A STUDY OF THE SEQUENTIAL EFFECTS OF
PREDICTION OUTCOME ON CHOICE REACTION TIME

by

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I. INTRODUCTION

A consistent finding of choice reaction time (RT) studies in which Ss make stimulus predictions before each stimulus is presented has been that Ss react faster to correctly predicted stimuli than to incorrectly predicted stimuli (e.g., Bernstein & Reese, 1965; Hinrichs & Craft, 1971; Geller & Pitz, 1970). Recently, choice RT to a given stimulus has been shown to be reliably influenced by the prediction outcome (PO) on the trials immediately preceding that stimulus (Whitman & Geller, 1971a, 1971b, 1972a, 1972b). A result common to these studies of the sequential effects of PO on choice RT has been that RT to correctly predicted stimuli was shorter when the preceding PO was correct than when the preceding PO was incorrect.

On the other hand, the sequential effect of PO on RT to incorrectly predicted stimuli has varied among studies. One variable which was shown to influence the sequential effect of PO on RT to incorrectly predicted stimuli was the compatibility of the stimulus--response mapping (Whitman & Geller, 1971b). When a compatible mapping of right and left responses to right and left stimuli was employed RT following incorrectly predicted stimuli was somewhat longer if the preceding PO was correct. However, in an incompatible S--R situation, RT to incorrectly predicted stimuli was shorter when the preceding PO was correct (Whitman & Geller, 1971b).

A partial explanation of the sequential effects of PO has been derived from a notion that stimulus "expectancy" varies along a continuous dimension, and that an increase in expectancy (i.e., S's anticipation of a particular stimulus) facilitates the identification of correctly predicted stimuli and inhibits the identification of incorrectly predicted stimuli (Geller & Pitz, 1970).

Subsequently, Whitman and Geller (1971a, 1971b, 1972a, 1972b) proposed that confidence in stimulus prediction mediates sequential fluctuations in stimulus expectancy in this manner: correct prediction of a stimulus is assumed to increase confidence in subsequent predictions and thus augments expectancy for the predicted stimulus, while an incorrect PO decreases subsequent prediction confidence and thus lessens expectancy for the predicted stimulus. Thus, the continuous expectancy theory assumes that RT to correctly predicted stimuli is facilitated by preceding correct POs but that RT to incorrectly predicted stimuli is inhibited by preceding correct POs.

These relationships were observed with a compatible S--R mapping, a condition which is assumed to maximize the role of stimulus expectancy as a determinant of choice RT

(Geller, Whitman, & Farris, 1972; Keele, 1969). When the S--R relationship was incompatible the theory accurately predicted the finding that RT to correctly predicted stimuli preceded by correct POs was shorter than RT to correctly predicted stimuli preceded by incorrect POs. However, the theory failed to explain the result that RT to incorrectly predicted stimuli preceded by correct POs was shorter than RT to incorrectly predicted stimuli preceded by incorrect POs.

A basic assumption of the continuous expectancy hypothesis is that Ss generally increase their confidence in a stimulus prediction following correct POs and decrease prediction confidence following incorrect POs. But, prediction confidence may not always increase following correct prediction and decrease following incorrect prediction. The present analysis divides data into two categories: "consonant" when confidence change is consistent with the continuous expectancy model, and "dissonant" when confidence change is contrary to the assumption of the model. Experiment 1 is a between-Ss design in which Ss are dichotomized as generally changing their confidence judgments in a manner consistent or inconsistent with the model; while Experiment 2 is a within-Ss design in which each choice RT trial is dichotomized according to whether or not S's confidence judgment followed the expectancy model.

II. EXPERIMENT 1

Method

Subjects. Forty-three *S*s (24 males, 19 females) volunteered from introductory psychology classes at Virginia Polytechnic Institute and State University. Three *S*s made errors (anticipatory responses or inaccurate identifications) on more than 5% of the trials and were excluded from the data analysis.

Apparatus and Procedure. In a two-stimulus, two-response, choice RT task with one-to-one S--R mapping, *S*s made stimulus predictions and judged their chance of being correct (i.e., confidence) to be 50, 60, 70, 80, 90, or 100 prior to each of 600 stimulus presentations. The task instructions stated that a confidence estimate of 50 should indicate complete uncertainty in the prediction and that 100 should indicate complete certainty, and requested careful consideration of each prediction and confidence estimate. The instructions emphasized the importance of both speed and accuracy in choice reactions.

The two equiprobable stimuli were the symbols $\sqcup$ and $\sqcap$ (verbally labeled "up" and "down" respectively) presented by a 1.5 x 2.5 cm digital readout which was centered on a black screen separating *E* from *S*. The two response mechanisms were telegraph keys spatially separated by 25 cm. Twenty Ss used their right forefinger to press the right key following $\sqcup$ and their left forefinger to press the left key following $\sqcap$, while the remaining 20 Ss used the reverse S--R mapping arrangement.

For each of the 600 trials, the sequence of events was as follows: S verbally predicted which stimulus would occur next and then estimated a prediction confidence by verbally indicating which of the six numbers printed on a card above the stimulus readout was appropriate (50, 60, 70, 80, 90, or 100), E sounded a brief warning buzzer, a stimulus was presented after a random time interval of between .5 and 2 sec., S's choice response terminated the stimulus presentation and stopped a digital millisecond timer. The S initiated the next trial by verbalizing a stimulus prediction and a confidence judgment. At the start of the individual sessions Ss were given ten practice trials during which their questions concerning the task were answered. After the initial 300 trials a ten minute break was provided.

Results

To study the effect of PO on confidence, the mean changes in confidence judgments following correct and incorrect POs were computed for each S. The mean change in confidence following correct predictions was a 1.2 point decrease on a 50 point scale (i.e., there was a fifty point difference between 50 and 100, and a confidence estimate of 70 followed by one of 60 was considered a decrease of 10.0). The average change in confidence following incorrect POs was an increase of 1.7.

As an example of what is meant by "average change in confidence" consider a S who was correct on 300 trials. If confidence increased by 10 points on 200 trials and decreased by 10 points on 100 trials, then the average change in confidence following correct POs was an increase of 3.3 points.

