)
            RETURN
            END
```

APPENDIX C

The program for experiment III.

SRTEXP 1

```
      C     ******************************************************
      C     *                                                    *
      C     *                   MAIN PROGRAMM                    *
      C     *                        TO                          *
      C     *                      CONTROL                       *
      C     *             THE SIMPLE REACTION TIME               *
      C     *                     EXPERIMENT                     *
      C     *                                                    *
      C     ******************************************************
      C
      C
      C                       INSTRUMENT LAYOUT
      C
      C                  OUT40          INP40        INP41
      C
      C       BIT7       LED            START        RESPONSE
      C
      C
            DIMENSION  A1(15),A2(15),A3(15),A4(15)
      C
            CALL OUT40(0)
            CALL OUT41(0)
            WRITE(2,1000)
       1000 FORMAT('SUBJECT NAME ?')
            READ(1,1100)A1
       1100 FORMAT(15A4)
            WRITE(2,1200)
       1200 FORMAT('COMMENT ?')
            READ(1,1100)A2
            WRITE(2,1300)
       1300 FORMAT('START TIME ?')
            READ(1,1100)A3
            CALL BLK1
            CALL BLK2
            CALL BLK3
            CALL BLK4
            CALL BLK5
            CALL BLK6
            CALL BLK7
            WRITE(2,1400)
       1400 FORMAT('END TIME ?')
            READ(1,1100)A4
            WRITE(6,2000)A2,A1,A3,A4
       2000 FORMAT(1H1,10(/),4(10X,15A4//))
            CALL DTANL1
            CALL DTANL2
            CALL DTANL3
            CALL DTANL4
            CALL DTANL5
            CALL DTANL6
            CALL DTANL7
            WRITE(6,3000)
       3000 FORMAT(1H1,10(/))
```

SRTEXP 1

```
      STOP
      END
```

SRTEXP 2

```
      SUBROUTINE  BLK1
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/3,0,3,4,0,0,0,2,2,3,3,3,4,2,4,1,0,4,1,3,
     *           0,3,3,0,2,1,2,3,4,1,4,0,3,1,0,3,2,2,4,0,
     *           1,3,2,0,1,2,4,0,4,4,3,4,3,2,4,4,2,4,4,0,
     *           1,4,3,2,0,1,1,1,4,0,1,3,1,1,0,0,3,3,3,4,
     *           1,1,1,4,2,2,4,2,2,2,0,2,2,1,0,0,2,3,1,1/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 1...READY ?')
      CALL BLK0(ISTM,XRT)
      CALL FL1
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRTEXP 3

```
      SUBROUTINE  BLK2
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/0,1,1,0,2,0,4,4,1,3,3,1,0,1,1,3,0,1,2,3,
     *           2,1,2,2,3,3,3,0,2,1,4,0,4,2,2,1,4,3,2,0,
     *           0,4,2,1,4,4,1,3,2,0,2,1,0,3,0,4,4,2,4,3,
     *           2,1,1,1,0,2,4,4,3,3,1,3,3,0,0,2,1,3,4,2,
     *           4,1,3,4,2,3,3,1,4,2,0,2,0,4,4,0,3,4,0,0/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 2...READY ?')
      CALL BLK0(ISTM,XRT)
      CALL FL2
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRTEXP 4

```
      SUBROUTINE  BLK3
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/1,4,1,0,0,4,4,3,1,0,4,2,1,1,4,1,2,1,4,4,
     *           3,4,2,2,2,4,2,0,0,1,2,3,0,3,3,1,0,2,0,1,
     *           4,4,0,1,4,2,0,2,4,0,2,0,0,3,1,2,4,3,4,3,
     *           3,2,3,3,0,2,3,1,1,4,2,0,0,1,3,2,3,3,0,1,
     *           3,1,2,0,4,0,2,3,4,3,3,4,2,1,4,0,3,2,1,1/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 3...READY ?')
      CALL BLK0(ISTM,XRT)
      CALL FL3
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRTEXP 5

```
      SUBROUTINE  BLK4
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/0,0,0,3,4,3,4,0,2,4,1,0,1,4,4,4,0,1,1,2,
     *           2,1,0,1,3,2,0,4,4,4,4,0,1,1,3,0,1,3,3,0,
     *           3,1,2,4,3,2,2,3,4,0,1,3,0,3,4,2,2,2,3,1,
     *           2,0,1,3,2,0,1,4,2,2,4,3,1,0,3,0,4,2,3,0,
     *           2,2,4,1,3,4,4,1,2,4,1,1,1,3,0,2,3,2,3,0/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 4...READY ?')
      CALL BLK0(ISTM,XRT)
      CALL FL4
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRTEXP 6

```
      SUBROUTINE  BLK5
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/3,4,1,Ø,3,1,Ø,Ø,2,2,Ø,1,4,2,Ø,Ø,1,Ø,4,2,
     *           3,4,1,Ø,3,2,3,3,Ø,Ø,1,3,4,2,1,2,4,Ø,4,Ø,
     *           4,3,Ø,3,3,4,Ø,4,1,3,3,2,3,2,1,1,1,Ø,2,2,
     *           2,1,1,2,1,2,3,2,4,3,3,3,1,1,1,2,2,Ø,2,Ø,
     *           4,4,4,3,4,Ø,3,Ø,Ø,1,4,1,1,2,3,2,4,4,4,4/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 5...READY ?')
      CALL BLKØ(ISTM,XRT)
      CALL FL5
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRTEXP 7

```
      SUBROUTINE  BLK6
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/4,1,3,4,1,1,4,4,1,2,2,Ø,2,1,2,1,Ø,4,4,Ø,
     *           1,4,Ø,4,1,2,3,2,1,Ø,2,2,3,1,Ø,4,Ø,4,3,3,
     *           4,1,Ø,4,Ø,3,2,1,3,1,1,3,Ø,Ø,4,3,1,3,2,2,
     *           Ø,3,1,2,3,3,Ø,3,4,2,2,1,4,2,4,3,4,3,3,1,
     *           Ø,Ø,3,2,Ø,Ø,2,Ø,1,2,3,1,3,4,Ø,2,4,4,Ø,2/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 6...READY ?')
      CALL BLKØ(ISTM,XRT)
      CALL FL6
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRTEXP 8