To examine the relationship between changes in confidence and the sequential effects of PO on choice RT two groups of 15 Ss were selected as follows. Fifteen of the 40 Ss exhibited an average increase in confidence following correct predictions and an average decrease in confidence following incorrect predictions. These 15 Ss were labeled as "consonant," or correct--positive change, incorrect--negative change (Group C+/I-) and the group mean confidence changes were a 2.3 point increase following correct predictions and a 2.5 point decrease following incorrect predictions. From the remaining 25 Ss the 15 who exhibited the greater opposite changes in confidence (i.e., correct--negative change, incorrect--positive change) were labeled "dissonant," or Group C-/I+ and the group mean confidence changes were a 4.8 point decrease following correct predictions and a 6.3 point increase following incorrect predictions. Thus, 10 Ss who exhibited group average confidence changes of .9 point decrease following correct POs and 1.2 point increase following incorrect predictions were not included in subsequent analyses. Because the 2 groups of 15 Ss each had 8 Ss from one S--R condition and 7 from the other, the S--R mapping was essentially balanced between groups.

The sequential effect of PO on choice RT was studied for each group by computing the mean RT for each S for the four second order PO categories: two consecutive corrects, a correct preceded by an incorrect, two consecutive incorrects, or an incorrect preceded by a correct. The group averages of the S's means are depicted in Figure 1 and clearly indicate shorter latencies on trials preceded by correct POs than on trials preceded by incorrect POs for Group C+/I- but only slight differences in mean RTs due to preceding POs for Group C-/I+.

An overall analysis of variance, a 2(Groups, C+/I- vs C-/I+) x 2(Current PO, correct or incorrect) x 2(Preceding PO, correct or incorrect) factorial analysis, indicated a reliable second order interaction, i.e., Group x Current PO x Preceding PO, $F(1,28) = 5.12$, $p < .05$. To examine the interaction in detail, a 2(Current PO) x

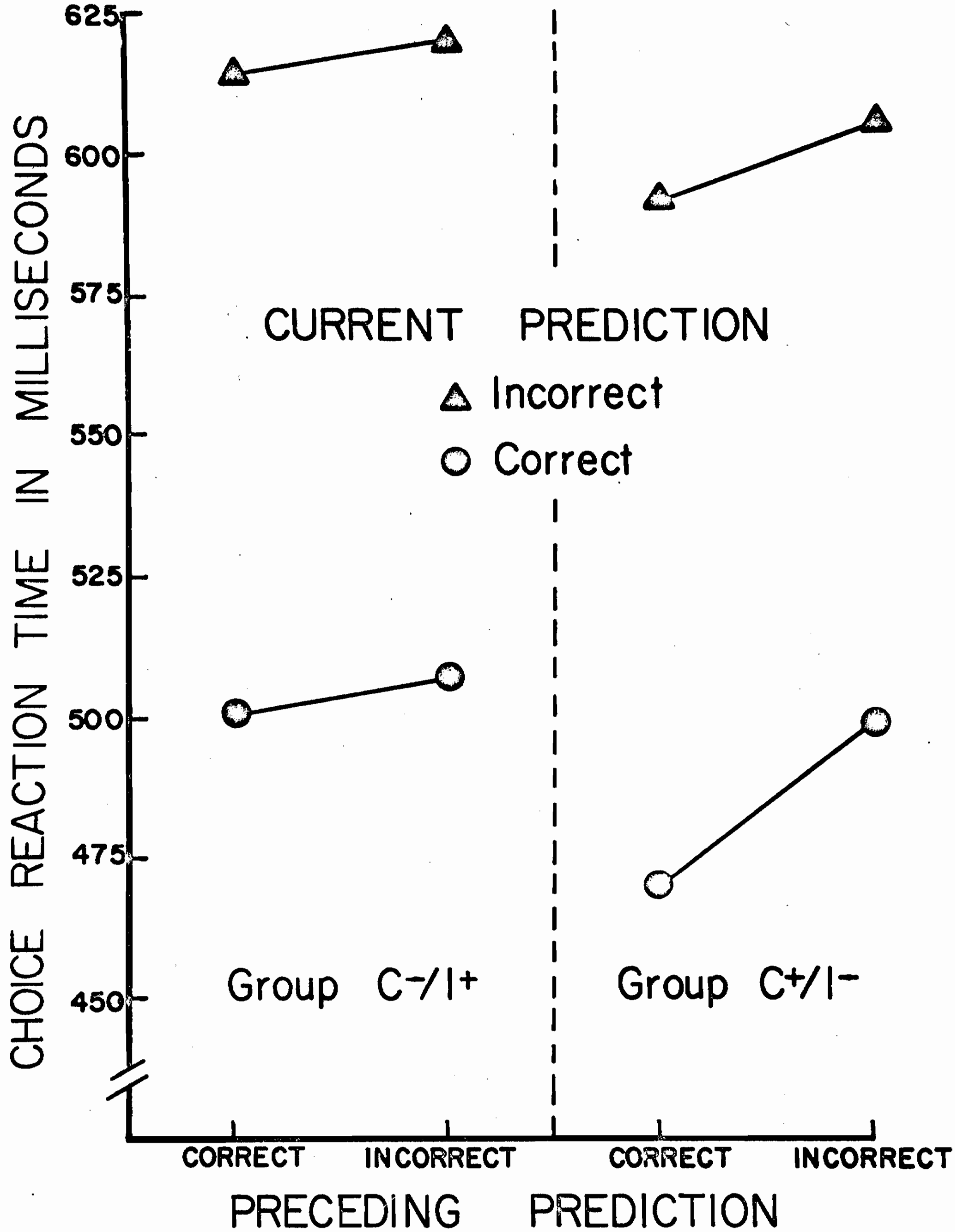

Figure 1. Choice reaction time as a function of consonant (C+/I-) subjects versus dissonant (C-/I+) subjects, current prediction outcome, and preceding prediction outcome.

2(Preceding PO) analysis of variance was computed for each group. For Group C+/I-, all three *F*s were significant: current PO, $F(1,14) = 112.29$; preceding PO, $F(1,14) = 10.06$; and their interaction, $F(1,14) = 9.47$, $p < .01$. The Current PO x Preceding PO interaction for Group C+/I- reflects a 26 millisecond difference between mean RTs to correctly predicted stimuli preceded by correct POs and RTs preceded by incorrect POs, and only a 12 millisecond difference in mean RTs to incorrectly predicted stimuli preceded by correct POs and RTs preceded by incorrect POs. In contrast, the analysis for Group C-/I+ indicated differences in mean RT due to preceding PO of less than 7 milliseconds for both correct and incorrect current POs and thus only a main effect of current PO was reliable, $F(1,14) = 45.89$, $p < .001$, with no effect of preceding PO, $F(1,14) = 2.62$, $p > .10$, nor an interaction, $F < 1$.

Discussion

Choice RT of *S*s whose average confidence changes were influenced by PO contrary to the direction suggested by the continuous expectancy hypothesis (Group C-/I+) demonstrated no reliable sequential effects of PO. However, the RT of *S*s whose average confidence judgments did change in the direction hypothesized by the expectancy notion (Group C+/I-) was influenced by preceding PO. Moreover, when the current PO was correct, the nature of the preceding PO effect was as hypothesized. However, in spite of the occurrence of the hypothesized changes in confidence for Group C+/I-, the hypothesized effect of preceding PO on choice RT to incorrectly predicted stimuli did not occur.

This result is consistent with the results of previous research because the sequential effect of PO on choice RT to incorrectly predicted stimuli has varied between and within studies (Whitman & Geller, 1971a, 1972a, 1972b). Only once has the effect of preceding PO on RT to incorrectly predicted stimuli been correctly predicted by the continuous expectancy hypothesis and this occurred when the S--R mapping was extremely compatible (Whitman & Geller, 1971b). The S--R relationship of Experiment 1 was the same relatively complex one used by Whitman and Geller (1971a) and the effects of preceding PO in that study were similar to those of the present experiment. The effects of confidence and preceding PO in Experiment 2 included S--R compatibility as a between-groups variable.

A major weakness of Experiment 1 was that the change in confidence criteria used to categorize Ss were determined by averaging over 600 trials. In part, this problem occurred because prediction confidence varied among six values while the analysis was concerned only with the occurrence of an increase or decrease in confidence as a function of PO. Another problem was that a confidence change of 50 to 60 was equated to a change of 90 to 100. Also, ceiling problems were possible if S estimated a confidence of 50 and then felt less confident in the subsequent prediction, or if S reported 100 and on the next trial felt more confident.

The second experiment was designed to overcome these weaknesses by requiring Ss to judge whether their confidence in a current prediction was greater or less than their confidence on the previous trial. Thus, Ss could not indicate the same degree of confidence on consecutive trials and there was no limit to the number of consecutive "less" or "more" judgments. In addition, Experiment 2 provided a more refined test of the continuous expectancy hypothesis through dichotomous categorization of each confidence change as being consistent or inconsistent with the continuous expectancy hypothesis. That is, the variable C+/I- vs C-/I+ was a between-Ss variable in Experiment 1 but was a within-Ss variable in Experiment 2.

III. EXPERIMENT 2

Method

Subjects. The participants were 42 volunteer Ss from introductory psychology classes who had not previously participated in RT experiments. The Ss were randomly assigned to a compatible or an incompatible S--R mapping situation with the restriction that there were 10 males and 11 females for each compatibility condition.

Apparatus and Procedure. The choice RT apparatus consisted of spatially separated left- and right-hand reaction triggers, two 1 x 3 cm digital readouts separated on a horizontal axis by 35 cm, a digital millisecond timer, and relay-logic equipment. The symbol ⊓ was displayed on the left and right readouts by illuminating five of the seven segments.

During individual one hour sessions, each S received 310 stimulus presentations, including ten practice trials during which questions concerning the task were answered. The instructions emphasized both speed and accuracy in the choice reactions and urged careful consideration of both predictions and the confidence statements.

The sequence of events for each trial was: a) verbal stimulus prediction and judgment of "more" or "less" confidence in the prediction, b) warning buzzer, c) variable time interval of between .5 and 2 seconds, d) stimulus presentation, and e) choice response which stopped the digital timer and turned off the stimulus. The Ss were informed immediately following subject error, i.e., whenever the response anticipated the stimulus or was incorrectly matched to the stimulus.

Stimulus location was determined by a random number generator on an IBM 370 system and each occurred on 50% of the trials, with the restriction that within each block of 100 trials 25 of the following four second order stimulus patterns occurred: left, left; left, right; right, left; and right, right. The 21 Ss of Group Compatible responded with the right-hand trigger to the right stimulus and with the left-hand trigger to the left stimulus. Conversely, the 21 Ss of Group Incompatible responded with the right-hand trigger to the left stimulus and with the left-hand trigger to the right stimulus.

Results

Choice Reaction Errors. Subject error trials were deleted from the data analysis. No S made more than 15 errors, or an error rate greater than 5%. The Ss of groups Compatible and Incompatible had average error rates of 1.2% and 1.8% respectively. This error rate difference was not significant at the .05 level, $F(1,40) = 3.94$, $.05 < p < .10$.

<u>Prediction Outcome and Confidence</u>. One analysis evaluated the effect of PO on subsequent prediction confidence. Those trials on which "more" confidence was preceded by a correct prediction, or "less" confidence was preceded by an incorrect prediction were separated in one data category referred to as C+/I-. In addition, trials on which judgments of "less" confidence were preceded by correct POs, or statements of "more" confidence were preceded by incorrect POs were classified in a C-/I+ category. The variables: preceding PO, confidence, and confidence change category (i.e., C+/I- vs C-/I+) were confounded in that the same data could be described as a Preceding PO x Confidence design, or as a Preceding PO x Change Category design, or as a Confidence x Change Category design. The mean percentage of occurrences of the four categories was calculated for the compatible and incompatible S--R conditions and is presented in Table 1. Since the frequency data represented an interval scale and Hartley's test for homogeneity of variance indicated acceptance of the null hypothesis, that homogeneity of variance was present at the .05 level, an analysis of variance was applied to the 2(Group) x 2(Confidence) x 2(Change Category) factorial design.