```
      SUBROUTINE BLK7
      DIMENSION ISTM(1ØØ),XRT(1ØØ)
      DATA ISTM/Ø,2,Ø,1,1,4,4,3,3,Ø,2,Ø,1,4,2,Ø,1,Ø,3,2,
     *          3,3,3,3,3,2,4,3,4,Ø,2,1,2,4,1,Ø,1,3,Ø,2,
     *          Ø,1,1,1,2,3,4,1,4,3,2,1,2,1,Ø,4,3,2,4,1,
     *          2,Ø,Ø,3,3,1,3,1,Ø,1,4,Ø,Ø,1,2,4,3,Ø,4,4,
     *          2,4,1,3,2,3,2,2,1,4,Ø,4,Ø,4,2,2,4,3,Ø,4/
      WRITE(2,1ØØØ)
 1ØØØ FORMAT('BLOCK 7...READY ?')
      CALL BLKØ(ISTM,XRT)
      CALL FL7
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRTEXP 9

```
      SUBROUTINE BLK0(ISTM,XRT)
C
      DIMENSION ISTM(100),XRT(100)
C
      READ(1,1001)A
1001  FORMAT(A4)
100   CALL INP40(IRES)
      IF(IRES.EQ.0)GO TO 100
      CALL INTLTM
101   CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.50)GO TO 101
      CALL OUT40(128)
102   CALL INP41(IRES)
      IF(IRES.EQ.0)GO TO 102
      CALL OUT40(0)
      DO 110 I1=1,2
      CALL INTLTM
111   CALL TMR(I10MS,ISEC)
      IF(ISEC.LT.2)GO TO 111
      CALL OUT40(128)
112   CALL INP41(IRES)
      IF(IRES.EQ.0)GO TO 112
      CALL OUT40(0)
110   CONTINUE
      DO 200 I2=1,100
      CALL INTLTM
      I21=ISTM(I2)
      ITI=100
201   IF(I21.EQ.0)GO TO 211
      ITI=IFIX(FLOAT(ITI)*1.3)
      I21=I21-1
      GO TO 201
211   CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.ITI)GO TO 211
      CALL OUT40(128)
      CALL INTLTM
212   CALL INP41(IRES)
      CALL TMR(I10MS,ISEC)
      IF(IRES.EQ.0)GO TO 212
      CALL OUT40(0)
      XRT(I2)=FLOAT(I10MS)/100.0
200   CONTINUE
      CALL OWARI
      RETURN
      END
```

10

SRTEXP 10

```
      SUBROUTINE  DTANL1
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL  FL1
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 1'///
     *       1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRTEXP 11

```
      SUBROUTINE  DTANL2
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL  FL2
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 2'///
     *       1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRTEXP 12

```
      SUBROUTINE  DTANL3
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL  FL3
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 3'///
     *       1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRTEXP 13

```
      SUBROUTINE  DTANL4
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL4
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 4'///
     *          1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRTEXP 14

```
      SUBROUTINE  DTANL5
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL5
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 5'///
     *          1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRTEXP 15

```
      SUBROUTINE  DTANL6
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL6
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 6'///
     *          1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRTEXP 16

```
      SUBROUTINE  DTANL7
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL7
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 7'///
     *        1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRTEXP 17

```
      SUBROUTINE DTANL0(ISTM,XRT)
C
      DIMENSION ISTM(100),XRT(100),XITI(5),XTBL(5,5,10),
     *          JTBL(5,5),XSTM(5),XXRT(5)
C
      DO 100 I1=1,20
      DO 110 I11=1,5
      J1=(I1-1)*5+I11
      XXRT(I11)=XRT(J1)
      KSTM=100
      KSTP=ISTM(J1)
  112 IF(KSTP.EQ.0)GO TO 111
      KSTM=IFIX(FLOAT(KSTM)*1.3)
      KSTP=KSTP-1
      GO TO 112
  111 XSTM(I11)=FLOAT(KSTM)/100.0
  110 CONTINUE
      WRITE(6,1100)(XSTM(J1),XXRT(J1),J1=1,5)
 1100 FORMAT(1X,5(F5.2,F6.2,3X))
  100 CONTINUE
C
C
      DO 200 I2=1,5
      DO 201 I21=1,5
      DO 202 I22=1,10
      XTBL(I2,I21,I22)=99999.9
  202 CONTINUE
      JTBL(I2,I21)=0
  201 CONTINUE
  200 CONTINUE
      K2=ISTM(1)+1
      DO 210 I2=2,100
      K1=K2
      K2=ISTM(I2)+1
      JTBL(K1,K2)=JTBL(K1,K2)+1
      K3=JTBL(K1,K2)
      XTBL(K1,K2,K3)=XRT(I2)
  210 CONTINUE
      KITI=100
      DO 300 I3=1,5
      XITI(I3)=FLOAT(KITI)/100.0
      KITI=IFIX(FLOAT(KITI)*1.3)
  300 CONTINUE
      WRITE(6,2000)
 2000 FORMAT(1H1,5X,'CONTINGENCY TABLES')
      DO 400 I4=1,5
      WRITE(6,2100)XITI(I4),(XITI(J4),J4=1,5)
 2100 FORMAT(///15X,'RT''S FOR',F5.2,1X,'SEC. FP'//
     *       12X,'CONTINGENT ON PREVIUOS FP''S.'//
     *       10X,5(F5.2,' SEC.')//)
      WRITE(6,2200)((XTBL(JK1,I4,JK2),JK1=1,5),JK2=1,10)
 2200 FORMAT(10(10X,5(F5.2,5X),/))
  400 CONTINUE
```

18

SRTEXP 17

```
C
C
      RETURN
      END
```

APPENDIX D

The programs for experiment IV.

The program for the continuous(in session 1)-then-discrete(in session 2) condition.

SRT.C.D   1

```
C     ****************************************************
C     *                                                  *
C     *                MAIN PROGRAMM                     *
C     *                     TO                           *
C     *                  CONTROL                         *
C     *           THE SIMPLE REACTION TIME               *
C     *                EXPERIMENT                        *
C     *       (CONTINUOUS-DISCRETE CONTEXT)              *
C     *                                                  *
C     ****************************************************
C
C
C                    INSTRUMENT LAYOUT
C
C               OUT40      OUT41      INP40      INP41
C
C     BIT7      LED        BUZZER     START      RESPONSE
C
C
      DIMENSION  A1(15),A3(15),A4(15)
C
      CALL OUT40(0)
      CALL OUT41(0)
      WRITE(2,1200)
 1200 FORMAT(//'CONTINUOUS-DISCRETE CONTEXT CONDITION.'//)
      WRITE(2,1000)
 1000 FORMAT('SUBJECT NAME ?')
      READ(1,1100)A1
 1100 FORMAT(15A4)
      WRITE(2,1300)
 1300 FORMAT('START TIME ?')
      READ(1,1100)A3
      CALL BLK1C
      CALL BLK2C
      CALL BLK3C
      CALL BLK4C
      CALL BLK5C
      WRITE(2,4000)
 4000 FORMAT(///'CONTEXT WILL CHANGE.'/
     *       'ATTENTION PLEASE !'//)
      CALL BLK6D
      CALL BLK7D
      CALL BLK8D
      CALL BLK9D
      CALL BLKAD
      WRITE(2,1400)
 1400 FORMAT('END TIME ?')
      READ(1,1100)A4
      WRITE(6,2000)A1,A3,A4
 2000 FORMAT(1H1,10(/),10X,
     *       '****  CONTINUOUS-DISCRETE CONTEXT  ****'
     *       ///,3(10X,15A4//))
      CALL DTANL1
```

SRT.C.D 1

```
        CALL DTANL2
        CALL DTANL3
        CALL DTANL4
        CALL DTANL5
        CALL DTANL6
        CALL DTANL7
        CALL DTANL8
        CALL DTANL9
        CALL DTANLA
        WRITE(6,3000)
 3000   FORMAT(1H1,10(/))
        STOP
        END
```

SRT.C.D 2