The frequency data in Table 1 indicated that confidence judgments of "more" occurred on a greater number of

Table 1

Mean Percentage of Events as a Function of Change Category, Preceding Prediction Outcome, Confidence, and Compatibility

Data Category			Percentage of events	
			Group	
Change Category	Preceding PO	Confidence	Compatible	Incompatible
C+/I-	correct	more	33.5	33.3
C+/I-	incorrect	less	21.6	19.3
C-/I+	incorrect	more	23.6	27.5
C-/I+	correct	less	16.7	16.2

trials than judgments of "less" confidence, and the analysis of variance reflected this with a significant main effect of confidence, $F(1,40) = 47.31$, $p < .001$. Furthermore, Ss were more likely to indicate "more confident" when the preceding PO was correct than on trials when the preceding PO was incorrect, and, to a slightly lesser degree, Ss were more likely to indicate "less" confidence on trials when the preceding PO was incorrect than on trials when the preceding PO was correct, an observation supported by the reliability of the main effect of change category, $F(1,40) = 6.10$, $p < .025$. Finally, since the magnitude of the effect of preceding PO on subsequent confidence judgments was greater when the subsequent confidence judgment was "more" than when the judgment was "less," the Change Category x Confidence interaction was significant, $F(1,40) = 11.09$, $p < .005$. None of the interactions involving groups was reliable, $p > .05$.

Prediction Confidence and Choice RT. One analysis of RT data investigated the effects of prediction confidence and PO on choice RT by categorizing each RT into one of two mutually exclusive categories dependent on the relationship between confidence judgment and the preceding PO. That is, trials which consisted of confidence judgments of "more" preceded by correct POs or judgments of "less" preceded by incorrect POs (C+/I-) were analyzed independently from trials on which judgments of "more" were preceded by incorrect POs or when "less" was preceded by correct POs (C-/I+). As in the analysis of prediction outcome and confidence, the C+/I- vs C-/I+ variable will be referred to as change category. Thus, the variables Group, Current PO, Preceding PO, and Change Category occurred in a 2 x 2 x 2 x 2 factorial analysis. The group means of the S's mean RT for each of these eight categories are presented in Figure 2.

An analysis of variance indicated reliable main effects of current PO, $F(1,40) = 64.43$, $p < .001$; preceding PO, $F(1,40) = 32.71$, $p < .001$; and change category, $F(1,40) = 6.02$, $p < .025$. There was no reliable main effect of compatibility, $F(1,40) = 2.73$, $p > .10$. In addition, three interactions were significant. The Preceding PO x Change Category effect was reliable, $F(1,40) = 4.12$, $p < .05$, since, collapsing across current PO and groups, there was a greater effect of Preceding PO for C+/I- trials than for C-/I+ trials. The Current PO x Preceding PO x Change Category interaction was significant, $F(1,40) = 8.28$, $p < .01$. That is, combining compatibility groups, when current PO was correct, the effect of preceding PO was present for condition C+/I- but was absent in condition C-/I+; but given an incorrect current PO, the sequential effect of PO was slight regardless of the change category. Finally, the

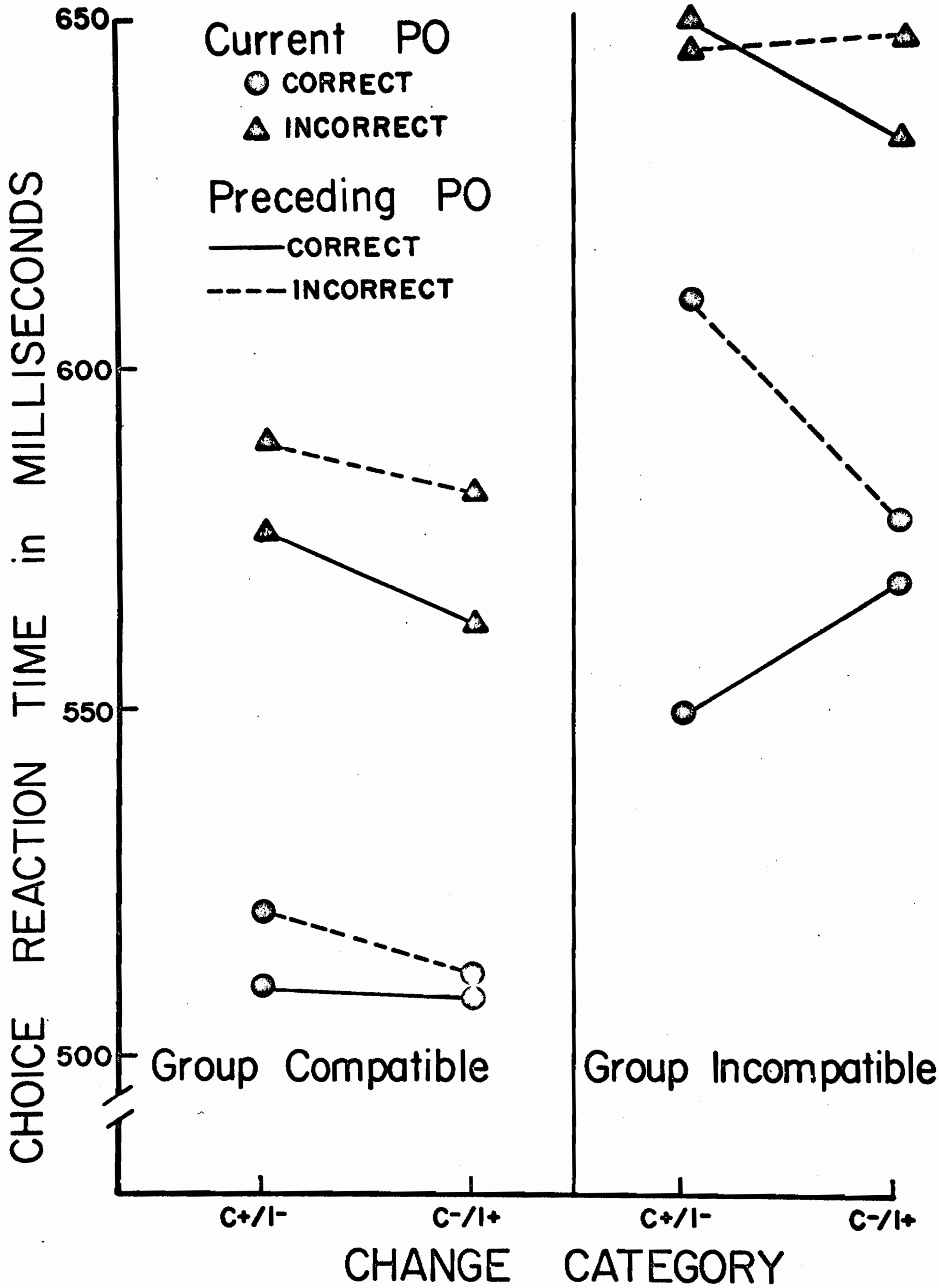

Figure 2. Choice reaction time as a function of S--R compatibility, consonant (C+/I-) versus dissonant (C-/I+) trials, current prediction outcome, and preceding prediction outcome.