```
           SUBROUTINE  BLK1C
           DIMENSION ISTM(100),XRT(100)
           DATA  ISTM/3,0,3,4,0,0,0,2,2,3,3,3,4,2,4,1,0,4,1,3,
                      0,3,3,0,2,1,2,3,4,1,4,0,3,1,0,3,2,2,4,0,
          *           1,3,2,0,1,2,4,0,4,4,3,4,3,2,4,4,2,4,4,0,
          *           1,4,3,2,0,1,1,1,4,0,1,3,1,1,0,0,3,3,3,4,
          *           1,1,1,4,2,2,4,2,2,2,0,2,2,1,0,0,2,3,1,1/
          *
           WRITE(2,1000)
      1000 FORMAT('BLOCK 1...READY ?')
           CALL BLK0C(ISTM,XRT)
           CALL FL1
           REWIND 8
           WRITE(8)ISTM,XRT
           RETURN
           END
```

SRT.C.D 3

```
           SUBROUTINE  BLK2C
           DIMENSION ISTM(100),XRT(100)
           DATA  ISTM/0,1,1,0,2,0,4,4,1,3,3,1,0,1,1,3,0,1,2,3,
          *           2,1,2,2,3,3,3,0,2,1,4,0,4,2,2,1,4,3,2,0,
          *           0,4,2,1,4,4,1,3,2,0,2,1,0,3,0,4,4,2,4,3,
          *           2,1,1,1,0,2,4,4,3,3,1,3,3,0,0,2,1,3,4,2,
          *           4,1,3,4,2,3,3,1,4,2,0,2,0,4,4,0,3,4,0,0/
           WRITE(2,1000)
      1000 FORMAT('BLOCK 2...READY ?')
           CALL BLK0C(ISTM,XRT)
           CALL FL2
           REWIND 8
           WRITE(8)ISTM,XRT
           RETURN
           END
```

SRT.C.D 4

```
            SUBROUTINE  BLK3C
            DIMENSION ISTM(100),XRT(100)
            DATA  ISTM/1, 4, 1, 0, 0, 4, 4, 3, 1, 0, 4, 2, 1, 1, 4, 1, 2, 1, 4, 4,
     *                 3, 4, 2, 2, 2, 4, 2, 0, 0, 1, 2, 3, 0, 3, 3, 1, 0, 2, 0, 1,
     *                 4, 4, 0, 1, 4, 2, 0, 2, 4, 0, 2, 0, 0, 3, 1, 2, 4, 3, 4, 3,
     *                 3, 2, 3, 3, 0, 2, 3, 1, 1, 4, 2, 0, 0, 1, 3, 2, 3, 3, 0, 1,
     *                 3, 1, 2, 0, 4, 0, 2, 3, 4, 3, 3, 4, 2, 1, 4, 0, 3, 2, 1, 1/
            WRITE(2, 1000)
     1000   FORMAT('BLOCK 3...READY ?')
            CALL BLK0C(ISTM,XRT)
            CALL FL3
            REWIND 8
            WRITE(8)ISTM,XRT
            RETURN
            END
```

SRT.C.D 5

```
            SUBROUTINE  BLK4C
            DIMENSION ISTM(100),XRT(100)
            DATA  ISTM/0, 0, 0, 3, 4, 3, 4, 0, 2, 4, 1, 0, 1, 4, 4, 4, 0, 1, 1, 2,
     *                 2, 1, 0, 1, 3, 2, 0, 4, 4, 4, 4, 0, 1, 1, 3, 0, 1, 3, 3, 0,
     *                 3, 1, 2, 4, 3, 2, 2, 3, 4, 0, 1, 3, 0, 3, 4, 2, 2, 2, 3, 1,
     *                 2, 0, 1, 3, 2, 0, 1, 4, 2, 2, 4, 3, 1, 0, 3, 0, 4, 2, 3, 0,
     *                 2, 2, 4, 1, 3, 4, 4, 1, 2, 4, 1, 1, 1, 3, 0, 2, 3, 2, 3, 0/
            WRITE(2, 1000)
     1000   FORMAT('BLOCK 4...READY ?')
            CALL BLK0C(ISTM,XRT)
            CALL FL4
            REWIND 8
            WRITE(8)ISTM,XRT
            RETURN
            END
```

SRT.C.D 6

```
      SUBROUTINE  BLK5C
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/3,4,1,0,3,1,0,0,2,2,0,1,4,2,0,0,1,0,4,2,
     *           3,4,1,0,3,2,3,3,0,0,1,3,4,2,1,2,4,0,4,0,
     *           4,3,0,3,3,4,0,4,1,3,3,2,3,2,1,1,1,0,2,2,
     *           2,1,1,2,1,2,3,2,4,3,3,3,1,1,1,2,2,0,2,0,
     *           4,4,4,3,4,0,3,0,0,1,4,1,1,2,3,2,4,4,4,4/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 5...READY ?')
      CALL BLK0C(ISTM,XRT)
      CALL FL5
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRT.C.D 7

```
      SUBROUTINE  BLK6D
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/4,1,3,4,1,1,4,4,1,2,2,0,2,1,2,1,0,4,4,0,
     *           1,4,0,4,1,2,3,2,1,0,2,2,3,1,0,4,0,4,3,3,
     *           4,1,0,4,0,3,2,1,3,1,1,3,0,0,4,3,1,3,2,2,
     *           0,3,1,2,3,3,0,3,4,2,2,1,4,2,4,3,4,3,3,1,
     *           0,0,3,2,0,0,2,0,1,2,3,1,3,4,0,2,4,4,0,2/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 6...READY ?')
      CALL BLK0D(ISTM,XRT)
      CALL FL6
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRT.C.D 8

```
              SUBROUTINE  BLK7D
              DIMENSION ISTM(100),XRT(100)
              DATA  ISTM/0,2,0,1,1,4,4,3,3,0,2,0,1,4,2,0,1,0,3,2,
     *                   3,3,3,3,3,2,4,3,4,0,2,1,2,4,1,0,1,3,0,2,
     *                   0,1,1,1,2,3,4,1,4,3,2,1,2,1,0,4,3,2,4,1,
     *                   2,0,0,3,3,1,3,1,0,1,4,0,0,1,2,4,3,0,4,4,
     *                   2,4,1,3,2,3,2,2,1,4,0,4,0,4,2,2,4,3,0,4/
              WRITE(2,1000)
        1000  FORMAT('BLOCK 7...READY ?')
              CALL BLK0D(ISTM,XRT)
              CALL FL7
              REWIND 8
              WRITE(8)ISTM,XRT
              RETURN
              END
```

SRT.C.D 9

```
              SUBROUTINE  BLK8D
              DIMENSION ISTM(100),XRT(100)
              DATA  ISTM/2,4,2,4,2,1,1,2,4,4,2,2,1,0,2,0,1,3,3,0,
     *                   4,0,3,2,4,2,2,3,4,1,4,1,1,0,1,3,1,3,0,1,
     *                   2,3,2,1,4,0,2,1,3,3,1,2,4,4,1,2,4,0,4,1,
     *                   0,4,4,1,3,4,0,1,3,0,0,3,0,0,3,0,2,4,3,1,
     *                   2,3,0,2,1,0,2,2,0,3,4,3,1,4,3,4,0,0,3,3/
              WRITE(2,1000)
        1000  FORMAT('BLOCK 8...READY ?')
              CALL BLK0D(ISTM,XRT)
              CALL FL8
              REWIND 8
              WRITE(8)ISTM,XRT
              RETURN
              END
```

SRT.C.D 1Ø

```
      SUBROUTINE  BLK9D
      DIMENSION ISTM(1ØØ),XRT(1ØØ)
      DATA  ISTM/1, 3, 2, 1, 4, 3, 4, 4, 1, 4, 4, 3, 4, Ø, Ø, 1, 3, 4, 2, 2,
     *           3, Ø, 2, 4, Ø, Ø, 1, 1, 3, 3, 4, 4, Ø, 3, 1, Ø, Ø, 4, Ø, Ø,
     *           2, 3, 2, 3, Ø, 2, 4, 4, 2, 2, 4, Ø, 2, 1, 2, 3, 2, Ø, 1, 1,
     *           1, 3, 1, 1, 1, 2, 2, Ø, 4, Ø, Ø, 1, 1, 4, 4, 1, Ø, 3, 2, 2,
     *           2, 3, Ø, 3, 1, 3, 3, 1, 4, 1, Ø, Ø, 2, 3, 2, 3, 4, 3, 4, 2/
      WRITE(2, 1ØØØ)
1ØØØ  FORMAT('BLOCK 9...READY ?')
      CALL BLKØD(ISTM,XRT)
      CALL FL9
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRT.C.D 11

```
      SUBROUTINE  BLKAD
      DIMENSION ISTM(1ØØ),XRT(1ØØ)
      DATA  ISTM/3, 1, 4, 2, 3, 4, 4, 4, 1, Ø, Ø, 2, Ø, 3, Ø, 2, Ø, 2, 1, 3,
     *           Ø, Ø, 3, 1, 1, Ø, 4, 4, Ø, 1, 2, 2, 4, 2, 3, Ø, Ø, 3, Ø, 4,
     *           3, 1, 2, 4, Ø, 3, 4, 4, 2, Ø, 2, 1, 3, 1, 1, 3, Ø, 3, 1, 1,
     *           Ø, 4, 4, 2, Ø, 2, 3, 4, 4, 1, Ø, 2, Ø, 4, 4, 4, 2, 2, 2, 3,
     *           3, 2, 3, 2, 1, 3, 1, 4, 1, 4, 1, 3, 2, 1, 3, Ø, 3, 2, 1, 1/
      WRITE(2, 1ØØØ)
1ØØØ  FORMAT('BLOCK 1Ø...READY ?')
      CALL BLKØD(ISTM,XRT)
      CALL FLA
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRT.C.D 12

```
      SUBROUTINE BLK0C(ISTM,XRT)
C
      DIMENSION ISTM(100),XRT(100)
C
      READ(1,1001)A
 1001 FORMAT(A4)
 100  CALL INP40(IRES)
      IF(IRES.EQ.0)GO TO 100
      CALL INTLTM
 101  CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.50)GO TO 101
      CALL OUT40(128)
 102  CALL INP41(IRES)
      IF(IRES.EQ.0)GO TO 102
      CALL OUT40(0)
      DO 110 I1=1,2
      CALL INTLTM
 111  CALL TMR(I10MS,ISEC)
      IF(ISEC.LT.2)GO TO 111
      CALL OUT40(128)
 112  CALL INP41(IRES)
      IF(IRES.EQ.0)GO TO 112
      CALL OUT40(0)
 110  CONTINUE
      DO 200 I2=1,100
      CALL INTLTM
      I21=ISTM(I2)
      ITI=100
 201  IF(I21.EQ.0)GO TO 211
      ITI=IFIX(FLOAT(ITI)*1.3)
      I21=I21-1
      GO TO 201
 211  CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.ITI)GO TO 211
      CALL OUT40(128)
      CALL INTLTM
 212  CALL INP41(IRES)
      CALL TMR(I10MS,ISEC)
      IF(IRES.EQ.0)GO TO 212
      CALL OUT40(0)
      XRT(I2)=FLOAT(I10MS)/100.0
 200  CONTINUE
      CALL OWARI
      RETURN
      END
```

SRT.C.D 13

```
      SUBROUTINE  BLKØD(ISTM,XRT)
C
      DIMENSION ISTM(1ØØ),XRT(1ØØ)
C
      READ(1,1ØØ1)A
1ØØ1  FORMAT(A4)
      DO 11Ø I1=1,2
      CALL BUZZER
      CALL INTLTM
111   CALL TMR(I1ØMS,ISEC)
      IF(ISEC.LT.2)GO TO 111
      CALL OUT4Ø(128)
112   CALL INP41(IRES)
      IF(IRES.EQ.Ø)GO TO 112
      CALL OUT4Ø(Ø)
11Ø   CONTINUE
      DO 2ØØ I2=1,1ØØ
      CALL BUZZER
      CALL INTLTM
      I21=ISTM(I2)
      ITI=1ØØ
2Ø1   IF(I21.EQ.Ø)GO TO 211
      ITI=IFIX(FLOAT(ITI)*1.3)
      I21=I21-1
      GO TO 2Ø1
211   CALL TMR(I1ØMS,ISEC)
      IF(I1ØMS.LT.ITI)GO TO 211
      CALL OUT4Ø(128)
      CALL INTLTM
212   CALL INP41(IRES)
      CALL TMR(I1ØMS,ISEC)
      IF(IRES.EQ.Ø)GO TO 212
      CALL OUT4Ø(Ø)
      XRT(I2)=FLOAT(I1ØMS)/1ØØ.Ø
2ØØ   CONTINUE
      CALL OWARI
      RETURN
      END
```

SRT.C.D 14

```
      SUBROUTINE BUZZER
      CALL INTLTM
300   CALL TMR(I10MS,ISEC)
      CALL INP40(IRES)
      IF(IRES.NE.0)GO TO 400
      IF(I10MS.LT.50)GO TO 300
      CALL INTLTM
      CALL OUT41(128)
100   CALL TMR(I10MS,ISEC)
      CALL INP40(IRES)
      IF(IRES.NE.0)GO TO 400
      IF(I10MS.LT.20)GO TO 100
420   CALL OUT41(0)
      CALL INTLTM
500   CALL TMR(I10MS,ISEC)
      CALL INP40(IRES)
      IF(IRES.NE.0)GO TO 400
      IF(I10MS.LT.10)GO TO 500
200   CALL INP40(IRES)
      IF(IRES.EQ.0)GO TO 200
      RETURN
C
400   CALL INP40(IRES)
      CALL OUT41(128)
      IF(IRES.NE.0)GO TO 400
      CALL INTLTM
410   CALL TMR(I10MS,ISEC)
      IF(ISEC.LT.5)GO TO 410
      GO TO 420
C
      END
```

SRT.C.D 15