Group x Current PO x Preceding PO interaction was reliable, $F(1,40) = 10.81$, $p < .005$, and was due to the result that, collapsing across the change categories, the effect of preceding PO for Group Incompatible was 34 milliseconds when the current PO was correct, in contrast to a less than 17 millisecond effect of preceding PO in any of the other compatibility and PO categories. None of the remaining interactions was significant. Thus, the effects of first and second order PO on choice RT were shown to be influenced by the compatibility of the S--R relationship and by confidence judgment.

Stimulus Patterns and RT. For purposes of this analysis, a "stimulus repetition" was defined as the second of any two consecutive identical stimuli, and a "stimulus alternation" was the second of any two consecutive dissimilar stimuli. An analysis of choice RT data included stimulus pattern in addition to the variables compatibility, current PO, and preceding PO. The results of the analysis are depicted in Figure 3 in the same format as the data in Figure 2, with the exception that the variable on the abscissa is stimulus pattern. As evident in Figure 3, the stimulus pattern variable interacted with S--R compatibility such that Ss of Group Compatible exhibited shorter latencies to stimulus alternations than to repetitions, but

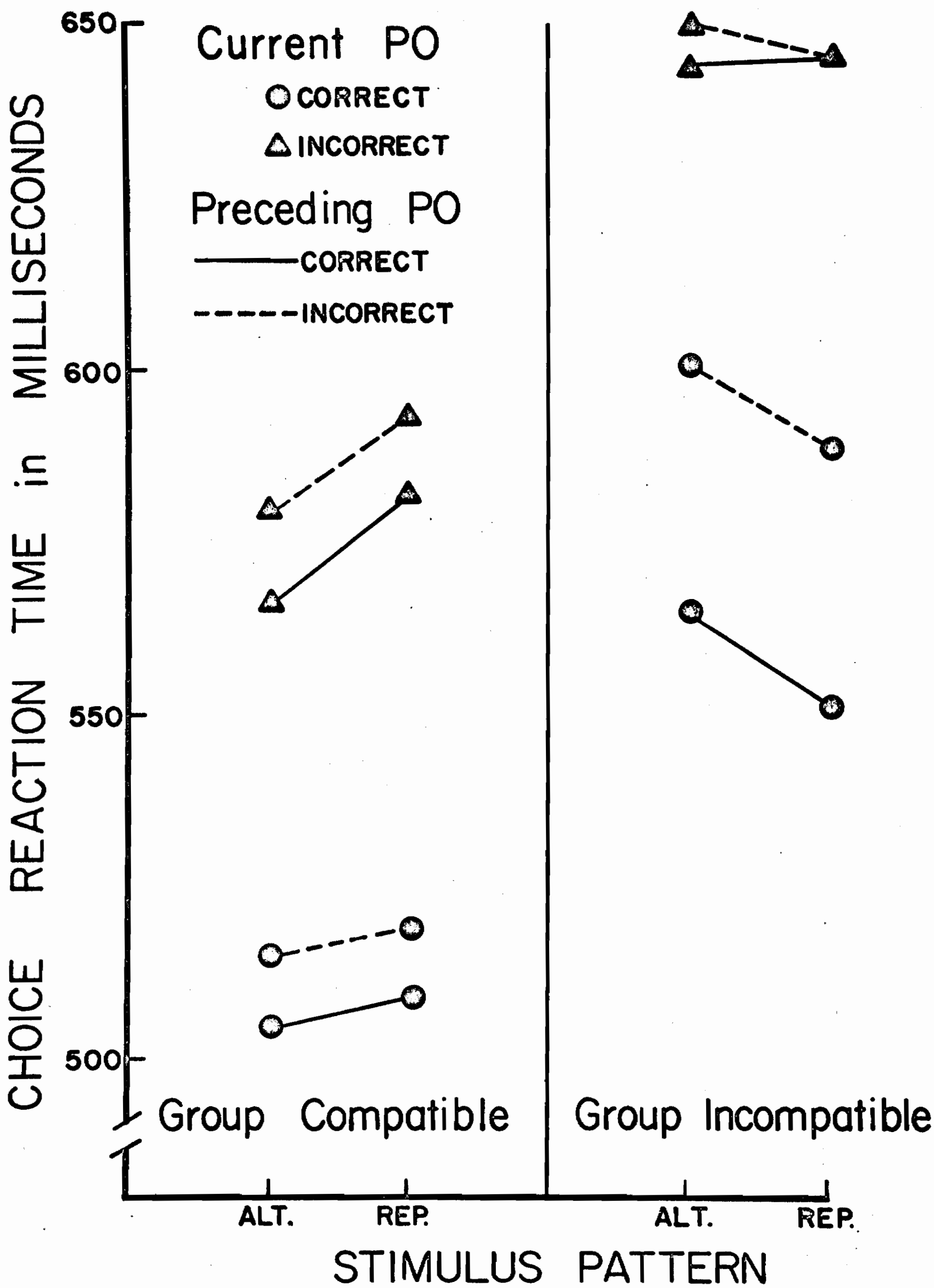

Figure 3. Choice reaction time as a function of S--R compatibility, stimulus alternation versus repetition, current prediction outcome, and preceding prediction outcome.

Ss of Group Incompatible exhibited shorter latencies to stimulus repetitions than to alternations.

The analysis of variance applied to these data was a factorial of 2(Groups) x 2(Current PO) x 2(Preceding PO) x 2(Stimulus Pattern). Only two main effects were significant, current PO, $F(1,40) = 67.27$, $p < .001$, and preceding PO, $F(1,40) = 28.91$, $p < .001$. The Group x Stimulus Pattern interaction was reliable, $F(1,40) = 5.36$, $p < .05$, as described above. The Current PO x Preceding PO effect was also reliable, $F(1,40) = 4.88$, $p < .05$, due to the greater effect of preceding PO when the current PO was correct. As observed in the previous analysis of RT as a function of prediction confidence and preceding PO, the Group x Current PO x Preceding PO interaction was significant, $F(1,40) = 6.04$, $p < .025$, and was a result of the prominent effect of preceding PO on RT to correctly predicted stimuli for Group Incompatible. No other main effects or interactions were significant, $p > .05$.

Prediction Strategies. To understand prediction strategies, it may be helpful to study three second order variables: the stimulus pattern, the predicted stimulus pattern, and the prediction pattern. Considering S's predicted stimulus pattern, when S predicts that the stimulus which has just occurred will appear again on the subsequent trial, S has predicted a stimulus repetition. In contrast, predicting an alternation occurs when S predicts the stimulus alternative which was not presented on the preceding trial. However, prediction strategies may also consist of prediction patterns. That is, when S makes the same prediction on two consecutive trials, S has repeated the prediction, in contrast to changing the prediction from one trial to the next or alternating the prediction.

One problem involved in the analysis of the variables stimulus pattern, predicted stimulus pattern, and prediction pattern is that they are confounded. As presented in Table 2, frequency may be considered as the dependent variable of a 2 x 2 x 2 factorial combination of current PO, preceding PO, and any one of the variables: stimulus pattern (SP), predicted stimulus pattern (PSP), or prediction pattern (PP). However, it should be noted that each of the three possible factorials including current and preceding PO must confound the two variables not included.

In the analysis of variance Current PO x Preceding PO x Stimulus Pattern, the variables predicted stimulus pattern and prediction pattern are confounded because they vary concomitantly with the interactions Current PO x Stimulus Pattern and Current PO x Preceding PO x Stimulus Pattern, respectively. That is, the predicted stimulus pattern is a linear combination of current PO and stimulus pattern, so that predicted stimulus pattern is identical to stimulus

Table 2

Mean Percentage of Events as a Function of Prediction Pattern and Predicted Stimulus Pattern, Second Order Prediction Outcome Category, and the Stimulus Pattern

PPO[a]	CPO[b]	SP[c]	PSP[d]	PP[e]	Mean Percentage Group Compatible	Incompatible
cor	cor	rep	rep	rep	17.3	17.1
inc	cor	rep	rep	alt	12.6	9.0
cor	inc	rep	alt	alt	8.0	10.1
inc	inc	rep	alt	rep	11.7	13.3
cor	cor	alt	alt	alt	8.3	10.1
inc	cor	alt	alt	rep	12.0	15.3
cor	inc	alt	rep	rep	16.5	14.0
inc	inc	alt	rep	alt	12.4	9.3

[a] Preceding PO
[b] Current PO
[c] Stimulus Pattern
[d] Predicted Stimulus Pattern
[e] Prediction Pattern

pattern when current PO is correct, and is opposite to stimulus pattern when current PO is incorrect. Correspondingly, the prediction pattern is a linear combination of current PO, preceding PO and stimulus pattern such that prediction pattern is identical to stimulus pattern when current PO and preceding PO are the same, and prediction pattern was opposite to stimulus pattern when current PO and preceding PO are not the same. Thus, for example, the next to the last source of variance in Table 3 may be regarded as the Preceding PO x Current PO x Stimulus Pattern interaction, or the Preceding PO x Predicted Stimulus Pattern interaction, or the main effect of prediction pattern since these terms are all labels for the same source of variance.

The analysis of variance presented in Table 3 was computed with the frequency data of Table 2. Each row in Table 3 indicates a unique source of variance, and the analysis may be interpreted alternately as effects of stimulus pattern, predicted stimulus pattern, or prediction pattern. Since Ss made more correct predictions than incorrect predictions, the analysis of variance indicated reliable main effects of both current PO and preceding PO. The reliable main effect of stimulus pattern was due to the fact that each S observed 149 stimulus repetitions and 150 stimulus alternations, a small but obviously consistent difference. The Current PO x Stimulus Pattern effect (or the main effect

Table 3

Analysis of Variance for the Group x Current PO x Preceding PO x Stimulus Pattern Design, with the Equivalent Sources of Variance Indicated for the Predicted Stimulus Pattern Design and the Prediction Pattern Design

Analysis of Variance

Stimulus Pattern (SP)	Predicted Stimulus Pattern (PSP)	Prediction Pattern (PP)	F (1,40)	p
Group (G)	G	G	3.94	.10
Current PO (CPO)	CPO	CPO	10.48	.005
GxCPO	GxCPO	GxCPO	1.99	.20
Preceding PO (PPO)	PPO	PPO	11.10	.005
GxPPO	GxPPO	GxPPO	3.04	.10
CPOxPPO	CPOxPPO	CPOxPPO	1.40	.25
GxCPOxPPO	GxCPOxPPO	GxCPOxPPO	0.30	---
SP	CPOxPSP	CPOxPPOxPP	52.20	.001
GxSP	GxCPOxPSP	GxCPOxPPOxPP	3.09	.10
CPOxSP	PSP	PPOxPP	13.81	.001
GxCPOxSP	GxPSP	GxPPOxPP	4.37	.05
PPOxSP	CPOxPPOxPSP	CPOxPP	0.51	---
GxPPOxSP	GxCPOxPPOxPSP	GxCPOxPP	0.01	---
CPOxPPOxSP	PPOxPSP	PP	68.04	.001
GxCPOxPPOxSP	GxPPOxPSP	GxPP	1.16	---

of predicted stimulus pattern) was significant because Ss predicted an average of 8% more stimulus repetitions than stimulus alternations. The Group x Current PO x Stimulus Pattern interaction (or the Group x Predicted Stimulus Pattern interaction) was significant since Ss of Groups Compatible and Incompatible predicted stimulus repetitions on an average of 58.8% and 49.4% of the trials, respectively. Finally, the Current PO x Preceding PO x Stimulus Pattern interaction (or the main effect of prediction pattern) was reliable because Ss repeated predictions on an average of 58.6% of the trials.