```
        SUBROUTINE  DTANL1
C
        DIMENSION  ISTM(100),XRT(100)
C
        CALL FL1
        REWIND 8
        READ(8)ISTM,XRT
        WRITE(6,1000)
 1000   FORMAT(1H1,10X,'DATA OF BLOCK 1'///
      *        1X,5('ITI   RT(SEC)   '),//)
        CALL DTANL0(ISTM,XRT)
        RETURN
        END
```

SRT.C.D 16

```
        SUBROUTINE  DTANL2
C
        DIMENSION  ISTM(100),XRT(100)
C
        CALL FL2
        REWIND 8
        READ(8)ISTM,XRT
        WRITE(6,1000)
 1000   FORMAT(1H1,10X,'DATA OF BLOCK 2'///
      *        1X,5('ITI   RT(SEC)   '),//)
        CALL DTANL0(ISTM,XRT)
        RETURN
        END
```

SRT.C.D 17

```
        SUBROUTINE  DTANL3
C
        DIMENSION  ISTM(100),XRT(100)
C
        CALL FL3
        REWIND 8
        READ(8)ISTM,XRT
        WRITE(6,1000)
 1000   FORMAT(1H1,10X,'DATA OF BLOCK 3'///
      *        1X,5('ITI   RT(SEC)   '),//)
        CALL DTANL0(ISTM,XRT)
        RETURN
        END
```

SRT.C.D 18

```
      SUBROUTINE  DTANL4
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL4
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 4'///
     *       1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.C.D 19

```
      SUBROUTINE  DTANL5
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL5
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 5'///
     *       1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.C.D 20

```
      SUBROUTINE  DTANL6
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL6
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 6'///
     *       1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.C.D 21

```
      SUBROUTINE  DTANL7
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL7
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 7'///
     *        1X,5('ITI   RT(SEC)    '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.C.D 22

```
      SUBROUTINE  DTANL8
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL8
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 8'///
     *        1X,5('ITI   RT(SEC)    '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.C.D 23

```
      SUBROUTINE  DTANL9
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL9
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 9'///
     *        1X,5('ITI   RT(SEC)    '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.C.D 24

```
      SUBROUTINE  DTANLA
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FLA
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(IH1,10X,'DATA OF BLOCK 10'///
     *        1X,5('ITI   RT(SEC)    '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.C.D 25

```
          SUBROUTINE  DTANL0(ISTM,XRT)
C
          DIMENSION  ISTM(100),XRT(100),XITI(5),XTBL(5,5,10),
        *            JTBL(5,5),XSTM(5),XXRT(5)
C
          DO 100 I1=1,20
          DO 110 I11=1,5
          J1=(I1-1)*5+I11
          XXRT(I11)=XRT(J1)
          KSTM=100
          KSTP=ISTM(J1)
    112   IF(KSTP.EQ.0)GO TO 111
          KSTM=IFIX(FLOAT(KSTM)*1.3)
          KSTP=KSTP-1
          GO TO 112
    111   XSTM(I11)=FLOAT(KSTM)/100.0
    110   CONTINUE
          WRITE(6,1100)(XSTM(J1),XXRT(J1),J1=1,5)
   1100   FORMAT(1X,5(F5.2,F6.2,3X))
    100   CONTINUE
C
C
          DO 200 I2=1,5
          DO 201 I21=1,5
          DO 202 I22=1,10
          XTBL(I2,I21,I22)=99999.9
    202   CONTINUE
          JTBL(I2,I21)=0
    201   CONTINUE
    200   CONTINUE
          K2=ISTM(1)+1
          DO 210 I2=2,100
          K1=K2
          K2=ISTM(I2)+1
          JTBL(K1,K2)=JTBL(K1,K2)+1
          K3=JTBL(K1,K2)
          XTBL(K1,K2,K3)=XRT(I2)
    210   CONTINUE
          KITI=100
          DO 300 I3=1,5
          XITI(I3)=FLOAT(KITI)/100.0
          KITI=IFIX(FLOAT(KITI)*1.3)
    300   CONTINUE
          WRITE(6,2000)
   2000   FORMAT(1H1,5X,'CONTINGENCY TABLES')
          DO 400 I4=1,5
          WRITE(6,2100)XITI(I4),(XITI(J4),J4=1,5)
   2100   FORMAT(///15X,'RT''S FOR',F5.2,1X,'SEC. FP'//
        *        12X,'CONTINGENT ON PREVIUOS FP''S.'//
        *        10X,5(F5.2,' SEC.')//)
          WRITE(6,2200)((XTBL(JK1,I4,JK2),JK1=1,5),JK2=1,10)
   2200   FORMAT(10(10X,5(F5.2,5X),/))
    400   CONTINUE
```

26

```
SRT.C.D  25

    54: C
    55: C
    56:          RETURN
    57:          END
```

The program for the discrete(in session 1)-then-continuous(in session 2) condition.

SRT.D.C 1

```
C    *****************************************************
C    *                                                   *
C    *                  MAIN PROGRAMM                    *
C    *                       TO                          *
C    *                     CONTROL                       *
C    *            THE SIMPLE REACTION TIME               *
C    *                   EXPERIMENT                      *
C    *         (DISCRETE-CONTINUOUS CONTEXT)             *
C    *                                                   *
C    *****************************************************
C
C
C                      INSTRUMENT LAYOUT
C
C               OUT40      OUT41      INP40      INP41
C
C     BIT7       LED       BUZZER     START     RESPONSE
C
C
        DIMENSION  A1(15), A3(15), A4(15)
C
        CALL OUT40(0)
        CALL OUT41(0)
        WRITE(2,1200)
  1200  FORMAT(//'DISCRETE-CONTINUOUS CONTEXT CONDITION.'//)
        WRITE(2,1000)
  1000  FORMAT('SUBJECT NAME ?')
        READ(1,1100)A1
  1100  FORMAT(15A4)
        WRITE(2,1300)
  1300  FORMAT('START TIME ?')
        READ(1,1100)A3
        CALL BLK1D
        CALL BLK2D
        CALL BLK3D
        CALL BLK4D
        CALL BLK5D
        WRITE(2,4000)
  4000  FORMAT(///'CONTEXT WILL CHANGE.'/
       *        'ATTENTION PLEASE !'//)
        CALL BLK6C
        CALL BLK7C
        CALL BLK8C
        CALL BLK9C
        CALL BLKAC
        WRITE(2,1400)
  1400  FORMAT('END TIME ?')
        READ(1,1100)A4
        WRITE(6,2000)A1,A3,A4
  2000  FORMAT(1H1,10(/),10X,
       *        '****  DISCRETE-CONTINUOUS CONTEXT  ****'
       *        ///,3(10X,15A4//))
        CALL DTANL1
```

SRT.D.C 1

```
        CALL DTANL2
        CALL DTANL3
        CALL DTANL4
        CALL DTANL5
        CALL DTANL6
        CALL DTANL7
        CALL DTANL8
        CALL DTANL9
        CALL DTANLA
        WRITE(6,3000)
  3000  FORMAT(1H1,10(/))
        STOP
        END
```