Prediction Strategy and Confidence. Preceding PO, prediction confidence, and prediction pattern were studied as independent variables in an analysis of prediction strategies. The relative frequency of each of the eight categories was determined by dichotomizing each trial threefold: according to correct or incorrect preceding PO, "more" or "less" prediction confidence, and repetition or alternation of a prediction. The average percentage of events in each category for each group is presented in Figure 4.

A factorial analysis of 2(Groups) x 2(Preceding PO) x 2(Prediction Pattern) x 2(Confidence) indicated three reliable main effects: preceding PO, $F(1,40) = 11.10$, $p < .005$; prediction pattern, $F(1,40) = 68.04$, $p < .001$;

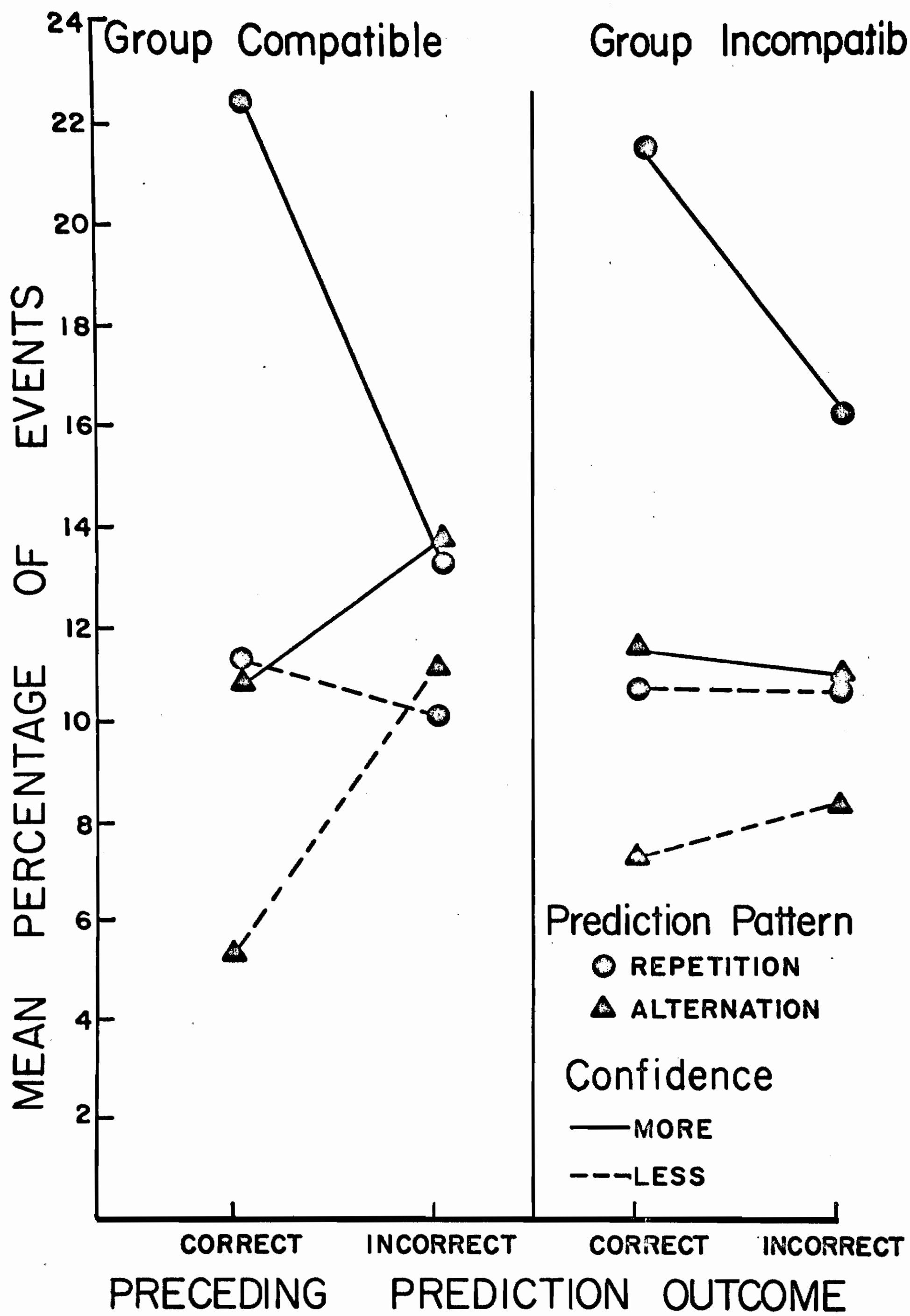

Figure 4. Mean percentage of events as a function of S--R compatibility, preceding prediction outcome, prediction alternation versus repetition, and prediction confidence.

and confidence, $F(1,40) = 47.31$, $p < .001$. The Prediction Pattern x Confidence interaction was significant since Ss tendency to repeat rather than alternate a prediction was more prominent when they were "more" confident than when they were "less" confident, $F(1,40) = 14.34$, $p < .001$.

In addition, there were three significant interactions involving preceding PO which indicated that preceding PO was a determinant of subsequent prediction as well as subsequent confidence judgment. The Preceding PO x Prediction Pattern effect was reliable, $F(1,40) = 13.81$, $p < .001$, because Ss repeated predictions following correct POs to a greater extent than following incorrect predictions. Again Ss were more confident following correct POs than following incorrect predictions and consequently the Preceding PO x Confidence interaction was reliable, $F(1,40) = 6.10$, $p < .025$. As evident in Figure 4, the between-groups variable (compatibility) influenced prediction such that Group Compatible indicated a more prominent Preceding PO x Prediction Pattern interaction than did Group Incompatible, and therefore the Group x Preceding PO x Prediction Pattern interaction was significant, $F(1,40) = 4.37$, $p < .05$. Thus, the variables compatibility and preceding PO influenced prediction strategies and confidence.

IV. DISCUSSION

An important test of the continuous expectancy hypothesis was provided by the study of confidence change as a function of preceding PO. As hypothesized, Ss indicated "more" confidence following correct POs nearly twice as often as "less" confidence. However, subsequent to an incorrect PO, Ss also indicated "more" confidence on a greater number of trials than "less" confidence, a result which is inconsistent with the continuous expectancy model.

The results of this study also suggest that significantly greater effects of preceding PO occur when the current PO is correct and confidence changes in a manner consistent with the basic assumption of the continuous expectancy model. Thus, when the current PO is correct and confidence change conforms to the assumption of the continuous expectancy hypothesis, a prominent preceding PO effect results (i.e., RT was longer when the preceding PO was incorrect than when the preceding PO was correct). However, when the current PO is correct but confidence change is opposite to that hypothesized by the continuous expectancy hypothesis, the preceding PO effect is not apparent. Thus, "continuous expectancy" is a model of the effects of preceding PO on prediction confidence and choice RT limited to correctly predicted stimuli. RT to incorrectly predicted stimuli does not consistently indicate effects of preceding PO consistent with the expectancy model. This finding replicates previous studies of the sequential effects of PO (Whitman & Geller, 1971a, 1971b, 1972a, 1972b).

The present research failed to replicate the previous finding that choice RT was significantly shorter in a compatible than an incompatible S--R mapping situation (Geller *et al.*, 1972; Keele, 1969). This unexpected result was apparently due to the fact that the compatible and incompatible conditions of Experiment 2 resulted in mean RTs of approximately 550 and 610 milliseconds respectively, as compared to 425 and 525 milliseconds respectively when RTs were collected with the same apparatus and procedure as in the present study, except without the requirement of confidence judgments (cf., Whitman & Geller, 1971b). Hinrichs and Craft (1971) observed longer RTs when *S*s were required to make stimulus predictions than when they were not, and suggested that stimulus predictions added one step to the information-processing of the stimulus, or that the basic choice processes of the two conditions differed. It is possible that the longer

RTs of the present experiment, as compared to Whitman and Geller (1971b), were the result of an additional step of information-processing, due to indication of prediction confidence; but it is difficult to imagine the nature of such a step, or its role in information-processing.

The present results replicated the observations of Schvaneveldt and Chase (1969) that a compatible S--R condition resulted in shorter RTs to stimulus alternations than to repetitions, whereas an incompatible S--R relationship resulted in shorter RTs to stimulus repetitions than to alternations. Both Bertelson (1963) and Schvaneveldt and Chase (1969) concluded that an incompatible S--R condition influenced _S_s to check for a stimulus repetition before retrieving a complex S--R mapping. In contrast to the present results and those of Schvaneveldt and Chase (1969), Bertelson (1963) observed shorter RTs to stimulus repetitions in both compatible and incompatible S--R conditions. However, both Bertelson (1963) and Schvaneveldt and Chase (1969) observed greater effects of stimulus pattern in an incompatible S--R condition than in a compatible situation, and the present research observed the interaction between S--R compatibility and stimulus pattern to be independent of current or preceding PO. Furthermore, the absence of a reliable Preceding PO x Stimulus Pattern interaction suggested that the sequential effects of PO on RT were not influenced by sequential effects of stimulus on RT, and vice versa.

The detailed analysis of frequency as a function of second order prediction sequences revealed several interesting aspects of prediction strategies. For example, the main effect of prediction pattern indicated that Ss repeated their predictions more often than they alternated predictions, in spite of the fact that stimulus alternations occurred on one trial more than stimulus repetitions. Thus, the Group x Stimulus Pattern interaction observed in the analysis of choice RT data could not be accounted for by group differences in stimulus pattern or prediction pattern frequency.

Differences due to S--R compatibility occurred in the predicted stimulus pattern analysis: Ss of Group Compatible predicted stimulus repetitions more often than Ss of Group Incompatible. However, this result was in contrast to the observed Group x Stimulus Pattern interaction in choice RT: Group Compatible predicted more stimulus repetitions but reacted slower to them, while Group Incompatible predicted fewer stimulus repetitions but reacted faster to them. Thus, the effects of S--R compatibility on choice RT to stimulus patterns were not due to the effects of compatibility on prediction strategies.

Previous analyses suggested that Ss tended to repeat their predictions when the preceding PO was correct. The new finding of the analysis of prediction strategies and confidence is that Ss tend to indicate "more" confidence when they repeat their predictions. Thus, prediction patterns may influence subsequent confidence judgments. However, the result may also indicate an influence of preceding PO on both prediction pattern and confidence.

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VI. VITA

Charles Philip Whitman was born on February 1, 1949, in Topeka, Kansas. He attended public schools in Ontario, Canada, Colorado, Hawaii, Illinois, and Virginia. He graduated from Annandale High School, Fairfax County, Virginia, in 1967. He completed degree requirements at Virginia Polytechnic Institute and State University in July, 1971, for a Bachelor of Science in math, and began graduate study in psychology in January, 1971. In June, 1972, he married the former Cynthia McIlnay, of Bedford, Pennsylvania.

Charles Philip Whitman

A STUDY OF THE SEQUENTIAL EFFECTS OF PREDICTION OUTCOME ON CHOICE REACTION TIME

by

Charles Philip Whitman

(ABSTRACT)

Change in prediction confidence was studied as a determinant of the sequential effects of prediction outcome (PO) in a two-stimulus, two-response reaction time task.

In a between-groups experiment, the RTs of "consonant" Ss, whose average confidence in a stimulus prediction increased following correct POs and decreased following incorrect POs, were reliably influenced by preceding PO. In contrast, "dissonant" Ss, whose average confidence decreased following correct POs and increased following incorrect POs, exhibited no reliable effect of preceding PO on RT.

Analogous results were obtained in a within-Ss experiment when each trial was categorized according to the relationship between preceding PO and Ss statements of having "more" or "less" prediction confidence than on the previous trial. "Consonant" trials, on which Ss indicated "more" confidence following correct POs and "less" following incorrect POs evidenced a significantly greater preceding PO effect on RT than did "dissonant" trials. The results

partially support a continuous expectancy model of the sequential effects of PO on choice RT.