SRT.D.C 2

```
      SUBROUTINE  BLK1D
      DIMENSION ISTM(1ØØ),XRT(1ØØ)
      DATA  ISTM/3,Ø,3,4,Ø,Ø,Ø,2,2,3,3,3,4,2,4,1,Ø,4,1,3,
     *           Ø,3,3,Ø,2,1,2,3,4,1,4,Ø,3,1,Ø,3,2,2,4,Ø,
     *           1,3,2,Ø,1,2,4,Ø,4,4,3,4,3,2,4,4,2,4,4,Ø,
     *           1,4,3,2,Ø,1,1,1,4,Ø,1,3,1,1,Ø,Ø,3,3,3,4,
     *           1,1,1,4,2,2,4,2,2,2,Ø,2,2,1,Ø,Ø,2,3,1,1/
      WRITE(2,1ØØØ)
 1ØØØ FORMAT('BLOCK 1...READY ?')
      CALL BLKØD(ISTM,XRT)
      CALL FL1
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRT.D.C 3

```
      SUBROUTINE  BLK2D
      DIMENSION ISTM(1ØØ),XRT(1ØØ)
      DATA  ISTM/Ø,1,1,Ø,2,Ø,4,4,1,3,3,1,Ø,1,1,3,Ø,1,2,3,
     *           2,1,2,2,3,3,3,Ø,2,1,4,Ø,4,2,2,1,4,3,2,Ø,
     *           Ø,4,2,1,4,4,1,3,2,Ø,2,1,Ø,3,Ø,4,4,2,4,3,
     *           2,1,1,1,Ø,2,4,4,3,3,1,3,3,Ø,Ø,2,1,3,4,2,
     *           4,1,3,4,2,3,3,1,4,2,Ø,2,Ø,4,4,Ø,3,4,Ø,Ø/
      WRITE(2,1ØØØ)
 1ØØØ FORMAT('BLOCK 2...READY ?')
      CALL BLKØD(ISTM,XRT)
      CALL FL2
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRT.D.C 4

```
       SUBROUTINE  BLK3D
       DIMENSION ISTM(100),XRT(100)
       DATA  ISTM/1,4,1,0,0,4,4,3,1,0,4,2,1,1,4,1,2,1,4,4,
     *           3,4,2,2,2,4,2,0,0,1,2,3,0,3,3,1,0,2,0,1,
     *           4,4,0,1,4,2,0,2,4,0,2,0,0,3,1,2,4,3,4,3,
     *           3,2,3,3,0,2,3,1,1,4,2,0,0,1,3,2,3,3,0,1,
     *           3,1,2,0,4,0,2,3,4,3,3,4,2,1,4,0,3,2,1,1/
       WRITE(2,1000)
 1000  FORMAT('BLOCK 3...READY ?')
       CALL BLK0D(ISTM,XRT)
       CALL FL3
       REWIND 8
       WRITE(8)ISTM,XRT
       RETURN
       END
```

SRT.D.C 5

```
       SUBROUTINE  BLK4D
       DIMENSION ISTM(100),XRT(100)
       DATA  ISTM/0,0,0,3,4,3,4,0,2,4,1,0,1,4,4,4,0,1,1,2,
     *           2,1,0,1,3,2,0,4,4,4,4,0,1,1,3,0,1,3,3,0,
     *           3,1,2,4,3,2,2,3,4,0,1,3,0,3,4,2,2,2,3,1,
     *           2,0,1,3,2,0,1,4,2,2,4,3,1,0,3,0,4,2,3,0,
     *           2,2,4,1,3,4,4,1,2,4,1,1,1,3,0,2,3,2,3,0/
       WRITE(2,1000)
 1000  FORMAT('BLOCK 4...READY ?')
       CALL BLK0D(ISTM,XRT)
       CALL FL4
       REWIND 8
       WRITE(8)ISTM,XRT
       RETURN
       END
```

SRT.D.C 6

```
      SUBROUTINE  BLK5D
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/3,4,1,0,3,1,0,0,2,2,0,1,4,2,0,0,1,0,4,2,
     *          3,4,1,0,3,2,3,3,0,0,1,3,4,2,1,2,4,0,4,0,
     *          4,3,0,3,3,4,0,4,1,3,3,2,3,2,1,1,1,0,2,2,
     *          2,1,1,2,1,2,3,2,4,3,3,3,1,1,1,2,2,0,2,0,
     *          4,4,4,3,4,0,3,0,0,1,4,1,1,2,3,2,4,4,4,4/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 5...READY ?')
      CALL BLK0D(ISTM,XRT)
      CALL FL5
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRT.D.C 7

```
      SUBROUTINE  BLK6C
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/4,1,3,4,1,1,4,4,1,2,2,0,2,1,2,1,0,4,4,0,
     *          1,4,0,4,1,2,3,2,1,0,2,2,3,1,0,4,0,4,3,3,
     *          4,1,0,4,0,3,2,1,3,1,1,3,0,0,4,3,1,3,2,2,
     *          0,3,1,2,3,3,0,3,4,2,2,1,4,2,4,3,4,3,3,1,
     *          0,0,3,2,0,0,2,0,1,2,3,1,3,4,0,2,4,4,0,2/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 6...READY ?')
      CALL BLK0C(ISTM,XRT)
      CALL FL6
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRT.D.C 8

```
      SUBROUTINE  BLK7C
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/0,2,0,1,1,4,4,3,3,0,2,0,1,4,2,0,1,0,3,2,
     *           3,3,3,3,3,2,4,3,4,0,2,1,2,4,1,0,1,3,0,2,
     *           0,1,1,1,2,3,4,1,4,3,2,1,2,1,0,4,3,2,4,1,
     *           2,0,0,3,3,1,3,1,0,1,4,0,0,1,2,4,3,0,4,4,
     *           2,4,1,3,2,3,2,2,1,4,0,4,0,4,2,2,4,3,0,4/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 7...READY ?')
      CALL BLK0C(ISTM,XRT)
      CALL FL7
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRT.D.C 9

```
      SUBROUTINE  BLK8C
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/2,4,2,4,2,1,1,2,4,4,2,2,1,0,2,0,1,3,3,0,
     *           4,0,3,2,4,2,2,3,4,1,4,1,1,0,1,3,1,3,0,1,
     *           2,3,2,1,4,0,2,1,3,3,1,2,4,4,1,2,4,0,4,1,
     *           0,4,4,1,3,4,0,1,3,0,0,3,0,0,3,0,2,4,3,1,
     *           2,3,0,2,1,0,2,2,0,3,4,3,1,4,3,4,0,0,3,3/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 8...READY ?')
      CALL BLK0C(ISTM,XRT)
      CALL FL8
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRT.D.C 10

```
      SUBROUTINE  BLK9C
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/1,3,2,1,4,3,4,4,1,4,4,3,4,0,0,1,3,4,2,2,
     *           3,0,2,4,0,0,1,1,3,3,4,4,0,3,1,0,0,4,0,0,
     *           2,3,2,3,0,2,4,4,2,2,4,0,2,1,2,3,2,0,1,1,
     *           1,3,1,1,1,2,2,0,4,0,0,1,1,4,4,1,0,3,2,2,
     *           2,3,0,3,1,3,3,1,4,1,0,0,2,3,2,3,4,3,4,2/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 9...READY ?')
      CALL BLK0C(ISTM,XRT)
      CALL FL9
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRT.D.C 11

```
      SUBROUTINE  BLKAC
      DIMENSION ISTM(100),XRT(100)
      DATA  ISTM/3,1,4,2,3,4,4,4,1,0,0,2,0,3,0,2,0,2,1,3,
     *           0,0,3,1,1,0,4,4,0,1,2,2,4,2,3,0,0,3,0,4,
     *           3,1,2,4,0,3,4,4,2,0,2,1,3,1,1,3,0,3,1,1,
     *           0,4,4,2,0,2,3,4,4,1,0,2,0,4,4,4,2,2,2,3,
     *           3,2,3,2,1,3,1,4,1,4,1,3,2,1,3,0,3,2,1,1/
      WRITE(2,1000)
 1000 FORMAT('BLOCK 10...READY ?')
      CALL BLK0C(ISTM,XRT)
      CALL FLA
      REWIND 8
      WRITE(8)ISTM,XRT
      RETURN
      END
```

SRT.D.C 12

```
      SUBROUTINE  ELK0C(ISTM,XRT)
C
      DIMENSION ISTM(100),XRT(100)
C
      READ(1,1001)A
1001  FORMAT(A4)
100   CALL INP40(IRES)
      IF(IRES.EQ.0)GO TO 100
      CALL INTLTM
101   CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.50)GO TO 101
      CALL OUT40(128)
102   CALL INP41(IRES)
      IF(IRES.EQ.0)GO TO 102
      CALL OUT40(0)
      DO 110 I1=1,2
      CALL INTLTM
111   CALL TMR(I10MS,ISEC)
      IF(ISEC.LT.2)GO TO 111
      CALL OUT40(128)
112   CALL INP41(IRES)
      IF(IRES.EQ.0)GO TO 112
      CALL OUT40(0)
110   CONTINUE
      DO 200 I2=1,100
      CALL INTLTM
      I21=ISTM(I2)
      ITI=100
201   IF(I21.EQ.0)GO TO 211
      ITI=IFIX(FLOAT(ITI)*1.3)
      I21=I21-1
      GO TO 201
211   CALL TMR(I10MS,ISEC)
      IF(I10MS.LT.ITI)GO TO 211
      CALL OUT40(128)
      CALL INTLTM
212   CALL INP41(IRES)
      CALL TMR(I10MS,ISEC)
      IF(IRES.EQ.0)GO TO 212
      CALL OUT40(0)
      XRT(I2)=FLOAT(I10MS)/100.0
200   CONTINUE
      CALL OWARI
      RETURN
      END
```

SRT.D.C 13

```
          SUBROUTINE  BLKØD(ISTM,XRT)
C
          DIMENSION ISTM(1ØØ),XRT(1ØØ)
C
          READ(1,1ØØ1)A
1ØØ1      FORMAT(A4)
          DO 11Ø I1=1,2
          CALL BUZZER
          CALL INTLTM
111       CALL TMR(I1ØMS,ISEC)
          IF(ISEC.LT.2)GO TO 111
          CALL OUT4Ø(128)
112       CALL INP41(IRES)
          IF(IRES.EQ.Ø)GO TO 112
          CALL OUT4Ø(Ø)
11Ø       CONTINUE
          DO 2ØØ I2=1,1ØØ
          CALL BUZZER
          CALL INTLTM
          I21=ISTM(I2)
          ITI=1ØØ
2Ø1       IF(I21.EQ.Ø)GO TO 211
          ITI=IFIX(FLOAT(ITI)*1.3)
          I21=I21-1
          GO TO 2Ø1
211       CALL TMR(I1ØMS,ISEC)
          IF(I1ØMS.LT.ITI)GO TO 211
          CALL OUT4Ø(128)
          CALL INTLTM
212       CALL INP41(IRES)
          CALL TMR(I1ØMS,ISEC)
          IF(IRES.EQ.Ø)GO TO 212
          CALL OUT4Ø(Ø)
          XRT(I2)=FLOAT(I1ØMS)/1ØØ.Ø
2ØØ       CONTINUE
          CALL OWARI
          RETURN
          END
```

SRT.D.C 14

```
         SUBROUTINE  BUZZER
         CALL INTLTM
   300   CALL TMR(I10MS,ISEC)
         CALL INP40(IRES)
         IF(IRES.NE.0)GO TO 400
         IF(I10MS.LT.50)GO TO 300
         CALL INTLTM
         CALL OUT41(128)
   100   CALL TMR(I10MS,ISEC)
         CALL INP40(IRES)
         IF(IRES.NE.0)GO TO 400
         IF(I10MS.LT.20)GO TO 100
   420   CALL OUT41(0)
         CALL INTLTM
   500   CALL TMR(I10MS,ISEC)
         CALL INP40(IRES)
         IF(IRES.NE.0)GO TO 400
         IF(I10MS.LT.10)GO TO 500
   200   CALL INP40(IRES)
         IF(IRES.EQ.0)GO TO 200
         RETURN
C
   400   CALL INP40(IRES)
         CALL OUT41(128)
         IF(IRES.NE.0)GO TO 400
         CALL INTLTM
   410   CALL TMR(I10MS,ISEC)
         IF(ISEC.LT.5)GO TO 410
         GO TO 420
C
         END
```

SRT.D.C 15

```
      SUBROUTINE  DTANL1
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL1
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 1'///
     *        1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.D.C 16

```
      SUBROUTINE  DTANL2
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL2
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 2'///
     *        1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.D.C 17

```
      SUBROUTINE  DTANL3
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL3
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 3'///
     *        1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.D.C 18

```
      SUBROUTINE  DTANL4
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL4
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 4'///
     *       1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.D.C 19

```
      SUBROUTINE  DTANL5
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL5
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 5'///
     *       1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.D.C 20

```
      SUBROUTINE  DTANL6
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL6
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 6'///
     *       1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.D.C 21

```
      SUBROUTINE  DTANL7
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL7
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 7'///
     *        1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.D.C 22

```
      SUBROUTINE  DTANL8
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL8
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 8'///
     *        1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.D.C 23

```
      SUBROUTINE  DTANL9
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FL9
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 9'///
     *        1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.D.C 24

```
      SUBROUTINE  DTANLA
C
      DIMENSION  ISTM(100),XRT(100)
C
      CALL FLA
      REWIND 8
      READ(8)ISTM,XRT
      WRITE(6,1000)
 1000 FORMAT(1H1,10X,'DATA OF BLOCK 10'///
     *        1X,5('ITI   RT(SEC)   '),//)
      CALL DTANL0(ISTM,XRT)
      RETURN
      END
```

SRT.D.C 25

```
          SUBROUTINE  DTANL0(ISTM,XRT)
    C
          DIMENSION  ISTM(100),XRT(100),XITI(5),XTBL(5,5,10),
         *           JTBL(5,5),XSTM(5),XXRT(5)
    C
          DO 100 I1=1,20
          DO 110 I11=1,5
          J1=(I1-1)*5+I11
          XXRT(I11)=XRT(J1)
          KSTM=100
          KSTP=ISTM(J1)
    112   IF(KSTP.EQ.0)GO TO 111
          KSTM=IFIX(FLOAT(KSTM)*1.3)
          KSTP=KSTP-1
          GO TO 112
    111   XSTM(I11)=FLOAT(KSTM)/100.0
    110   CONTINUE
          WRITE(6,1100)(XSTM(J1),XXRT(J1),J1=1,5)
    1100  FORMAT(1X,5(F5.2,F6.2,3X))
    100   CONTINUE
    C
    C
          DO 200 I2=1,5
          DO 201 I21=1,5
          DO 202 I22=1,10
          XTBL(I2,I21,I22)=99999.9
    202   CONTINUE
          JTBL(I2,I21)=0
    201   CONTINUE
    200   CONTINUE
          K2=ISTM(1)+1
          DO 210 I2=2,100
          K1=K2
          K2=ISTM(I2)+1
          JTBL(K1,K2)=JTBL(K1,K2)+1
          K3=JTBL(K1,K2)
          XTBL(K1,K2,K3)=XRT(I2)
    210   CONTINUE
          KITI=100
          DO 300 I3=1,5
          XITI(I3)=FLOAT(KITI)/100.0
          KITI=IFIX(FLOAT(KITI)*1.3)
    300   CONTINUE
          WRITE(6,2000)
    2000  FORMAT(1H1,5X,'CONTINGENCY TABLES')
          DO 400 I4=1,5
          WRITE(6,2100)XITI(I4),(XITI(J4),J4=1,5)
    2100  FORMAT(///15X,'RT''S FOR',F5.2,1X,'SEC. FP'//
         *       12X,'CONTINGENT ON PREVIUOS FP''S.'//
         *       10X,5(F5.2,' SEC.')//)
          WRITE(6,2200)((XTBL(JK1,I4,JK2),JK1=1,5),JK2=1,10)
    2200  FORMAT(10(10X,5(F5.2,5X),/))
    400   CONTINUE
```

```
SRT.D.C  25

   54:  C
   55:  C
   56:          RETURN
   57:          END
```

APPENDIX E

The program for calculating the values in Figures 6 and 7.

```
L
C
C        MAIN PROGRAMM
C
      WRITE(6,1000)
 1000 FORMAT(1X,'MIN T =')
      READ(5,1010)XMINT
 1010 FORMAT(F7.2)
      WRITE(6,1020)
 1020 FORMAT(1X,'MAX T =')
      READ(5,1010) XMAXT
      WRITE(6,1030)
 1030 FORMAT(1X,'ROU =')
      READ(5,1010)ROU
      WRITE(6,1040)
 1040 FORMAT(1X,'LAMDA =')
      READ(5,1010)XLAMD
      WRITE(6,1050)
 1050 FORMAT(1X,'DELTA =')
      READ(5,1010)DELT
      WRITE(6,1070)
 1070 FORMAT(1X,'MEAN RT IN THE NOT READY STATE =')
      READ(5,1010)RTNR
      WRITE(6,1080)
 1080 FORMAT(1X,'MEAN RT IN THE READY STATE =')
      READ(5,1010)RTR
      WRITE(6,3000)
 3000 FORMAT(1X,'BACKGROUND WEIGHT =')
      READ(5,1010)WB
      WRITE(6,3010)
 3010 FORMAT(1X,'PREV. ST. WEIGHT =')
      READ(5,1010)WPR
      WRITE(6,3020)
 3020 FORMAT(1X,'BACKGROUND SET UP TIME =')
      READ(5,1010)TB
      WRITE(6,2030)
 2030 FORMAT(1X,'PREV. T =')
      READ(5,1010)TPR
      READ(5,1060)A
 1060 FORMAT(A4)
C
C
      WRITE(6,2000)XMINT,XMAXT,ROU,XLAMD,DELT,RTNR,RTR,
     *                  WB,WPR,TB,TPR
 2000 FORMAT(5X,'MINIMUM VALUE OF T =',F7.2//
     *         5X,'MAXIMUM VALUE OF T =',F7.2//
     *         5X,'ROU =',F7.2//
     *         5X,'LAMDA =',F7.2//
     *         5X,'DELTA =',F7.2//
     *         5X,'MEAN RT IN THE NOT READY STATE =',F7.2//
     *         5X,'MEAN RT IN THE READY STATE =',F7.2//
     *         5X,'WEIGHT OF BACKGROUND =',F7.2//
     *         5X,'WEIGHT OF THE PREVIUOS STIMULUS =',F7.2//
     *         5X,'BACKGROUND SET UP TIME =',F7.2//
     *         5X,'PREVIUOS T =',F7.2//)
C
C         **********     DELT MODIFIED      ***********
C
      T0=(WB*TB+WPR*TPR)/(WB+WPR)
      DELT=DELT*T0
      WRITE(6,4000)DELT
 4000 FORMAT(5X,'MODIFIED DELTA = ',G12.5//
     *     //5X,'T =',17X,'P =',17X,'MEAN RT ='/)
      T=XMINT
  200 IF(T.GT.XMAXT)GO TO 100
      XP=P(T-T0,ROU,XLAMD,DELT)
```

```
      RT=XP*RTR+(1.0-XP)*RTNR
      WRITE(6,2010)T,XP,RT
 2010 FORMAT(5X,G12.5,8X,G12.5,8X,G12.5)
      T=T+0.1
      GO TO 200
C
C
 100  WRITE(6,2020)
 2020 FORMAT(//5X,'NORMAL END')
      STOP
      END
C
C
C
C          ***********    SUBROUTINE     **************
C
      FUNCTION P(T,ROU,XLAMD,DELT)
      P=0.0
      DT=0.0
 300  IF(DT.GT.T)GO TO 200
      P=P+G(T-DT,ROU,XLAMD)*H(DT,DELT)*0.0001
      DT=DT+0.0001
      GO TO 300
C
 200  RETURN
      END
C
C
C          ***********    SUBROUTINE     **************
C
      FUNCTION H(T,DELT)
      IF(T.LE.0.0)GO TO 100
      IF(T.LT.DELT)GO TO 200
      H=0.0
      RETURN
C
 100  H=0.0
      RETURN
C
 200  H=1.0/DELT
      RETURN
C
      END
C
C
C          ***********    SUBROUTINE     **************
C
      FUNCTION G(T,ROU,XLAMD)
      IF(T.LE.ROU)GO TO 100
      IF(T.LT.(ROU+XLAMD))GO TO 200
      G=0.0
      RETURN
C
 100  G=1.0
      RETURN
C
 200  G=(ROU+XLAMD-T)/XLAMD
      RETURN
C
      END
KEQ52500I END OF DATA SET
E
```

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